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What are the barriers to using straw bale construction in cities for mid-rise and high-rise structures in Toronto, ON: looking at attitudes, knowledge, policies and practices.

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MSc Sustainability and Adaptation in the Built Environment
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ABSTRACT

With continuing growth, the global population and cities of the world have become a cause for sustainable and environmental concern. Cities are constantly constructing high density buildings to keep up with the demand with condos being the common choice which are built from conventional materials (steel, brick etc) that are energy intensive and CO2 producing. As a result, environmental targets have been put in place requiring swift and meaningful action with designs and materials that offer solutions.

One such material solution is straw in the form of straw bales. Straw is natural by-product of the food industry that grows quickly, sequesters carbon and works well as both a structural and insulating material. This paper investigates why straw bales have not been widely adopted as a construction material and aims to identify the barriers to their widespread use (for mid to highrise buildings).

Through an analysis of data collected from a literature review and data collected through inductive qualitative semi-structured interviews, a variety of themes arose from legal, physical, experiential and social perspectives. Overall, a lack of publicly accessible knowledge, official / governmental codes and standards as well as the fact that straw bales are not seen as a ‘product’ are identified main barriers to straw use. This investigation is designed to highlight these barriers for the purpose of general clarity and to be used as the groundwork for further research into potential for straw bale application.

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Thank you.

ABBREVIATIONS

CoT – City of Toronto
TAF – The Atmospheric Fund
GHG – Greenhouse Gas
CMU – Concrete Masonry Unit
IPCC – Intergovernmental Panel on Climate Change
IEA – International Energy Agency
ICC – International Code Council
IER – Institute for Employment Research
IDRE – Institute for Digital Research and Education

FIGURES

Only figures and tables sourced and not created by the author are referenced below.

1.1 World Bank Group (2018) Urban population (% of total) [online graph] Available at: https://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS?end=2017&start=1960&view=chart Accessed on: 12 November 2018

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CONTENTS:

1.0 INTRODUCTION

1.1 THE TOPIC

The aim of this study is to identify and analyse the barriers to using straw bale as a construction material in mid to high rise buildings. This paper will examine whether straw could be a sustainable building material solution for ever growing demands in urban areas (mid-rise and high-rise buildings), and if so what are the causes of it's underutilisation.

1.2 CITY GROWTH

With its continuing growth, the world's urban population has been a important issue for many over the past few decades. Approximately 55% of the world's population now live in urban environments (see figure 1.1) and by the year 2050 that is likely to increase to 66% (United Nations, 2014). These numbers suggest an expected increase of 2.5 billion people who will live in or move to urban environments (United Nations, 2014) within the next 32 years. These 2.5 billion people are going to require towns and cities to provide affordable housing with region appropriate thermal comfort and when considering the environmental impact of the materials involved, it is as critical as ever that we do so in a sustainable, environmentally friendly manner (Petkar SS, 2015).

World Population Line graph

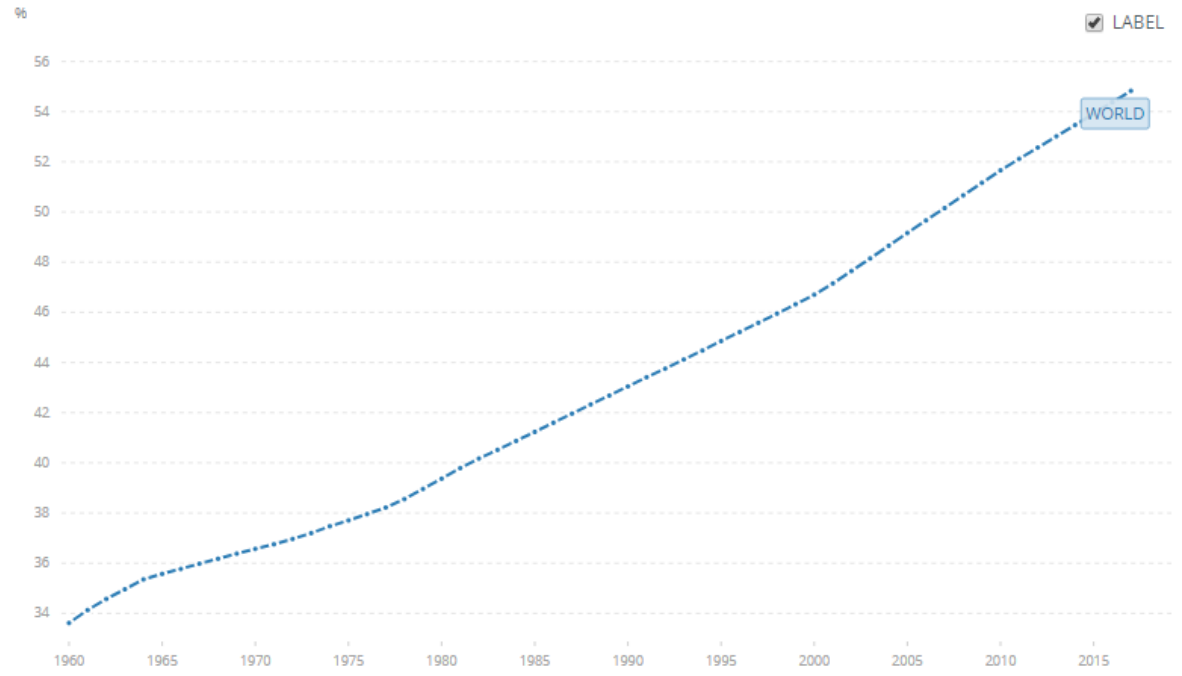

Figure 1.1 *A line graph depicting the steadily growing percentage of people living in an urban environment. It shows an increase from 34% to 55% over the past 55 years (1960 - 2015).*

According to *The City of Toronto* (CoT) and *The Atmospheric Fund* (TAF) (2017) the city of Toronto is one of the most rapidly expanding cities within North America with "85,166 residential units and 2.69 million m² of non-residential floor area" (CoT and

TAF, 2017) added to the area inside of a 4-year window (between the years of 2011 and 2015). With this trend, as well as implemented legislation such as the 'Ontario Places to Grow' Act (Ministry of Public Infrastructure Renewal, 2006), viable building land is becoming ever scarcer (McLean S 2018, Dingman S 2018, Saminather N and Scuffham M 2018). In order to keep up with Toronto's increasing demand for property within these restricted areas of land, many of the structures that the city is currently building are condominiums (condos). According to the realty brokerage *GTA-HOMES* (2018) it is predicted that Toronto will be the city which has the greatest number of high-rise condos in the world by 2020. These condos are being built relatively quickly and using the building materials that Toronto is most familiar with: brick, concrete, steel, glass and timber (see Figures 1.2, 1.3, 1.4 and 1.5 below). Most of these materials are energy intensive to produce (Pelsmakers S 2015, US Energy Information Administration 2013, Stahl N/A, D'Antonio M et al. 2003, Gopalakrishnan B et al 2005) and possess a high level of embodied energy which is damaging to the environment (Bribián et al. 2010, Thormark C 2006, Venkatarama Reddy BV and Jagadish KS 2001).

Figure 1.2 (left) *A photograph showing a new building under construction in downtown Toronto which is being erected in concrete and steel.*

Figure 1.3 (right) *A photograph showing high-rise office buildings in downtown Toronto which are wrapped in concrete and glass.*

Figure 1.4 (left) *A photograph showing retail buildings in downtown Toronto built with red brick.*
Figure 1.5 (right) *A photograph showing high-rise mix use buildings in downtown Toronto wrapped in glass.*

1.3 CITY CLIMATE AND COMFORT

Toronto's extreme seasonal climate swings add an additional level of environmental challenges and damage from excessive heating and cooling needs. High summer temperatures average approximately +27°C (a Weather Underground 2018, Government of Canada 2018) which often feel higher due to humidity, requiring buildings to use excessive and constant air conditioning. Conversely, during winter the city experiences an average temperature of approximately -12°C (b Weather Underground 2018, Government of Canada 2018) which often feels much colder due to wind chill requiring excessive and steady heating needs. These severe differences in temperature push the city's energy use above ideal usage in order to attain good levels of thermal comfort (Carlson K, 2015, Touchie MF et al. 2013). These factors are a challenge for the CoT who have pledged to reduce their 1990 levels of greenhouse gas (GHG) emissions by 80% by the year 2050 (Cot and TAF, 2017). Because of this, the broader underlying question this study is looking to help answer is: "How can Toronto address its growing carbon emissions while continuing to prosper and ensure the construction of safe and durable buildings for its residents?" (Cot and TAF, 2017).

Although wooden buildings are currently experiencing a design renaissance (Tollefson J 2017, Kelly L 2018, Nathan S 2012) and are introducing the possibility to provide Toronto (as well as many other cities around the world) with a more affordable housing solution that can also be erected quickly and safely (Tollefson J 2017), wood still does not necessarily provide an answer for environmentally friendly, thermal comfort for its occupants (which is a necessary requirement for Toronto).

1.4 LITERATURE INFLUENCE

The aims and objectives of this study have been moulded and tailored by information that has been discovered through a review of the relevant available literature. Whilst there are currently many viable alternative building materials available including timber and rammed earth (MakeItWood 2018, Understanding Building Construction N/A, Bui QB et al. 2008, Rammed Earth Constructions N/A), straw has not received the same level of attention despite its many useful qualities and historical applications. There have been many successful builds using straw bale construction in the province of Ontario such as 'Headwaters Farm House' (Straworks Inc, 2014) (figure 1.6) and 'Home Alive!' (Harvest Homes, 2003) (figure 1.7) which demonstrate that attractive, thermally sound eco design is possible to achieve in low-rise buildings.

Figure 1.6 *Photograph of 'Headwaters Farm House' built by 'Straworks'. A 1-2 storey Straw bale and timber frame building located in rural Ontario, Canada.*

***Figure 1.7**: Photograph of 'Home Alive!' by 'Harvest Homes. A 2 storey Straw bale and timber frame building located in rural Ontario, Canada.*

Looking to other countries such as France and the UK, straw has also been making progress in low rise buildings with building like the 'dome home' (Geiger O 2013) and the 'Yorkshire self-build' (Yorkshire Post 2017) with associations like Straw bale building UK (2019) becoming active. With these areas of knowledge this study aims to assess the viability of using straw bale construction in mid-rise and even high-rise property in Toronto and why the practise hasn't yet been approached. Despite the province of Ontario being a world leader of straw bale construction (with names such as Chris Magwood and Tim Krahn), there are still many gaps in available and accessible knowledge as well as a lack of excitement for experimentation or development from professionals and interested laypersons alike.

1.5 THE STUDY QUESTION

Due to these uncertain areas, this study question holds a level of importance for encouraging future investigations into the opportunities of straw as a building material and its practical applications. The question has been formed with the holistic consideration of Toronto's environmental, energy and social demands and concerns for its urban residential and commercial buildings. Straw is a very attractive natural building material within these categories due in part to the fact that it is already a natural by-product of the food industry (Hay! Straws, 2019) and therefore at present it does not require much if any more land (in North America at least) on which to produce it; it has an R-value of R-30 (Designing Buildings, 2018) compared to a standard 8 inch thick concrete masonry unit (CMU) wall which is R-1.11 (Archtoolbox n/a, ColoradoENERGY, 2016, Ching FDK, 2014) and it has very low embodied energy and carbon (Dr Geiger O, N/A) whilst also being excellent at carbon sequestering (Li S et al 2016). This research and the consequent findings are firmly

grounded in and relate to the ‘Sustainability and Adaptation in the Built Environment’ Master of Science degree as they investigate the ways in which buildings can “be made sustainable, and...designed to take account of the effects of climate change” (Centre for Alternative Technology, 2018)

1.6 THE METHOD

This study question will aim to be answered through 3 stages of inductive qualitative social research and analysis of the data. Below are the aim and objectives:

Aim

The leading aim of the study is to determine what the existing barriers are to using and utilising straw bales for construction in city buildings with specific reference to mid-rise and high-rise buildings in urban Toronto, Canada. This will be an inductive qualitative social research study which aims to understand on a professional level what barriers those in the building industry (architects, engineers, educators, etcetera) face when it comes to learning, designing, influencing and building city structures with straw. This study aims to highlight the areas that require closer attention and further research into how to make and present straw as a more desirable, well known and confidently used building material within urban environments. These aims will be met by completing these study objectives:

Objective 1

The first objective is to utilise existing research and literature in order to develop an understanding of where existing barriers to using straw in city construction generally lie. It will also take note of what information is not immediately available and / or accessible and therefore presents itself as a barrier in that form.

Objective 2

The second objective is to gain primary accounts from professionals. This will be achieved via one-on-one open question interviews in order to establish an understanding of what they have experienced as first-hand barriers to straw use (or any informed opinions they hold). This will encompass (but is not limited to) any attitudes towards straw as a product, product knowledge, any policies and legislation faced as well as how that might fit in with their general practices. Also, a collection of demographic survey questions will be performed in order to help identify any key areas of knowledge and / or influence in the field.

Objective 3

The final objective is to document, analyse, compare and contrast the primary data with that of other participants in addition to the data collected from the literature

review. The goal is that through this process the main barriers to straw use in city construction can be highlighted. The findings will be transcribed, coded, analysed and the data findings converted into systematic information in order to present the findings clearly.

1.7 BOUNDARIES AND SCOPE

Whilst this study's topic connects and associates to a plethora of related areas in environmental and industrial design, it is important to maintain direction and focus for clarity throughout this piece. This dissertation will therefore only investigate so far as to identify the barriers to using straw bale construction in mid-rise and high-rise buildings in urban environments like Toronto, Canada and will not analyse in any great detail the viability of potential solutions at this time. This includes investigation into the literature barriers, personally experienced barriers and the perceived barriers of the interviewed professionals and educators in the field of construction design. It will not significantly or extensively explain topics such as (but not limited to) general city planning, council funds, alternative energy or developing technology etcetera.

2.0 LITERATURE REVIEW

2.1 INTRODUCTION

This literature review offers contextual scope, justification for study and topical background to this dissertation. There are numerous works and areas of relevant literature that together highlight and illustrate the necessity for this research. Linked with reference to the aim and objectives (section 1.6 of the introduction) the main drives for this study predominantly fall under the subjects of city needs and desires to achieve and maintain their environmental targets as well as adopting and using sustainable and alternative building materials. At the beginning of each subsection a definition will be provided to act as the foundations to understanding and direction of the following literature research.

Firstly, in section **2.2** an investigation into environmental targets will take place. This will take a broader, more general look at the background and the need for city environmental targets as well as a closer observation of the specific targets laid out for Toronto, Canada. Section **2.3** provides a brief look at the topic of the future of mid-rise and high-rise buildings in Toronto; specifically identifying what they are, their history with cities and their development since. Section **2.4** offers a contextual examination of straw; an observation into its history, its use as a building material, contribution to thermal comfort and overall sustainability aspects. Section **2.5** will highlight buildings codes and legislation for Toronto and for straw bale construction.

2.2 ENVIRONMENTAL TARGETS

2.2.1 DEFINITION

Firstly, a definition of what this dissertation understands to be 'environmental targets': They are the goals and objectives put in place to guide governments and cities in their holistic adaptation and sustainability journey to "have the lowest possible impact on the environment" (Arctic Paper, 2016) that they can achieve (Condon C, 2012).

2.2.2 WHY A NEED FOR ENVIRONMENTAL TARGETS?

Here, a variety of literary resources (scientific and political groups, journals, publications and articles) have been collected that they may give context to the need for environmental targets and why they have become important. To this day, it stands that GHG emissions are the predominant cause of climate change (NASA 2018, IPCC 2014). According to *Intergovernmental Panel on Climate Change* (IPCC) (2014) the percentage of annual GHG emissions has risen approximately 2.2% over the past decade and "around 50% of CO2 from human sources is not reabsorbed and remains in the atmosphere" (Pelsmakers S 2015). This has led to elevated pollutant levels and changing temperatures (see Figures 2.1, 2.2 and 2.3 below) which cause there to be a shift in normal regional weather patterns (Carbon Footprint, n/a).

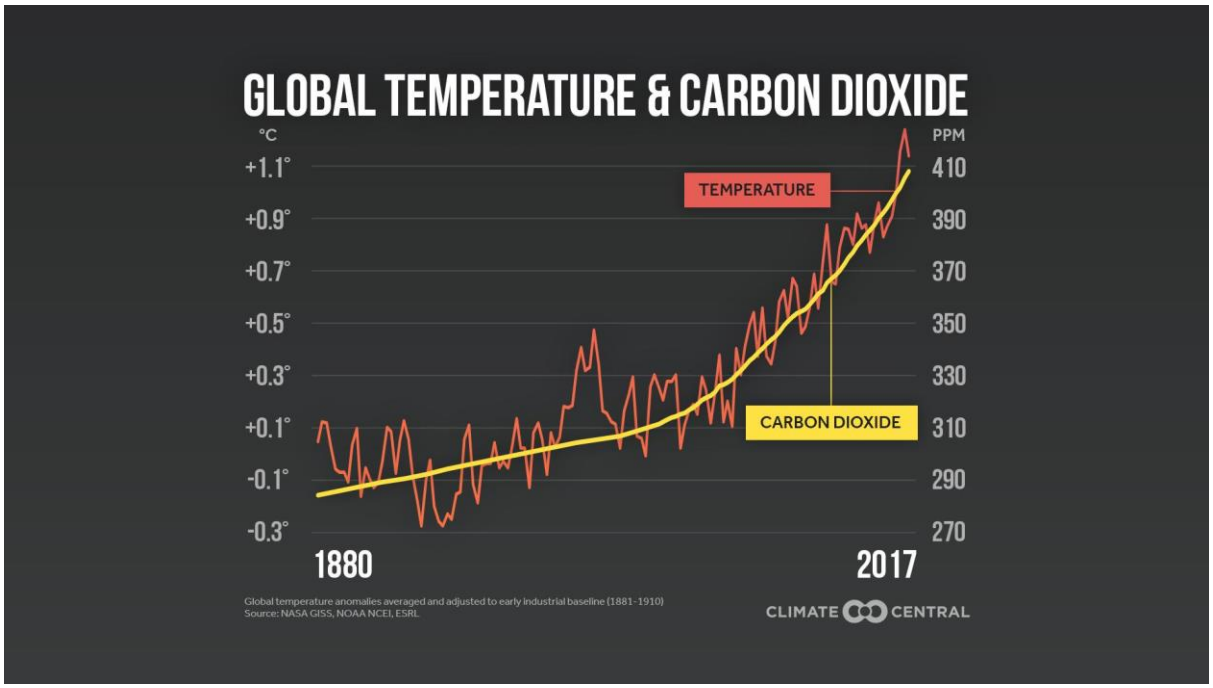

Figure 2.1: This line graph displays a correlation between rising levels of CO2 (measured in parts per million (PPM)) and an increase in global temperature (measured in degrees celsius) between the dates on 1880 and 2017.

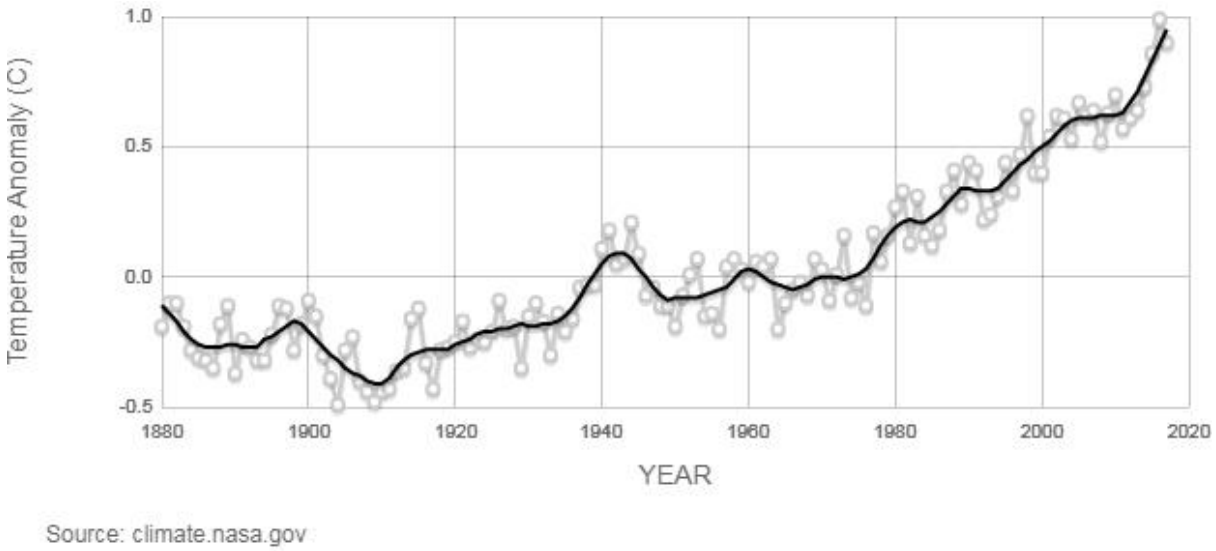

Figure 2.2: Line graph illustrating how global surface temperature has fluctuated and changed between the years of 1880 and 2017 showing relative average temperatures between 1951 - 1980. The grey lines indicate 'Annual Mean' whilst the black line shows 'Lowess Smoothing'.

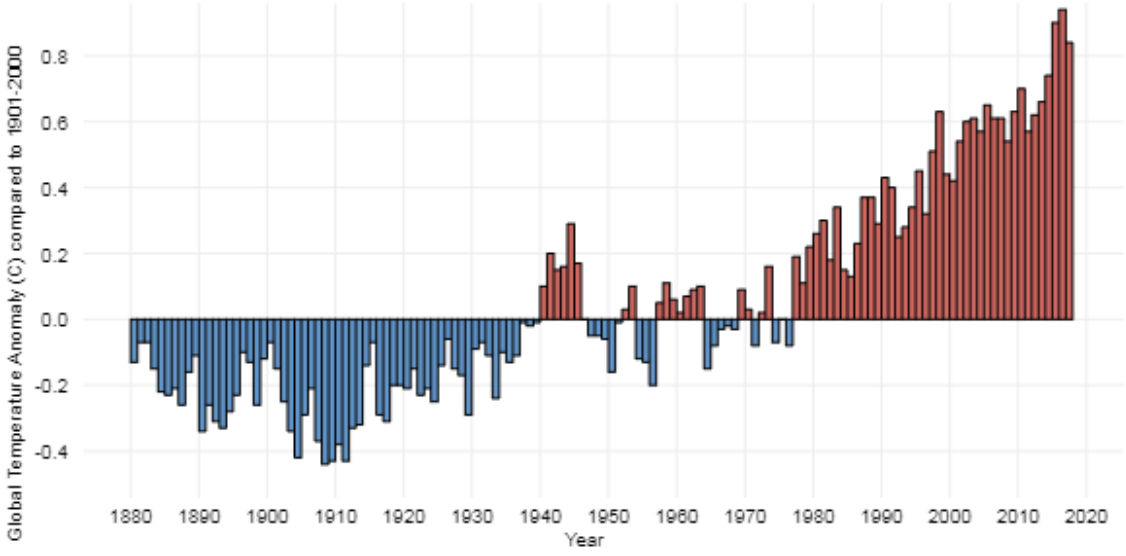

Figure 2.3: A bar graph showing the "History of global surface temperature since 1880" (Climate, 2018). 0.0 indicating the globe's long-term average temperature. Blue bars show below the average and red bars above the average.

In addition to this, findings from the *2018 Emissions Gap Report* (UN environmental, 2018) have concluded that environmental efforts must be increased by 5x more than is currently being achieved in order to meet the ambitious 1.5°C temperature targets set out by the *Paris Agreement* (UNFCCC 2018, UN environmental 2018). The 2018 November report shows that the world has reached historically high levels of emissions which as of 2017 stand at 53.5 $GtCO_2e$ (UN environment, 2018), a 0.7$GtCO_2e$ increase from 2016 (United Nations Environment Programme, 2018). Since 1992, modern day environmental concerns have predominantly been brought forward by the *United Nations Framework Convention on Climate Change* (UNFCCC) with an aim to rally "intergovernmental climate change negotiations" (UNFCCC, 2018) across the globe. These discussions and negotiations have been the primary driving force behind the encouragement, choices and decisions made to implement environmental targets on cities. As highlighted in sections *1.2* and *1.3* of the introduction, due to ever increasing urban population and changing levels in urban thermal comfort, there are both global and local sustainability issues that must be addressed.

The director of the UN DESA's Population Division, John Wilmoth has been quoted by many saying that "managing urban areas has become one of the most important development challenges of the 21st century" (Peris-Ortiz M, et. al. 2017, United Nations 2014, DeVry University 2016).

2.2.3 PEOPLE, BUILDINGS AND CITIES

It is a well known fact that through the design of today's infrastructure, people and buildings require the use of a lot of fuel and energy in order to maintain current

operations and levels of habitable comfort; unfortunately this has lead to a point where "'human' CO_2 emissions exceed the capacity of natural reabsorption mechanisms, and this causes climate change" (Pelsmakers S, 2015). Information provided by the International Energy Agency (IEA) (2018) states that both 30% of global energy consumption and over 55% of the electricity demand comes from the buildings sector alone. There are two main parts to a building's life which are considered above all others. Cradle-to-site where: "it is estimated that 10% of a building's total carbon footprint comes from industrial manufacturing of materials and their transportation from extraction to factory and finally to site." (Pelsmakers S, 2015) and the operational life-span of the building because: "buildings and cities also require energy to function. This is referred to at operational energy...we rely on these systems to use our buildings with comfort" (Pelsmakers S, 2015). Focusing on the latter, the United Nations' (b) (2017) conducted their Global Status report which indicates that in 2015 fossil fuels were the source of 82% of building energy consumption. Considering the aforementioned CO_2 goals laid down, this can easily be flagged as a point of interest and investigation.

2.3 THE FUTURE OF MID AND HIGH RISE BUILDINGS

2.3.1 DEFINITION

Mid rise buildings are vertical multi-occupant structures that typically do not exceed a height equivalent to "the width of the right-of-way" (Milton, 2018). A high-rise building can be defined as a multi-occupant building which exceeds 10 storeys and that requires occupants "to use a lift to reach their destination" (Designing Buildings Wiki, 2018)

2.3.2 HISTORY

Similar to today, many urban cities during the 19th century were becoming cramped overpopulated and required a need to house and employ the growing population (History 2018). In Chicago, high rise buildings were the best solution to this dilemma but could only practically be built and safely designed after two key components were developed (Enright B 2019). The first was the safety elevator designed by Elisha Otis circa 1857 (Encyclopedia Britannica (a) 2018) and the other was the development of steel beams as a frame (Enright B 2019) to replace timber and brick (History 2018, Encyclopedia Britannica (b) 2018). This offered greater stability and allowed the building to be lighter than when using solid masonry and the first recognized skyscraper was built in 1885 (History 2018). Whilst originally built with commercial values in mind, high rises have become known for their residential applications also (Encyclopedia Britannica (b) 2018)

2.3.3 DEVELOPMENT

Today, high rise buildings are popular for the same reasons as in the 19th Century. As of January 2018, China holds the record for the greatest number of high rise buildings in the world with a total of 1,651 (Equity, 2018). The design of high rise structures has been in constant flux ever since its early days with architecture firms competing to re-design it, this can be witnessed via websites like ‘dezeen’ (dezeen 2019). As stated in the introduction, many of these buildings are made of steel, concrete and glass (see Figures 2.4 and 2.5 below).

Figure 2.4 Glass and concrete high rise building with large terraces. Beirut Terraces, Lebanon, by Herzog & de Meuron

Figure 2.5 : A photograph of a glass high rise building. Chaoyang Park Plaza, China, by MAD

Whilst not reaching those numbers, Toronto in Ontario, Canada has more high-rises than major cities of Canada combined (DH Toronto Staff, 2017) and had caused a resurgence of timber as a building material. The University of British Columbia in Vancouver, Canada designed their student accommodation tower out of predominantly timber with a concrete core for support and thereby building the tallest hybrid timber building in the world as of 2017 (Hasan ZG 2017). The architects said that working with timber reduced their construction timelines and was a more

environmentally friendly material than steel or concrete (Hasan ZG 2017). More environmentally conscious building design is being recognised publicly as discussed by ‘Futurism’ magazine’ when they talk about reasons for building high rise with wood / timber as being environmentally friendly, cost-effective and renewable (Galeon D 2018).

2.4 STRAW AND STRAW BALE

2.4.1 DEFINITION

Not to be confused with hay, ‘straw’ is identified as “the dry, dead stems” (Myhrman M and MacDonald SO, 1997) of cereal grain crops after the grain has been harvested. A ‘straw bale’ is the gathering of straw into “a large bundle...tightly compressed and secured by wires, cords”, etcetera (Dictionary, 2019).

2.4.2 A BRIEF HISTORY

Straw has been used for at least 10,000 years as a building material in dwellings made with both cob and adobe bricks (Abundant Edge 2016, Edwards & Eve Cob Building 2019). The first documented straw bale houses were built in Nebraska, U.S.A. circa 1903 (Myhrman M and MacDonald SO 1997, U.S. Department of Energy 1995), about half a decade after the first straw baling machine was built circa 1850 (Beyond Architecture Group, 2014) as a response to the lack of available timber in the area (U.S. Department of Energy 1995, Admin 2013). Straw bale saw a decline in popularity with the rise of the industrial revolution which introduced the mass production of bricks and concrete to the building industry (Admin, 2013). It was not until later in the 1980’s that two people by the names Matts Myhrman and Judy Knox of Tuscon, Arizona became intrigued by straw bale construction, performed their own investigations into how successful straw bale buildings have been over the years (Sustainable Practices, 2008) and reignited a common interest amongst like-minded people by founding the publication ‘The Last Straw’ (The Last Straw, 2019, Sustainable Practices 2008).

2.4.3 GENERAL PROPERTIES AND SPECIFICATIONS

Magwood C et al. (2005) describe straw as not only resembling tiny, narrow, hollow tree trunks but that it also shares a similar chemical makeup to trees (of cellulose and lignin) enabling straw to possess an impressive level of strength, resilience and durability. Generally, rectangular bales fall in to two size categories: 2 string bales are on average 14” high x 18” wide x a variable length of 30” - 40” and 3 string bales which run on average up to 17” high x 24” wide x 48” in length (Magwood et al 2005, Straube J 2009) see Figure 2.4 below.

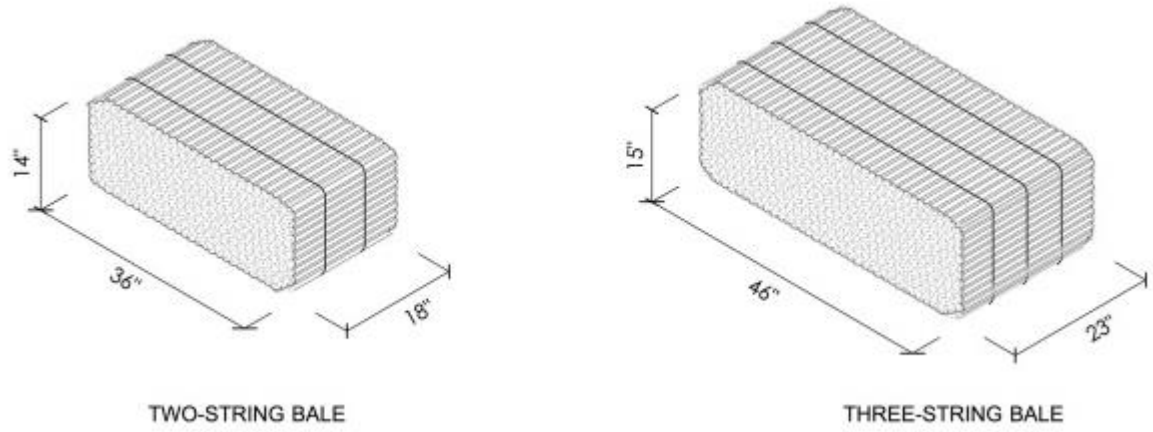

Figure 2.4: A detail drawing of the approximate common sizing for straw bale dimensions for both 2 string bales and 3 string bales.

Bales are designed to have a high level of density and tightness which is important as this “solidity...is what allows it to be used as a building material” (Magwood et al 2005). Whilst bale tightness can be adjusted on the baling machine to different specifications, the majority of building codes across the United States state that straw bales should have a “minimum (dry) density of 7.0 pounds per cubic foot or 110 kg/m3” (Straube J 2009, Magwood et al 2005). Despite this heavy denseness, bales “are actually 80% air by volume” ((b)Straworks, N/A) due to its tubular shape making it an effective and natural option for insulation. Bales must also be dry for construction, containing less than 20% moisture in order to avoid damp and mould issues (Magwood et al 2005, Straube J 2009).

2.4.4 STRAW BALE AND BUILDING CODES

Around the globe, different countries have addressed the inclusion and guidance of straw bale building codes with varying degrees of support and restrictiveness.
The United States’ ‘International Code Council’ (ICC) is one such document that provides a large number of straw bale code specifications and guidelines to be used as common practice across all states. The information in this document ranges from the basics of straw bale anatomy, to wall finishes, basics in structural and non-structural bale wall construction, typical infills, foundation types as well as explanations of fire resistance with different finishes and R-values etcetera (ICC, 2017). Although at present only guidelines rather than code, in 1995 California passed the *State Guidelines for Straw Bale Structures* as a response to the 1991 *Rice Straw Burning Reduction Act* where alternative disposal methods were required (Farraj A et al, 2009). Since then, with over 1000 commercial and residential straw bale buildings (ICC, 2017) “California has been the sight of exceptional change towards straw bale building, including legislation” (Farraj A et al, 2009).
Straw bale building codes can also be found in Belarus who adopted their code in 1999 and in Germany who adopted their code in 2006 (King B 2006, Searle C N/A). However, unlike in the United States who allow for straw bale to act as a structural

component, both Belarus and Germany “only allow straw bale to be used in an infill insulating capacity” (Searle C N/A, King B 2006).
There are also many countries like Australia, Canada, China, Denmark, France, UK, Italy and Japan, who do not have official building codes for straw bale construction but do have work-around guidelines in place to allow for well-designed and well researched projects to go ahead (King B 2006, Searle C N/A). Although interestingly, “in Italy there is no restriction on building with wood structure and straw bale infill walls” (Beyond Architecture Group, 2014). Also like that of Belarus and Germany, in Italy there is no law allowing the construction of load bearing walls because the country does not consider straw bale to be a structural material (Beyond Architecture Group, 2014).
Whilst there are official codes and well documented practices with straw bale construction readily available to view globally, some countries like Canada require building materials to be tested locally before being officially introduced into the code (Government of Canada (b) 2018, Government of Canada (c) 2018). This has delayed and prevented straw from being seriously recognised because testing local materials to local criteria “requires considerable effort and cost for field and laboratory testing” (Gunawardena K-c, 2008) which very few people have. Gunawardena (2008) also notes that because natural building materials rarely require much if any processing they are rarely subjected to standard quality checks. This has promoted uneasiness “with regard to guarantees and defects liabilities that can be reasonably honoured”(Gunawardena K-c, 2008) for builders and contractors, making it easier for them to stick to materials they know.

2.4.5 THE PROS AND CONS OF STRAW BALE

“At world level, civil works and building construction consumes 60% of the raw materials extracted from the lithosphere” (Bribain IZ et al. 2011). Therefore, making a rapid decrease in global construction and / or finding and utilising alternative materials and methods is of paramount importance (siteadmin 2018). There are a few ways in which straw could contend to be considered for this purpose. According to information provided by the U.S. Department of Energy (1995) every year there is enough straw produced across the United States to build 4 - 5 million, 2000 square-foot straw bale homes at cost of $1000 USD each on average. However, when its compared with the still green and nutritious hay that can be utilised as animal feed, the majority of straw that is produced is currently either burned or is tilled back into the land because it is seen as a “low-value, nutrition-poor, by-product” (Myhrman M and MacDonald SO, 1997). Despite this, there are people and companies such who are strong advocates of straw for a number of reasons: partly because of its thickness and partly due to its hollow tubular shape, straw possesses good insulating qualities which can provide a U-value of 0.2 (Harris C and Borer P, 2005) or of R-30 leading to a reduction in both energy usage and bills;
With this in mind, companies like ‘ModCell’ in the UK are promoting designs for prefabricated straw bale panel walls (ModCell, 2019). Gunawardena KC (2017)

discusses that “modular composite-panels” that are designed as a single ‘cell’ can provide “greater opportunity for widespread application, particularly for urban construction conditions” (Gunawardena KC 2017) However, they do also note that care must be taken to avoid the manufacturing process from increasing the products’ embodied carbon through vast amounts of energy use as this will render the effort a waste.

3.0 METHOD AND METHODOLOGY

3.1 INTRODUCTION

This section of the dissertation aims to provide both perceptive details and an explanatory outline of how this study was conducted. Including a literature review of the field, it accomplishes this by providing both reasoning and justification for the chosen method and with a clear breakdown of the steps taken within the final choice of method to ensure the clarity of the work.
Firstly in section 3.2, definitions of this study's understanding of the terms "method" and "methodology" will be presented for continuity reference throughout this section. Secondly in section 3.3, in relation to the aim and objectives (stated above in section *1.6 The Method* of the introduction) and using appropriate literature, an evaluation of the chosen methodology for this study will be provided along with a summative conclusion. Finally in section 3.4, this will be followed by a clear presentation of the method performed for this study, illuminating what was achieved in order to complete this work.

3.2 DEFINITIONS

To clearly understand the parameters of this section, definitions of 'methodology' and 'method' are presented below:

Method: An outlined body of principles or rules to highlight and recommend for how to progress within a certain discipline. In short, steps for how one collected the data (Merriam-Webster 2018, Kallet RH 2004, Little D 2014, Collins English Dictionary 2018, Brookshier K 2018).

Methodology: The justification and rationale behind the choice of the method/s used to collect data (Brookshier K 2018, Gabriel D 2011, Kallet RH 2004).

3.3 METHOD

3.3.1 THE BEGINNING

This dissertation adopted a mixed method strategy which required both qualitative secondary data as well as qualitative primary data. In order to guide and pace the research process, a Gantt chart was produced (see Figure 3.1) however this was used more as a guideline and prompt. The job of the interviews was to identify and examine what working professionals identify and recognise as barriers to straw bale construction through their experiences and opinions and compare that to the available, relevant secondary data collected from literature that highlighted any known or suggested barriers and access to straw bale construction.

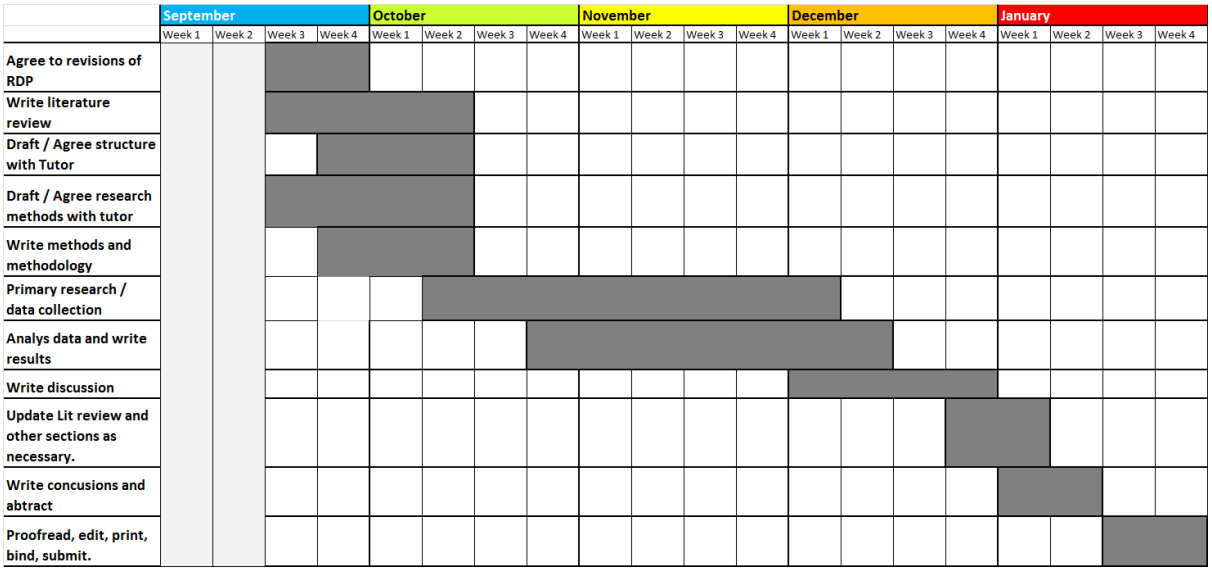

Figure 3.1 Gantt chart showing the timeline of the dissertation project from start to finish.

3.3.2 LITERATURE REVIEW

A literature review delving into environmental targets, alternative building materials and straw bale was performed. Thorough research utilising both online and printed materials with a focus on peer-reviewed and published journals as well as books (with the addition of popular and well known websites) took place. Topics surrounding environmental targets such as population, global pollution levels and legislations as well as insights into alternative building materials (relating to type and properties) produced a vast amount of data and results. Whilst the topic of straw did led to a fairly comprehensive amount of results, the majority was collected from North American community and independent investigation based sources rather than from official codes and government legislation. Any official codes and government legislation that could be found were from the United States or Europe. Analysis of this secondary data also aided the identification of what information is not immediately available and / or accessible. The literature review also covered research made for the method section of this paper. A separate and specific investigation into qualitative data, its collection and analysis were performed so as to present the most appropriate and clear display of the data.

3.3.3 INTERVIEW AIMS

The semi-structured interviews aimed to offer a platform for working professionals to openly discuss their experiences, knowledge and opinion of straw bales as a building material, its functionality, its relationship with code and legislation and how they understood the public's perception of straw as a material.

3.3.4 REQUEST TO INTERVIEW

Through a mixture of online research and word of mouth 25 individuals were contacted as potential participants. These people all worked in or along side the building industry as architects, engineers, builders, educators, designers and contractors. 18 of these working professionals were initially approached via e-mail. The request was that if they were interested in the topic of this study that they positively respond, await a follow up email with further information and a consent form. They were also asked if they could suggest any other potential participants adding 7 more contacts to the list. In total, the request received 8 responses, 7 of which became the final interview participants.

3.3.5 INTERVIEW DESIGN

In order to create the best platform to obtain qualitative answers, a short series of open ended questions were the best choice to keep the research relevant, unrestricted and on topic after a review of appropriate scientific research methods. Overall the questionnaire had a total of 18 questions that were split into two sections, Part A and a Part B. Part A consisted of 11 open ended questions that were refined for this dissertation. The first 3 questions were designed to understand and establish the knowledge and familiarity that the participant had with straw. These questions were also used as warm up and set up to the following interview questions. The next 8 questions were designed to discuss participant experiences, knowledge and opinions of straw bales as well as research and legislation in an open format allowing for uninfluenced individual answers. Part B consisted of 7 objective response demographic questions that were designed in order to evolve more contextual background of the participants as well as potentially highlight any demographic themes to be explored in future. The questions from the final questionnaire are as follows:

QUESTIONS:

PART A

1. What is your job title?

2. Could you summarize your role and its relation to the building / planning industry / built environment?

3. What is your familiarity with designing / building with straw? (i.e. witnessed only, read about only, number and / or range of projects you have been involved with etc...)

4. When you were reading about / have designed or built with straw bales have you:

a. Been able to find the information that you needed / wanted?

b. How easy or challenging was it to find what you needed?

c. Was there any particular areas of information that were easier or harder to uncover than others? (i.e. acoustics, approvals, building codes, fire, insurance, moisture, structural, etc...)

5. Where have you uncovered the information and knowledge on straw that you needed? (i.e. During education (which level), academic journals, social media, through business, published and online articles, etc...)

6. How frequently do you notice the general discourse of straw in the public domain?

a. ...and where? (i.e documentaries, school, business, journalist articles, conventions / expos, television, social media etc.)

7. Have you or your business:

a. Performed your / their own research about straw bale construction and why?

b. Performed research in collaboration with other companies or anyone else about straw bale construction and why?

c. If so, were your findings positive or negative to the use of straw and why?

8. When reading about / designing or building with straw what was your experience with planning, codes and standards? (i.e. were they helpful or restrictive and why?)

9. Why do you think straw is not commonly used as city / urban building material...

a. ...in general?

b. ...specifically for mid-rise and high-rise buildings?

c. ...think the idea of straw buildings are to wider population?

10. How desirable do you personally think the idea of straw buildings are?

*11. What do **you** think the barriers are to using straw bale construction in cities...*

a. ...in general?

b. ...for mid-rise and high-rise buildings?

c. ...specifically for Toronto, Canada?

PART B

Please circle one answer on each question (and provide further information when required):

12. Age bracket:

0 - 19

20 - 29

30 - 39

40 - 49

50 - 59

60 - 70

70 +

13. Do you live in an urban or a rural setting?

Urban

Rural

14. Is your practice / place of work urban or rural?

Urban

Rural

15. Do you live in or near Toronto, Canada?

Yes

No

16. Number of years learning through further education?

0 1 2 3 4 5 6 7 8 9 10+

17. Number of professional years in the industry?

0 - 5

5 - 10

10 - 20

20 - 30

30 - 40

40 +

18. Are you still in the industry?

Yes

No

3.3.6 ETHICS AND PARTICIPANT INFORMATION

As is common practice the ethical aspects of performing scientific research that involves humans were considered (Allmark PJ et al 2009). The basis and outline were provided by the school and were consequently evaluated and tailored to all likely and comprehensible outcomes (see Appendix 2: Ethics Form) as this study was performed in Canada, country specific conduct was taken into consideration (Panel on Research Ethics, 2014). This set of specific ethics also formed the base for the participant information sheet (see Appendix 4 participant information sheet) which informed all participants of their rights. This included but was not limited to: their freedom to withdraw any or all information without reason at any given time before submission, that their identities would be concealed for privacy reasons and that they could (and were encouraged) to ask any and all questions that they might have had. This information was provided to the participants via e-mail correspondence.

3.3.7 INTERVIEW DATA COLLECTION

Firstly, a date and a time for the interview to take place was discussed and pre-arranged with each interview participant via e-mail correspondence. The participants were also provided with a copy of the interview questions ahead of time for their own reading. Following this, data was collected over the course of 4 days with between 1 and 3 interviews per day recorded in both written and audio format (with permission of the participants). 3 of the sets of data were collected with face-to-face interviews in either their place of work or in a mutually accessible cafe. The remaining 4 sets of data were collected via a Skype-to-phone call.

3.3.8 ANALYSIS OF INTERVIEWS

As a result of qualitative nature of the study, the analysis was also performed using qualitative methods. Firstly, after the interview data was collected, it was transcribed and descriptively summarised for the purpose of displaying the data in this paper. Following this, the interview transcriptions were coded through the process of repeated readings of the data in order to help conceptualise and identify categories / themes that run throughout the text. These categories / themes were:

Negative responses / cons
Positive responses / pros
Mention of other building materials
Environmental connotations
Reference to others in the field
Personal musings / opinions
Reference to consumerism / a product
Journeys (do it yourself project)
Sharing (information, projects helping)
Re-occurring regularities from other interviews (thickness, fire or mold, legislation)
Perceived public opinion: good
Perceived public opinion: bad

Below (see Figure 3.2) is an example of a transcribed interview after the categories / themes have been highlighted. Proceeding this, the data from the demographic questions were correlated and displayed in a table for clarity.

Figure 3.2 An image of a transcribed interview for the purpose of displaying the colour coded theme analysis.

From here, the coded data was collected from all seven interviews and separated into their individual colours so as to analyse and discuss the identified emerging categories / themes more closely. Subsections of these categories / themes were also created as and when required, for thorough clarity of the data. Throughout this process it came to light that whilst interesting, some of the colour coded themes were either too similar to others and could be nestled or they were redundant to this particular research (such as Re-occurring regularities from other interviews). Therefore the themes were reduced and edited to 8 categories / themes which were:

- Negative responses / cons
- Positive responses / pros
- Mention of other building materials
- Information sources
- Reference to others in the field
- Reference to consumerism / a product
- Participant journeys
- Perceived public opinion (by the participants)

The data from the demographic questions were then displayed as pie charts so as to provide a visual representation of the common or differing themes between those that were interviewed with hope of acting as contextual data for the research overall. Finally, the main barriers to straw bale construction were extracted through the appearance of recurring themes from within the data analysis and summarised in the conclusion below.

3.4 METHODOLOGY

In order to validate research, it is important to construct scientific papers and investigations in such a way that they can be reviewed and replicated by others in order to test the soundness of the study and to verify the work (Shuttleworth M, 2009). This is why including a 'methodology and method' section is of paramount importance. The processes that follow were based off of the "qualitative analysis process" laid out by Dr M de Hoyos and Dr SA Barnes (2014) in a flow chart (see Figure 3.3)

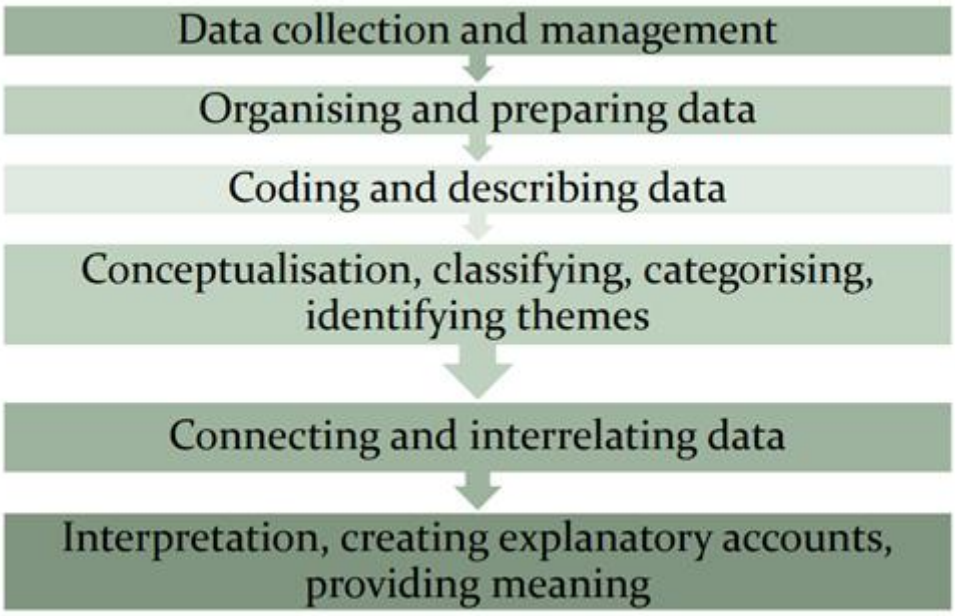

Figure 3.3 A flow chart describing a method for a qualitative analysis process.

Firstly, an evaluation of the aim and objectives indicated that as the focus was on identifying specific details from within both the written literature field of knowledge and what was identified by working professionals as their common knowledge the collected data should be analysed through a mixed qualitative conceptualisation of inductive and thematic approaches. Below is a breakdown of these approaches.
Qualitative methods and data focus on “experience, meaning and perspective” (Hammarberg K et al, 2016) which echo the investigative aims of this dissertation. Techniques for qualitative research include “semi-structured interviews … in-depth interviews” and “analysis of texts and documents” (Hammarberg K et al 2016). Typically, the sampling capacity for qualitative investigation is small to prevent saturation (Dworkin SL, 2012, Statistics Solutions N/A). These parameters allow for a closer focus on a participant’s background, personal views and experiences on a specific topic, highlighting any “beliefs, attitudes and concepts” (Hammargerb K et al, 2016). An examination of where intelligence is shared through “governmental reports, media articles, websites or diaries” (Hammarberg K et al 2016) are also included which support the scope of the literature review.
According to Dr M de Hoyos and Dr SA Barnes (2014) of Warwick Institute for Employment Research (IER) inductive research is where the researcher has zero to minimal “predetermined theory, structure or framework” and relies solely on the data to source and determine the analytical structure. This is useful for a study that has minimal to no prior knowledge on the topic by offering a “comprehensive, in-depth...yet time-consuming” (Dr de Hoyos M and Dr Barnes SA, 2014) approach and analysis of the collected data. This is in keeping with the parameters for this dissertation which is investigative.
A thematic approach allows for pattern identification and analysis of the data which (if done well) will provide “a rich interpretation of the study” (Dr de Hoyos M and Dr Barnes SA, 2014). This is in opposition to a deductive approach which would limit qualitative exploration of the data where “probable participant responses are known” (Dr de Hoyos M and Dr Barnes SA, 2014). This approach reflects the direction of the aims of this dissertation.
Secondly, a review of the applicable literature indicated that the collected qualitative data was to be identified as ‘categorical data’ for analytical purposes. Donges N (2018) and Stats Direct (2018) identify the term ‘categorical’ as describing data that can be represented by both categories and characteristics. This supports the aims of this dissertation. According to the Institute for Digital Research and Education (IDRE) (2019), Stats Direct (2018) and Donges N (2018), this type of categorical data can further be identified as being ‘nominal’; meaning that the categories of data have no specific ordering and their values would not change if the order was rearranged.
These methods, approaches and analytical parameters support this dissertation’s choice of to perform a qualitative, semi-structured interviews and compare that to a qualitative investigative review of the literature.

4.0 DATA AND ANALYSIS

4.1 INTRODUCTION

This section will first present a summary of both the data from Part A and then Part B of the qualitative interviews performed for this dissertation for reader knowledge and context. The summaries will then be followed by an analysis of the data collected. Finally, there will be a discussion looking into what the data findings mean and offer to the current knowledge and whether that highlights any new theories and themes around the overall topic. Each interviewee will be identified as “Person A”, “Person B”, “Person C” and so on to maintain anonymity and keep a simple clarity for the data and its presentation.

4.2 DATA RESULTS FROM THE INTERVIEW: PART A

The section below is comprised of qualitative data collected from each of the seven interviews that were performed for this study. Firstly, summaries of the raw data that was collected from the individual interviews in Part A will be presented. These summaries will be comprised of the most relevant and on topic data collected from the participant responses.

4.2.1 PERSON A

Person A is a ‘building scientist’ and new to the professional field (0-5 years of experience). Through their job in Toronto they are lead by scientific building design, focusing on function and performance of a building (for example “energy flows through the envelope, air, water moisture, thermal” etcetera) during the design phase.

Person A’s familiarity with straw comes predominantly through observations of buildings that have been built on their previous school’s site (one is in good shape and the other is deteriorating) as well as through text based learning at their master's level of schooling. They have not been very successful at finding any specific information about ‘straw bale’ stating that they “don’t find it easy to get information on that” and that they “couldn’t find information on...generic information” such as embodied energy, carbon and R-values. However, Person A has had success uncovering information on companies such as ‘Modcell’ who manufacture prefab straw bale wall panels as a finished product for buildings which was readily accessible. Any information that has been gathered by Person A had been procured through “random” online searches intended for a materials database for work or been provided by tutors during school.

Person A says that they do not notice talk of straw or straw bale as it “doesn’t seem to be on anyone’s radar”. They attended lectures by Chris Magwood who provided

information on straw as he works with the material, however Person A has no memory of straw being mentioned in any other medium such as architectural magazines.

As far as performing research is concerned, Person A has not collaborated with others to investigate straw properties / design their own nor have they looked into any legislative planning /codes. They are aware that their current place of work has been involved in one straw bale house project but is unsure about the levels of research involved into the use / properties / adaptability / etcetera, of straw. Overall their impression of research into straw is negative predominantly due to the lack of readily available knowledge, “it doesn’t seem like there are a lot of people promoting it”.

When questioned more broadly regarding straw bale absence from cities and midrise and high rise buildings, Person A thinks that straw is not appropriate for many reasons. Firstly because material would need sourcing from afar and is not readily available in the city as raw or pre-fabricated products. Secondly because of the thickness required to achieve the R-Values the city asks for. Thirdly, comparing straw to other insulation products which are manufactured more locally in nearby towns and cities. Fourthly, other insulative materials can also achieve the recommended R-Values at a thinner capacity, maximising the usable space. Fithly, A lack of construction knowledge, awareness of straw and straw bale across the board. Person A believes that thick straw bale in mid /high rise structures would result in a “beefy”, heavy, expensive building which “is not what the construction industry is about.” They feel there is stigma that straw bale buildings appear “hippy-ish” and always “look like they’re eco-buildings” to city dwellers who generally “want to flaunt that city style” over a “hippy sustainable building”.

As Person A lives in the city, they think that other options (that may be less sustainable) such as using cellulose would be a more effective building material than straw, however if they ever move to the countryside and have plenty of land they like the idea of building with straw as it was their dream to do so.

Overall, Person A summarizes the barriers that they see to straw bales being:
A lack of general knowledge on straw, it is not a very accessible product in the city (there aren’t any companies promoting or advertising), cost, weight and thickness of bales for building on a larger scale will deter contractors and builders, and consumer demand as “People want glass towers that the industry tells them they want.”

4.2.2 PERSON B

Person B is the Principal Architect at their Toronto based sustainability driven architecture practice with 30-40 professional years in the industry. Their predominant role is as Design Architect and Team Leader. On larger projects they initiate and

establish goals / frameworks with clients for the project concept. On smaller projects they take the project all the way through from design to production and construction. Person B gained familiarity and personal experience with straw bales when they helped design and build a friend's house in 2002. They have been an external reader for Master's Thesis at an Ontarian university where one student proposed the use of straw bales for extensions in downtown Toronto. Person B comments how over the past 17 years since the straw house, information on straw and straw bale is much easier to come by due to "a much more robust and functioning internet". Previously it had been extremely difficult to find information outside of small groups / like mind communities of people and contractors with names such as 'Camel's Back Construction' and Chris Magwood. Person B uses these human resources for information today but likes that this information can be verified with industry literature in order to help build client trust. Despite this, building code approvals have been the most difficult area over the years as straw has is still a relatively unknown material.

Person B gathers most of their information on straw via online publications /articles as well as books predominantly written by or with Chris Magwood. They almost never notice discussions on straw unless they bring it up in conversation or are with like-minded architects who are interested in carbon.

Person B has not performed investigative research into straw bale construction personally unless counting the reading of the Master's Thesis, (they researched mineral wool as an insulation option). Through their own research and that of the master student they read for, Person B has found research into straw bale to be negative due to the Thesis discovery that conventional straw bale thickness is not ideal as a building material for extension in urban environments, due to limited buildable area on already constructed land.

Person B has not encountered codes and standards for fire or durability concerns surrounding straw. They believe there needs to be more testing "so that there are recognised standards...that satisfy building officials". Person B believes that the primary reason that straw bale is not more commonly used is bale thickness verses expensive land. People want to convert their land "into as much usable either rentable or saleable square footage as possible". With straw creating a thick exterior wall, it covers more land rendering it unusable. They also believe a lack of current knowledge leading to general biases and myths about straw stand in the way of straw. Biases and myths such as; it is not resistant to fire, not durable (relating to 'The Three Little Pigs') and being food for rodents which has become "common knowledge". Lastly, Person B discussed how the steel and concrete industry have been "denigrating wood and all things natural" since there were a few urban fires around 1900 which prompted modern building and fire codes.

They love the idea of building with straw and have always been interested in it. They note how it is a great carbon sink, grows fast, harvests fast, provides insulating

qualities and can hold itself up through its tubular structure making it adaptable. Person B remarks how when they and their work colleagues went to the straw bale house for a corporate retreat one winter, they all enjoyed how soft it felt to be in the space. Having soft acoustics and air created a comfortable environment.

In summary, Person B believes that negative public perception, bale thickness and unanswered concerns about fire and durability are the recurring barriers.

4.2.3 PERSON C

Person C is a professor of human ecology who primarily works in ‘sustainable energy management’ and ‘renewable energy and economics’ at a private, not-for-profit college in the North-East of the United States. They have 20-30 professional years of experience in their field having a background in engineering and environmental policy, writing their PhD on public policy for climate change. They work with students who are moving towards professions as solar installers, wind turbine technicians and renewable energy sales and management.

Person C’s familiarity with straw started in the 1990’s when they visited the Centre for Alternative Technology for the first time and seeing the straw building there. Their interest in straw resurfaced in the 2000’s when they needed to build a reasonably priced home to live in that was close to work. They built their home which was a combination of straw bale and recycled materials with basic background knowledge and learning on the job which lead to a tiny home that “didn’t work particularly well to begin with”. They recognise that having a lack of expertise at the time caused mistakes to be made and meant their home was not built as it should have been, both in general and for their chosen site (they have since grown in their understanding of the material).

Person C had trouble uncovering information about straw bale builds, relying on other people for information. Insurance was particularly hard to uncover information for which would have helped early on during the design process; as such they have only been able to insure their straw home as a “camp” (a weekend / holiday home). Person C found no issue with building codes for straw as there were none in their area. Although they were able to talk to farmers about bale pricing, underestimating the quantity required meant they fell short and needed to import bales from farther afield (at a premium). Through their occupation, Person C uncovered and accessed information predominantly through like-minded connections but also via social media platforms such as Blogger as well as books, newsletter and brochures from organisations such as the Centre for Alternative Technology. They comment that it has been easier over the years as green building has become more mainstream.

Person C rarely notices conversations about straw and notes they “notice more of a buzz about it in Britain” where cobb and stone and lime plaster are more common

practices.
Person C has performed their own research with straw bale on their home after moving out. Over the past 15 years there has been a wall left open and unprotected from the elements except for an overhanging roof. They found that despite mould appearing and drying out a number of times as well as repeatedly having bees and wasp nest, the exposed straw has not rotted or lost its visual appearance as straw. Although the straw was susceptible to mould and insects, Person C finds their research to be positive as the straw has outperformed its lifespan expectations in its unprotected state.

Person C believes that the reasons that straw is not more commonly use as a city building material is due to the wealth of other available materials available in its stead. These primarily include recycled material such as reclaimed foam board from renovation projects and recycled newspapers into cellulose (both of which can easily attain regular house insurance).

Despite this positive outcome, Person C does not find straw bale to be a desirable building material, primarily for their location in the damp North-East of the United States. They found it difficult to source enough of the material, learn thoroughly about the building processes /ideal site specifications and get the correct type of insurance for the property. Person C would not recommend anybody in the same or a similar climate to build with straw bale. They believe that straw bale has been romanticised and needs to be considered more rationally in future. They do not believe that city projects in Toronto are a good idea due to sourcing, a damp climate, lack of knowledge and the presence of reclaimed and recycled insulating materials.

4.2.4 PERSON D

Person D is a Sustainable Builder with 10-20 professional years in and out of their trade. Their role is to create a relationship with the home-builder client to establish the most holistic, environmentally friendly plan for construction through the use of sustainable materials. Their main area of expertise is in plastering as well as looking at straw bale build plans, rammed earth walls and some construction work.

Person D’s experience with straw bale come from when they were at design school. There they learned the principles, science and details of straw bale construction, how to read plans of straw bale buildings and how to plaster the straw. They were able to find the information needed for working with straw bale through their hands on experience and education. Areas that Person D found challenging were uncovering and understanding building codes and the legality of certain building procedures with certain buildings. They also found that marrying the natural building method with conventional building methods was challenging due to a lack of previous references as well as explaining new methods to clients who cannot

conduct research themselves so often become cautious. This made working with contractors challenging as they needed to understand variants in building procedure from conventional projects. Locating and obtaining local sustainable materials was noted as another area of difficulty. With no one advertising their straw they would sometimes have to source it from further afield (which would increase the price and the carbon footprint).

Person D noted that they gathered most of their information through their education at design school, books and internet research as well as through emailing others now running their own business or alumnus of sustainable programmes.

Person D doesn't hear talk about straw often. They think that there is awareness to straw which comes through platforms such as YouTube and other internet sources. They find that people tend to say "oh I think I saw something like that once" but lack knowledge of it. As such Person D does not find there to be much "hype" about straw and straw bale. They did reminisce about a company who made prefabricated straw bale panels in Canada, but that they had to shut down because they did not get enough business.

Person D, whilst not purposefully setting out to perform any kind of official research on straw bales, they do experiment project to project sampling and testing plaster on a bale from site. This is to see how that batch of materials stand up to the straw in different qualities and colours, how well it adhered to the straw as well as helping to figure out the final ratios required. Person D finds their research to be positive as it allowed for the most successful combination of materials for each project to avoid a poor build and an unhappy client years down the line.

Person D finds planning standards and code to be restrictive. This is predominantly due to the fact that legislation and standards for straw either do not existing or are not mainstream enough to be visible. Person D find that this has led to a lack of confidence in the product with no will to experiment in order to figure out the details. Person D believes that straw bale is not commonly used as a city building material because of the public comfort in mediocrity. They believe that people do not want to change from their current building methods because they have a safety net in the familiarity and knowledge of the materials already in use despite any environmental issues attached to them. They also believe that when people think about straw and straw bale "they think of the Big Bad Wolf" and straw being weak. Person D thinks it's not commonly used for midrise and high rise properties because people do not believe that it could be commonly used. They believe that if a 3 storey walk up apartment building with 16 apartments were all built with straw bale and executed well, people would see that it's a safe building, just a different process.

Overall, Person D likes working with straw and thinks that the pros outweigh the cons. The cons predominantly coincide with the short term growing pains of initial

learning and familiarisation, limited legislation and codes as well as the need to build up an attractive dollar value for people and businesses to be interested. Person D thinks about straw from the holistic and spiritual point of view, likening the understanding of the product to enjoying a healthy meal that leaves you feeling nourished. They also enjoy working with straw from a technical perspective. Person D says that its fire safe as it's slow burning from the density which is more appealing when compared to foam insulation which would go up in flames instantly and remarks how that does not make them feel safe at night.

4.2.5 PERSON E

Person E is a Director and Educator at a sustainable building school just outside of Toronto which offers "experiential education" to its students. They are very experienced with 20 - 30 professional years in their field. Their job role is to run a school where the curriculum involves both designing and construct a sustainable building for a client.

Person E's familiarity with straw comes from having built the first ever code approved straw bale house in Ontario 22 years ago and has been building with straw as the main wall material ever since, designing, producing and constructing nearing 50 projects.
At the beginning of their career Person E did not find any local information on straw. Stating that 25 year ago it was difficult to find any information and that most of the available information came from the mid-west of the United States and was not always applicable to the colder climate that Person E was building in. Since then, Person E has used their career to generate the information they wish they had during their early years. In 2000, Person E and their partners wrote the first northern climate straw bale book. Person E notes that since beginning their journey, information has become more easily available in the form of books, websites and academic journals in addition to a well-developed network for researchers and developers to discuss questions through forums. Through their field, they now find the body of literature getting bigger and state that no one should have a problem finding information about the basics. Person E has personally found information through academic journals and a selection of building networks and associations such as the 'Natural Building Coalition' and the 'California Straw Building Association' as and when new information becomes available, it will generally circulate through those mediums.
Person E does not notice the talk of straw bale much but finds that if they bring it up in conversation it's very rare that people have not heard of straw bale building. They note that public information is predominantly delivered occasionally through home design TV shows and magazines /publications such as 'Fine Homebuilding'.

Person E has performed much research over the course of their career. They have formerly worked with a number of different universities with Queen University in

Kingston, ON being the main one. They have worked with them predominantly on structural questions and the university has performed testing programmes based on load bearing capacity and plastering. They also partook in a study looking into the use of round straw bales as structural columns. These tests have mostly taken place in order to answer any questions that the building department are going to ask for a new build design. One predominant test performed by Person E involved placing moisture monitors in the walls of every building over the first 10 years of building. They would revisit the buildings over the course of the decade to do readings on the walls and states that they never saw any cause for concern.

Generally speaking, Person E has found the testing to be positive and that they have never produced a non-feasible outcome from their investigations. Person E also notes that in this modern building climate where codes are more strictly enforced, their tests and investigations are building up a stronger case for straw which until recently was not backed up by any formal research.

Person E has found planning standards, codes and building permits a challenging and changing area. They think that at this point every municipality in the province does have a straw bale building which has provided local authorities with a level of familiarity and information making it easier for others to follow suit. Person E has used code language that has been written in the United States, Germany and other countries to help produce stronger cases to present to the building department to show the feasibility.

Person E thinks straw bale is not a more commonly used building material in cities for midrise and high rise buildings for a number of reasons. For instance unlike new building products or materials, straw bale is not something that can be developed or patented by a company. This leads to straw bale not being desirable enough to invest money in for large scale tests required that would entice buyers to a code approved product. As such, there is no company with a great interest in promoting straw bale and no company that is going to benefit financially from using it either. However, Person E notes that the interest in straw bale is grass roots and even then farmers will not benefit greatly from the sale of 100 bales. There is no one promoting straw bale and it is not currently in the building supply chain. Person E also believes that due to this lack of investment interest a person would have to travel quite far from the city in order to source the necessary supply for a build. They comment that a person could not make more money as a straw bale builder and cannot charge a premium for your work due to a lack of demand by the clients. Finally, its weight makes straw bale a harder sell especially for taller building projects.

Despite the above reasons, Person E says that straw is always their go-to building material. When they weigh up key points about materials they think that straw is the best option, particularly “when looking at its value in terms of climate change”, such as carbon sequestering and emissions. Calling straw “remarkable”, Person E states

that when looking holistically at one of their straw bale buildings, they are “typically net stores from between 20 - 60 tonnes of CO2” and that “typically a building of similar size would emit 20 - 60 tonnes of CO2”. Looking forward, Person E believes that prefabricated straw bale panels will address the concerns that lead to straw not being more commonly used, offering a measurable product that behaves more conventionally and is easily handled on site.

Overall, Person E recognised that although the many great advantages to using straw bale, those advantages do not reward the builder and actually at present make work harder for the builder. In short, to be used by the wider population, straw bale needs to be easier to handle on site through a system like the prefabricated panels. This would make straw bale accessible to builders, contractors, supplier and would be safer to use in higher building projects as they could then be craned into place quicker and without the need to be carried at such heights.

4.2.6 PERSON F

Person F is an architectural technologist with 20 - 30 professional years in the field. Their job consists of both house design and commercial design where they meet with clients and develop concepts into blueprints ready to be taken to permit issuing. Previously Person F’s job role had them acting as general contractor where they would design the house and build it.

Person F’s is “extremely familiar” with straw bale in relation to building and planning. Their interest in straw began in 1998 when they bought land and began research into straw bale houses. By the summer of 1999 they built their first straw bale house, learning and gaining experience on the job. This was the 5th or 6th straw bale house in the province of Ontario and they were breaking new ground as virtually no one had heard of it before. In the years after this they started building straw bale houses for other people and built approximately 20 straw bale buildings in total before beginning to produce the design work as well. Person F has also taught straw bale construction in a sustainable building college programme.

In the beginning, Person F found the information needed for designing and building with straw bale difficult to uncover. Since then they have noticed “a quick rise in the amount of information available” when compared to the start of their journey. One big challenge area for Person F has been building codes. This is because in the province of Ontario, Canadian based testing is required for all materials and there has been “very little” Canadian based testing on straw bale (the majority has been performed elsewhere). Therefore, whilst the information may be relevant and can be referenced in a permit application, often it will not be accepted unless the tests have been done in Canada and they note that there are “more hoops to have to jump through” in an a more densely populated urban area than in open rural land. Person F states that these tests mostly relate to the topics of fire and moisture and that as

far a building codes go, 99% of the time the building inspectors they have worked with are very keen to learn something new. (as long as the right information and the right specifications are provided). Despite this however, Person F still finds that clients have a difficult time obtaining ideal home insurance and finding a firm that understands straw.
Person F has uncovered the information they needed on straw from a number of sources. They have predominantly come from like-minded peers, the 'Natural Building Coalition' resources and a magazine titled 'The last Straw'. They also note that their information has more recently been accessed through books, academic journals, magazines, online web pages such as 'strawbalebuilding.com' as well as social media platforms such as 'YouTube' and 'Pinterest'. Due to these many access points and active personal interest, Person F sees "a lot of great examples" of information addressed to the general public, specifically through magazines, television and social media.

Whilst Person F has not specifically performed any academic or formal research into straw bale, they have participated in group meetings with other straw bale builders and people who work with straw. This was in order to swap experiences and bring forward information that all could learn from while developing their knowledge and skill set further. This lead to predominantly positive outcomes as the knowledge bank increased.

Person F's experience with codes and standards has been relatively straight forward. They note that the type of code present in the province of Ontario is referred to as "an objective based code", meaning that as long as the objectives for what is considered a good building in Ontario are met and you can prove that the method or material works, you can likely build it. Person F notes that this type of code is freeing as it does not restrict you an exact set of materials and rules as long as a person is on top of their details and research.

Person F thinks that straw is not commonly used as an urban building material primarily because the general public prefer more generic materials with predictable outcomes and smooth finishes. Due to straw's natural aesthetic it presents more rural connotations which can be hard to get used. This is, in part, because the city construction industry use cast, smooth and flat materials and finishes as they also offer consistent results with a manageable supply chain; "and none of those things are things hat straw bale can currently offer". When referring to the supply chain, Person F notes that it is not possible "to get 10,000 straw bales dropped off from a farmer", and that the only people addressing these concerns are small companies who are "dabbling in manufacturing pre-build straw bale panels".

Personally, Person F think's straw bale buildings are extremely desirable. This is because they love the aesthetic of the wavy walls, how the light reflects as the

acoustics of the space that straw provides. The perfectly flat prefabricated panels do not excite Person F from a purely aesthetic setting.

Overall, Person F believes that the main barriers to straw bale use in cities as well as midrise and high rise buildings, starts with straw bales inconsistent dimensions bale to bale, straw's need to stay dry through the short construction window of Canadian weather, its high fire risks before being plastered as well as additional on site safety concerns such as making sure contractors are not pipe cutting near the bales and creating sparks etcetera. They believe that to deal with these concerns, creating plastered panels ready to use so that the straw does not need to be handled on site is the way to move straw bale construction forward.

4.2.7 PERSON G

Person G is an Engineering Manager at a building alternatives company and is also a partner and half owner of the business. They are very experienced with 10 - 20 professional years in the field. Their job role is a specialist consulting and design engineer dealing with natural, alternative and pre-industrial materials. These materials include straw, cellulose, hemp, wheat straw, oat flax straw, re-used fibres, earthen materials and naturally cementitious materials. Due to the nature of the materials they use Person G has become one of the "building science people" and is often brought in for emergency consultations on various projects.

Person G's is very familiar with straw. Their familiarity with straw began through the principle at the company who is also a professor at the University of Manitoba. They were one of the early academic researchers who worked with Person G on general straw projects throughout the 1990's including their own straw bale house extension which they often perform quality control and moisture checks on. Person G has "built dozens of straw bale projects across Canada which might get into the 100's with their latest projects".

Person G experienced trouble finding the information they needed when reading about and designing with straw. They say that they had to do their own testing to get information which was not easy due to a lack of an industry proponent. Person G says that there is enough basic information available to build a two and a half storey building with straw bale (such as the insulation values) but there are many areas of research that could be done in order to catch up to the level of detail found in more common building materials. Areas of research that remain lacking include both basic and extensive detailing on fire testing and thorough material properties such as density, lateral capacity etctera that is available for materials like timber and concrete.

The primary sources of construction information have been obtained through Person G's college and university level research. In terms of information on straw and straw

bale, that was gained through attending sustainability building, building design and sustainable agriculture conferences in the 1990's. Another area is through communities of like-minded individuals in Colorado, California and Ontario which have offered Person G "a wealth of information" (in addition to publications such as 'The Last Straw').

Person G says that social media is where they have seen conversations about straw the most through natural building forums and some 'Facebook' groups of which Person G is a moderator for one and occasionally contributes to and reads from.

Person G has performed research with the University of Manitoba, Queen's University and the Rocky Mountain Institute as well as more generally with companies such as 'Evolve', 'Straworks' and the 'Endeavour' centre. This was in order to get information on insulation, vapour permeability of straw and plaster and bale orientation. Although overall positive, Person G has found one negative to do with the straw bale density and bale creep. This is where the bales sink and compress further under a constant heavy load.

Person G has found codes and standards for engineering are becoming constricting. They explain that in Canada, all engineering design is now "moving toward being 'limits based design' which is reliability and statistics based". Meaning that it is very unlikely that "any material aside from steel, concrete or wood", which have been thoroughly tested, will be able to match the desired criteria. They say that this is why straw has not made an appearance in Part 9 of the Ontario Building Code. They also tell of their shock that their "peers in the United States were able to get straw bale into the appendix of the national residential code". Person G does state that there is an alternative solution provision to get around this issue on individual projects. On top of composing a reasonable proposal, Person G has been taking responsibility for all liabilities in order for these projects to move forward.

Person G thinks that straw is not more commonly used as an urban building material for a few reasons. These include straw bale thickness, especially when considering the high price of Toronto real estate and the square footage that would be lost under the bales. When referring to mid /high rise buildings in an urban environment, Person G thinks construction would only be viable and safe through prefabricated panelization of the straw bale as they are too much of a fire hazard when bare. They also think that people are not interested in learning about materials, rather just the surfaces, finishes and aesthetic.
Person G is torn on how desirable the idea of building with straw is and notes that rammed earth is their favourite material. They like straw for its carbon sequestering, natural cradle to grave cycle, insulation values, acoustics and they value the notion of an organic "honest structure". However Person G struggles with the logistics of using straw in urban building safely as well as the thickness.

Overall, Person G believes the barriers to straw bale construction being used in cities lies with a lack of education across the board including farmers, regulators, industry, producers, refiners, designers, engineers and architects. They believe that people are stuck in their ways with demand for materials and products that no longer meet the needs of today and suggest that pricing carbon and understanding sequestering cereal crops is a good starting point to change people's thinking. Finally, Person G believes that it comes down to economic, educational and regulatory issues.

4.3 DATA RESULTS FROM THE INTERVIEW: PART B

Presented below is the data from Part B of the interviews. The participants were asked a series of demographic based questions in order to help this study identify any other recurring factors that encourage the most and / or least contributions and interests to the topic of straw bale construction. As data collected from Part B is demographic in nature, it will be presented through a table. This offers a closer look at the individual participant answers side by side will be displayed in a table (Table 4.1).

A Table of Results From Part B of the Interview

	Age bracket	Urban or rural: live	Urban or rural: work	Live near Toronto	Years in further education	Years in the industry	Still work in the industry
Person A	20 - 29	Urban	Urban	Yes	6	0 - 5	Yes
Person B	50 - 59	Urban	Urban	Yes	10+	30 - 40	Yes
Person C	50 - 59	Rural	Rural	No	10+	20 - 30	Yes
Person D	40 - 49	Urban	Rural	Yes	3	10 - 20	Yes
Person E	50 - 59	Urban	Urban	Yes	10+	20 - 30	Yes
Person F	40 - 49	Rural	Rural	No	3	20 - 30	Yes
Person G	40 - 49	Rural	Urban	Yes	10+	10 - 20	Yes

Table 4.1: A table presenting the full spectrum of answers by all participants for each of the demographic questions from Part B of the interview.

4.4 ANALYSIS AND DISCUSSION

This section of the dissertation aims to highlight the key results of the overall research. Here a series of common themes have been identified from Part A of the interviews and separated into colour coded categories (see below) to be compared with data collected from the literature review. As data collected from Part B is demographic in nature, it will be presented through a series of charts to offer a visual

insight to the comparisons and differences and aid the identification of any emerging themes.
For brevity, the “ Common / recurring topics” category has been omitted from this section. While this information was valuable to identify, the topics that were identified are covered in detail in other sections.

4.4.1 ANALYSIS OF NEGATIVE RESPONSES / CONS:

Available information on straw and its perception

Most of the participants noted that it was difficult to find the information that they were looking for on straw bale construction, five of the seven stated that there was a lack of easily accessible general information overall. This is true when compared to materials such as steel, concrete and timber that have an abundance of scientific, governmental and general public sources by which to cross reference. This is in contrast to the literature review which identified many sources that offered basic and general information on straw bale (please refer to the sub-section 2.4 of the literature review). Whilst information on straw bale construction exists and is accessible there are fewer available scientific and governmental sources, thereby lowering the quality and reliability of overall knowledge. This is in keeping with the findings in the literature review. Similarly, two of the participants said that they had not come across any academic publishings specifically on straw bale construction while the remaining five noted that although they know that academic publishings existed, only a few were available. This again is true when compared to other more common building materials and is reflected through the number of sources found for the literature review. In addition to this most participants commented that straw is not commonly taught as part of many standard programs as well as a lack of inclusion in building conventions (compared to wood / steel etcetera) and a lack of serious coverage in general construction magazines (often portrayed as a novelty). According to many of those interviewed, this add to the public stigmas surrounding straw being associated with natural, “hippy” aesthetics and combined with the lack of advertising / promotion of straw does nothing to increase the already low consumer demand for straw in construction.

Codes, Standards and Research

One of the main negatives brought forward by all participants was the lack of codes and standards for straw in general and specifically within Canada. This reflects what King B (2006), Searle C (N/A) discuss in their papers, indicating that straw is mostly if not completely absent from official documentation. A frequently occurring theme from all participants was the lack of large scale research / testing of straw bales in construction (especially, as it was discovered through the literature review, that Canada requires its own testing). Many participants commented that while many small scale test have been carried out, straw is lacking large financial contributors to

be driving the research and performing tests on a industrial scale. Many other participants also commented on the inherent lack of consistency that comes with using straw (being a natural material), which makes it difficult for building formulas to be made and standardized. This can be seen in the literature review from the varying bale sizes and tightness producer to producer as well as from observations of natural building materials made by Gunawardena K-c (2008).

Hazards

When taking a closer look at straw bales for construction, all participants commented that fire, damp and mould were common concerns if the building was not constructed with the proper procedures. Magwood et al (2005), Straube J (2009) and Myhrman M and MacDonald SO (1997) from the literature review share the same concerns. However, Magwood et all 2005 and Myhrman M and MacDonald SO 1997 identify ways to avoid this - predominantly proper plastering to ensure the bales are protected from moisture and as well as protection from fire. It was commented that although prefabricated wall straw bale panels help to alleviate some of these risks, they are not only large in size but extremely heavy which brings about its own concerns. Due to the concerns not only present in the construction phase but also inherent in the material, many participants commented that obtaining a building permit can be difficult (location depending) and that they often have to take on all liability for the build themselves.

Straw as a Material

Six out of the seven participants interviewed were able to offer their first hand practical experience with straw construction. A frequently occurring difficulty they faced was finding the right people for the build. Participants cited a lack of construction knowledge as well as little incentive for builders to learn about straw as contributing factors. Many participants who took part in builds made reference to the straw itself being difficult to source in large quantities; If it could be sourced it was often more expensive to import as it was located further away which also conflicted with the sustainable eco-friendly nature of the project. Many cited that prefabricated straw panels would help counter these difficulties, like those created by ‘Modcell’ in the UK (this is also reflected in the literature review), however, none knew of any business in Canada that could provide this service. Many participants also experienced difficulties with the limited construction months in Canada due to the seasonal shift in temperature, and when combined with the abundance of more conventional building materials (Wood, steel etcetera) found it difficult to justify using straw from a financial and practical perspective. Also it was noted by many participants that the bale thickness (both produced by the balers (14-16 inches on average) and required for effective R-Values) compared to thinner, more conventional insulation (such as foam board) has a significant impact on the ideal square footage for a build. With space being a premium in urban areas, this makes

straw bale a less affordable choice when compared to more traditional insulating materials.

4.4.2 DISCISSION OF NEGATIVE RESPONSES / CONS:

The fact that information is difficult to come by has lead to there being limited or no official acknowledgements, codes or standards for straw bale in general (with Canada not having any). This makes people and working professionals hesitant to use straw bale because codes and standard are what builders and contractors rely upon to avoid uncertain liabilities. It also seems apparent from both the interviews and the literature review that having more officially recognised testing and research would help to outline the potential natural and construction hazards of straw use, make straw bale easier for working professionals to learn about and trust as well as potentially increasing supply and demand. This can be seen in the data from section 2.4.4 of the literature review which demonstrates the necessity for testing in order to bring it into code. The interviews also brought to light that local sourcing and transportation of raw straw bale to site was difficult because of the distances / transportation costs involved. In addition to this, straw bale was often referenced as a potential fire hazard which discourages working professionals from using the material and / or taking the extra precautions required. However, information from the literature review counteracts this notion by declaring that the US and rural Ontario have an abundance of straw bale to utilise (US Department for Energy 1995). Instead of bringing straw in its raw form to site, manufacturing those bales into prefabricated straw bale panel walls would help to solve both issues of sourcing and fire hazards in both production and pre-production. In addition to this, panellisation would prevent other hazards such as mould as well as speed up construction time for the short building season in Canada.

4.4.3 ANALYSIS OF OTHER BUILDING AND INSULATING MATERIALS AND METHODS:

Structural

Participants frequently made comments and comparisons to a range of structural materials used with straw bale construction including; timber frames, stud walls (for internal walls), and prefabricated straw bale panels. When comparing to more conventional structural materials, reference was often made to brick and steel (this is reflected in sources from in section 1.2 of the introduction). One participant commented that using rammed earth in conjunction with straw bale for a build that aimed to be as sustainable as possible, although they concluded the resulting wall would be extremely thick.

Insulating

Many different insulating materials were suggested by participants as either more accessible or more common alternatives to straw bales. These include: recycled foam board, mineral wool, cellulose (from recycled paper), cellulose (from wood / plant fibers), rammed earth and prefabricated straw bale panels.

Foundation

Identifying suitable foundation materials for straw bale builds was covered by a small number of participants. These included: cedar posts, sandbags and rubble walls. Whilst less specific, the literature review notes the need for solid, raised foundations to aid in the prevention of damp.

Plaster

All participants that were interviewed detailed the need to plaster straw bales in order to utilise them effectively as a building material. The various materials used to cover the straw bales were identified by a couple of participants and included: clay, sand, lime, crushed brick, cement, concrete and hemp.

4.4.4 DISCUSSION OF BUILDING AND INSULATING MATERIALS AND METHODS:

Analysis of the interviews found that participants often referred to (or recommended) other materials for structural /insulating purposes because they were covered by codes and standards and / or can be sourced with greater ease making them more common, accessible and desirable than straw bales. These other suggested insulating and structural materials (aside from rammed earth) appear to be thinner than straw bale. This makes them more attractive to working professionals when comparatively straw bale takes up much more space (see approximate sizes in section 2.4.3 of the literature review). Talk of straw bale also brought up discussions on foundation types and plastering as additional requirements to consider for successful straw bale construction. While these requirements are necessary, they again add to the workload and learning of working professionals. The material suggestions brought forward by the participants were simpler in their application making them more attractive to working professionals.

4.4.5 ANALYSIS OF INFORMATION SOURCES:

One focus of the interview process was to establish what sources of information the participants have used or perceived as being useful or lacking. These have been categorised into major and minor contributors of information below:

Major sources of information

Most participants made extensive use of the internet to access much of their information, as well as books and in-person information gathering from like minded people, straw bale communities and coalitions alike. Six out of the seven participants had performed their own testng at one point in their careers whilst also relying on collaborative outsourced testing done by Canadian Universities and onsite builds. Most participants also made reference to resources from ‘Camel’s Back Construction’ and the ‘Endeavor Center’.

Minor sources of information

Whilst five out of seven participants did not receive any information on straw bale construction through school / college / university, many made reference to improvements being made to the programs offered to include material on straw. Many participants commented that although published and scientific journals were not in abundance on the topic of straw, those they could find provided useful as learning and reference material. This is reflected through the sources in the literature review. Lectures and conferences were also mentioned as useful when they were available as well as sustainable business newsletters. Codes from other countries were cited as useful when they were established (although the adoption rate of straw bale into building codes remains small - see section 2.4.4 of the literature review). Other minor sources of information that participants used includes: articles, social media forums, ‘Youtube’, ‘Pinterest’, documentaries and home improvements TV shows.

4.4.6 DISCUSSION OF INFORMATION SOURCES:

From the indicated major sources above, it appears that the general public have had to produce their own resources and information on straw bale construction. Which while helpful (and shows a public interest), it means that people / working professionals are having to look to unofficial / non-governmental sources for their information. The unofficial nature of these sources means that they can run the risk of not meeting the high quality standards usually set out by governments which can turn many people away from straw as they act as barriers to information and intellectual accessibility. These sources of information bring to light that although scientific testing and research is being produced, there is not enough to form quality answers for all questions relating to straw (like there is with steel or concrete), meaning that working professional are less inclined to work with straw as they do not fully understand / trust the material. This is something that needs to change and adapt as straw is beginning to appear sporadically across social media platforms and other forms of media meaning that there is a growing (but uncertain) interest in the material.

4.4.7 ANALYSIS OF THE REFERENCE TO OTHERS IN THE FIELD:

Throughout each interview participants made specific reference to academic institutions, straw bale organisations as well as people of note in the field which they identified as having influenced their work.

Academic Institutions

The academic institutions noted as either assisting in testing or including new academic programmes from participants included: The Centre for Alternative Technology, The University of Manitoba (Manitoba), Unity College (Maine), The University of Waterloo (Ontario), Queen University (Ontario) and Algonquin College (Ontario).

Organisations

Many Participants accessed information and resources form organisations, associations and companies with a focus on straw bale building (or where part of them). These included: The Endeavour Centre, California Straw Bale Coalition, Colorado Straw Bale Association, Ontario Straw Bale Building Coalition, Straworks Building Company, Camel's Back Construction and Modcell.

Individuals

During the interview process, different participants often made reference to them same specific individuals in the field of straw bale construction that influenced their work, are integral to moving the industry forward or whom they reached out to / collaborated with personally. These include: Chris Magwood, Peter Mac, Tina Terrian, Chris Dick, Bruce King and Tim Krahn. Many of these names can also be identified through the literature review as well as in the references.

4.4.8 DISCUSSION OF THE REFERENCE TO OTHERS IN THE FIELD:

Based on analysis of the interview results in conjunction with the literature review, it can be said that the active straw bale field is dominated by working professional / public individuals and groups who often interlink and share their resources. However, academic institutes are rising in their awareness of environmental values meaning that a new wave of interested persons are beginning to enter the field. Whilst still scarce, academic institutes are where a lot of testing is performed as students can dedicate the time and resources to their cause. This means that there is a much wider community of straw bale enthusiasts than first considered providing evidence and incentive to official / governmental bodies that straw should be considered by them for recognised documentation. If this were to happen, then 'official /governmental bodies' would likely become the main point of reference for people,

meaning that straw bale carried official representation and working professionals would be more inclined to use it.

4.4.9 ANALYSIS OF REFERENCES TO CONSUMERISM / A PRODUCT:

All participants made extensive reference to the need for increased industry surrounding straw bales. Many commented that straw bale is dwarfed by the industry demand for more traditional materials such as Timber and Steel, and having large financial backing would help reinforce supply chains, generate demand for the material as well as establish more financial incentives for research /development and standardisation. This is echoed in section 2.4.4 of the literature review. Many of those interviewed made reference to consumerison in general noting that the public /builders tend to prioritise consistency and quality finishes regardless of the material itself. Many participants theorised that should a large corporation become interested in straw this would generate more standardisation and make it more financially viable for builders and clients alike to consider straw bale construction.

4.4.10 DISCUSSION OF REFERENCES TO CONSUMERISM / A PRODUCT:

This section indicates a strong need for straw bales to be considered as a “product” rather than as a raw material. If this came to pass, it would allow straw bales to more easily become a part of the building status-quo. ‘Product’ status would also mean that straw bales could be easily advertised and create more public interest /demand. Judging from the interviews and the literature review, prefabricated straw bale panels (comparable to those produced from ‘Modcell’ in the UK) would be a good solution for the sourcing and construction of straw bales in Canada. However, to avoid the same fate as the last company attempt in Canada (see section 2.4.2 interview with Person D), a survey on public interest would be wise to consider before proceeding. Prefabricated panels would also allow for standardisation, ensuring the availability of official guidelines and therefore an increased amount of widely accessible knowledge (which would in turn make straw more desirable)

4.4.11 ANALYSIS OF PARTICIPANT JOURNEYS:

All but 1 of the participants had personal stories of builds using straw bales. From these, all of them began small, either designing their own or a friend’s straw bales building. All six of these participant conducted their own research, learnt on the job and generally broke new ground as their builds continued. All participants were happy to share information with others and many of those interviewed spend their career’s generating information that was not available 20+ years ago when they began.

4.4.12 DISCUSSION OF THE PARTICIPANT JOURNEYS:

This section's results echo the discussions had in previous sections and mean that if there had been official codes and standards in place, the interview participants (along with authors from the literature) would have had an easier, safer time on their projects. However, their stories do mean that straw bale is presented a desirable building material to work with as they all persisted and learnt through trial and error. This means that they have been able to provide others with knowledge of their experiences to refer to where official / governmental sources fail. This also explains why there is a wider straw bale community to fall back on and provide some accessibility to straw bale knowledge.

4.4.13 ANALYSIS OF PERCEIVED PUBLIC OPINIONS (BY PARTICIPANTS):

As outlined in the interview questions, all participants gave their opinions on the public perception of straw. The consensus among those interviewed is that there remains a stigma surrounding straw due predominantly to it's rural connotation and limited application (compared to common application of timber and brick for urban houses), and it's perception as a weak material not to be associated with building (some participants made specific reference to the story of "Three little pigs"). Many participants assume that the public (in general) are not willing or comfortable enough to take a risk when it comes to their home (they see straw as an unproven / unknown material); which combined with the lack of awareness of straw bale construction prevents home builders from seriously considering it. However many participants have noticed a rising interest in straw during recent years that they attributed to an increased awareness of climate change, the influence of social media (being more aware of the aesthetic appeal of straw bale) and a romantic attitude towards getting back to the land.

4.4.14 DISCUSSION OF PERCEIVED PUBLIC OPINIONS (BY THE PARTICIPANTS):

A review of the above section shows that the interview participants mostly perceive the public to have negative opinions of straw bale use. This is somewhat in opposition to the literature review if the popular coalitions and communities are included which the literature research identifies as an enthusiastic and active source (see section 2.4.4). These opinions risk causing feedback loop through which the negative public opinions cause working professionals to feel less inclined to promote straw bale as a visible, viable possibility (further reinforcing the negative public perception and so on). Despite this, there is a rising public interest in straw bale and if working professionals were able to focus their efforts on those potential clients, it stands to reason that experience, knowledge and reputation would increase, trickling out to the wider population and effect overall opinion.

4.4.15 ANALYSIS OF POSITIVE RESPONSES / PROS:

Qualities of straw

All of the participants noted the attractive qualities straw has as a building material for both insulating and structural purposes. Many participants noted straw as a great sequester of carbon combined with it's fast growing nature, making it an attractive sustainable and eco-friendly material. These noted qualities are reflected in the literature review. The Structural integrity was a common theme, with mention of plastered straw bales being more resilient to fire that more common forms of insulation. Practical benefits were frequently brought up with specific reference to the incredibly low (virtually none) living cost of straw buildings / properties (as mentioned in the literature review), in addition to straw bale homes typically lasting 100+ years.

Attitudes on straw

Positive attitudes towards straw were a common topic among those interviewed, with many references to personal / anecdotal stories of straw bale buildings feeling soft and pleasant to be in. Many of the participants made reference to an increased interest in straw from students in addition to frequent mentions on social media. Many participants commented on architectural and engineering firms being open to using straw as well as building inspectors (at least in rural areas) being willing to learn about straw bale construction. Of those interviewed, six of the seven interviewed were admirers of straw and enjoyed or wanted to work with the material.

Information available on straw

Since they were first introduced to the material many participants commented that there has been steady (but slow) improvement on the quantity and quality of information available via; online / printed sources, scientific literature and conferences /lectures (a selection of these can be found within the literature review). When questioned on what information can be found easily, moisture and insulation values were cited as being simple to find (although from a small data set). As for the sources of information, participants made references to universities assisting in material testing (again on a small scale), environmental business centers providing learning and information on straw (such as the Endeavour Centre, 2018) and from communities and coalitions (many referenced that the small community around straw is enthusiastic and eager to share information). The company 'Modcell' (who design and build prefabricated straw bale panel walls in the UK) was also frequently referenced as a leading source of information on fabricated straw bale panels. This reflects information in the literature review.

Legislation / Codes / Tests

While the tests conducted on straw bales is lacking compared to more traditional building materials, many participants noted improved traction in this area as some countries (like Belarus and Germany) have tested and accepted straw as a viable building material. According to those interviewed there are qualified people in the field who could perform the official tests for code that Canada requires. Those that have performed their own tests said have said that they have been predominantly positive across the board.

Practical Applications

When questioned on their real world experiences and knowledge with straw construction many participants made reference to the huge agriculture sector in Ontario which would make sourcing the material in small quantities relatively easy. In addition to this they made comment to there being physical examples of straw bale buildings in the region that are available to see and learn from (with rural properties being especially easy to design and build with straw bale). Property insurance was noted by most participants to be more challenging to come by or obtain from insurance companies. When questioned on the use of straw in more urban areas, all participants agreed that prefabricated panels allow for an engineered / consistent product that is much more practical to work with in those settings and on a larger scale (this is reflected in 2.4.5 of the literature review).

4.4.16 DISCUSSION OF POSITIVE RESPONSES / PROS:

An analysis of this section brought to light that although there are many positive useful aspects to straw bale, these focus more profoundly on its contributions and solutions to the current environmental crisis and do not always focus on building construction solutions (which are currently lacking). The literature review also focused on straw's positive impact on the environment (section 2.4.5) suggesting that overall straw has been thought about and brought into conversations by environmentalist and the wider population (section 2.4.4), but has struggled to gain traction. This also includes the notion of producing prefabricated straw bale panels. From a review of both the literature and analysis of the primary data above, panelization would appear to help alleviate those building concerns and strengthen the case for the adoption of straw bale as a serious, practical material contender.

4.4.17 ANALYSIS AND DISCUSSION OF THE DEMOGRAPHIC INTERVIEW QUESTIONS:

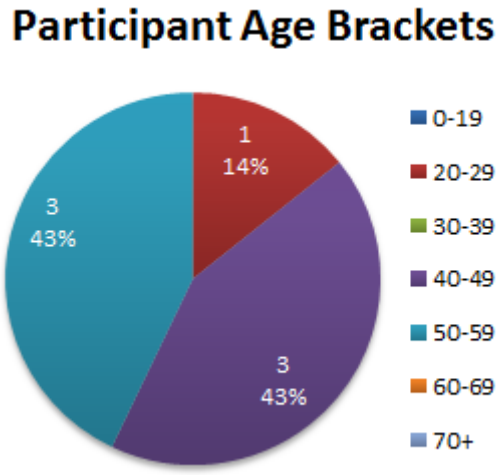

Chart 4.1: A pie chart displaying the number of participants that fall into each age bracket and the percentage those numbers take of the overall number.

The 'Participant Age Brackets' chart above shows the results of which age brackets the participants fall in to at the time of the interview. From this chart we can see that the majority of participants are over the age of 40 (86%) and that this larger group of people fall equally into both the 40-49 age bracket (43%) and the 50-59 age bracket (43%) with three people in each. The chart also displays that just 1 of the interview participants fell into the 20-29 age bracket (14%). These results suggest that there are fewer youthful persons interested in exploring the topic of straw compared to people with more life experience.

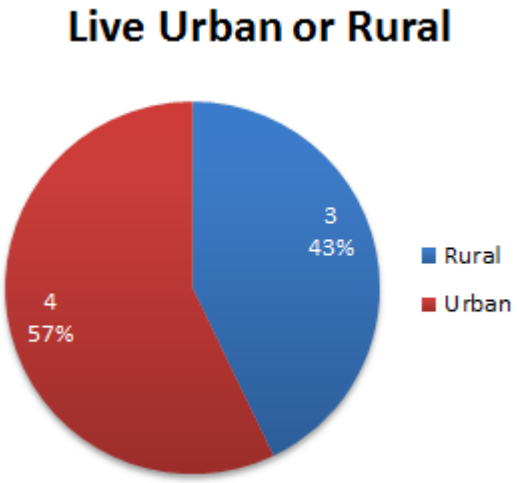

Chart 4.2: A pie chart displaying whether the participants reside in a rural or an urban environment and the percentages they take of the overall number.

The ‘Live urban or rural’ chart above shows that the majority of the interview participants live in an urban environment. These results suggest that living in a rural environment does not make a person more likely to be interested in the topic straw. However, with a ratio of 3 people (43%) to 4 people (57%) the difference in this small study group is not significant enough to indicate a trend as a stand alone question.

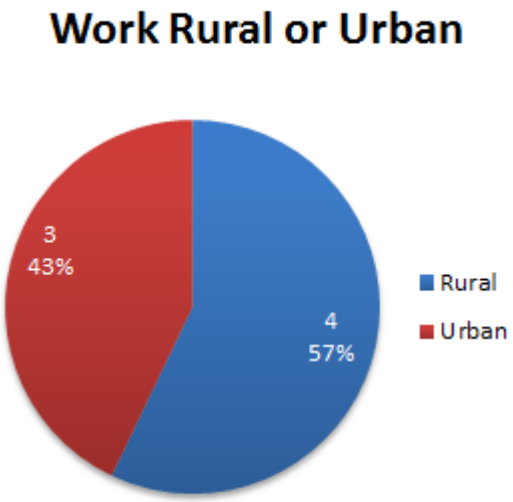

Chart 4.3: A pie chart displaying whether the participants place of work is in a rural or an urban environment and the percentages they take of the overall number.

The ‘Work rural or urban’ chart above shows that the majority of the interview participants work in a rural environment. These results suggest that working in an urban environment does not make a person more likely to be interested in the topic of straw. Also, when in relation to the previous chart, the combined results indicate that those who live in an urban environment and work in a rural environment are most likely to be interested in the topic of straw. However, as with the previous chart, with a ratio of 4 people (57%) to 3 people (43%) the difference in this small study group is not really significant enough to indicate a trend as a stand alone question.

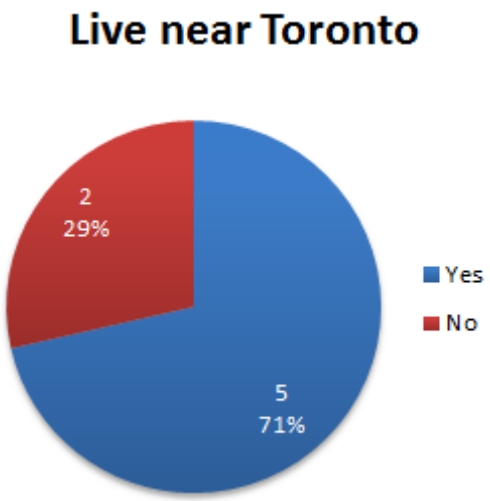

Chart 4.4: A pie chart displaying whether the participants live near to the city of Toronto, Canada or not and the percentages they take of the overall number.

The 'Live near Toronto' chart above shows that the majority of the interview participants do live near the city of Toronto, Canada. The results of this chart indicate that 5 (71%) out of the 7 interview participants are more familiar with the chosen city of study and are therefore more likely to provide more accurate data for Toronto than the remaining 2 (29%) people.

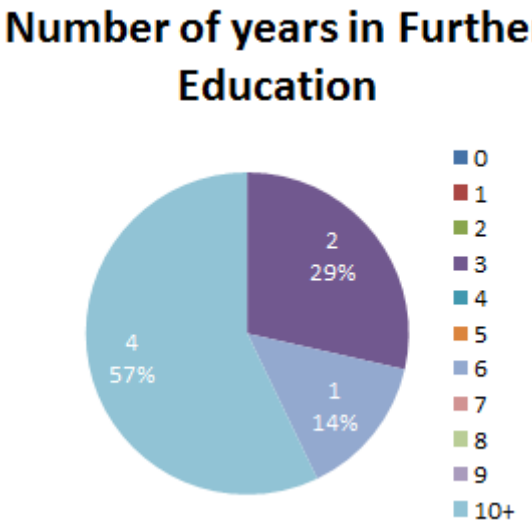

Chart 4.5: A pie chart displaying the number of years each participant spent in further education and the percentages they take of the overall number.

The 'Number of years in further education' chart above shows that all of the interview participants have spent time studying in further education. With 4 out of 7 people (57%), the majority of interview participants say that they have spent 10+ years in further education. 1 person (14%) spending 6 years and the remaining 2 people (29%) spending 3 years. This chart indicates that those people interested in the topic of straw have dedicated time to further education. However, considering the small

size of study group involved these results should not be used as a true representation of the population but merely as an indication for this particular study.

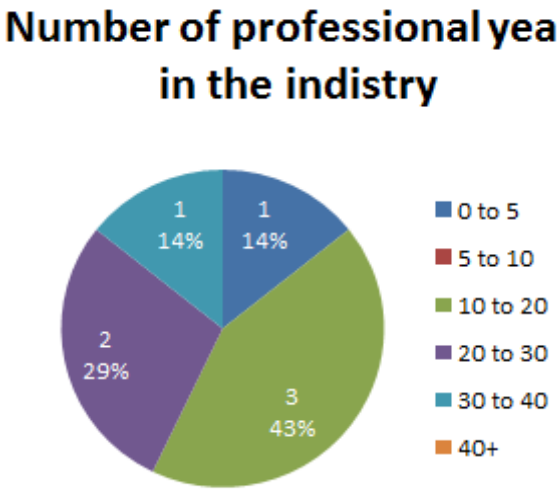

Chart 4.6: A pie chart displaying the number of professional years each participant spent in their industry and the percentages they take of the overall number.

The 'Number of professional years in the industry' chart above shows the results of how long the interview participants have spent working professionally in their industry. From this chart we can see that the majority of participants (86%) have spent 10+ years working professionally. Within this larger group, 3 people (43%) have spent 10 - 20 years, 2 people (29%) have spent 20 - 30 years and 1 person (14%) has spent 30 - 40 years professionally working. Just 1 of the interview participants (14%) were new to professionally working with 0 - 5 years. These results suggest that the more professional years of working a person has, the more interested in the topic of straw bale they are.

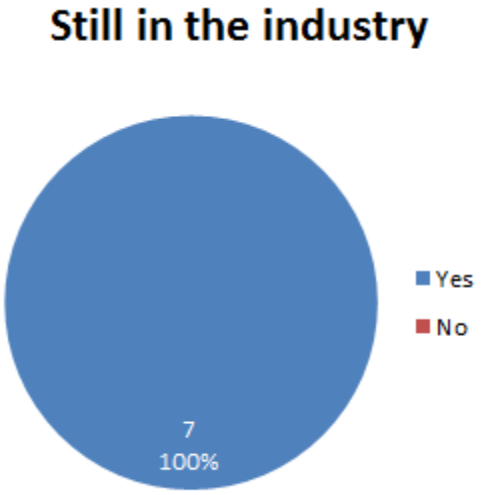

Chart 4.7: A pie chart displaying how many of the interview participants still work in their industry and the percentages they take of the overall number.

The ‘Still in the industry’ chart above shows that all of the interview participants are still working in their industry.

This analysis shows that the most of the willing interview participants are on average, quite similar and identify a certain criteria: All of these people are in the industry itself. All but one of participants started with straw bales at a similar time (during the 1990’s - 2000’s) and fall between the ages of 40 - 60. Whilst they all have spent time in further education, the majority have spent 10+ years learning and on average have a live-urban, work-rural life.

5.0 CONCLUSION

5.1 SUMMARY

The aim of this study was to identify the existing barriers to using straw bale for urban / city constructions with a view to using it in midrise and highrise buildings in Toronto, Canada.

The results of this study were achieved through the steps laid out in the objectives. Firstly, background knowledge was established through a collection and review of the available literature. This helped to develop an understanding of what and where any pre-existing barriers may originate from. Secondly, qualitative semi-structured inductive interviews were constructed and performed on seven willing participants who are working professionals related to the building industry (architects, engineers, builders, contractors, educators). This was in order to establish an understanding of any first-hand barriers by gathering primary knowledge and experiences data. Thirdly, from this point a comprehensive analysis comparing and contrasting the collected data was performed with the aim to highlight emerging categories / themes and bring clarity to the results. The categories / themes then helped to identify and deduct the barriers to using straw bales in construction from the text.

As a result of this study, there appear to be three main interconnected barriers brought forward by the themes. These are:

1. A lack of accessible knowledge on straw bales and their construction
2. A lack of official / governmental codes and standards
3. Straw bales are not seen as a ‘product’

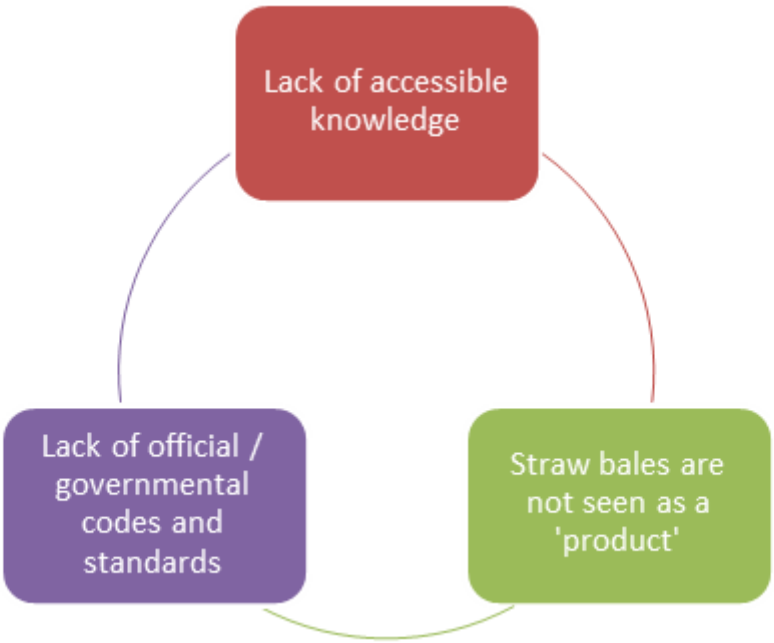

Figure 5.1: This cycle chart displays the three main interconnected barriers identified from the study and how they support each other.

All three of these main barriers are interconnected as they hinder and prevent an understanding of straw bales in terms of their properties and applications; an awareness that straw bales exist as a viable building material; an interest in learning more about straw bales and in using them; safe construction of a building both structurally and the building's lifetime; a trust from the wider public that straw bales will be able to do their intended job and a demand for straw bales as a building material.

5.2 LIMITATIONS

This study was limited to only identifying the barriers to straw bale in construction and has not set out to overcome these barriers or to analyse in any great depth potential solutions that may have presented themselves. The execution of the research itself was restricted by a set timeframe in which it had to be conducted and completed, therefore if presented with more time this paper would have been able to conduct a second set of interviews to further discuss the emergent themes analysed in the first round. The success of gathering a larger number of willing interview participants was also restricted by the presence of a time limit as communications were predominantly conducted via e-mail and during business hours. Whilst the participants were moderately representative with a decent variety of working professionals from within the urban building industry, the study would have benefitted from the presence and participation of government code makers, building inspectors, farmers and other architects and engineers who did not have any experience with straw bale. These additions would have added a broader and even more in depth understanding to the body of knowledge (likely through more experience and opinion based questions such as 3,5,6,9,10 and 11) which would likely have revealed additional barriers not covered by this paper. As stated in the literature review / analysis, there exists little in the way of official / governmental building codes for straw. This posed a challenge as much of the information on straw bale construction in the literature review had to be sourced from in more general green building / environmental discussions as well as in coalition and community reference pages.

5.3 IMPLICATIONS

The aim of this study was to address why straw bale was not being used and utilised considering its qualities. Whilst the barriers identified in this paper stem from different places of factual acknowledgement, this paper brought them together as a single work with the intention to be both a reference for the barriers themselves as well as a point of reference for interested persons who wish to do further research.

5.4 FURTHER RESEARCH

From this investigative study, it has come to light that although the study question is valid, the study results show that a more appropriate question would have looked into identifying what the barriers are to using straw at all let alone in midrise /highrise buildings. This paper therefore laid down the groundwork for this topic of investigation, and means that there are certain fundamental areas such as an analysis of straw itself (outside the scope of this paper) that would benefit from being examined further.

Firstly, this dissertation question would benefit from a second study which (using the results and experiences of this paper) focused solely on investigative discussions on the future of midrise and highrise buildings with a view to using straw bales or prefabricated straw bale panels.

Secondly, a quantitative version of this study question would open up the discussion and allow for a much broader and varied set of primary data. Survey questions could be formed using the research from this paper to create appropriate scales of predetermined multiple choice questions with the aim of scaling the identified barriers and causes by their influence. This could provide hard numerical quantitative data by which to form action plans / appropriate route to investigate .

From here, different branches of practical straw bale testing, market research and social research into the barriers to straw bales would also benefit the field in either solidifying what these barriers are, and / or beginning to analyse the viability of potential solutions.

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APENDIX 1: Example of a transcribed, colour coded interview.

Negative responses / cons
Positive responses / pros
Mention of other building materials
Sources of information
Reference to others in the field
Personal musings / opinions
Reference to consumerism / a product
Journeys (do it yourself project)
Sharing (information, projects helping)
Re occuring regularities from other interviews (thickness, fire or mold, legislation)
Perceived public opinion: good
Perceived public opinion: bad

1. What is your job title?
Building scientist.

2. Could you summarize your role and its relation to building, planning and built environment?
Building scientist within an architectural firm. We like to say that our firm is science led design which means that we look at building science as part of the design and not necessarily an afterthought. So the building science is like the physics of a building... how to deal with energy flows through the envelope, we look specifically at air, water, moisture, water vapour and thermal.

3. So what is your familiarity with designing and building with S.B.?
Probably my only familiarity with straw is what we learned a CAT and so the buildings that they have on site that are built with straw they have a few: one of them's the two-story Theatre, one of them's just a little shed and that one sort of deteriorating, the plaster has ripped off of the straw so you can see a little bit more of a breakaway section. And then the materials course where we've learned to work with straw in building buildings.

4. When you were reading about S.B., have you been able to find the information that you needed?
Straw bales specifically, no I find that information much harder to come across than opposed to like the Modcell in the UK which does prefab straw bales panels. So if you're researching that specifically, it's easier to find, but straw bales, I don't find easy. I don't find it easy to get information on that.

B. How challenging was it to find what you need?
There was something recently I was trying to look at straw for, were doing a

materials database within the office and so I was trying to research all these different insulation types and the straw bale, I couldn't find, I was looking specifically for embodied energy and embodied carbon, R-value, all sorts of things like that, I couldn't find information on that, just like, generic information. I think if i were prob to contact straw bale supplier, it would be easier to (obviously) find what i need. but i remember also doing one of the projects at CAT i had to research...you had to pick a location and research at all the raw materials in that area and so i picked a location close-ish to toronto and I couldn't, it was really hard to find suppliers of straw bale, or even straw firms or anything.

C What was easier or harder to find?
On a seperate project I think i looked at straw from a hydrothermal performance and it was easier to find the moisture information like how straw deals with moisture. I know from, it might just be from CAT has some structural properties but that's just because we were given that information up front. I definitely didn't come across insurance or anything like that but I feel like there's probably something about acoustics and having some sort of acoustical properties but I couldn't tell you for sure.

5. Where have you uncovered information on S.B. that you needed?
Mostly through CAT and then just a little bit of research that I have been trying to do here.
Just randomly online. It's not through any sort of academic publishing, I might have grabbed some information from Modcell because they work exclusively with straw, also the Endeavour Centre because they work a lot with straw and I just adapted that information for what we needed.

6. How frequently do you notice and talk of S.B. in the public domain?
Not very, I would say. Especially in this area it doesn't seem to be on anyone's radar. I'm trying to even think about like the architectural magazines or like lectures I've gone to recently and it hasn't been a lot about straw except for I did see Chris Magwood talk and he talks a lot about straw. I've actually seen him speak a couple of times recently. He talks a **lot** about straw.

7. You or business done research
so I'm sure our business has because they've done at least one straw bale house and I'm sure Paul talked about it and then just some research that was required from CAT and then again the little bit of research that I have been trying to gather on the straw for the office. One of them was for the assignment, the other was for the office so we have like a materials database.

B. in collaboration with other companies no with anybody else about straw bale construction. I wouldn't say research the fact that we were in contact with Chris about getting him to speak about straw for us but I don't classify that as research.

c. positive or negative

My own research? Actual information is neutral it's not really advocating for or against straw. From my personal impression of my findings I found them to be negative because... negative in the sense that it was hard to find the information it's not readily available and it doesn't seem like there are a lot of people promoting it.

8. planning and standards:

I don't think that I have researched straw in relation to codes and standards just because that wasn't part of the research so its not that it wasn't there just that I didn't look into it.

9. why do you think S.B. is not more commonly used in the city:

a. in general I think that the material isn't readily available in the city. like some of the other insulation products are manufactured in like Milton or Mississauga, Oakville where as I think straw would have to come from a little farther away. I think its not used because you need a lot of straw in order to achieve the R-values that you are looking for which can be achieved through much more compact material and I think it's not commonly used because there's a stigma about building with straw that's kind of like a Hippyish and all the buildings built with straw look like they're eco-buildings and generally people who live in the city want to flaunt that city style they don't want to flaunt this like this hippy Sustainable Building.

B. Midrise and highrise

I think the biggest factor is the thickness you would have to build in order to achieve the R-values and then if you're looking at the system like Modcell that has the prefab panels they are super heavy and if you're trying to build high-rise buildings the higher you get the structures actually just going to be really beefy and that is not what the construction industry is about they're all about making it cheaper and easier not heavier and more expensive. There is also noone in Canada who does prefab straw so that would make it expensive to bring those over from the UK.

C. Wider population

I think it just has poor representation which gets back to like the eco building and how people think about straw... there's probably a lack of knowledge. I think it still has to do with the thickness of the walls even if you're in a suburban area people want to maximize the interior of the house but they also want to maximize their lots, their little outdoor space and they're now building these massive houses on these tiny lots so I think straw is not an appropriate... they think it's not appropriate to use because that wall is going to be super thick I think that's probably also just a lack of construction knowledge in straw and an awareness and it doesn't help that information is hard to find.

10. Personally building with S.B.:

I like the idea of building with straw, it used to be my dream to build with straw. but for probably all the reasons that I've stated I'd think there are other options that are maybe not as sustainable as straw but like using cellulose system would be probably more effective in a City specifically that using straw and I don't see myself moving to a giant farm with tons of land so I don't think I could see myself using straw in a building.

11. what do you think the barriers are:

I think in general there's probably not a lot in codes and standard that even dictate that you can use straw...its something like a work around. It's not very accessible there aren't companies or manufacturers or whatever, growers, that are advertising; the information is hard to find; and the lack of knowledge again, people probably don't know all about straw building. we've been building in Canada with wood frame forever so people know about wood framing houses and even people who aren't in the industry know about wood frame houses...and fiberglass insulation and all that they probably don't know anything about Straw Bale. Mid-rise and high-rise buildings I think the barriers again are cost and weight and thickness. I think cost is probably the biggest one. the construction industry revolves around money and if it's not going to benefit the developer in any way then I don't think they'll be willing to change what they already know. But a lot of it actually is probably from consumer demand because we tell them that we want these glass towers and they're like "oh yeah, I want that glass Tower. Industry Drives demand which drives industry. It's a vicious circle. Specifically with Toronto I think it's like a combination of both of them because a lot building in Toronto is high-rise.

Appendix 2: Ethics Form

Instructions:

- **All students** must complete Overall Legal, moral responsibilities, codes of conduct Section.
- Students doing environmental or science research must complete **section 1**.
- Students doing research which involves human participants or existing datasets or archives must complete **section 2**.
- Students doing mixed environmental and research involving people or existing datasets or archives must complete **both sections 1 and 2**.
- **ALL STUDENTS must complete sections 3, 4 and 5.**
- **FOR FURTHER INFORMATION PLEASE SEE ETHICS REQUIREMENTS FAQ'S**

Overall Legal, moral responsibilities, codes of conduct

Are there any conflicts of interest between the researchers, CAT and/or research subjects/environments?	No
Is the research compliant with the General Data Protection Requirements (GDPR) (2018)?	Yes
Separate from any legal obligations, is there a moral responsibility to provide feedback or results to research participants/landowners?	No
Will you take all necessary measures to maintain the integrity of the research?	Yes
Will you abide by codes of conduct from any professional associations or organisations that should guide your research?	Yes
a) Will your study involve research outside the UK? If so, have you checked whether there are any research governance, ethics and other legal regulations in place in that country with which you will need to comply? *Please detail in section 3c below.* .	Yes
Does your research concern groups which may be construed as terrorist or extremist?	No
I am aware that cases of proven misconduct, in line with UEL and GSE policies, may result in formal disciplinary proceedings and/or the cancellation of the proposed research	Yes

SECTION 1. SCIENCE PROJECTS

Consent:

	To be completed by the student	To be completed by the supervisor:	
		Inspect steps taken	Refer to GSE Ethics Committee
a) Will the fieldwork be conducted in an environmentally sensitive area or area of Special Scientific Interest, OR require crossing a sensitive area? *If so, please detail procedures for obtaining informed consent in section 3a*	No	Yes/No	
b) Will you need permission for access to the research site? *If so, please detail procedures for obtaining informed consent in section 3a (i.e. how will you ensure that the land owner is fully aware of what the research might uncover?). Please attach information sheet and consent form.*	No	Yes/No	

Confidentiality:

c) Will the land or land owner be identifiable from your research? *If yes, please explain procedures for minimising potential harm in section 3b.*	No	Yes/No	

Other issues:

d) Will the study involve environmental damage or site disruption? *If yes, please detail the measures which will be taken to minimise harm in section 3c.*	No	Yes/No	
e) Have you read, and will you uphold the countryside code? (e.g. litter, closing gates, etc). *If no, please explain why in section 3c.* http://www.naturalengland.org.uk/ourwork/enjoying/countrysidecode/default.aspx	Yes	Yes/No	
f) Does the fieldwork involve sampling rare or endangered species?	No	Yes/No	
g) Will a third party have an interest in a particular outcome of your research? If yes, p*lease address any issues arising from this in section 3c.*	No	Yes/No	
h) Will your study involve research outside the UK? If so, have you checked whether there are any research governance, ethics and other legal regulations in place in that country with which you will need to comply? *Please detail in section 3c.*	Yes Yes		Yes/No

If your research also involves talking to people or existing data sets or archives please complete section 2. Otherwise, proceed to section 3.

SECTION 2. SOCIAL SCIENCE PROJECTS (and science projects which involve using human subjects- or use of existing data sets or archives)

Consent:

a) Does your research involve use of already existing data sets or archives? If so, do you have permission to use these datasets? *Please detail in section 3a.*	No n/a	Yes/No	
b) Will the study seek written, informed consent? *Please detail in section 3a and attach information sheet and consent form.*	Yes	Yes	
c) Will participants be informed that their participation is voluntary and that they can withdraw at any time up to the point of research project submission? *Please explain in section 3a.*	Yes	Yes	
d) Will the study involve research with people who cannot give informed consent (e.g. for research involving children or people with learning or communication disabilities) which will therefore require obtaining consent from a 'research participant advocate' (e.g. parents/carers/guardians, etc)? If yes, p*lease detail how in section 3a.*	No		Yes/No
e) Will financial inducements (other than the provision of refreshments, for example) be offered to participants? *If yes, please outline and address issues relating to possible coercion in section 3a.*	No		Yes/No
f) Will your research involve covert research (i.e. where participants aren't aware of your role as researcher) or extended long-term engagement where participants might forget you are a researcher? *If so, please address these issues in section 3a.*	No		Yes/No

Confidentiality

g) If your research involves already existing datasets or archives, will you comply with the requirements of the General Data Protection Regulations (GDPR) (2018) and Data Protection Act 2018 concerning confidentiality and anonymity? *Please detail in section 3b.*	N/a	Yes/No	
h) Will participants' data and organisations remain confidential? *If yes, please detail procedures to ensure confidentiality in section 3b. If not, please explain how you will obtain appropriate consent in section 3b.*	Yes	Yes	

Other issues:

i) Will the study involve recruitment of participants from	Yes		Yes

	outside the UK? *If so, please explain how you will address country-specific research governance regulations in section 3c.*			
j)	Does your research involve children or vulnerable adults *(e.g. children, adults whose* ability to protect their own interests are impaired or reduced in comparison to that of the broader population. Vulnerability may arise from the participant's personal characteristics (e.g. mental or physical impairment) or from their social environment, context and/or disadvantage (e.g. socio-economic mobility, educational attainment, resources, substance dependence, displacement or homelessness). Where prospective participants are at high risk of consenting under duress, or as a result of manipulation or coercion, they must also be considered as vulnerable. If so, do you have up-to-date Disclosure and Barring Service check (DBS) certificate? See www.gov.uk/disclosure-barring-service-check *Please provide details in section 3c* NOTE: information concerning activities which require DBS checks can be found via https://www.gov.uk/government/publications/dbs-check-eligible-positions-guidance This will not be necessary if using secondary data authorised for use by the data collector for research purposes if anonymized/pseudonymised before your receipt of it i.e. you cannot identify participants.	No N/A		Yes/No
k)	Will the study discuss sensitive topics that may cause distress or embarrassment to the participant or potential risk of disclosure to the researcher of criminal activity or child protection issues? *If yes, please explain how you will address these issues to minimise harm to participants in section 3c.*	No		Yes/No
l)	Will the study potentially expose the researcher to criminal activity? *Please provide details in section 3c.*	No		Yes/No
m)	Will research subjects be informed of your responsibilities to report any evidence of criminal activity?	Yes		Yes

Please provide details of the "clear disclosure": N/a to this study

Date of disclosure:
Type of disclosure:
Organisation that requested disclosure:

DBS certificate number:

(NOTE: information concerning activities which require DBS checks can be found via https://www.gov.uk/government/publications/dbs-check-eligible-positions-guidance)

Module Leader – please sign off below

SECTION 3. ALL STUDENTS: Additional information

Please provide additional information supporting your answers to the above questions, explaining any specific precautions you intend to take. *(e.g. from whom do you need to obtain permission and what stake does this third party have in your research; why is it necessary to work with vulnerable groups; why you will not be seeking written, informed consent etc.)*

3a. Consent *(please give further information here relating to the questions about consent)*

Section 2 (b) *The study will seek written informed consent of any and all participants in this research. A signature will be required for the information sheet and consent form as approved by CAT.*

Section 2 (c) *All participants will be informed via e-mail correspondence and the information sheet and consent form that they may withdraw at any time up to submission.*

3b.Confidentiality *(please give further information here relating to the questions about confidentiality)*

Section 2 (h) *Participants data and organization will remain confidential if they have decided that is what they want. This will be achieved by removing names and replacing names with "Person A" or 'Company A' and using group terms such as 'they'. All data collected by myself for my own personal use in communicating with participants will be kept locked on my personal computer devices and email, will not be made available to anyone else unless permission is granted and finally will be deleted after project submission should they request so.*

3c. Other issues *(please give further information here relating to the questions about other ethical issues)*

For those studies requiring DBS disclosure, please fill in the following: N/a

Date of disclosure:
Type of disclosure:
Organisation that requested disclosure:

DBS certificate number:

Other issues:

Section 1 (h) *Canadian research governance states that participants have the right to confidentiality and withdrawal at any time and they are to be fully informed of the scope of the research so they can have informed consent to help (link below).*
http://www.pre.ethics.gc.ca/eng/archives/tcps-eptc/interpretations/interpretation015/
Section 2 (i) *In accordance with Government of Canada: Panel of Research ethics, the indicated rules for research projects falls in line with that of CAT. I will keep these rules to hand and in mind and abide by them in order to maintain professional and legal levels of conduct.*

SECTION 4. ALL STUDENTS: Data access and storage

Please state what measures have been put in place to ensure confidentiality of personal data and the sharing of data or results from the study. Circle the appropriate response(s), providing explanations where necessary.

Electronic transfer of data of any kind.	*Personal data removed / Password protected files / Other (explain)* *Data will be kept on my password protected personal computer devices and password protected e-mail.*
Sharing of data with other individuals/organisations.	*Personal data removed / Only with permission of site-owner or participants / Other (explain)*
Use of personal contact details.	*Personal data removed / Only with permission of site-owner or participants / Other (explain)*
Publication of direct quotations.	*Anonymous / Only with permission of participants / Other (explain)*
Use of audio/visual recording devices.	*Only with permission of participants / Destroyed after ... months / Other (explain)* *Ideally only with permission but should destruction or other occur I will discuss with the participant what they would like to do and respect that.*
Storage of personal data on: - Manual files - Home/personal computer - University computer - Private company computers - Laptop computers	 *Personal data removed/Password protected/Deleted after ……. months/Other* *Personal data removed/Password protected/Deleted after 12 months/Other* *Personal data removed/Password protected/Deleted after …….. months/Other* *Personal data removed/Password protected/Deleted after …….. months/Other* *Personal data removed/Password protected/Deleted after 12 months/Other*

SECTION 5. ALL STUDENTS: Plagiarism and data integrity

a) Data Integrity: Do you agree to ensure that all data presented in your dissertation will be genuine data?	Yes
b) Plagiarism: Do you agree that all analysis and write up will be your own work?	Yes
c) Is the research expected to benefit research participants, landowners and/or local communities (directly or indirectly)?	Yes
d) Will you disseminate the findings to the study participants or land	Yes

owners?	

PLEASE SIGN STUDENT DECLARATION

ETHICS DECLARATION

I have read and understand the University's UEL Code of Good Practice in Research: https://www.uel.ac.uk/-/media/main/images/research/documents/pgrcodeofpractice.ashx

I understand that I am responsible for monitoring the research at all times. If there are any serious adverse effects, I understand that I am responsible for stopping the research and alerting my supervisor within 24 hours.
I understand my responsibilities to work within a set of safety, ethical and other guidelines as agreed in advance with my supervisor and understand that I must comply with the University's regulations and any other applicable code of ethics at all times.

Signature of student investigator:

Date: 09/11/2018
PRINT NAME: KATIE VICTORIA RAND

Where appropriate, please attach information sheet and consent form.

For Module Leader Use Only

PERMISSION TO PROCEED WITH THE STUDY:	**YES**
If no, give reasons and actions required:	**GSE Ethics Committee approval sought re section 2i)** 'recruitment of participants from outside the UK'
Ethics Committee recommendations (if applicable):	**Ethics Committee approval received by email 28th November 2018**
FINAL PERMISSION TO PROCEED WITH THE STUDY?	**YES**
Signature of tutor + date	**Tim Coleridge 3rd Dec 2018**

Appendix 3: Participant Consent Sheet

Title of Research: What are the barriers to using straw bale construction in cities for mid-rise and high-rise structures in Toronto, ON: looking at attitudes, knowledge, policies and practices.

Researcher: Katie Victoria Rand

	Please initial box
1. I confirm that I have read and have understood the participant information sheet for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.	☐
2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason, and without my rights being affected. I am also free to withdraw my data up to the point of submission.	☐
3. As a participant I have the option to be acknowledged in publications arising from this research and understand that the data generated may be used in future research	☐
4. I agree to take part in the study	☐
5. I consent to being contacted for further research studies	☐

Participant Name	Date	Signature
Researcher	Date	Signature

Contact details of researcher:

Katie V Rand
+1 437 344 2498
katie.rand91@gmail.com

Appendix 4: Participant Information Sheet

Dissertation Title
Participant Information Sheet

You are invited to participate in a research study. Before you decide whether to participate, it is important for you to understand why the research is being done and what it will involve.

Please take time to read the following information carefully and feel free to ask me if you would like more information or if there is anything that you do not understand. I would like to stress that you do not have to accept this invitation and should only agree to take part if you want to.

Thank you for reading this.

1. What is the purpose of the study?

To discover what the barriers are to using straw bale construction on mid-rise and potentially high-rise buildings in the cities, specifically looking at Toronto, ON. These barriers include attitudes towards straw bale, knowledge or lack of knowledge of straw bale, policies about straw bale, current practices etc.

2. Why have I been chosen to take part?

I am seeking to recruit a wide range of participants who work in and with the construction industry (Architects, engineers, policy makers etc.) or those who may have personal experience with building projects that may help to provide context to this social science discussion.

3. Do I have to take part?

Participation is voluntary and you are free to withdraw at any time without explanation and without incurring a disadvantage.

4. What will happen if I take part?

We will arrange a mutually convenient time to chat, whether that be via phone call, Skype or face-to-face (i.e at your place of work). You will be able to have access to the questions I will ask as well as chance to go through the whole of the participant information sheet and consent form before we officially chat. You are more than welcome to ask me as many questions as you need or want before, during and after our meeting.

5. Are there any risks in taking part?

I do not envisage any risks in taking part in the research

6. What if I am unhappy or if there is a problem?

If you are unhappy, or if there is a problem, please feel free to let me know by contacting myself or my supervisor.

7. What information will you be recording in relation to me?

I will be collecting your name, area of the field, contact details and your responses to my questions. You can find more about your rights at https://ico.org.uk/your-data-matters/

8. What will each bit of information be used for?

The main objective of this data collection is to investigate why a sustainable, accessible, building material that offers good thermal comfort solutions isn't being utilised in city construction. During this study I will be collecting various data in order to help me with my dissertation. I will be taking down your name and contact details for my own organizational purposes and your contact details will only be used to contact you. For data submitted and used in my study I will remove names and refer to people as "person a, person b" etc. I would like to record your interview responses in both written form and (with your permission) in audio format. This audio format will be used personally by myself and my supervisor in order to listen back to our discussion at a later date to gather details for the dissertation study. I am happy to delete any audio recordings if or when asked to. The transcript from your interview will be used to formulate a social science study into what barriers face straw bale use in city construction and to highlight where further research may be done.

9. What is your lawful basis for collecting this information?

My lawful basis for collecting your information is consent. I use legitimate interest as my lawful basis for storing and using your personal information for scientific research purposes. I use legal obligation as my lawful basis for sharing any information that may suggest criminal activity to law enforcement agencies. [For more information and for the extra lawful bases you need if processing special category data please see: https://ico.org.uk/for-organisations/guide-to-the-general-data-protection-regulation-gdpr/lawful-basis-for-processing/]

10. Who will my information be shared with?

Your information will be anonymised and collated with others in the final publication. Identifiable information will still be included in raw data which will be shared with academic staff at the Centre for Alternative Technology and University of East London/Liverpool John Moores University as part of my assessment and may be shared with collaborative researchers in future.

11. How long will my information be kept for?

Your information will be anonymised by the deletion of personally identifiable information upon completion of my research module.

12. What will happen if I want to stop taking part?

You can withdraw your participation at any time, without explanation. You can withdraw your consent for your data to be used until the point of submission. You may request to exercise your rights to access, rectification, erasure, restriction of processing, data portability and to object at any point. These requests will be responded to within one calendar month. Please be aware that the research cannot be amended after submission.

13. Who can I contact if I have further questions?

Katie V Rand: researcher

E-mail: katie.rand91@gmail.com

Tel: +1 (437) 344 2498

Tim Coleridge: Supervising tutor

E-mail: tim.coleridge@cat.org.uk

Appendix 5: Risk Assessment(s)

A Risk Assessment Matrix and suggested control measures is available on Moodle

Section A1: Assessment Information

Assessment reference number	*Student number u1629758*	Assessor	*Name of student Katie Victoria Rand*
Assessment date	19th Nov 2018	Review date	Before activity begins
Activity / item / area	*Brief title/description*	Monitoring frequency	Before each activity
Persons at risk	*Student and/or public?*	Authorised by	*Tim Coleridge*

Is your research wholly desk or computer based? This includes research comprised collating information from the internet, libraries or data bases.

NO

If 'YES' then you are not required to complete the rest of this form.

If 'NO' you must complete parts A2, A3 and seek authorisation from your RDP/dissertation tutor.

Section A2: Hazard Table

If a hazard does not apply please put an 'x' in the **N/A** column.

Hazards that are applicable to your research must be classified according to their degree of risk i.e. Low (**L**) Medium (**M**) or High (**H**) – please put an 'x' in the appropriate column.

See 'Risk Matrix & Suggested Control Measures' document for further information.

Hazard	**Risk**				**Hazard**	**Risk**			
	N/A	**L**	**M**	**H**		**N/A**	**L**	**M**	**H**
Asbestos*	x				Moving vehicles		x		
Asphyxiation	x				Noise	x			
Burns / scalds	x				Overturning	x			
Chemicals / fumes / dust /	x				Oxygen depletion	x			

substances*									
Collapse	x				Oxygen enrichment	x			
Drowning	x				Personal Health		x		
Electric shock	x				Protruding objects / parts	x			
Explosion / bursting	x				Respiratory	x			
Falling objects		x			Stress*		x		
Falls		x			Trapping	x			
Fire / flammable atmosphere*	x				Tripping / slipping		x		
Flying particles / objects		x			Vibration	x			
Heating / ventilation		x			Violence / aggression	x			
Lone working		x			Personal Information Breach or complaint (incl. risk to participant and student/CAT)		x		
Machinery / moving parts*	x								
Manual handling*	x								

* May require further in-depth assessment, e.g. Fire, COSHH, Manual Handling. Ask your tutor for more information.

Section A3: Control Measures

What measures are required to reduce the risk? See 'Risk matrix & suggested control measures' document for further information.

When going to an interview, either going with a friend or letting someone know where I am going and at what time.
When using public transport to get to and from an interview, always pay attention to the vehicles, roads, tracks, safety signs and any personnel who may be present.
When out in public on the way to and from an interview, be aware of my surroundings for any potential falling objects, stairs, steps, and other hazards.
Dressing appropriately for any heated or ventilated areas for reasons of maintaining

personal health.
Behave in a civilized, polite and helpful manor in order to avoid any complaints and supply participants with the participant form and consent sheet to make them aware of the rights of the use of their personal information
Lone working: Student has been made aware of the risks of lone working. The student will ensure they carry a mobile phone during focus group visits away from their home and to inform a family member or colleague of their whereabouts beforehand.
Site safety: The student is likely to conduct interviews in typical office settings where the hazards are anticipated to be low-risk. In the event the interview/s are conducted in situations where other hazards might be envisaged e.g. on a construction site, the student will comply with the relevant site specific health and safety requirements.

Section A4 : Contact details for lone workers

All lone workers must advise their supervision tutor of their itinerary and the following:

Mobile phone: +1 437 344 2498

Next of kin contact details:

Name: Aaron Gordon

Mob: +1 437 344 2700

E-mail (home): aarongordon1@googlemail.com

E-mail (work): aaron.gordon@ubisoft.com

Supervisor: Please confirm if the research can go head proving the student agrees to adhere to the stated control measures

YES or NO?

If 'No' YOU (the student) MUST NOT PROCEED WITH THE RESEARCH

APPENDIX 6: Research Design Proposal

Analysing the viability of straw based building techniques for mid/high-rise structures in Toronto, Canada:

Investigating current attitudes, knowledge and practices of straw bale construction, the barriers to wider adoption and what can be done to overcome them.

1. Introduction

Toronto is ever growing and expanding. In 2013 alone it was the number 1 city in North America for high-rises and skyscrapers by having 130 projects in place (George-Cosh D, 2014). Most of the high-rise structures being built were for residential purposes. With a population increase 1.2% higher than the national growth rate (National Post, 2017) more and more multi-occupancy mid/high rise buildings and skyscrapers are being constructed. With the go-to materials being concrete and steel coupled with being a country with extreme temperatures, C02 levels have been steadily increasing from building construction as well as heating and cooling measures (figure 1) (Purcell B 2016) and was accountable for approximately one quarter of the Province's greenhouse gas (GHG) emissions (Ontario 2016).

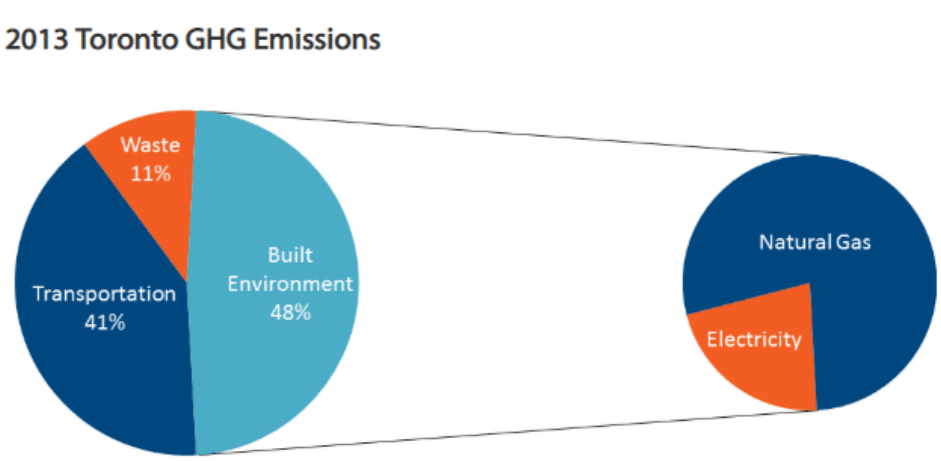

Figure 1 Showing the percentage of where the Green House Gas emissions are coming from.

2. Research Question

For this paper, the research question will be: "Analysing the viability of straw based building techniques for mid/high-rise structures in Toronto, Canada: Investigating current attitudes, knowledge and practices of straw bale construction, the barriers to wider adoption and what can be done to overcome them"

2.1. The aim

The aim of this research question is to better understand on a professional level how feasible it would be to use straw based building techniques (such as straw bale and straw

insulation) in mid-rise and high-rise property in the city of Toronto, Canada. Are other known techniques that have seen success elsewhere viable for Toronto and can these be carried out sustainably? This research will be conducted with specific reference to the current knowledge and practices of relevant professionals (including architects and builders in the area), as well as their attitudes towards straw bale construction and the additional expertise required to advance the practice.

2.2. Why this question is important

In 2013 Canada contributed 13.53 metric tons of C02 per capita (figure 2) (World Bank (a), 2014) with 35.15 million people (World Bank (b), 2014), compared with the UK which in the same year produced 7.13 metric tons of C02 per capita (World Bank (a), 2014) despite the population being nearly double that of Canada at 64.12 million (World Bank (b), 2014). With Toronto's population last year circulating at approximately 2.81 million (World Population review, 2017) and ever growing, it is important to develop sensible housing solutions for both personal thermal comfort of living and financial implications.

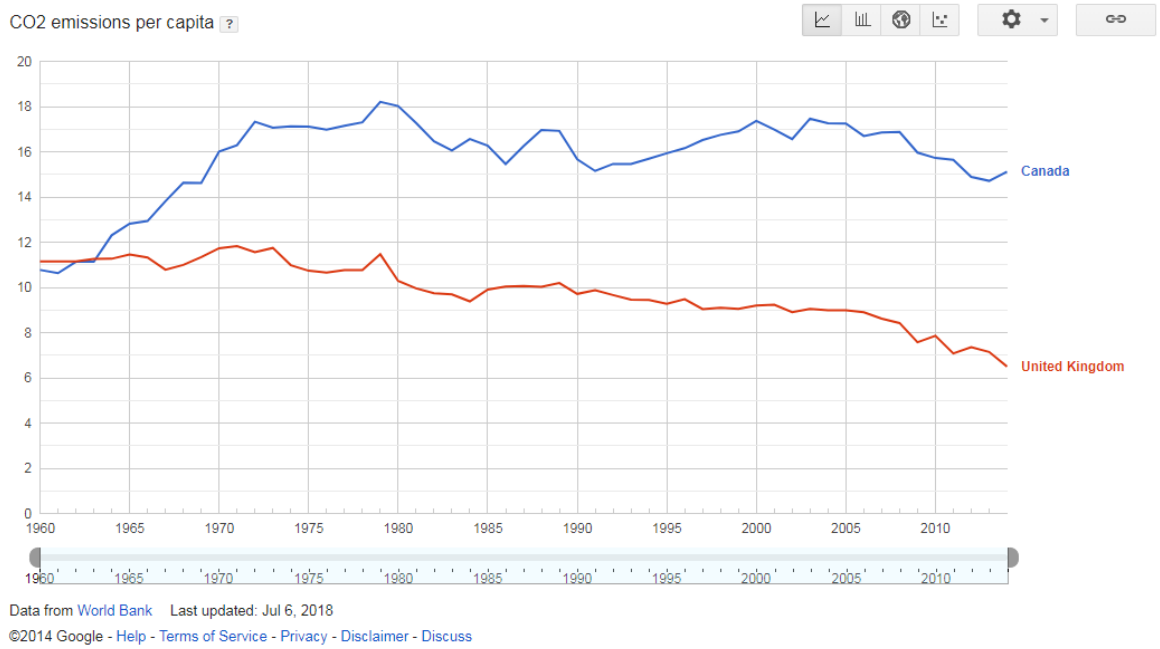

Figure 2 A line graph showing how many metric tonnes of C02 have been produced by both Canada and the United Kingdom and the difference between them.

2.3. Readings and Literature Review

An in depth analysis of leading sustainable building techniques for use in high/mid-rise environments will play a key role in this paper. One such resource can be found in Chris Magwood's work which has made him one of the current leading figures in straw and green building techniques (Endeavour, 2017). Not only is his work in Ontario especially relevant to this paper but so are his books published worldwide such as 'Making Better Buildings' and 'Essential Prefab Straw Bale Construction". Other readings involve articles and blogs on straw bale buildings. Hartmut Hering's article on the 'Wood Solutions' blog takes a look at France with a specific interest in timber buildings, one in particular with straw bale bricks (Hering H, 2014).

Further reading into the current government policy and guidelines surrounding the use of straw bale / insulation in the Province of Ontario will be of great significance to this paper, in order to better understand any limitation / guidelines unique to the province. In addition to this, research into established groups such as the 'Ontario Straw Bale Building Coalition' (OSBBC) and the Ontario Natural Building Coalition (ONBC) will prove useful regarding currently known examples of straw applications in the surrounding area.

3. Data and Data Collection

3.1. The Research Methods

This research paper will be using both mix method Primary data and Secondary data research.

3.2. Primary Data

The primary data research method that will be used shall be conducted through a mixed method qualitative and quantitative (McLeod S A, 2017) social research questionnaire. It is important to have both qualitative and quantitative date because while raw data will be useful to get a scope of the situation, a theory must also be extracted from this data in order to produce a forward thinking direction. This questionnaire is to be aimed towards both architects and builders as they are the primary users and designers of the techniques being discussed.

3.3. Secondary Data

The secondary research will be collected through a case study analysis of past and current straw projects such as the 'Inspire Bradford Business Park' building (Brown A, 2011), Pelican Eyes Hotel (Harvest Homes, 2017), a 26 apartment timber and straw project 'Jules Ferry' (Pagnoux A 2014) and the first straw bale council houses in the UK (Harris C, 2011). In addition to this, existing government data on straw policy restrictions will be analysed, including documents from places such as Canada Mortgage and Housing Corporation (CMHC, 2002) which will add important context to this study.

Both primary and secondary research are equally important for our purposes as the data collected will influence this study's reasoning and/or bring to light issues / misgivings that surround the topic of straw based building techniques.

It is vital to get a thoroughly grounded qualitative theory of the current view and use of straw in order to effectively assess the barriers (and where identified, practical solutions) that exist currently for straw based construction techniques.

3.4. The Problems and Planning Ahead

One potential difficulty lies in gathering quantitative data as part of the primary research questionnaire. There is a risk that the volume of responses may not be large enough to draw strong conclusions from. To mitigate against this the questionnaire will be circulated to a large number of participants and individuals will be followed up on periodically throughout the study period.

If the questions provided to architects and builders are not specific enough they run the risk of producing answers which may stray from the topic or not divulge enough information to form critical data for evaluation. To counter this, the questionnaire will be structured as to not overly rely on open ended questions and contain a good mix of key words and careful overall choice of wording to ensure the answers remain within the scope of this study and within the context of straw bale construction.

A potential problem that could arise from the secondary research methods includes insufficient specific literature findings which would otherwise enrich the study and help form more comprehensive arguments. A sufficient amount of time will be set aside in order to help avoid this problem as well as keeping the research to reliable sources such as academic papers, journals, periodicals, well accepted / recognised online blogs and company and society websites.

4. Analysis of Data

4.1. Grounded Theory

The qualitative data that will be gathered via the mix method questionnaire will be analysed using the Grounded Theory process (Scott H, 2009), as well as being compared and contrasted to secondary data collected through already existing documentation. This is in order to explore the range of connections that current attitudes and knowledge of practice have in relation to what is accepted at large; with hope of bringing to light more of the social barriers regarding straw bales that are in place.

While the Grounded Theory process is a well-recognised practice, it is much more time consuming than other methods. By having to develop independent concepts and coding from the data at hand much time can be misplaced into discovering what it is that the research holds. One way to alleviate such an outcome would be to conduct the questionnaire with plenty of time remaining for the required analysis work needed. By keeping in contact with those who are participating in the project it will improve the chances of producing quality and useful results.

4.2. Statistical Analysis

The quantitative data that will also have been gathered via the mixed method questionnaire will be interpreted via statistical analysis (Dillard J, 2015) and be presented as charts and graphs for helpful visual aids. This is an effective way to achieve to-the-point data rapidly and clearly. Hopefully this will also produce rational and objective results that can then be used in correlation with the qualitative data and offer a greater insight into what are the more common understandings and miscommunications about the topic.

There many other specific methods for statistical analysis of data in which to address and present results. While most are well regarded methods (such as Standard Deviation, Median, Regression etcetera), if taken separately they can offer skewed versions of the truth. For example if just taking the Mean value of results to determine an general trend there is a risk of excluding important variants in order to provide a distinct result (Dillard J, 2015). In order to avoid drawing such conclusions, it would be prudent to conduct a greater variety of statistical analysis methods and analyse them individually to be able to yield more

comprehensive results. The planning of strict time management will be of great help and allow for sufficient time to be devoted to producing these data analysis sets.

Conclusion and Summary

This research design proposal study aims to outline what the barriers are to using straw bale and straw insulation procedures on mid/high-rise buildings. This in order to then objectively see and move practices forward with applying more advanced techniques on these straw styles of building in the future. With Toronto's population ever growing and with the extreme temperature variants throughout the year, it is important to produce buildings which cater to people's thermal comfort and monetary stability within that whilst considering the environmental impacts at play. By producing a questionnaire for architects and builders to respond to, with a mixture of qualitative and quantitative questions the study looks to produce an insight into what is a factual barrier to straw progress and what is merely opinion/lack of resources and knowledge. Data collection via questionnaire may cause some difficulty if the response numbers aren't high enough and/or the questions have not been produced well enough to encourage good responses. As the timeline for this will be relatively short for a scientific study, strict time management will be implemented and a steady stream of communication with the participants will aid in moving the project along.

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Figure1) Percell B (2016) New GHG report shows bold action is needed to meet Toronto's Targets. Available at: http://taf.ca/new-ghg-report-shows-bold-action-is-needed-to-meet-torontos-targets/ Accessed on: 14 December 2017

Figure 2) World Bank (a), (2014) C02 emissiona per capita. Available at: https://www.google.ca/publicdata/explore?ds=d5bncppjof8f9_&hl=en#!ctype=l&strail=false&bcs=d&nselm=h&met_y=en_atm_co2e_pc&scale_y=lin&ind_y=false&rdim=region&idim=country:CAN:GBR&ifdim=region&hl=en_US&dl=en_US&ind=false Accessed on: 16 December 2017

REMAINING COLOUR CODED TRANSCRIBED INTERVIEWS

These pages are only present in the TurnItIn submission and digital copy versions of this dissertation as per suggestion and request of the supervising tutor for the benefit of the markers.

Negative responses / cons
Positive responses / pros
Mention of other building materials
Environmental connotations
Reference to others (people and companies) in the field.
Personal musings / ideas / opinions
Mention of The three little pigs
Reference to consumerism / being a product
Journeys
Sharing (information, projects helping)
Re occuring regularities from other interviews (bale/wall thickness, fire or mould concerns)
Perceived public opinion: good
Perceived public opinion: bad

PERSON B

1.job title
Principal architect at Sustainable.

2. Could you summarize your role and its relation to the building / planning industry / built environment?
My role here is of course leader of the team at sustainable and as design architects we work with clients to establish the initial of frameworks goals and overall design concept of the larger projects that we work on. The smaller projects that we work on we take right from design through to production and construction we oversee all of that. But on the larger project we generally just be the design architect and then a larger firm will do the production of the construction documents and oversee the construction etc. We figured out where our best value is it's at the front end establishing what's this project is going to be.

3. In 2002 I was called upon to design a straw bale house for a friend which you've probably seen on our website, if you haven't I wouldn't check it out. The Hunter House on our website. So, that was one designing with straw and helping with the construction as well the great thing about when somebody you know is building with straw you a building with straw They call all their friends to the party which is great and then when it comes to plastering with straw everybody runs away everybody wants to help stacking the straw bales because that takes the weekend and is kind of fun and there's a lot of satisfaction at the start of the morning of Saturday morning that was a pile of straw bale and by the end of Sunday afternoon its a house and then the hard work. Then the plastering starts. So additionally I've also been called upon many times to be an external reader for Masters Thesis at the University of Waterloo and one of them in particular was the proponent was proposing that straw bales particularly were a perfectly viable building material and method for building additions in dense urban downtown Toronto. More on that later. SO that's my sort of familiarity with straw. I have always been interested in straw as something which is a great carbon sink, it grows fast, it harvests fast it provides insulative qualities all these things, you know, the tubular structure of it is so adaptable for construction it can hold itself up as well as providing insulative qualities, a great carbon sink much quicker than wood.

4. a Going back to 2002 when I was designing a straw bale house that answer would be no. Today information is much more available partly because there's a much more robust and

functioning internet than there was in 2002 but there are also more books on the subject there's more and more scientific literature.

b.Challenging

back then it was difficult to find we relied a lot on the constructors of the straw bales, on the directors of the project. There was a group called 'Camel's Back Construction' Chris Magwood was one of the leaders for that and probably seen lots of literature from Chris Magwood...yeah, so he was involved with 'Camel's Back' as well as Peter and Teresa I think.. I could be wrong on Theresa… but something like that. It was a long time ago. so they were invaluable with their knowledge that they were like a single source so we had to absolutely trust them that they were right.

Now you know I would still get the information from people like Chris Magwood, Its nice to get it first hand from someone who has actually done the work but then of course I could verify that with industry literature today . So if I was going to a client saying yeah trust me because I've talked to Chris I could actually back it up with peer reviewed articles

c.More difficult?

building code approvals were difficult because it was, again we have to recall it was way back in 2002 it was very unknown even in rural Ontario.. but really unknown everywhere. I think if I'd taken the idea to City Hall in downtown Toronto they really would have looked at me funny, however the building inspector in this rural municipality he was very willing to learn, so he didn't say no to anything he just asked a lot of questions, and that was fine which was fine because then we would go and find the answers to the questions and he would be satisfied.

5 mostly the internet... online publications, articles, things like that as well as various books published...largely with Chris Magwood's fingerprints all over them.

6. almost never. I think that straw gets talked about in the public domain if I bring it up or very infrequently I like minded person like myself who is an architect who thinks a lot about carbon.

Own research

a nope, no. Certainly not building something and testing it. not with straw.

b not to with straw. with mineral wool yes but with straw no.

C I think maybe we could talk about that Masters student I was the external reader for. Because she was definitely doing research into straw, so let's back up and try that one again. because there might actually be some information in there that is useful. So her thesis proposed that straw bale was a viable construction material and method for additions to 100 year old housing stock in downtown Toronto where are very tight where there is no distance from the building to the property line Etc. it's turned out that she went through quite a few gymnastics of logic to get to a positive answer and I think that was partly driven by the habit of architecture schools I had never before seen a thesis that came out negative that was accepted and I think that's partly the teaching in architecture school whereas in the Realms of Science and Mathematics if you propose a thesis and yeah research proves it in the negative you've still added to the body of knowledge/ And therefore, your thesis is successful because you've added to the body of knowledge so in this person's thesis when she got to the end of her presentation and as the external reader I get to speak first and I said "I'm sorry but to me your proposal that straw bale is a perfectly viable Building Material based on what he's have presented I think is completely false" and of course her face fell

and she was terrified that she was now going to fail her thesis and have to redo it etc. and I also knew that I would get the chance to speak again being the external reader I get two chances to speak so I save the second bit for later. And we went on and discussed some other things and the other professors and other critics chimed in picked up the thread that I had been going on and when it came back to me I said "however like Science and Mathematics I think that you have added to the body of knowledge therefore I think your thesis was very successful" and now her face just got all confused and the other professors are looking at me like "what?" and so then when we broke myself and the other professors broke to discuss it privately it was the longest discussion of a thesis that I had ever been part of we talked for about an hour and a half wrangling over this idea that proving something in the negative can be a successful thesis. eventually they all came round when we went back to the candidate the only thing that we asked her to do was to change her conclusion from the positive to the negative. so she also got the easiest follow up completion work that I had ever seen and she was perfectly happy… like all her research was great but it was just didn't prove the thesis in the positive. now it would be very nice to see somebody else figure out a way to prove the thesis in positive but what she was showing was using full Straw Bales in their conventional way and the trouble is these properties were on average 16 feet wide and when you have to leave a walkway down one side of the house, little bit of Fire separation on the other side and youre taking these 16 to 18 inch thick walls… theres not a lot left in the middle and it's a simple fact that In a dense Urban environment the most valuable thing as usable floor space, it's converting very expensive land value into usable floor space. And what is sitting under the straw bales is not usable floor space. SO there's our challenge: how do we take all the benefit of straw and if we want to use them in an urban context, how do we make them thin? I don't have the answer to that question but that is basically the problem. Obviously on a rural property then it doesn't matter. but in an urban context we start to have a different problem. so I think that's where I participated in some research and of course that we found that the findings were negative to the use of straw simply for that economic Factor that what governs here is usable floor space.

I should maybe find out who that thesis student was there but you have access to her thesis, would that help you? Was about Straw Bale in the annex her name is Terri Boake this is going back about 2 or 3 years now.

8 personal

I think the concern always comes up is fire first and foremost and second what comes up from codes and Standards is durability of straw. I think that there just needs to be more testing of straw both in a fire situation and in for durability so that there are recognized standards that straw achieves that satisfy building officials. I haven't seen them if they exist, I haven't seen them.

9Why not common used city

a. thickness. that is the primary reason. And then general biases against things which are natural because they're not resistant to fire.. these are the myths...not resistant to fire, not durable they'll just rot, myths that straw is a food source to vermin and all sorts of things like that what other things have I heard.. jokes about the Three Little Pigs just about anything to demograte straw. that's a natural human instinct and other people just kind of latch onto that They latch onto the myths and that latch onto the whole "oh well even The Three Little Pigs learned that they should build with brick. and where do you go from that? it's a difficult one to get out of. So, human prejudices are another issue. and of course the concrete and steel industry has done an amazing job since about 1900 denigrating wood and all things natural there were a number of urban fires in Chicago, in Toronto, in New York, which set up the modern building codes and fire codes that we have. and of course the concrete and steel industry looking for a foothold in this world because prior to that you go down to say the King and Spadina area in Toronto, and the buildings are all mass timber with brick Exteriors. So

the brick is very often... the brick is very often structural but then the interior, all the floors and all of the columns and beams are all wood. And the concrete and steel industry wanted to get in and they saw The Great Fire of Toronto as a prime opportunity. so they spread so word that you shouldn't build with wood that's the problem and of course we all know today that was not the problem. however, it's very hard to overcome those deep seeded, common knowledge, common wisdom.

B

again wall thickness would be the first thing in anything that is going high it's going high for a reason that land is very expensive and therefore they are conversing Limited but high...very expensive land value they are converting that into as much usable either rentable or saleable square footage as possible. and a thick exterior wall is neither rentable nor usable. so when we get straw to be the thickness of aerogel insulation we're on! if we can do that piece of Magic.

c public perception

10.

I love it, I love the idea of straw, I'm a big proponent of straw. as an example I have spent a lot of time at my friend Glenn Hunter's house we also as an office we went there for a corporate retreat one winter a few years back and everybody noticed when they were in the space how soft it felt, soft was the word that kept coming up. the lights was soft, the acoustics where soft the air felt soft, everything just felt so comfortable that was nothing harsh it wasn't like this room that we are currently in, where the Acoustics in this room are anything but soft. I think the Acoustics in this room or fairy sharp and in this straw bale house even though it has a concrete floor the Acoustics were like it was being in a room covered in velvet everything was just so Pleasant to the ear, to the eye, just to all the senses. We've just got to get it thin!

11.

public perception, thickness of walls, concerns about fire and durability. Those are the 4 that keep coming up over and over. all of the myths surrounding those things.

PERSON C

1. Professor of human ecology. Which is a little misleading since I work primarily in renewable energy and economics. But when I first came here I was hired at the human ecologist because I had a background in ecological economics and they thought that was a match and I've been so ever since. SO my role is I'm a professor at a private not-for-profit college in the United States. It has 4 year bachelor's degrees and I run a program called 'Sustainable Energy Management' which is all about renewable energy and its implementation. My expertise for that is that I have a background in engineering and also in environmental policy, particularly ecological economics. so I combine economics, engineering, policy...quite a bit of my PHD was on climate change, public policy for climate change. So that's what I do, I do anything to do with how to solve climate change using energy and economics and engineering. And I do a number of different Public Service roles in that regard in addition to teaching and a little bit of research.

2. I work with students that are going to go on in some cases to either be Journeyman solar installers and wind turbine technicians more often they are going to be working in renewable energy sales and management occasionally they are going to go on to graduate school and public policy focusing on climate change policy of different kinds.

3. I first went about it when I went to CAT for the first time and I think it was the early 1990s when I became interested in it then. when I got done with my PhD and I took this job at Unity College I... Unity College didn't pay particularly well and this was in the early 2000s and I fairly quickly got a fiance and was getting ready to be married and she was finishing up her own PhD at the time so between the two of us we really didn't have very much money...we had student loans to pay and so the amount of money that we had available or any kind of residence was minimal and so we decided to build one, so we built a combination of straw bale and recycled materials home about $20,000 and we lived in it for about three years by which time she got hired full time at the same collage and I got promoted and by the end of that three years our income was almost three times what that had previously been and that was no longer any need to live in the straw bale which itself was Tiny and didn't work particularly well to begin with. So we quickly after about 3 years we went out and bought a typical run down main farm House and rebuilt that instead. And so when we moved on fairly quickly from the straw bale. And quite a lot of the reason for moving on from the straw bail was just essentially the lack of expertise in execution that I had in building I had at that point and so it wasn't particularly well built and it was built frankly with a whole bunch of junk recycled building materials and reclaimed building materials. So quite a lot of the mistakes were my own and you know they always say that the first house that any builder builds is sort of disposable you don't expect good results the first time. So since then we've built a lot of other buildings. Yeah, we moved on there were lots of difficulties a better executed straw bale would have been a better building even on that site for quite a lot of difficulties related to the sites that we chose. We were sort of talked into building it on a piece of rented land from the folks that owns a land. Turns out that they were acolytes of 'The Good Life Center' you know about the good life right the Nearing's book from the 1960s not the British TV program of the 1970s but the American book of the 1950s that was the TV program was founded on, right? If you read 'The Good Life' book you'll discover the Nearling's were in the habit of leasing land for people to build on close to their own home and that gave them, in essence, access to funds but also cheap labor. By the time we had done this for about three years we quickly realized that this wasn't a particularly good site in the first place we should never have built the building on that site and now we couldn't really sell it so we are stuck with the building, we still own it and we couldn't move on from that so it was kind of a... turned out to be a bit of a financial disaster all told. Since then we've had a series of...essentially homeless friends live in the place and they've managed relatively well because there are virtually no costs to living there and so it served its purpose but it's not served the purpose

that it was intended for that's for sure. And I do to some extent blame the romantic aspirations that we had but also the Nearling's theory which is sort of self-interested on the part of both the Nearling's and there's now quite a lot of critical studies of even the Nearling's. So we moved on you could actually do a straw bale a lot better than. There are a few difficulties I think with the concept that are sort of hard to overcome. I think people tend to approach it from a romantic point of view you know they think, 'oh cheap living, build a house, well-insulated not very much money…' It turns out straw bale is not the cheapest form of insulation that you can get in this particular ecosystem. That turns out to be recycled foam board insulation which is easily available. There's an Amish man just down the road that specializes in it. All of our local Amish build with this material. Its very much cheaper, very much more effective, makes a better building envelope, isn't a particularly toxic foam board and it's reclaimed and so every other building that I built since then that has needed to be insulated has used recycled foam board insulation and that's being much better, much better results. If you look on my blog on my web page you see that's an awful lot of romantic 'back to the lander's' that want to build themselves the straw bale house and I try to talk them out of it and you can't, you can't talk them out of it because they're not being rational they're being romantic.

4. One of the difficulties with straw bale and a moist environment is that you have to either have a very good dry site with very dry ground or you have to build a pretty big foundation and make sure that its towed up high enough off of the ground and Foundation is expensive and difficult to put together. It wasn't so much the difficulty in finding information on straw bale it was the difficulty in finding information on adapting straw bale to a really damp climate and we were building it on the northeast slope of a little mountain in Maine, in a spot that was essentially a wetland, well very close by there was a wetland and that gets about 60 inches of rain a year and about four to five feet of snow. The biggest problem was figuring out how to adapt a foundation that was cheap enough if you were going to stay true to the promise of straw bale you weren't going to put a lot of concrete into a foundation. So we got around that by using the bale wrap technique and by having a proper building envelope around the straw bale and by using essentially a Cedar Post Foundation for the greater part of the building which is simply just not going to last very long.There are alternatives, you know you could use sand bags, rubble walls there are different ways you could get a straw bale high enough up off of the ground in Maine that you could protect it but you can't really have Adobe covered with snow. So if you are going to get five feet of snow even the best lime plaster it's not going to keep the moisture out of the Adobe and so you've got to get it so far off the ground that you can either escape that snow or you've got to put some kind of building envelope around the straw bale so we settled for the latter. And nobody really talked about that, and so it was very difficult to figure it out. Luckily I think that we figured it out ahead of time, it would have been easier to make mistake and allow the snow to come up against the bale and against the adobe if we had built with traditional Adobe walls that would have been a problem. But you know the book, the straw bale Bible I forget what the title of it is but it's the same one that everybody gets. We went to CAT we saw the straw bale theatre at CAT we were impressed by that. We figured if they could do it in a quarry in Wales with all that rain we can probably do it in Maine. it was hard to find straw bale it wasn't cheap. That was the first inkling we got that this was romanticised and not actually rational. when we discovered that we could only get straw bale at $7 a bale... we looked into straw bale early on at $2.50 and then $3, but when it came to getting the last 100 or so bales we found ourselves having to spend very high dollar and it turns out that straw bale is not actually that available in the state of Maine. The only local grain crop that produces straw is barley which is good straw for straw bale building but we don't grow as much barley as we perhaps could in Maine and there's no other products that you can use. So we have to find a local farmer that was willing to sell straw bale and then when he ran out we have to have it trucked in very expensively and that was I think some of the information that we lacked at the beginning and if we had known that we were going to pay $7 a bale we probably would have

done something different. It just didn't make any sense anymore and it's supposed to be this is supposed to be cost-effective building technique and it's not in Maine.

How easy or challenging was it to find what you needed?
Well I certainly learned a lot but I would never build another Straw Bale in this ecosystem.

Anything easier or harder to uncover?
What people didn't tell us, it took a while to figure out, that you could not get standardized home insurance for any kind of home build level on a straw bale. So we finished up for the first several years we wanted to insure the building, we finished up getting, what was it called, something lines... extra lines or external lines insurance I forget the actual formal title. But there's a kind of insurance that you can get that some underwriters provide for non-standard buildings and we finished up having to get that. After a while we found another Insurance Company once we had moved out and the building was mostly empty a lot of the time, even though once in awhile we have some of our friends that needed a place to stay would stay there, we found another insurance company that was willing to call it a Camp. In Canada you have Cottages, here in Maine we have camps and these are essentially just weekend buildings that people have in nice areas up in the woods you can go camping and fishing and hunting and so on. so it's now officially a camp and we insure it as a camp and that's a lot cheaper. I think if we'd known about the extra insurance costs to begin with we would have had more of a problem. We didn't have any trouble with building codes this is because there were none, in the town of Monroe, Maine, there are none in the town of Jackson, Maine essentially which is where we live right now. The only thing they require is a septic permit so you have to get a septic systems design by an appropriate septic system designer and we did that with the straw bale and so we were able to get a small septic put in. Its got a composting toilet but it uses just a little drain field for the kitchen sink and for the bathroom. Not for the toilet at all just for the shower in the bathroom.

5. Well I'm in the business right? So I have to teach students about buildings and about to run renewable energy in a building. And more and more we have renewable energy and Sustainable Building industry has got more and more mainstream and so materials have gone more and more mainstream. 20 years ago the industry was looking at a lot more natural materials and you know contractors weren't selling nearly as many green homes and solar Power Systems in the early 2000s and when they were selling them they were selling them to high end specialized purchasers. Now it's very mainstream and so the materials have gone more mainstream. Back in the early 2000s there was a big buzz about natural lime and lime coloring and different kinds of plaster, about straw bale, about Adobe and we tapped into that material and we used to get regular updates not so much through the academic press but through friends, through what passed for social media in the early 2000s and we'd go to CAT and we can go to other places where we have people experimenting with natural materials so that's how we stayed connected to this industry. Now what happened is we're very busy training students to go into the renewable energy industry and the kinds of jobs that they are getting are more and more mainstream and they sort of dropped the alternative rubric, you know I mean CAT is still the Centre for Alternative energy well renewable energy is now mainstream and it's just not alternative energy. I have some of the most straight, mainstream students so you can imagine coming through my program shooting high, straight A students who are very different from the radicals that I was working with in the early part of my career even up to Unity College. And so I think what has happened is that some of the materials science that was being done with things like rammed earth and straw bale and lime plaster back in the 2000's and even going back to the early 1970s cuz I've been in and out of this business since the 1980s... but some of that early material science has gotten a little more fringe-ish because the mainstream applications have got more popular and there's money to be made, does that make any sense? You

know I mean if you can make decent money as a contractor in Maine executing for instance timber frame with steps in solar PV which is sort of the state-of-the-art here right now you're going to do that not Straw Bale and you're still doing Green Building and yet your income is now much higher than it was when you were trying to be a radical. But then you know that's been an interesting transformation to watch when I first started working / teaching in this area the students that I would get would be essentially quite radical. funnily enough some of those students have become more and more mainstream as they've gone further into the solar industry or the building industry and they've learned to market their wares to a more conventional audience too.
You know, back then it wasn't Facebook and Twitter... things like blogger and other kinds of social media that you could hook up and you could learn about straw bale through self-publishing essentially. If you look at my Google Blogs you'll discover they go back to the 2006/2007 period. And you know we were getting that kind of material then and we were also getting CAT's annual newsletters and you know other kinds of information. I would make a point of picking up a lot of paper whenever I would go and visit CAT you know I would come back with reams and reams of brochures and books and things like that so that's primary the kind of information that we would get.

6. Rarely. I notice there's more of a buzz about it in Britain and so you have industry leaders like Womersley's Limited that you know, they're not necessarily selling straw bale but they're selling lime plaster and lime plaster colour and showing people how to use it doing workshops and so on. Much more mainstream, but I think what Womersley's are doing is working with a lot of older buildings that it's not so much straw bale that they're working with but its Cobb and Stone and Lime Plaster. I know of no straw bales under construction right now in the whole state of Maine. I might be out of it but I know of none and I haven't heard anything about, erm, no one interested in straw bales and this state's is come to talk to me in 2 or 3 years. I think it's beginning to drop out of sight.
(Talking about timbers panels stuffed with straw instead of bale being more talked about)
That's really more of an adaption of Tudor wattle and daub kind of stuff and I think of that as not necessarily more sustainable but at least you have a structure that is engineered. The problem with straw bale is that there is that there is no way to engineer it particularly if you don't have a frame at all, if you'll just going to build bale walls and so you can't certify a building that you can't engineer.

7. So i have an experiment that we're running at the bale house. Just to see what would happen I left one wall unprotected by any kind of building envelope and I only patched a few areas of it with Adobe and it's been that way since 2003. and so this straw bale has been open to the elements except that it's got an overhanging roof I'm just essentially trying to figure out how long it is going to take before it falls apart and it's turns out that what is happening what has been happening more than anything is that insects have been making nests in that and we've had repeated, had bees nests, wasp nests and so on but it hasn't rotted there has been mold form on the outside but because it's not permanently wet it gets chance to dry out. It's actually retained some integrity, not structural integrity but it's still visibly straw it's not compost which is sort of what you would expect. so that's been ongoing for about 15 years and I haven't had a chance to look at it for about a year cuz there's somebody living in the house and I prefer to leave them to their own devices since it's their home. but you know every time somebody moves out I go around and fix the place up again you know there's usually repairs to do and I take a look at this one wall and I scratch my head and say "We'll look at this it still there!" I keep expecting that so I'm going to have to fill it full of fiberglass or something and I don't expect that's going to protect many insulation anymore because there's nothing to stop cold air getting into that space but the straw is still there that's the sort of the take home. So that's information of a sort and it helps you to begin to understands how Nebraska style Straw Bale you know, the kind of straw bale where you just have straw and nothing else. There are some Nebraska style houses that are a hundred

and twenty years old that if you can keep the weather out then and you can keep it dry then the straw does maintain its integrity at least as straw, not sure how strong it is structurally but at least it remains straw. So that's sort of an interesting finding and you could put that in as a positive finding for your (7c) that's really the only experiments that I have been involved in you know other than building the building itself but you know you have to it is an experimental it's not necessarily very formal experiment but you know it is experimental, it's not necessarily a very formal experiment but it is experimental.
So if you go to my blog and Google "Straw Bale" this would be the.. Well there's 2, but the important one is what you''s see is a link there to a post that's got a large number of comments and what we see is me essentially giving advice to people typically in Maine wanting to build straw bale houses and yeah there's more than one post in that regard and so what I've been doing over the years is passing out advice to folks that for the most part want to come to Maine and build a straw bale house now in a lot of cases this advice was "don't do it" or at least "don't expect to be happy with it if you do do it" because of the difficulties that we discovered particularly it isn't cheap that are cheaper ways to build a home built house here in Maine. it might be cheap someplace where there's a lot more straw bale if you can get straw bales for $1 a bail that would be much more cost-effective.

C. I think that there are better building materials I'm not fond of toxic chemicals I think we probably put way too many chemicals in the environment that we don't understand particularly well... but mold is probably as dangerous to human health as quite a lot the chemicals that people object to in the instance foam board. Now you know, that chemical blue board is very bad for the climate but there are other kinds of foam board insulation that are not... fiberglass insulation is bad for you when you're putting it in if you're not wearing a nuisance dust mask but other than that is completely inert and doesn't have terrible chemicals involved in it. My favorite is cellulose. Just ordinary recycled newspaper which is enormously cheap very cost-effective very much easier to apply and can get ordinary house insurance and building insurance for it because there are codes and *under rights as laboratory* has gone through and told contractors how to do it safely. So I wouldn't build another building but straw, I wouldn't advise anyone to build another building with straw I certainly wouldn't want to build it as a city building where I had to deal with building codes, where I had to deal with restrictive planning permission that kind of thing... I would probably go to a recycled or reclaimed insulation like cellulose or like reclaimed foam board...there's an enormous amount of reclaimed foam board on the market and so you can argue against brand new blueboard on the grounds that it's bad for the climate you can't argue against the use of reclaimed blue board or reclaimed Polyisocyanate board on that basis you can argue against it on the basis of chemical outgassing but I think if it's reclaims it's already lost quite a lot of the gas it's going to lose and then you're going to put it inside a building envelope... I don't quite understand how people think that formaldehyde gets into the building in large quantities through a building envelope. So I think there's just a lot of silliness going on with regards to insulation and straw is at least as likely to be bad for People's Health as a result of mold and insects and rodents as particularly reclaimed board insulation or cellulose so it doesn't make sense to me that you would want to use the stuff or that anybody would want to use that particular in a city. I think people are looking for answers the climate change, and looking for ways to recycle products, this is not a good answer, it's not a good idea. I think they're are better ways to do this. So I think that covers your 8, 9 and 10 doesn't it, and 11. You will find lots of advocates for this idea still right and they are out there.

We have a local Amish community and they are very inventive and they build every building they own they build themselves right down to the wire and what they've done put together a building system that suits them based on essentially a modern version of Amish industries so they're not technologically deficient, they're just not allowed to use electricity… they are allowed to use compressed as they are allowed to use Hydraulics for this particular Amish community is, the different ordinance between vary from Amish to Amish. And these guys

have put together a building system based on metal panels that they get in the raw steel on roles and they make corrugated metal panels. They use reclaimed foam board insulation which they bring in in tractor trailer loads from big cities where shopping malls and industrial buildings are getting repurposed and the stuff gets taken out of those building and they get it for like $3 a sheet and they sell it on for $5 a sheet which is 1/3 of the cost that you would pay at least if not more that you would pay at 'Home Depot'. You know they build industrial-scale building using this technique and they reclaim other buildings using this technique. Since they have arrived here, which is only been about 10 years, they've built thousands of square feet of farm houses and Industrial scale buildings that they use for their different operations. And they've used this technique which you know you could argue is not naturally good for the environment because they are using a lot of metal and a lot of brand new wood products for the frames of the buildings... but you know it's likely that these buildings are going to last for years... probably dozens, tens.. in a place where it's rare to see buildings over 100 years old that aren't already severely compromised I think these guys have got some interesting ideas here and you've got to price in how long the building lasts and use that as a factor in understanding how cost-effective it is and how sustainable is, it makes sense to me that they are using these materials which are intrinsically more sound, certainly than straw bale, but they are also a more sound than some of the materials that other builders are using around here even conventional builders. And I think that we're going to be seeing these Amish buildings long after I'm dead the buildings at these guys are pushing up I still going to be around… they are not going to be pretty, but they are going to be functional. And so I think, you know, when it comes to trying to figure out what an appropriate building technique is for an ecosystem if you subtract the romance and take a look at what a community that doesn't have that is doing… you know, the scales begin to fall from your eyes and you begin to realize "wow. I mean just look at how well built this stuff is and how long it's going to last."

It's amazing and they're into solar power and they're into wind power… you know obviously they use horses all of the time. Long since we built the straw bale house the Amish community started to arrive around 2008/2009 you know long after the Bale House was built and we had even moved out of it and we got to know them I got to be friends with them my wife comes from a German-American Peace Church community not the Amish but one of the other ones and so it was natural for us to go and make friends with them... I was a Quaker, I'm not a practicing Quaker anymore and so we you know we made connections with these folks and it's just been wonderful and I get them to come talk at my classes quite a lot.

PERSON D

1)

Sustainable builder. I was a contractor at one time but just for a very short time. I contracted my own jobs hired my crew that kind of stuff.

2)

So my role basically was to create a relationship with the client regarding their home (so it was a home builder) and establish the most holistic environmentally friendly way of constructing that home through the use of sustainable materials. And then of course once agreed on all the details, the application of building the structure was my role.

3)

Design as is witness. My only experience with design is that i went to school and i learned how to read plans. So that i could take your basic generic, engineered, stamped, architectural plans and know how to read them. With straw bale, i went to school, i learned the principles, the science and a lot of details pertaining to building with straw. So that became my focus, straw and plastering on top of that straw.

4:
a)

I would say the information that i needed pertaining to building with straw, because of my educational background and the people involved in the straw bale community i found it relatively easy to find the information. I had those resources because of my education and because of my building experiences. What was challenging was finding out weather i was legally, through building code, if i was allowed to do certain building proceedings / certain buildings. What was challenging was marrying or merging that building method with conventional building methods that you'll always find in a conventionally built home (on grid). I think the only area that i found most challenging was convincing the client who was witness to a lot of the procedures and the step by step procedures that we had to take, all of a sudden something became new for them and they started seeing methods that they had never seen before or that they couldn't look up so they became very cautions. It wasn't that they didn't trust what we were doing, just that they were a little more reserved whether it would work. The challenge was trying to explain to them and trying to convince them that A it would work and B when other contractors would come in to do other jobs how important it was to make sure other jobs were done for example making sure the space between the roof and the walls were completely waterproof. In one house in particular i put in a 60ft wall of straw bale and they hadn't properly vapour barriered or air barriered and they were calling for rain and they wanted to put the bales in and i told him i wasn't going to put those bales in until that was done which wasn't my job it was the site chief's job to make sure that was done and it hadn't been done. That was the most challenging i think was trying to merge with the conventional side of things and making sure that they were at a standard or in a place where we could continue on with our work without - as i mentioned with straw bale before you have to retain less that 18% moisture in the straw bale before it goes in the wall. I pretty much had to check over 900 bales in one job.Very labour intensive, it's a lot of work. But what a beautiful house. Unbelievable. I wasn't willing to sacrifice that many straw bales and that much time because a contractor wasn't doing something. You know there's always a schedule for building. Where you get one job done and just as that's finishing the subcontractors come in and start their work and that's how the building goes up, job by job by job. Well i could not carry on in that situation. There's been other situations like this, and

that's been the most challenging part, is merging these too. Some general contractors don't have experience with sustainable building so they can be difficult to work with. They can be difficult to work with anyway but when they walk in and see something like this happening it's even more beyond them, they think it's tomfoolery, they think it's ridiculous so they take it even less seriously so when certain things need to be done to make sure my job is done properly without any setbacks with time or money, it can be very difficult to convince them look this has to be done. *Otherwise i'm jeopardising a big part of my build, a build that they don't quite understand because sustainable building is still so mainstream.* Once you get building, these really no challenges because most of the work that you do is done in the preparation and making sure that all those little fine details are put into place so you don't have any setbacks. Because it's so labor intensive you have to spend even more time and focus on making sure that you don't run into any errors or problems. Whereas conventional building you run into a problem and go to home depot to replace that material and it's easy and cheap. With sustainable building it's not easy to replace 100 bales. Especially if you're plastering over winter, that can backset the construction time by months.

What finer details would always give you a problem?

I found that as a sustainable builder you want to acquire your materials as close to the jobsite as possible. That was, you're reducing your embodied energy. Especially materials that you want to obtain / that were made as sustainably as possible, you just want to reduce your footprint. So i found that very difficult, because sometime the only natural material that i would be able to get would be quite a distance away and would be a lot of money to have it shipped. So that was a challenge.

5)

I would say books, Magwood who has played a big role in the straw building world. General research, books and a lot of googling. A lot of emails with people who have been educated and are now running their own business. So alumnis of sustainable education programs. You can get a lot of information from them because it's such a small world they love sharing, they want to give you as much information because we all want it to grow bigger. So it's not compartmentalised, it's not secret, everyone shares their secrets. Again profs and people who taught me all had a history in building, they all had experience, hands on. So their knowledge base came from the principles of application of what they actually did, which was great.

6)

To be honest no often. I think there's an awareness to it, but only because of youtube and what you can find on the internet now. It's one of those rarities that people stumble upon it and share it or you bring it up and they say "oh i think i saw something like that once" but they don't have any knowledge of it. So i don't find that there's a lot of hype, i'd say generally speaking i don't hear a lot about it.

7)

I'm gonna say no. for the time i was in construction i did a lot of good builds but it was so scattered, it wasn't just straw buildings. I did an insulation that was all sheeps wool and plastered on that, I mean that was a whole new experience . It was difficult but once you understood it and you took what you knew and the principles and all your knowledge and applied it they it was like "i know how to do this".

Did you experiment with plastering over straw bales?

With me the only research i did A) where the straw was coming from. b) my relationship with the straw e.g moisture content, size application. And that's basically it. Once those established then we could just move forward with the build. We had our insulation, that was it, we had our straw we trusted it to do what it needed to do and we moved onto all the other applications to protect that straw.

Did you ever try any different types of plaster on the straw?

Absolutely. I would always take a bale from wherever i was resourcing it from, I would take it home or go and get samples and i would do test plasters on that bale. And that was for my own benefit to see how the materials stood up to the straw, to see how it adhered. It also helped me figure out what my ratios needed to be. You might get sand from one quarry but it might have a little bit more salts than another you know? Or they don't wash their sand and it's full of salt which you don't want. And there's different grades of sand, you' know there's all these different details. The clay, i got clay from one company who mixed it with crushed brick. At first i was really upset about it and then realised how amazing it worked in the wall. Whenever you do a clay wall like natural plaster, of course you're using lime, your ratios are different you do a push coat, then a scratch coat, then a finish coat. Maybe they just want a push coat and a finish coat on the inside and 3 finish coats on the outside, it all depends on the client. But when you're figuring out the ratios you need to cover your tensile strength, what are you using for your bonding, what are you using for moisture retention. The materials, each one that you're using, how are you introducing them to each other to make sure they can do they job you need them to do, and in what ratio and that's figuring it out on the balse. It's really fun it's great! If you're adding dyes or you don't know how it's going to setup and what colour, it's great to do this and take it back to the client and say hey look this is what it's going to look like on your walls. Like a paint chip but it's natural, with plaster and straw. It's fantastic plus they get a chance to see what colour the straw is. They get a chance to see the process before we it start. And it doesn't cost anything, i didn't pay for any of it it was just my time. And one client actually kept the bale because they live on a farm and they put it up on the shelf like "this is how it all began we chose that one and we chose this paint stick and this design this colour". You know i'd add a little bit more clay with one or add less clay or have less sand or whatever. Yeah just figuring out, more lime, less lime. You know all those things.

Also depends on local climate?

Absolutely. There was one corner of a house that even though it had an overhang at the back that came to the corner then there was probably a radio length, with a radio gap where there was no overhang right on the corner and then the other overhang started down the side of the house at about a 3 foot overhang which was huge. But that radio gap was where they got all their weather during a certain time of the year, so instead of plasters, i used cement. I reinforced the wall with a cement plaster and i had to colour it and ration that so it looked relatively the same. But we used more of a concrete as opposed to straight up clay and sand and lime. Going back to the crushed brick, most of the time we knew, when you plaster a house you're going to get cracks because plaster shrinks. There's a whole process to keep it wet, hose down the walls 3 times a day because lime is always moving, and if you do your plaster correctly there's all these molecules, for lime water, lime. The water molecules will evaporate but until it evaporates if you put too much water into the mix it takes up too much room... it pushes all those other elements away, so when it dries and evaporates... so when it dries, that sand and tensile is further away form that other sand and tensile and now you have a crack. So you have to be really particular about your mixes because if you overmix or undermix you're going to have a lot of problems and then you have to go back and do it again but crack it and fix it. More money, more labour, more time

so if you can really do that test on that straw bale in the climate that it's going to be. Always remind your client that what they're dealing with is an unsure process. This is an unsure building, that there is no guarantee. But that's the beauty of it, it's holistic that way. There's no guarantee that when you go on the plan to go wooffing or go do whatever you do in life that it's going to work out 100%. Conventional building you know you're going to get a sheet of drywall that's 8ft by 4ft, much more predictable. With sustainable building if you do your research if you do your work if you have your knowledge base chances are it's going to work out. But there's still an unsureness and that's where you can't give your guarantee. It's definitely a science. The art comes when you're done and finished building the structure using the scientific methods that are required to make sure the building will do its job, as a natural building. The walls are breathing, that they're the right thickness, that all those elements are in place and you can allow nature to do what it needs to do. Then you do the rest. One client wanted shelves, that looked like they naturally grew out of the wall so i had to think of a way to do that but that was after pretty much everything was done. So going back to the brick it allowed for no cracking. The brick acted like chopped straw would for tensile. Using chopped straw is like rebaring concrete. With plaster, it's going to want to pull apart but it can't because of the straw. The brick does almost the exact same thing. It acted like stronger aggregate (i had sand in there as well). Lime has a relationship with sand where it will always move and try and move that sand around into the most natural place. With the crushed brick, it does the same thing. So it basically bond it even tighter. The only cracking i had in this one building where i used that with was over the doors and windows and that's natural because that's where most of the movement is. Everywhere else there's no cracking, i couldn't believe it for the amount of square footage. This house was solid, it's going to be standing 500 years from now, guarantee. And it's also using up surplus materials, all those bricks that would have been thrown up they put in here, it's great.

Collaboration with anyone else in the business?

Not really. You send out emails to other companies who have been doing it just to get answers to questions. Like when i did that concrete corner i got a hold of a company where that's what she uses all the time, that's her mix. So i called her to say look i need to do this corner can you give me come ratios and she gave me some strong ratios, no problem. There's always positives with straw, only negatives would be the climate, you have to make sure to keep everything dry. Which isn't necessarily a negative you just have to keep on top of it so that you don't have an upset client 10 years down the line when they have mold growing in their wall.

8)

I think it was restrictive in that... It's restrictive in that if you're trying to merge 2 types of building methods together, it's very difficult to know whether or not what you're doing will coincide with that conventional standard. There's nothing worse than having to tear something down and go back and rebuild. So i think that's the only frustrating part.

Is that more to do with the people in those more conventional roles?

It was that, but it's also more about legislation. The field is growing and interest is growing so the standards need (i think) as far as building codes go maintain an equilibrium with the interest of doing these builds. Because people are turning towards it but finding it difficult because the unknowns are not being written down so they're being passed off as unsafe and getting told it shouldn't be done. Which i think is really unfortunate because i think we've proven with architecture that has been around a long time, i think a lot of these methods are very well proven to last, to hold up, it does maintain its standard. Why we're not implementing them now?... Other people may have better answers as to why these

standards are so restrictive. That's my personal opinion. I think it's restrictive because of the unknown and it's not being written down. They're not leading the way, you know we have a lead and we have these companies that are really trying to leave a mark but i don't know it's just… when it comes to building maybe a low rise building a 3 story walkup (i live in one) there's 6 apartments in this 3 story walkup it was built a long time ago, it could easily be built with straw bale. No problem. You know we're not talking about a 60 story building.. yet . But even that, there was a building where we're doing prefab straw bale walls. It was really expensive we were ordering from them i think 6 tiers and they were pre built they were 8ft by 8ft. They showed up they were huge almost a ton each. But the embodied energy that these things had. It was the only company that was doing it. They were new to it, they were trying to revolutionising it, pioneer something that could be. The company shut down because they didn't get enough business because their method was unknown. People didn't know enough about it. If we open the market to these possibilities, i think people are smart enough to get out there and figure out how to do it. So instead of these construction cranes hauling up these steel beams, we can have them hauling up these straw walls. Even if we still used steel as a structure and as a frame, and used straw as a insulation, absolutely no problem. Because the field is so slow moving we're not really allowing ourselves to dive into the deep end of trial and error. We're not letting our engineers get our hands dirty to figure out all the problems. It's indicative of our society, the oldest car is 100 years old and it was an electric car and then we went to petroleum and use it forever now we're coming full circle with electric cars for environmental reasons for our health and the environmental reasons. Imagine how advanced we could be with electric cars is we had just stuck with that? I'm standardising it but everything is predicated and based on the bottom line. Money. And i think that's a big part of it. This is a personal area, and we're talking about holistic building methods and if we gave the right people the right opportunity Pat and Tim Krahn I think if we and contractors we could go a lot further figuring out how to advance our building and our method with materials such as straw bale. It's just undiscovered and really difficult.

9)

I personally think it's not used because it's of mediocrity. People go to Tim Hortons, not because the coffee is good but because they know exactly what they're going to get. They don't want that to change. People in the building world, their are methods proven and good conventional methods, (conventional building is great in a lot of ways). When they think of straw and straw bale in general? They think of the big bad wolf (3 little pigs story) because it gets blown down. Specifically for mid and high rise buildings, it's a lot for people to think about as a home. As a mid/high rise building? I don't think people could wrap their heads around ti. I don't think it's commonly used because i don't think people believe that is COULD be commonly used, that it's an actual possibility, to be used as a building material. I think it simply comes down to that

Why do you think companies don't use it? Or try to use it for higher buildings? What is stopping them using straw or straw bale?

I think that comes down to A) Accessibility B) volume. Could the demand for straw bale be met with productivity of the straw bale? Would we be able to for lack of a better term manufacture enough material to meet that demand. That's why i think the low rise building? No problem. 2-3-4 floors. High rise buildings? That would be tough. I think that would be really tough. That;'s a lot of straw bale. If it was prefabed, you'd have to spend years pre-fabbing it… I'm not an engenerer, but you build the structure then you'd have all those pre-fab's already built sitting in a warehouse and they you'd bring them in and put them in place like lego. Done. But that would involve a LOT of straw and straw bale. And there's only so many places that grow straw. And it's small things like how much area can 100 straw bales

cover? I don't think a lot of that research has really been done in terms of an architectural standpoint. When you're looking at a medium to low rise buildings and you've got apartments that are [x] amount of square feet you can kind of idea once you have all your dimensions how many sheets of drywall you're going to need based on your window schedule and you'r door schedule based on your footprint and all those other details. It kind of calculates itself. With straw bale, i don't think there are many formulas that say, a 3 story building, we're definitely going to need [x] amount of straw. There's no standards for that, that's where i think there's been a lot of red tape. A lot of people that have this knowledge are setback. And these details when it comes down to convincing those that have the power to sign off on it i think it's those details where someone will walk in and say "look it's going to take this much straw, we have these farmers they can get it done in this season, boom boom boom, done" it's no different than ordering 1000 sheets of drywall. You have to make it feel like it's accessible, and that's when we can really explain, using straw bale we're cutting down on energy it's so much more sustainable. And it's costing us no more or even less. Straw bales are not a lot of money, it depends how much the materials are used.

This is where like people like tim Krahn are really trying to push through this kind of building, they're being blocked by these details and no one is trying to give these details and chance and it's only through trying it having some trial and error and given a chance figuring out what does and doesn't work and we come to that resolution, oh my god we could create a 3 story walk up apartment building 16 apartment all straw bale. And people would be like my god that's all straw bale? And it could be the first one in Toronto. That's how i look at it because being the construction world you have to look at all these details while building. People think if it's not broken don't fix it, they're just looking at the dotted line and making sure nothing comes back on them. But if it can be proved that it's just the same just a different process..that's where i think things come to a screeching halt, and certain people aren't given a chance to push the envelope and do the research needed to find answers to these questions.

Final Thoughts?

Straw bale as insulation has its pros and cons. The pros, outweigh the cons i the long run. In the short term, straw bale is difficult. I think from a holistic and a moral and spiritual point of view, i think it should be the way to go. It's the difference between knowing you just ate a really healthy meal and you feel great about yourself and your body feels good, as opposed to eating that bad meal and feeling sluggish and bleh. Walking into a straw bale house knowing it was built that way. There's just something about it. You feel very clean and pure. And from the technical side it's very safe. The fire standards in a straw bale house. It's so compressed it's like throwing a phone book on a fire, you'll smother it before the phonebook catches light. It takes a long time before it will become unsafe. Where as compared to straw, foam insulation it goes up in flames instantly which doesn't make me feel safe at night. For me it's all those little details. I imagine it would be great to build a home that one day just fall back into the earth into its natural state. It'll decompose and there'll be nothing left standing that wasn't there in the beginning. And while it stands it does everything a conventional home does and better. What do people want, to walk into their house be warm, be comfortable, be safe. That's what it comes down to. They're not walking into this house going "oh i love this drywall, i love that we chose this foam insulation" people don't think about the details, they want it to be warm and cozy and want something to build memories in. They don't care about the details, let us think about those. That's what i think about when i think about straw bales. We just need it to be common knowledge. For Toronto, i think it's the legislation and code that's a limiting factor. There's always an $ value attached. It all comes down to money and not enough people who believe in it who are in the right positions to maybe push that forward to cut that tape.

PERSON E
61)

The three of us who are full time here in Endeaver, we call ourselves Director / Educator.

In summary we run a school where the curriculum is that we build a building with our class from start to finish so by definition we're all designers / builders / teachers. We spend our off season working with clients and designing a project for delivery to the following season's full time class.

What is your familiarity with building with straw?

I ended up building the first code approved straw bale house in Ontario, 22 years ago, and have essentially been building with straw as the main weall material i've used ever since. So probably number of projects is getting close to 50 now and for most of those i've been on the design team as well as the construction side of things.

So you're physically getting involved and building yourself?

Yeah my role now is much more directing but i'm also onsite and working with the class as we do projects, and pretty much i don't think we've done a class that hasn't involved straw bale. It's not always the only wall material we're using but it's always part of the build if not the entire focus.

4)

Certainly my very first build my answer is definitely no. There was not a lot of information available at the time and what information that was available was coming from the US midwest so it wasn't always applicable to the cold climate that i was building in. My whole carrere ever since then has been an attempt to basically generate the information i wish i had, and wanted to have. I think in 2000 my partners and i wrote the first northern climate straw bale book and updated it again in 2005 and really been actively to be the ones who are trying to get the information out to people like ourselves who like the idea but don't know where to start.

How easy or hard has it been to find that info

With my very first build the internet didn't exist or it was very new and there was nothing about straw bale building on it for a while so 25 years ago it was pretty tough to find that information. But now there many books and websites and resources available that it's definitely getting much easier to find that stuff, and you know people have been researching this stuff at the universities so we're able to look through the academic journals and records to see what people are doing. That makes it much more accessible. There's also you know a well developed network of researchers and developers so whenever anyone has a question there's a lot of good forums with many experienced people you can throw questions out to and answers come back quite quickly.

Any pieces of info that were hard or impossible to find?

At this point there's good information on all of the basics that has been built up over time, so noone should have any problem in finding information about you know any of the basics. And in some cases things have really changed, for example straw bale is included in the straw bale residential code now so that was a pretty big step forward in terms of acceptance in terms of people being able to find that information without having to go find specialty sources. There's a whole trove of it that people can access for free in the international

residential code. And the number of fire tests the number of moisture / structural test keeps getting bigger and bigger so the body of literature is getting bigger now. We've gone past the point of proving that it's a feasible / reasonable thing to do and now it's getting into the fine details. For example what's the difference between doing this or that detail, so the studies are getting more focused and detailed now because the basic questions have all been answered for the past 15 years or so.

5)

There's still a few main sources. Academic journals are definitely one key source. I would say that network or straw bale building associations are probably the most useful resource. In particular the california branch has an amazing network of designers and builders who are are real treasure trove information and experience and here in ontario the natural building coalition basically has all of the straw bale builders are professional members so that's a really great group to when you need to find information. Quite often when something new gets published someone in one of those networks will see it and it'll get circulated that way. The community of people who are interested in straw bale are pretty active in sharing and hosting and getting new information out.

6)

I don't know that i hear it much day to day, but i definitely have noticed that from the time i started until now, early on if i said the word straw bale house most people would have no idea what i was talking about and now it's pretty rare if people haven't heard of it on one way or another. I don't think it's a top topic of conversation or anything but it's shown up enough in the media and online that it's rare to find somebody that has never heard of it and quite a few people have seen it in multiple articles or multiple ways., you know they heard that it's out there and i don't think there's many home design TV shows that haven't touched on a straw bale place now. All the main housing publications" fine homebuilding@ and all those places have all featured straw bale places. So I think it's not that people don't know much about it, people know it's out there. That's been a big change in the last 20 years.

7)

We have done a lot of research for most of my career it's been research in progress. Formally we have worked with a number of different universities, Queen university in kingston would be the one we have worked the most with. We've worked with them when we have a particular structural question that we need answered before we can do a building in a particular way, to have an engineer justify our method. We had Queen do 4 structural testing programs, mostly the load bear capacity of straw bale walls with different types of construction with different types of plaster, at different heights etc. We also did a study with them where we did a building where we used round straw bales as structural columns so we did the testing for that with them before we did that project. As to why it's mostly been because we need lab answers to questions that we know that building departments are going to ask us so we need to have some data to go to them and justify our designs, based on some lab testing.

What were the findings like? Positive negative or a mix?

Nothing we've ever tested has ever turned out to be not feasible so the findings are generally positive. We did a lot of long term moisture testing in the buildings over the first 10 years that i was doing this we put moisture monitors in the walls of every building we did and revisited them over the course of the decade and never saw any reading from any of those walls that were any cause for concern. So across the board in general all the findings have

been positive. What's interesting about research in a field like straw bale is that any building system that has been used fairly widely prior to the last 30 years never had to do that testing. Builders just built in ways they were pretty sure were going to be practical and feasible and they built the buildings and they either worked or didn't work and that was their testing. It's only been in the last 25 years that codes have really started to be enforced and come into play so you have to prove these things first before you're then be able to go do them. Most builders are not going to do something on a real building or in a test that they know isn't going to work because we would only do it because we really think it's going to work. But these days you need to go and show that in a lab first. Whereas you know noone tested a stud frame wall for the first 100 years, you know they were just built and they stood the test of time and everyone just agreed that they work. Straw bale has just gotten popular at a time where that is no longer the way that things work.

8)

I think again that's something that has really changed with time you know the first 10 years say that i was doing this we often ran into hurdles around getting building permits etc. But at this point in ontario i don't think there's a municipality in the provence that doesn't have an approved straw building in it. Once there's at least one everywhere it gets easier, it's always harder to be the first, it gets easier after that. Having code language written in the US and in germany and in other countries makes making the case to the building department here much easier. You can show that codes for straw bale have been written in other countries. Especially the US that makes the building department feel much more open to not thinking that this is a crazy liability that they'#re taking on, they clearly a country like the US has developed and implemented code language for straw that it must be feasible.

9)

There's a few hurdle for straw bale 1, it's not a proprietary system, you know most "new building products / materials" are something that a company has developed or a company has a patent on it and they undertake the testing and all the stuff you need to do to be included in the building codes. And they do that with money that's an investment so that people buy their product when it becomes a code approved thing. Straw bale has a disadvantage or not being a patentable material. There's no company with a great interest in promoting it, there's no company that's going to benefit financially from using straw bale. I'm sure if a large build company should patent a bale and promote it you know they would be able to do a very good job with that. But the interest in it is very grass roots. Even the 1 farmer won't benefit that much by selling 100 straw bales to a builder one time. That's a main disadvantage, there's no lobby group or financial interest in seeing it promoted. And you know it's a material that isn't currently in the building supply chain. So if someone want' to build with straw there's no way you can go to a building supplier or a masonry supply or any of the normal places you would usually go to get your building supplies, none of those places carry straw. So if you want to do this it's up to you to track down the material, get it delivered you know the whole thing is outside the regular supply chain. And then form the builders point of view nobody who is currently a professional builder has been trained on how to do theis, there's no great financial incentive for anyone who is a conventional builder to learn how to do it. You can't make more money as a straw bale builder, you don't charge a premium, people aren't knocking on your door asking for it so it's a hard sell to get builders on board. You're asking them to take on a bunch of extra work, do extra learning complicate the supply chain in exchange for no greater financial reward from if they just keep doing what they're doing.

10)

I've worked with pretty much every material a builder could work with in this environment and Straw is always my go to. When i weigh things up i think it's the best option, in particular when you look at it's value in terms of climate change. The amount of carbon that's stored in the straw that was in the atmosphere and has now been drawn into that straw, it allows us to make buildings that are net stores of carbon rather than producers of carbon which is a pretty remarkable thing when everyone is scratching their heads thinking about what to do about climate change. Our straw bale buildings when you look at the emissions form the materials we use and the carbon used, we're typically net stores from anywhere between 20 to 60 tonnes of c02 on out buildings. Typically a building of a similar size would be an emitter of about 20-60 tons of carbon, so it's remarkable that way. Plus it's using an agricultural by-products. It's local it's non-toxic it has lots of desirable properties. The work that we've been doing with straw bale for almost 10 years has all been looking at trying to prefabricate and panalise straw bale wall systems specifically to try and address those concerns that i outlines for why it's not commonly used. It's a lot to ask a builder to go and find straw to being it to their site to pack it bale by bale to learn how to do that properly and plaster it properly. So most of our work has been on how can we make a prefabricated wall pannel that comes to the site ready to install and it's the panel supplier that needs to worry about all of that stuff and not the actual builder on site and i think that there's a few companies doing that and starting to do quite well in europe. Hopefully soon there'll be north american companies doing the same because that can address most of the reasons for why straw isn't more widely used, and help to make it more time and cost competitive with other options.

11)

Even though there are a lot of great advantages with straw bale, those advantages does not reward the builder for any reason, it actually makes it harder for the builder. So i think the barrier is that it doesn't come in an easy to use use, easy to install quick and easy method. That's why we're really focused on panalisation. I don't know about mid rise but definitely low rise, panalisation helps there. There's just no way that a mid rise building can be stacked bale by bale and stacked by hand in any practical way. But using cranes and systems to install panels is a quite common practise so if the bales come in a panalised form they're able to fit more closely to what a mid rise builder would be used to installing.

PERSON F
1)

I'm an architectural technologist. Which means doing drafting and home design.

2)

Currently i'm just doing house design and commercial design.Previously we were acting as a general contractor so we were designing the house as well as building it. Now we've simply stepped back so my role is strictly doing the design. I meet with the client they have some goals that they want to meet, we develop a concept around their hopes and dreams and between 3 months to 1 year we develop a final set of plans where the blueprints will be taken for permit issuing and construction purposed. I develop the plans and consult with the client.

3)

Maybe i'll just give you a brief history of your time doing this. In 1998 we bought land in bycroft, and by that time we had learned of straw bale construction it was a pretty far out idea at the time, we started researching it and by the first week of january in 1999 we had found a contractor and an architect with some experience with straw bale. We jumped in very quickly with it, we were very inthralled with the idea. Summer of 1999 we built out first straw bale house for ourselves, it was a very big learning experience for us, i think we were the 5th or 6th straw bale house in ontario. Virtually no one has heard of it, so we were really trying to break new ground, and every step of the way was a learning curve and trying to learn how to do these things. There was very little information on how to do these things at the time. I had 1 book that was more of a coffee table book, with a lot of pictures but lite on details and instructions and that was pretty much it. There was a magazine called "The last straw" and it's still going on today, and we did get some information on other people's projects and what they had done and approaches they had taken so that's how we learned how to do what we were doing. Very early on we met up with another couple of people who were doing this kind of construction Chris magwood, Petter Mac and Tina Terrian. I don't know if you've seen their books. We met up with then and found that we had a kindred spirit so they helped with the plastering on our house and helped us becoming a general contractors and we worked with them quite often. So it was a big back and forth with learning what worked. We exchanged ideas on what worked and what didn't and we really collaboration and shared the information so it really helped out. So after the years after that we started building houses for people, we build around 20 straw bale buildings then we started doing the design work as well back in 2006 i started doing design. Slowly phased out of the building and now just doing the design. For a number of years i was also teaching straw bale construction in furming college in their sustainable building program. So in terms of my familiarity with straw, i'm extremely familiar with it in terms of building and planning and i'm a pretty big fan.

4)

Early on it was very difficult but there was a quick rise in the amount of information available as the number of books started to increase. Between the "last straw" magazine and the natural building coalition, through their website to have a good accumulation of resources and testing that has been done. So that's been extremely helpful over the last 10 years wherever there's questions. There's also a much larger community of people involved now and so there's more people doing research there's engineering firms who specialise in this kind of thing so the information's a lot easier to get now. One big challenge is that when we're building code in ontario we have to use canadian based testing, and there's very little

canadian based testing, the majority of it is done elsewhere. So while the information is relevant but being about to use it and reference it in a permit application often they won't accept it unless it's specifically canadian done. That is a challenge sometimes and i would say those relate mostly to fire or moisture. But the testing has gotten a lot better even in Canada so we are getting more and more of it, but i would say those are the most challenging areas to get information fire and moisture. As far as the insurance side of things for clients who are building and want to take out home insurance has been a challenge. I've had a number of clients that have phoned around the have found it difficult to find a firm that really understands it. As far a building codes 99% of the time they are very keen to learn something new and as long as you provide the right information and provide the right specifications from structural engeneras for example they're pretty straightforward. A few years back, we build a house in 2006 in Aurora and the building department there was very unsupportive of anything outside the traditional standard building. The building inspector was vey difficult to deal with we took about 3 months to get a building permit which is very long. There was another person who was building shortly after us and the department called them and said outwrite that you can't do that. So he took his case to a building code commision. It's where you can appeal. And the interesting thing about that case (which you can read up on) they commission when somebody has an issue, they apply and give the relative information and give the reason why their permission was denied. And the commission assembles a panel of people who can decide whether the decision was correct or if in fact the building can go ahead. What was interesting about this case is all of the issues that the building department that the building cited as the reason for denying the permit, moisture, structure, insulation, fire. The panel assembled experts on every one of those topics, and as the proceedings went along each time the building department would bring up these issues the panel would shoot them down. In the end they found there was no reason why this house couldn't be built and the built was allowed to proceed. It was amazing to see them address it in this way assembling a panel to assess rather than rely on bureaucracy.

I would say that overwhelmingly that we don't have a difficult time in this provence. It's fairly supportive . You get the odd case where somebody is difficult in the process but generally it's quite supportive.

Would you say it's predominantly it's in a more rural setting?

I would say the rural areas are easier. The more densely populated an area the more restrictive it gets and the more hoops you have to jump through.

5)

The natural building coalition resource was great. There's the last straw magazine i can send you some titles if that would be helpful. A couple of books, one in particular that's very research heavy so it's a great resource.

So did you go to school for any of this as well?

In terms of education no there was nothing that was offered for this. But in terms of academic journals… I would say the the majority of the information has come from my peers and from books and magazines, social media etc. For example if i want to find something out i might go on youtube or pinterest and see how other people have approached things. And then there's a number of websites that offer information, strawbalebuilding.com for example. They have a lot of information as well. In terms of the education, now there are some programs that deal with sustainable construction like forming collage, indevor center, algonquin college has a sustainable building program as well so there's more and more

information getting to younger people that's available. In my experience that wasn't available to me but there's more of it now and that's certainly helpful.

6)

We've read a lot of different articles in a lot of different magazines for example sustainable homes and the toronto star, fine homebuilding is a homebuilding magazine that has articles often about straw bale, very favorable articles. Then you have other things, we just saw a show from the uk (to build or not to build) where people are building their own houses where they were building straw bale homes so you see more of it for sure. There are a few homes shows like the toronto home show where people have set up booths where people have information for the general public and of yourself through youtube and pinterest you see a lot of great examples as well.

7)

Not in a formal manner in terms of an academic situation. But in terms of trying to establish your own best practises we've worked to develop better ways of doing things and analyse at the end of a project and what's a better approach for next time. We've also met with other straw builders and other straw folks. In the early 2000s we would meet quite regularly with the plastering company with solar, and other people usually 3-10 of us meeting 3-4 times a year and would talk about things we've done in the year and discuss out approaches. And it was great because we weren't competing with each other were just discussing best practises. There's even been scenarios where myself and another company were competing for a project and we'd have a discussion and it was always really nice, no competitive backstabbing it was always friendly with comradery.

Would they be positive or negative your findings?

I think we always came at it from an attitude where we were already positive about straw to begin with, so i'd say strongly positive. Some maybe negatives would be finding out that straw wouldn't be the best in say a roof or a foundation. So together we'd find where we can tailor out efforts but nothing that would say straw bale as a system is not positive.

8)

In ontario the type of code we have they refer to it as an objective base code. So the code lays out the objectives for what is going to make a good building it has to keep out the rain and the snow, has to keep the heat in not fall down not burn etc. So any particular aspect of a building that you're going to do has an objective around it, depending on the material and the system around it. The nice thing about an objective based code is that it doesn't say "you shall do these things and these things only" it says this is the intent of the code, here's what we want to achieve it, here's an prescriptive list of ways you can do these things. But if you don't want to do those things, you can choose to do those in a different way as long as you can find some expertise to prove it, some testing or someone with certifications to prove that what you want to do is going to meet the intent and objective of the code. What it does in nature is allows us to be a little more creative and do things like build thing out of straw or tires or rammed earth, whatever method you want to use, as long as there's been some testing and it's a viable way and it meets ther intent of the code you're free to do that. It does mean that we sometimes have to rely on other parties like structural engineers or research facilities to provide us with some testing but it does allow us to think outside the box. So i would say that they have been overwhelmingly been helpful. We've had cases where building inspectors have said lok i have no idea what you are doing, but i appreciate what you're doing. I have these concerns if you can help to address these concerns then we can

move forward. Overwhelmingly they've always been very helpful in letting you know what you need to provide them to move forward. I've heard in more built up areas such as Ottawa it can be a different experience and the inspector get much more difficult to deal with, but it just means you can't be sloppy you have to be on top of all the details and make sure to do your job properly.

9)

i think there's a couple of reasons why. Primarily the general public wants to see a more generic kind of material weather it's roofing or siding or interior finishes. The general public is not quite as open minded to things that are maybe a little bit standard looking. I would say in general straw bale construction has a little bit more of a free formed feel to it, sometimes more so than others. You have walls that are sometimes a bit wavey a bit inconsistent, which the people that love straw bale often find beautiful but the peopl who want uniformity it's maybe not that appealing. We've had a lot of people come to see out house and some people that come in are not happy to see walls that are not perfectly flat, not perfectly straight. So i think there's a general anesthetic at stake. We're all use to seeing perfectly smooth walls perfect broick perfect sideing etc. So something outside of that norm is sometimes a little hard for us to get used to. I would say in areas where there's more traditional building like in the UK or france or in older countries you've got a history of buildings that were made by hand and made from natural materials so it's an aesthetic that people are used to. But i thing here in north america people are used to seeing new / shiney / flat things in their homes. So i think aesthetically there are options for building with straw that can be casked and smooth and perfect;y flat so there are things that can address that. I think straw bales have a more rural connotations so there might be a mindset of "you want me to live in a house made of straw?" and of course you get the 3 little pig jokes. And from the perspective of the construction industry itself, if i'm being contracted to build a mid rise or a high rise building i want to build with a materials that is consistent that it homogenous where the supply chain is manageable. And none of those things are things that straw bale can currently offer. So i think a lot of it comes from the supply chain and management, how do you build a large building, you're not going to get 10 thousand bales dropped off from a farmer. So i think that predictability and management is part of it. Having said that there are small companies that are dabling in manufacturing pre-build straw bale panels that would address a lot of those concerns.

11)

First of all i don't personally have any experience with mid rise or high rise so i don't know the specific challenges that they have but i can imagine. So i'm answering from a perspective of imagining what their issues might be. Right form a design perspective, i think the idea of using an material that is inconsistent in width, length, height, density, nature and the type of materials very riskey on a job site until it's been plastered it's a high fire risk, so there's complications with the material. But form a design perspective if you're working with a fabricated panel and we know the panels are x high by y wide, and we design a building around this module i believe the design phase can be very straight forward in terms of designing with a modular system. And in terms of the actual construction if the building is made with a frame and a floor and you simply bring in the panels and install them in an industrial manor i think that could be quite productive in terms of straw bale. But in its raw form straw bale is awkward to deal with. On a residential build we have a lot of concerns in making the site ready for straw we have to have it water tight we have to make sure we have a spot that's elevated and dry to store it, we have to make sure there's no loose straw that could be a fire hazard , other contractors aren't cutting pipes and creating sparks near the straw, that people aren't smoking near the straw etc. So i would say there's a lot of things on a small residential scale that are important and challenging to watch for but on a large scale

they would be pretty terrifying to be. But again i think if the building material of straw was dealt with in a factory somewhere where they can construct these panels and deal with all these concerns on their end creating the plastered panel ready to use so the straw doesn't need to be handles on a construction site, i think that would be a good way for straw to move forward and address some of the barriers.
Specifically for Toronto Canada, in out climate here we have a small window of good weather. We periodically even in the summertime it's hard to go 5-6 days without rain so your constantly getting challenging weather. Our summer is fairly short in terms of good building weather. We get rain and snow and sleet pretty early in the season. So i say spefifically Toronto would be hard to deal. It's harder to deal with the weather we have here compared to say, santa fay.

10)

Personally i think extremely. I love the aesthetic of it, i love the things that may be barriers for other people in a less urban setting. I have built house with prefabricated panels that are perfectly flat and they don't excite me from an aesthetic setting. I love the waves of it i love how the light reflects off of it, i love the acoustics of it everything. I'd say most of my clients that come to me are pretty excited about the aesthetics as well.

PERSON G

1)

Engineering manager at ‘Building Alternatives Inc’. I’m also a partner, half owner of the company.

2)

We’re a relatively small consulting firm, so i’m a consulting and design engineer. We specialise in natural / alternative / pre industrial materials. So Basically straw or celulus fiber based, hemp, wheat straw, oat straw flax, also cellulose fiber from wood, re-used fibers, earthen materials, naturally cementitious materials, and artificially cementitious materials. I have a technical background so we do foundations and structures, because of the nature of the materials we work with we’ve also tended to become building science people. So we do design consultations, usually before construction but we are often brought in for say… triage. Say people discover that they need a permit and thought they could do without it or a oversear / financer has been brought into the situation and needs an assurance from a registered professional from someone who has liability insurance. So sometimes we just hold people’s hands and put out fires but on our best days we’re adding value and creating healthy sustainable designs.

3)

Our principal Kris Dick is one of early academic researchers who did some work with straw. He’s a professor at the university of manitoba and he did tests back in the 90s on styrofoam capacity of plaster and straw bale walls and I worked with chris into the 90s been officially part of building alternatives since 2005 but i’ve known him and worked with him for many years. So we’ve build dozens of straw bale projects across Canada. It might get into the 100s with the latest projects. Chris has a straw bale extension on his house, i frequently have to go and do quality control and moisture control, stuff like that. So the full range i would say. Yes very familiar.

4)

The short answer to A is no (i haven’t been able to find the information I need). It has gotten better but things have kind of staled now. In the 90s and early 2000s you really7 had to do testing yourself (which is what Chris did) but that was challenging because there is no industry proponent. There is no “Big Straw” there is no deep pockets, no income stream that easily relates to the current economy that thinks this would be a great thing to move forward. Bale by bale you can get more for bedding straw that you do for building straw, so what’s the incentive. Because you can get straw for bedding in large bales and people will just work with it where as bales for building straw needs to be human size which is getting less and less common.

So in 2006 ‘Bruce King’ published ‘ Designing Straw Bale Buildings” which at the time was a very state of the art and current summary of research research done all over the world (not all over the world but internationally). Which included fire testing which was a big barrier. From then on any reasonably risk averse company knew where to look and would generally stay away from straw bale. I don’t want to say that we’re the opposite of risk averse but we have - I once had a colleague tell me that i had a very diverse risk pallet. We deal at a scale where we know the builder, or we get to know the builder if it’;s an owner builder. If it’s an owner builder it’s not in their interest to cut corners or do things poorly and the builders that we know would do this more than once it’s also not in their interest at all either because it’s such a niche and notable material. If you consider conventional wood framing in the

Canadian context of residential construction, everyone is so familiar with it that if a building is build poorly and failed they will blame the method. They will not blame the material, because they know wood framed buildings work. But people have no such familiarity with Straw bale. If a Straw bale building fails they WILL blame the material and say 'Oh well that doesn't work, you can't do that" because they're not used to it.

Once we had the summary of basic structural analysis tools (and very basic), we don't have a pushons ratio for this stuff we don't have a clear correlation between density and crack behaviour, we don't have a whole lot of stuff about straw in bales. Nevermind straw in a light place lift. We could go into a lot of new areas of research for many years to catch up to the level of detail found in more common building materials. But we have enough basic design for a basic build for no more than 2 and a half story builds. We had insulation values, vapor permeability values for different kinds of plasters. More or less everyone in canada had gone away from load bearing straw bale by then so it was basically just infill. So not more of my job is proving to a building inspector that this material is a good insulator which at this point is a no brainer. There's a lot of information on the insulation value of straw. And if you're just putting it in a light wood frame well everyone knows that'll work so there you go.

So in terms of hard or easy to uncover Fire was a big one, it just needed someone with enough money to do a test. There have been a couple of tests done but a plastered bale is the best for this kind of test and getting a good rating (perhaps this is another discussion, on whether testing conditions match real world use). It's been very difficult to uncover thorough material properties that we have for things like timber, concrete, steel. And those things are still not there. Like i said we don't have a pushons ratio, we don't have a relationship between density and creek. We don't have really good numbers on lateral capacity which would be very useful. Yeah there's a lot of stuff that really should be tackled. The basics are there to do small scale construction.

5)

The primary sources have been my colleges and university level research. I did not gain any information or knowledge on straw bale building in my engineering education, either in the undergraduate or graduate level. But i did by attending sustainability conferences, building design conferences. I think the first time i was introduced to straw bale was at a sustainable agriculture / building conference in manitoba in the mid 90s and an architect (John Hockman) did a session on load bearing straw bale and that was an interesting introduction. Shortly after I met Kris and we started working with the stuff . But it never came up at the academic level other than very casual mentions (due to my relationship with Kris) but it wasn't in any courses. I have seen trade journals "Light construction" but no academic journals with some materials on green building. Those like Designing Straw Bale Buildings have good summaries of the current research and examples from construction. I've been part of that community and some others in California and Colorado since the 90s. Those are a wealth of information, those people. There's a journal called 'The Last Straw' with some good stuff in there. That and just talking with other colleges. There's actually a very good community here in Ontario, the (something) center and business like 'Straw Works' and Evolve Builders, Camel's Back. There's a bunch of great resources that way.

6)

Social media is probably where i would see it the most. In no small part because we have a big facebook presence and i'm a moderator on that page. So people ask about things there and there are other natural building forums on Facebook that i contribute to and read occasionally. I know there are documentaries, i don't spend a lot of time going after that sort of thing, it seems top be a bit of a time sync. I bring it up when i do presentations on

sustainable engineering, but in the context of a while swath of materials as just one of many that we design with. I do try to encourage engineering students that they can design with materials other than concrete or steel. Wood engineering is not taught in a lot of engineering schools in canada. In many it's only a 2 week section, it's really really sad, very sad. We're going to have a massive gap. If mass timber takes off, the number of engineers in canada who are actually confident to design timer is small. I mean there a certainly a number of brilliant ones, worldwide we're right up there, but there aren't many of them and those that are are in Quebec or BC. There's not a lot of people in Ontario who can do stuff. If you're not near the big mills then you're not on the cutting edge of things and they're all in BC and in Quebec. Blackwell here in Toronto good great stuff as do Moses Structural Engineers, but if the city of Toronto but our an RSP on a 20 story mass timber tower, i think they would be hard pressed to find firms that were confident to but in the structural bit in Toronto. They'd have to bring people in to fill the requirements. Maybe i'm wrong but i'm right in that industry and in a block you could find anyone to do a steel block that tall, but you'd have to cast your net pretty wide to find someone able to use other materials, including straw bale.

There is a massive gap between the producers and regulators.We have a huge agriculture sector, we are producing massive amounts of cellulose fiber in plant form, massive amount every year. And it's not like it's a huge waste, it goes back into the soil. But there's no industry. Traditionally those kinds of gaps are filled with industry, say between a producer and a regulator but that just doesn't exist. In the current economic way of doing things i don't see it happening. I think the regulator would have to reach back and say look this is a priority, we're going to incentivise this we're going to get something going.

7)

We've done research in cooperation with the university of manitoba, queen's university, rocky mountain institution in BC. As well as with companies like Evolve, Straw Works with the endeavor center in general. Mostly to get information about the particular insulation information or vapor permeability of a and plaster / straw combination, differences in orientation - a horizontal bale vs a vertical bale. Done some (something something testing) that was done early, but that was always with a much more conventional cement based, sucko plaster skin, although others have done earth and plaster as a structure we haven't gone there. It's always been generally speaking positive. Probably the biggest negative that i can think of is that that density that we use bales we find that the straw creeps. So that means that over time under a constant load it will deform plastically and if deformation and deflection is a key criteria (which it normally is) then it isn't acceptable as a structural material. So we have to make a more structural frame and use the bale as infill. Even though we know that with the creep behaviour you still get some lateral stability with that infill although we don't know how much. We've learned that we don't know enough and i don't know anyone where the wherewithal, the time the money to do the research to really get the answers that you would need to incorporate straw bale as both structure and insulation at a human scale (a bale that can be lifted by the average person and placed). There are high density bales but they're huige and you have to get machines to move them. They're the same material they're just big and operate at higher pressures. We don't have money or time to do more research, i've had discussions internationally with people in India with people in Italy, who are doing little bits of research that they can as a hobby on the side while they're in academic institutions. But it doesn't take to long before you need to do sets of test where you can't just do it on the drips of drabs of materials, you need a big chunk of money to do full scale testing, at various densities, different moisture contents. The testing matrix gets really large very quickly and that all just costs money. So sort of positive, sort of negative.

8)

Here in Canada all engineering design is moving to limits based design, which is reliability based, statistics based design. We have not reached a statistical significance with the test that we've done. I've heard of a professional engineer that i respect immensely he's a plan examiner in Ottawa and he thinks that at this point it would be impossible for any material aside from, steel, concrete or wood to meet the criteria that would desire that we are going to move to limit states. And he thinks that wood has just kind of been grandfathered in because we have used wood for so long we just know how it works, so we're looking to overlook those discrepancies in wood that you can get from tree to tree. That's his philosophical point of view, but it's not just an opinion if you take the math to a certain level he's right., There's just to much variation that you just can't get around it. The way we refine and make steel, the way we recycle steel is just so heavily controlled and for the vast vast number of structural engineers that's what they're comfortable with, they don't want to vary from that kind of comfort. They want to know that this is AFTON A307 high carbon steel, and then they know what that is and they can do a lot of things with that. We don't have that with that kind of material (straw Bale) not even close and we never will. But we could have assurance that the material is well within what a person needs to design and build something but that's not the direction that codes and engineering methodology has gone since the early 70s. It has gone to this very mathematically based, risk averse, statistically significant, number based design. And i'm not entirely sure how to bridge the gap beyond individual projects. On individual projects i can take the risk and really that's what ends up happening, the planning examiners look at it and go "well i'm not comfortable with this but if you can show me reasonably that it's going to work AND you take all the liability then we'll let you have a permit". Just to get this to a residential scale (not to even get started on some scales we could be talking about) for a residential scale for this to appear in part 9 of the ontario building code, if this happened in my lifetime i would be shocked… Happy! That would be great but… Wow. I'm still floored that my peers in the states were able to get Straw Bale into the appendix of the national residential code. That's a phenomenal amount of work to have accomplished that.

Codes are both helpful and restrictive, we're very lucky since 2005 in Canada to have the alternative solution provision. So if i can put together a reasonable proposal and accept liability you can get a permit. I've been able to get a permit for every project i've worked on with any material. It's not fast, clients have to be very patient, there's an education process for everyone involved. If you want wide adoption, you can't ask every project to go through those hoops. That's really unfair. Because the rest of the industry is not doing that, they're being ushered through the door in comparison.

9)

Well if you're looking at infill, the walls are just to thick. Real estate in toronto is worth too much to think about building 14-16-18 inch thick walls, that's crazy! That's square footage that you want to use and or sell.

For midrise / highrise buildings. To site build straw bale in an Urban environment i think is madness. You're much likely to succeed with some kind of prefab paneled system. And for many reasons, none of those have taken off here in Canada. There's been a few i"ve been involved with some i've heard about and a few i've seen some go bankrupt (for business issues rather than because of the material). We seen Mod Cell in the Uk doing reasonably well and something like that could work well, but i think it would have to be something like that i don't think you could use loose straw. On the site it's just to much of a fire hazard. During construction the loose straw lying around the site is a major problem in a tightly packed urban environment (which is less of a problem in a more rural setting where you have complete control of the site). I know i'd be suspicious if i was the fire commissioner, i

wouldn't be keen. Having said that i've worked on ones that did some renovations using straw bale and it was site built but you just have to be very very careful of the builder. And in those cases we had the right builders and the right clients. But if you're looking for the right builder and the right client every time that's telling you that it's not being widely adopted.

There's a huge education component and it's not just about straw. People don't think about materials, they think about surfaces. They might think about volumes, but very rarely do they really think about materials. They'll think about them if they become a problem. They won't think about material cycles like the carbon cycle for instance. And these things are starting to raise their heads, thing like microplastics where people realise they don't have a nice cradle to grave, por even cradle to cradle which is something that the steel guys are trumpeting and on paper they're right, steel is more recycled that anything, an incredibly reused material but that doesn't mean that it's energy and emissions free. But in terms of the material itself… But that's because it's a very high value material, it's a material that engineers can design with, with a huge range of confidence. That's just not there with these materials (Straw Bale). People think of products. The average city dweller if they think about rural dwellers at all (and i don't know that they do) they either look down on them and pity them because they're involved in extracting some kind of commodity, they don't add value, they don't make something shiny and nice, somebody takes what those rural people or miners or foresters (primary resource extractors) someone else takes those things and makes valuable thing, and those are the clever people that we like to buy things from. And even cleverer people put slogans on it to make them attractive, put a surface on ti. That's what urban people and wealthy people value and what they trade in. I think they'll always look down on rural people. That's why there are less and less farmers and their being asked to do more with less. They may have more mechanical advantages and more chemical advantages, and there's profit in their industry. There's been a renaissance in the farm to table movement, but broadly speaking people buy cornflakes they don't buy corn, and the value in that industry 99% isn't doing to the farmer it's going to everyone else. If you look at your pension fund, you're making money off of the industry in between. There's nothing in it for you to support the farmer. That's the way the economy is setup and there's no respect and confidence in the producer, it's all in the people who package and process the goods, the middle man..

10)

If we're talking desirable it's normally aesthetics. If you're the person that likes that sort of thing then it's the thing you like. Like deep window wells, they instantly become nooks for reading in the sun. That seems to be a characteristic of straw bale buildings that people love. They use the word organic all the time, and what they're referring to in my opinion is the texture of the wall. There's an undulating texture, it's not flat like drywall. There are plasterers who can achieve that but even if you get a dead flat surface if it's a plastered surface that is not covered in latex paint or whatever, it's different acoustically, it's different to the touch, different to the eye, rounded corners etc. People always notices the acoustics but they might say it "feels" different. But it's the same as if you come from a culture of heavy masonry it also "Feels" different in that space than it feels to be in a wood framed space.

I like it a lot in terms of the materiality, the cycle of the thing. I'm kind of torn because i really value the notion of an honest structure, a structure that appears to you to be what it is, but you never see the straw, it's always plastered, there could be anything behind the plaster. My favorite materia is rammed earth. Exactly what you see is what it is, you'll never have to paint it, it just… is. That doesn't mean that straw couldn't be made into a product that could work that way but it's very difficult to do that on site with simple tools, but with rammed earth you can. A rammed earth interior wall with Straw Bale as an exterior wall for insulation would be genius! But your walls would be in excess of two feet thick. Again for urban construction, no way. And you're not going more than 2 stories with that. Doesn't mean you couldn't but

not pracitaculy. To go higher than that with rammed earth you have to use a lot of stabilizers, you might as well use concrete. You could pannelise Bales to make an exterior insulation system, you could do all that. But now we're talking about Straw and not Straw Bale.

Straw as an insulating material is brilliant. The fact that it's anbulay, carbon harvested, that you can then hold for more than 100 years, to me it makes it a no brainer. Paul Hawkins was speaking, before he released his book and he was relating a story from a economist. 'If only there was a machine that took carbon out of the atmosphere and made it stable' then he looked out of the window and saw a tree. You moron! There's plants that do exactly that. Annually serial crops, it can be done. We can raise these crops in a way that does not deplete the soil we can harvest a certain amount of them every year that we can use in some project to capture the carbon in the atmosphere. It happens every year it's just that we're producing more carbon to overcome it.

So in that sense i would batch hemp in with that and any annual crop that we can harvest sustainably, and we should be doing that in some kind of forestry and agricultural combination are the things that we should be doing to draw carbon out of the atmosphere. It's not sexy! ?It goes back to that respect, none of the people what are making these decisions give a rats ass about these farmers or primary producers. They despise it. If you're living at certain elevations you should be looking for higher ground or leaving. New york city? They should be moving that thing. By the time it's too late it'll be stagertingly too late. Anyway... I don't know if people think about that as much as they should. The sea rising is going to phenomicaly affect people.

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There's a huge education element. For farmers and regulators and industry, the producers, refiners and innovators, as well as designers, engineers and architects. All of those people do not see an opportunity (broadly speaking). If they get a handle on how much opportunity there is that would be huge. Humanity can create demand for rocks, you know, for ridiculous things. A really good marketer could do a lot. There's a reason we have that expression Safe as houses, and houses should be safe, they should be an emotional place for relaxation, when you go to your home. And materials can play a big part of that, so there's a huge opportunity i think, but it is largely untapped and i don't know how high that hill is and where the tipping point is on that one. A good place to start would be to start pricing carbon and understanding the ability of serial crops to sequester carbon that would be a huge things.

I think for mid to high rise buildings it would be the lack of prefabrication. We need to have prefabricated panels or something that happens offsite that can be brought in an attached to another structural system quickly and easily. It's certainly doable there's nothing in the material that says you can't do that.

As for Toronto? Architecturally is Toronto a leader? I'm not sure. I don't know that there's any more barriers in Toronto than anywhere else. There should be more advantage. South western Ontario has a lot of farming area, there's plenty of Strawn, plenty of industrial knowhow in the GTA. There's no practical reason you couldn't harvest straw, bring it to a facility then put it up on various forms in Toronto. I don't see a barrier other than economic, educational, regulatory etc.