“Alternative Building Materials and Community Development: Are Building Regulations Limiting the Potential For More Affordable, Efficient Homes in Ontario?”

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A Major Paper submitted in partial fulfillment of the requirements for the degree of

Master of Science

University of Guelph

2015
# TABLE OF CONTENTS

## CHAPTER 1: INTRODUCTION

1.1 Problem Statement .................................................. 2  
1.2 Goal Statement ....................................................... 2  
1.3 Objectives ............................................................ 3

## CHAPTER 2: METHODS

2.1 Review of Current Literature ...................................... 4  
2.2 Interviews .............................................................. 4  
2.3 Case Studies ........................................................... 5

## CHAPTER 3: HOUSING

3.1 A Brief History of Housing ....................................... 6  
3.2 Conventional Materials ........................................... 9  
3.3 Alternative Materials .............................................. 13

## CHAPTER 4: COMMUNITY

4.1 Community Development ......................................... 16  
4.2 Role of Poverty in Community Development ................. 18  
4.3 Affordable Housing ................................................ 21  
4.4 The Relationship of Building Materials to Community Development ......................................................... 24

## CHAPTER 5: BUILDING REGULATIONS

5.1 Ontario’s Building Code ............................................ 27  
5.1.1 Approval Agencies ............................................... 28  
5.1.2 Other Options (Stamped/Informal Economy) .............. 30

## CHAPTER 6: CASE STUDIES

6.1 Bancroft Rammed Earth ............................................ 31  
6.2 Tillsonburg Rammed Earth and Guelph Straw Bale ........ 32
6.3 The Canelo Project 34

CHAPTER 7: RECOMMENDATIONS 36

7.1 For Ontario 36
7.2 Community Land Trusts (CLTs) 38
7.3 For NGOs 40
7.4 For Further Research 41

CHAPTER 8: CONCLUSION 42

APPENDIX 45

LIST OF TABLES 46

LIST OF FIGURES 48

GLOSSARY 53

REFERENCES 54
CHAPTER 1: INTRODUCTION

This document is organized into five separate sections each with various sub-sections. First, a brief history of housing is examined which provides relevant information to understand how our conceptualizations of housing in North America developed. Furthermore, there are two additional sub-sections that compare and contrast conventional building materials with alternative building materials and draw from a collection of previous empirical research. Second, the document focusses on the subject of community development, its spectrum of definitions, and the importance of community development for the well-being and social cohesion of residents. Additionally, this section will explore the subjects of poverty and affordable housing. Is it possible to address community development issues through the construction of alternatively constructed homes? Third, the Ontario building industry will be explored in regard to its stance and procedures for allowing alternative building materials in home construction. This section will describe what the Ontario Building Code is, and how it works. Moreover, the role and functionality of approval agencies will be examined, as well as other options for getting approval for alternative construction materials. Fourth, a number of case studies of both Ontario and international contexts will be examined to better understand how theoretical translation of the material explored in this document is expressed in practice. Furthermore, the case studies will provide a tangible and practical means of exploring the subjects discussed in this paper. Lastly, a series of recommendations will be suggested from improvements to the building code, to opportunities for collaborations between organizations, as well as further research.
1.1 Problem Statement

There are a number of issues being faced today as a global society. Most of these issues cross over numerous disciplines, which for most of history have been examined in silos as separate and unrelated systems (Brigg, 2007). These issues are the social, environmental, and economic issues of poverty, housing, energy, transportation, community, food security, environmental degradation and others. There is a growing understanding that issues of a social, environmental, and economic nature are, in fact, very interconnected to each of those realms and with other issues. The inspiration for this document is from the acknowledgement of this fact.

Housing is just one example of an issue that transcends any singular disciplinary realm (Edward & Turrent, 2000). Housing fulfills at least one of our basic human needs of shelter, and arguably fulfills more as it is often the vessel for other needs such as food, water, and energy. However, as this paper will explore, many individuals do not have access to appropriate housing due to socio-economic circumstances. Pertinent questions must be asked of our current housing development: Is the housing currently provided by the vast majority of western society environmentally and socially appropriate? If not, is it possible housing may contribute to issues of poverty or inadequate access to housing?

1.2 Goal Statement

The goal of this paper is to (1) highlight the benefits of alternative versus conventional materials, and (2) determine if alternative construction designs would be beneficial for community
development and what processes would be undertaken to incorporate them into normative practice.

1.3 Objectives

1. To compare and contrast the relationship between alternative and conventional building materials.

2. To compare the current building industry’s practices with normative practices suggested throughout the literature.

3. To compare case studies of buildings constructed with alternative materials and their similarities and differences between current building practices and normative practices suggested in the literature.

4. To analyze the capability of Ontario’s building code to address the differences between current and normative practices and make recommendations to improve any inadequacies.
CHAPTER 2: METHODS

2.1 Review of Current Literature

Much of the information contained in this paper was collected through a literature review which collected peer-reviewed perspectives on the history of housing in North America, conceptualizations of community development, as well as specific data regarding testing on conventional and alternative materials for housing construction. The majority of documents were searched by using key words and phrases such as “Alternative Housing”, “Affordable Housing”, “Sustainable Housing”. Specific documents for life-cycle analyses were found by searching the type of structure that was being sought (i.e. “Rammed Earth”) followed by “Life Cycle Analysis(LCA)” or “Embodied Energy (EE)”. Other articles were found by searching relevant and recent journals such as The Journal of Green Building, Building and Environment, or Structural Survey. Moreover, reports by government agencies or NGOs on relevant subjects were also examined as well as their cited sources.

2.2 Interviews

Numerous informal and individual interviews were conducted with building officials as well as individual homeowners who had constructed their own dwellings made from alternative materials. There were four Chief Building officials and six individual homeowners interviewed. Interviews were semi-structured with a list of questions prepared, but interviewees were encouraged to present their perspectives on the construction of alternative homes by simply
detailing their personal experiences. Only specific data regarding costs or timelines were recorded and no personal information that can be traced back to individuals are included in this paper. It took very little time for data received from interviews to become repetitive as individuals and building officials were all subject to the same regulations of Ontario’s building code and therefore used the same tactics, followed the same procedures, and had very similar experiences. The Interview Guide can be found in the appendix.

2.3 Case Studies

Case studies were obtained either through literature reviews or through interview style discussions with individual homeowners. The case studies were intended to highlight practical applications of the theoretical information presented throughout the paper. As described above, the experiences of building officials and homeowners in Ontario were almost identical in regard to the barriers faced and processes used. The case studies were chosen because of the close proximity to the location of the research, however, there are numerous other examples that could have been used throughout Ontario.
CHAPTER 3: HOUSING

3.1 A Brief History of Housing

While the history of housing can go back millennia, this section will largely focus in on the past 100 years. The past century has witnessed changes to our homes in North America that have been most influential in shaping how conventional homes are constructed today. During this time the real luxurious aspects of homes have become mainstream such as numerous windows, utilities and services brought right to the home such as running water and flushing toilets, let alone cable and internet (Wilcox, 1998). This section will briefly examine some major changes in the last century of housing and its sociological impacts.

At the tail end of the 1890s many hotel style apartments were being constructed. These apartments were equipped with benefits such as central hot water, gas mains for lighting and fully equipped bathrooms (Wright, 1991). However, there were many issues with size and space. These apartments became scapegoats for rises in divorce, declining birthrates, premarital sex, and growing social and economic marginalization. Moreover, there is speculation that during this time shared amenities thought to be too closely related with communist behaviour and were therefore demonized. These factors laid down a foundation for a new type of lifestyle in the Suburbs which were characterized by individual, rowed, single family homes. This type of living was perceived to be the pinnacle of community, private ownership, and of utmost importance to the proper functioning of the nuclear family (Wright, 1991).
By the 1900s standards were being applied to everything with the combined efforts of planners, engineers, sociologists and other “experts” of the time (Wright, 1991; Wilcox, 1998). This led to improved sanitation, more outdoor space, less crowding, and a uniform aesthetic such as well mown lawns. These improvements led to notions that suburban living was an example of the epitomization of community living. However, not everyone was convinced. Some believed this to be a facade, an empty shell where people lived two separate lives; one they could show the outside world, and one that could only be expressed privately. For many, this created a community of individuals living close in proximity, but socially distant and lonely. For example, some wrote about the loneliness from so much privacy and living such an artificial social life which was captured in an excerpt from an article in Outlook discussing their disdain for suburbia where “neat little toy houses on neat little patches of lawn and their neat little colonial lives, to say nothing of the neat little housewives and their neat little children — all set in neat rows, for all the world like children’s blocks” (Fredrick, 1928, p.60). This began the questioning of value brought by suburban living, and suggestions to improve it. One of the earliest critics of suburban living were, Catherine Bauer (1934), who advocated an approach to suburban development that promoted a diversity of ages and socioeconomic backgrounds. This resistance continues today and is continuing to influence ideas about normative community living arrangements.

The suburban ideal of community has exponentially increased whereby individual ownership is paramount, wealth is defined by money and material items, and standardization and permitting has been applied to almost any aspect of the built form (Wilcox, 1998). It is interesting to note
that throughout the history of suburban development a number of individuals have expressed how it makes them feel disconnected and lonely, despite geographical closeness and a wealth of material possessions.

“Many North Americans intuitively understand that the reason why economic growth no longer brings a sense of greater well-being, why the pleasures our new possessions bring swiftly melt away, is that at the level of affluence of the North American middle class ‘what really matters is not one’s material possessions but one’s psychological economy, one’s richness of human relations and freedom from the conflicts and constrictions that prevent us from enjoying what we have.’ Indeed, we have attempted to use economics to solve what are really psychological problems.” (Roseland, 2000, p.126).

Eisenstein (2011) echoes the same message where despite our suburban lifestyles where people are everywhere, privacy is a virtue and that is inherently what leaves us feeling lonely and disconnected.

“Life has become a private affair. We are uncomfortable with intimacy and connection, which are among the greatest of our unmet needs today. To be truly seen and heard, to be truly known, is a deep human need. Our hunger for it is so omnipresent, so much a part of our experience of life, that we no more know what it is we are missing than a fish knows it is wet. We need way more intimacy than nearly anyone considers normal. Always hungry for it, we seek solace and sustenance in the closest available substitutes: television, shopping, pornography, conspicuous consumption—anything to ease the hurt, to feel connected, or to project an image by which we might be seen and known, or at least see and know ourselves” (Eisenstein, 2011, p.289).
The history of North American housing and the global issues we face today point to the challenge of creating houses that are at once more affordable for all income groups, more efficient in the use of energy and other natural resources, and more sensitive to changing housing demands and needs (D’Amour, 1991). Perhaps housing cannot only address those objective and measurable issues, but also begin to address a seemingly broken social landscape where rather than feeling alone and disconnected in our suburban landscapes, we might begin to repair the damage we have done to our relationships with each other, our planet, and ourselves.

3.2 Conventional Materials

The housing industry is a significant portion of the Canadian economy, but similar to the rest of the big players in our economy, the housing industry has yet to incorporate long-term environmental considerations adequately into its cost-benefit analysis (D’Amour, 1991). One facet of this consideration are the building materials used to construct our homes. It is without a doubt that homes are constructed faster than ever before. But are they built better? In this section, conventional building materials will be explored in relation to their sustainable viability. Are the materials currently used cost efficient throughout their life cycle? Are the materials environmentally benign? And do they produce more efficient homes?

Although conventional materials are readily available and inexpensive in upfront cost the materials do not tend to be of the same quality as traditional materials, have a greater impact on the natural environment due to the materials being used, and also generate more waste (Choguill, 2007; Wright, 1991; Bribiàn, 2011). In fact, on average in Canada, 2.5 tonnes of waste is
produced in the construction of one new dwelling and ten percent of all lumber used in home construction ends up as waste (D’Amour, 1991). Despite best efforts code authorities remain responsive to and strongly influenced by the building industry (Eisenberg, 2005). Tasker-Brown (1991) echoed that claim by suggesting exclusionary regulations stipulate the use of expensive building materials for standardization. Moreover, many municipalities are facing issues of aging infrastructure, financial constraints, and continued expansion mandated by the *Places to Grow Act (2005)* which puts even more constraints on already aging infrastructure (Ministry of Finance, 2010). Considering the inviability of our aging infrastructure to continue service our needs or the financial capital to both maintain and grow it, it does not seem possible to maintain business as usual in the development of suburban landscapes.

Examination of the cost of building materials requires a systems approach that considers not only the final monetary cost of the material, but the amount of energy that was needed to collect, process, manufacture, and transport the materials, as well as life-time durability (Mora, 2007; Bribiàn, 2011). Environmental impacts of these materials are not separate from examinations of cost. The energy requirements to produce a material (the Embodied Energy, or “EE”), are often indicative of the environmental impact and the externalization of costs which are often not expressed in the final monetary price (Edwards & Turrent, 2000). Table 1 and 2 from Harris (1999) depict a quantitative lifecycle analysis (LCA) of typical building materials used in housing, and a comparison of steel and timber framed buildings, respectively. LCA is an analytic tool that includes a number of measurements and indicators that seeks to compare materials and make conclusions about efficacy in terms of cost, efficiency, environmental impact and the like.
It is important to acknowledge the limitations of LCA and EE values. For example, the conclusions of the same material may differ from researcher to researcher due to various calculation techniques and geographical areas in which the research was undertaken (Offin, 2010). However, it is the most common and widely accepted, empirical and quantitative evaluation method for determining normative construction materials.

Table 1 highlights the significant EE of metals and plastics that are becoming more widely standardized in conventional home building. Although the recycling potential of metals are far superior to that of other building materials the EE and the disruption caused to environments in order to extract the materials is extremely high. In fact, all materials for building construction with the exception of woods and cellulose insulation are considered to have a high disruption for local environments (Harris, 1999). Bribiàn et al. (2011) echo Harris’s findings with their own data which compare materials based on the amount of CO$_2$ generated and water required per kilogram of material produced. Some of the most widely used conventional materials, such as steel, ceramic, and cement were found to be among the most resource intensive.

Another cost not yet discussed in relation to current building materials are the long-term effects on the health of the inhabitants of these buildings. Wallace et al. (1987) found that residential indoor air concentrations of Volatile Organic Compounds (VOCs) were significantly higher than outdoors. VOCs are known to cause a range of health issues from general irritation to cancer, and very little is known about the direct health effects of VOCs within the home (EPA, 2012). Table 3 from Wallace et al. (1987) highlights carpeting was found to contain anywhere from 21 to 30
different VOC’s, while carpet glue was found to contain 111 VOCs. Although this article is from 1987 many of the materials examined are either still in use today, or are still present in older constructions such as Urea Formaldehyde Foam Insulation (UFFI), or even lead and asbestos. Despite the article being older, VOCs still remain an issue: recent research shows 26% of total VOC emissions are from coatings and paints used in home construction, and the next largest contributor are consumer products which account for 19% of all VOC emissions (Environment Canada, 2013).

Considering the results of LCAs and EE on conventional materials, not to mention the potential for toxic effects on inhabitants, why are these materials still the most widely used for the construction of buildings? Admittedly, it is difficult to make concrete conclusions about normative building materials when so many factors are examined. In the studies mentioned here alone, factors such as toxicity, local disruption, recycling potential, EE, CO₂ emissions, water usage, scarcity, thermal conductivity, and others were examined for a variety of materials with sometimes differing results. One explanation was provided by a survey participant with an engineering background stated, “The sustainable, low energy solution usually costs more and requires more design input/expertise. Client organizations still often want to spend the minimum time and money to achieve a suitable building to meet current regulations.” (Morton et al., 2011, p.1155). Furthermore, results from that survey found that 44% of respondents, all of whom were engineers in the construction field, believed current standards and regulations embodied normative construction guidelines. Despite 56% seeing room for improvement of the current
guidelines the costs associated with rectifying the issues are often not considered a wise financial investment.

3.3 Alternative Materials

Naturally constructed buildings attempt to reverse the trends whereby “industrial building replaces labour intensity with resource intensity” (Eisenberg, 2005, p. 23). However, Treloar et al. (2001) explains that the industrialization of alternative building materials in buildings can reverse the “high labor, low resource” intensity trend through the use of more machinery, fuel, or outsourced materials and ultimately increasing the environmental impact (and cost) in order to reduce required labor. In addition to design and energy systems, there is a renewed interest in alternative building materials and social innovations to housing (Vale and Vale, 2000). This section will approach alternative building materials in the same fashion the previous section examined conventional building materials. Do alternative building materials construct better homes? That question will be examined using three other questions. Are the materials cost effective throughout their life cycle? Are the materials environmentally benign? Do they improve the overall efficiency of the home?

Treloar et al. (2001) and Owen et al. (1999) examine rammed earth designs and both studies recorded energy savings of over 60% in comparison to both brick veneer and cavity brick. These calculations were also with the assumption of the use of cement in the rammed earth design added to the soil as a stabilizer. However, there are a number of other methods for building rammed earth structures. Michael Reynolds for example, designs homes of rammed earth
“encased in steel belted rubber”, which is the technical term for used automobile tires (Reynolds, 1999). Not only does this type of design negate the need for cement, but also repurposes a material that was considered waste. Furthermore, rammed earth structures are, as Mora (2007) would describe, transcendent; they are extremely durable and able to persist over many generations with very little maintenance. This is true even in extreme conditions, such as earthquakes and floods (Reynolds, 1999). Ip and Miller (2012) completed an LCA study of Hempcrete, or walls constructed from hemp and lime. Although their study did not include an EE component specifically, the researchers instead holistically examined the amount of CO$_2$ emitted by the process (Fig 1). Their study, as well as a comparable study by Boutin et al. (2006) funded by the French Ministry of Agriculture both found hemp-lime homes to have a negative CO2 emission of at least 35 kg. Hemp-lime walls are also highly durable in that they are slated to last for at least 100 years (Boutin et al., 2006; Ip and Miller, 2012). Offin (2010) conducted an LCA for straw bale constructions found that wall sections with a 6:1:1 plaster (Sand:cement:lime) contain six times less EE than conventional wood-frame constructions with brick siding. Furthermore, this research showed that straw bale designs with the highest amount of cementitious material in the plaster (used for extremely cold or wet climates) still had less of an environmental impact than the most environmentally friendly styles of conventional buildings (wood-frame with vinyl siding).

Not only do these alternative materials perform better under the scrutiny of LCAs in comparison to conventional materials, but the structure’s durability and efficiency after construction is far superior to that of conventional dwellings. This is largely due to the thickness of the load bearing
walls of these dwellings. The thickness of the walls provides structural integrity, but also provides thermal mass which drastically reduces heat loss. These buildings, as a byproduct of their need to bear large loads inherently allow for passive heating and cooling. This is an opportunity for major energy savings over the building’s lifetime.

Not all alternative materials are appropriate for all locations due to local availability or durability in particular climates. However, considering the LCA analysis and other potentials for energy and associated costs savings over the building’s lifetime it is vital to question the conventional building methods used in today’s building industry. Appropriate technology, a concept popularized by Schumacher in his 1973 book, *Small is Beautiful*, is an important concept to explore. The potential to create vast quantities of relatively cheap and standardized building materials that minimize labour costs are not environmentally favourable. Seyfeng (2010) bridges appropriate technology to housing through “adopting a scale and complexity of technology appropriate to its setting, and similarly were concerned with the effects of housing on human health and spirit. To meet the demands of householders wishing greater self-sufficiency from expensive and potentially unreliable energy supplies, this meant generally low-tech solutions which could be self-managed to create ‘natural’ homes” (Seyfeng, 2010, p.7626).
CHAPTER 4: COMMUNITY

4.1 Community Development

Community is an evasive term. It’s something that most can identify but not fully capture or have slightly different definitions for. Perhaps this highlights the uniqueness and complexity of community’s purpose and meaning for different cultures and individuals. The UN defines community development as "a process where community members come together to take collective action and generate solutions to common problems.". Others emphasize the importance of the individual’s realization of self-efficacy and interconnectedness to the larger community to truly develop selfless community (Wilson, 1996). One commonality between all rhetorics of community is the notion that humans are, on some level, connected and depend on each other for individual and collective wellbeing.

“Community, which in today’s parlance usually means proximity or a mere network, is a much deeper kind of connection than that: it is a sharing of one’s being, an expansion of one’s self. To be in community is to be in personal, interdependent relationship, and it comes with a price: our illusion of independence, our freedom from obligation. You can’t have it both ways. If you want community, you must be willing to be obligated, dependent, tied, attached. You will give and receive gifts that you cannot just buy somewhere. You will not be able to easily find another source. You need each other.” (Eisenstein, 2011, p. 289)
The principle in community of being connected and in need of each other is counter-intuitive to North American, and much of Westernized culture. Our western society is an individualistic culture that praises independence. However, this is an illusion considering the lifestyles we live as the material items we possess are dependent on thousands of global workers. Thus, we are independent in relation to the people we know, but entirely dependant on people we will never meet (Eisenstein, 2011). Furthermore, we compete so intensely for this illusory independence that we bear witness every day to people not having their basic needs met, while being surrounded by people who have far more than they need. What better example can there be of the decay of community in today’s world?

Healthy community development requires the consideration of many factors. However, having the basic needs of every individual meets a core and measurable principle of successful community. When these basic needs are met by people in the community who have more resources than they need the initial gratitude of those gifts reverberate throughout the community and strengthen social relationships. This is acknowledged by researchers who point to diversity of socioeconomic backgrounds, skill-sets and housing as being key issues to consider for developing healthy communities (Tasker-Brown, 1991; Maliene & Malys, 2009). Similarly Boothroyd and Davis (1993) describe a method of community economic development (CED) whereby the “C” is emphasized and is based on a set of close relationships that benefit the individual and collective. Haughton (1996) is another researcher who described a model of CED which emphasizes the importance of “focussing on resilient, autonomous, decentralized
economies of community-based small businesses catering for local needs, where possible using locally derived inputs and minimizing their ecological impact locally and regionally” (p. 19). The next sections will explore the relationship between poverty, affordable housing, and community development through the lens of these researchers unconventional community development models.

4.2 Role of Poverty in Community Development

Descriptions of poverty are typically vague due to the lack of a specific and globally accepted definition. Canada, for example, has no government mandated poverty line. While it is generally agreed poverty involves “adequate access to housing, essential goods and services, health, well-being and community participation” what constitutes ‘adequate’ is subjective and a point of contention among experts (Nova Scotia, 2008, p.1). Measures such as Low Income Cut-offs (LICO), Market Basket Measures (MBM), and Low Income Measures (LIM) are attempts to gain a statistical perspective on poverty in Canada, however, each have their own benefits and limitations (CCSD, 2001). LICOs have traditionally been used to understand poverty in Canada because these measures are part of the Canadian Census but even Statistics Canada warns that LICOs are a poor measure of poverty and should not be used as a sole indicator. This vagueness surrounding poverty definition and causation creates difficulty for forming solutions.

Poverty is often viewed as a cycle because individuals in poverty experience a series of feedback loops which entrench them further into impoverished conditions. This cycle is apparent on the level of the individual, family, and community. While a number of theories exist to describe
cycles of poverty and the mechanisms that drive them Hajnal (1995) suggests a similar reoccurring pattern in a number of urban areas in both Canada and the United States. Older manufacturing areas tend to have high concentrations of poverty that developed in six distinct stages: (1) a large influx of immigration, (2) rapid urbanization, (3) growth of the manufacturing industries, (4) closing of those same manufacturing industries, (5) concentrated unemployment, (6) a continuous cycle of dislocation and poverty. These are many of the same conditions that are described by Wright (1991) when exploring the development of slums in North America’s social history of housing. Therefore, it is common that entire communities concentrate around job availability and once those employment opportunities cease to exist the community economy is effectively destroyed. This cyclic example of poverty highlights the importance of diversity within communities to withstand changes.

Due to the unique nature of poverty in each community it is not always the case that whole communities are subject to cycles of poverty but it is interesting to note that trickle effects of poverty do occur from the community level down to the individual. In fact, concentrated poverty can bring non-poor individuals within the community into poverty from poor infrastructure or inadequate amenities (Hajnal, 1995). Once neighbourhoods or communities are subject to dislocation and unsatisfactory infrastructure, individual and intergenerational poverty begins to manifest. Common drivers of intergenerational and individual poverty are mechanisms such as poor living quarters, transportation amenities, educational facilities and being a member of a marginalized group (Baker et al., 2010). An example of concentrated poverty that leads to intergenerational poverty is described by Ron Finley (2013); he describes himself as living in a
“food desert” where all that exist are fast food restaurants and vacant lots; a common product of Hajnal’s (1996) cycle. He continues, “If kids grow kale, kids eat kale. If they grow tomatoes, they eat tomatoes. But when none of this is presented to them, if they’re not shown how food affects the mind and the body, they blindly eat whatever you put in front of them” (Finley, 2013).

An important factor in intergenerational poverty is the vital role of knowledge transfer to successive generations.

Either directly or indirectly, Finley understood how poverty was maintained in his community by lack of access to adequate nutrition. He also understood concepts of community development. Recognizing that appropriate food sources were scarce he created a program where community members planted edible gardens on public property; effectively getting individuals to reconnect with each other and nature, and produce a social good that solved a community problem (Finley, 2013). The role of poverty in community development is people are less concerned about doing things for others when they cannot meet their own basic needs. Therefore, the mentality of scarcity, competition, and individualism are reinforced. However, when the basic needs of sustenance of community members were being met by community members opposite is true and it produces a feedback loop of community development and strengthening (Senge, 1990; Eisenstein, 2011; Choguill, 2007).

The example of Finley (2013) is captured beautifully in Haughton’s (1996) model of “restructuring for community and ecology” which seeks to minimize the dependance on large centralized organizations and put greater control back into the hands of the local community.
This allows them greater control over their community needs, as well as what may impact their local natural environment. This type of control also echoes Arnstein’s (1969) ladder of citizen control. Rather than being influenced by the motives of larger organizations through lower rungs of the ladder, citizens having greater control over their sources of sustenance provided opportunities to immediately tackle an issue in their community which has the potential to alleviate poverty. Food is one aspect of basic human needs; another is housing which will be discussed in the next section.

The identification of poverty as being more comprehensive than purely the income of an individual or family is well recognized around the world. Social Determinants of Health are a comprehensive compilation of factors that contribute to the health of individuals and communities (Fig 2). Numbers six, seven, and eight on this list are Food Insecurity, Housing, and Social Exclusion which all share striking similarities to the subjects discussed in this chapter. Housing is identified as a crisis in Canada considering the degree of homelessness, the high cost of renting or owning a home, and the crowded or unsanitary living conditions present in many low cost homes each of which are determinants of adverse health outcomes (Mikkonen & Raphael, 2010).

4.3 Affordable Housing

Housing affordability is typically determined by the percentage of income dedicated to housing payments. It is widely accepted that housing becomes unaffordable when 30% of a household's income is spent on housing (Statistics Canada, 2006; NHC, 2006; Kirkpatrick & Tarasuk, 2007).
Surprisingly, one in seven Canadian households spend 30% or more of their income on housing with a proportionately high number of those households being renters and subsidized housing; a trend that has persisted for a number of years (Statistics Canada, 2002; 2006). Furthermore, statistics show that low-income families are far more likely to live in homes in a state of disrepair while also spending proportionately twice as much after-tax income on their homes in comparison to other families (Statistics Canada, 2002; Mikkonen & Raphael, 2010). This highlights a commonplace mechanism of the poverty cycle (Hajnal,1995); for example, old homes may expose families to lead and subsequent health problems, or financial pressure can exacerbate common issues of families struggling to afford both food and shelter (Baker et al., 2010; Kirckpatrick & Tarasuk, 2007). In 2011, the Ontario Ministry of Municipal Affairs and Housing introduced the Strong Communities Through Affordable Housing Act (2011) which made important changes to the Municipal Act and the Planning Act to promote affordable housing around Ontario (MAH, 2011). However, a clear limitation is that the Act favours new developments and does not provide many opportunities for renovation of older homes in which many impoverished families live, especially those in rural communities (SSCAF, 2008; Statistics Canada, 2006).

The real tragedy of unaffordable housing is apparent when making connections between affordability and the ability for community to alleviate poverty. Crabtree (2006, p. 522) states that “A lack of affordability implies lack of long-term tenure or choice, undermining social diversity and equity or the ability to commit to place”. Furthermore, a lack of affordability inherently minimizes the time to commit to community input. The less affordable housing
becomes, the less able individuals are to be part of a community, gather, organize and share
knowledge and provide support for each other (Mikkonen & Raphael, 2010). Therefore,
affordability is a factor that may inherently diminish the ability for communities to generate their
own unique solutions to issues of poverty. It is in this way that affordable housing is an
absolutely necessary social determinant of health.

Housing is an important facet of strong communities but should not be used as a “panacea for
determining and guiding the course of society” (Wright, 1991, p. 258). Nevertheless, affordable
housing can bring many positive benefits to local communities. Legislation such as the Strong
Communities Through Affordable Housing Act (2011) is ambitious but lacks a holistic
perspective to the affordable housing issue. The previous section highlighted how costly
conventional materials can be in the long term from the perspective of ecological impact,
requirements for heating and cooling, and overall robustness and longevity, particularly in
comparison to alternative building materials that are widely available. Coupling these individual
issues with global and regional issues inherently means our building technologies need to evolve
to meet demands of Climate Change predictions and increasing utility and servicing costs
(Ministry of Finance, 2010). For this reason, new sustainable buildings must incorporate
technologies such as shading, thermal mass, passive heating and cooling, etc. which can be
obtained by selecting appropriate building materials. These are necessary not only from an
environmental point of view, but also from a long-term affordability perspective (Seyfang, 2010).
Another way of living is possible and simple livelihoods can be obtained and managed without
the need for high-capital investment property or high incomes to service mortgages and utility bills (Vale and Vale, 2000).

Just as Finely (2013) began growing food in his community with the help of community members, communities may also help each other construct their own dwellings. As the section on alternative building materials specified, these constructions often replace resource “intensity, with labor intensity”, which means that as long as the hands are available, the total material costs should be relatively inexpensive in comparison to conventional homes. Understandably, the initial investment of labour in the community may be difficult to attract as every individual, particularly those in impoverished conditions, use the hours of their days trying to sustain themselves or loved ones. However, just like Finley’s gardens, if affordable housing made from recycled materials are constructed and are more efficient than conventional homes this will provide more financial freedom and time for community members to give back foster an even stronger and more resilient sense of community development. Just as it is said it takes a community to raise a child, “it also takes a community to build an affordable home” (CMHC, 2005, p.105)

4.4 The Relationship of Building Materials to Community Development

While again acknowledging that housing is not a panacea for healthy community development, it has potential contribute to better community by addressing issues of financially and ecologically expensive and inefficient housing. The need for adequate housing, health, community participation, and well-being are all intimately tied together from a systems thinking perspective
(Senge, 1990; Mitchell, 2010). With the use of alternative building materials and complementary technologies it is possible to construct affordable housing that is intensive on labour but not resources and is efficient in terms of required utility and service inputs. This opens opportunities for groups to construct efficient homes from affordable materials, thus contributing to the alleviation of poverty in their community. Furthermore, by using members of the community to produce a social good that solves a community problem there is inherent strengthening of social ties; very similar to the way Ron Finley did with his gardening program. This embodies Seyfeng’s (2010) notion of appropriate technology; although more technologically advanced materials exist, the less technological approach is more appropriate for the fostering of community, longevity of the buildings, overall affordability, and environmental sensitivity.

Again, going back to Finley’s gardens. When kids grew kale, they ate kale, and it has been witnessed in other communities that the same is true when people construct their own homes. Steen et al. (1994) is part of a community project that will be discussed as a case study and has witnessed that, “people seem to change fundamentally when they gain the added security that comes from knowing they are capable of providing their own shelter” (p.xvi). This change not only requires the knowledge they are capable of particular actions that provide them security, but also the means. Whether the means are the seeds and the land to grow your own food, or the financial capacity and accessibility to obtain alternative building materials. Ultimately, what these actions provide are the fostering of dependance, gratitude, and therefore stronger relationships towards people close to you, while depending less on global workers who are thousands of miles away with whom no relationships are developed at all. Not only are food and
shelter critical aspects of basic human needs, but so are close and intimate community relationships (Eisenstein, 2011).

While this sounds wonderful, an issue remains. In Ontario, the construction of homes requires a number of permitting and approvals. Homes are only granted approval if they meet prescribed standards. Most of the alternative building materials that are readily available, inexpensive, and produce efficient homes are not acceptable under Ontario’s current codes. The next section will examine Ontario’s building code by discussing the purpose of the code and detailing the actions of its various approval agencies.
CHAPTER 5: BUILDING REGULATIONS

5.1 Ontario’s Building Code

During interviews with building officials, all directed attention to their legal obligations outlined by Ontario’s Building Code (OBC) in which they must take reasonable care in reviewing plans and that the first duty is to the public at large, not designers or applicants, and that the municipality could be liable if it fails to detect deficiencies. Thus, the liability ultimately falls on each individual building inspector who may lose their livelihoods if they do not conform to their legal obligations and in many cases reinforce rigid rules and undermines new practices (Levesque, 2010; Brown, 2011). In fact, the OBC has specific stipulations for suppliers, retailers, and manufacturers (1.1(4)), builders (1.1(3)), and designers (1.1(2)) all of whom may be prosecuted for failing to fulfill obligations mandated by the OBC. This highlights a conclusion made by Seyfeng (2010) that much progress has been made in housing over the last few decades but has not been implemented by house builders “due to the co-existence of fundamentally different discourses, practices and governance of sustainability between the mainstream system of housing provision and free builders; consequently the barriers to this transfer of practices encompass ideological, cultural, social, political and ethical factors as well as economic and technical ones.” (p. 7624). A number of advancements have been made that could improve conventional housing, but a number of factors maintain the status quo and potentially prohibit innovation even in the face of immense benefits. This isn’t just a problem in Canada, the issues of inflexible bureaucracies which hold looming threats of prosecution over those who participate
in activities covered by building codes is evident internationally. Just one example is, Tony Wrench in Pembrokeshire National Park in Wales built a home for £3000 but was subjected to a large planning battle. However, Simon Fairlie suggests this type of home is so sustainable it is sufficient justification for a new category of planning law permitting low-impact development in rural areas to support sustainable livelihoods in the countryside (Vale and Vale, 2000).

Prior to 2006 the OBC only contained prescriptive codes, which dictated the way structures should be built with little room for officials to allow adaptations. However, the changes to the 2006 code allowed for what are deemed “Alternative solutions” which may substitute the solutions subscribed by the code (Brown, 2011). These alternative solutions require additional processes to be approved, and will be described later in this section. The progressive, albeit slow, improvements to the OBC appear to recognize there is no such thing in housing as a universal “best practice” (Choguill, 2007). The most recent OBC amendment took place in 2012 for which most requirements took effect by January 2014. While the 2012 OBC changes had no changes directly applicable to alternative building materials a number of alternative systems such as solar panels, composting toilets, and grey water systems were addressed. The changes in the 2012 OBC no longer require an alternative solution application for the previously mentioned systems. Although additional permitting fees are required, the process is not nearly as rigorous as the alternative solutions process.

5.1.1 Approval Agencies
There are two major agencies in the Ontario context which have the ability to approve construction materials and include them as “accepted solutions” within the OBC. The first is the Building Materials Evaluation Committee (BMEC) which is given authority through subsection 28(1) of the *Building Code Act 1992* (BCA) (Personal Communications, January 2015). It’s powers allow BMEC to conduct research or consult other parties for applications of innovative materials, make recommendations to the Minister of Municipal Affairs and Housing, and grant approval for the use of a material throughout the province of Ontario. However, BMEC approvals are only applicable in Ontario, and they will only review products or materials which it deems to be “innovative” (MMAH, 2012). The second approval agency is the spearheaded by the federally operated National Research Council under the Canadian Construction Materials Centre (CCMC) which provides the same functions as BMEC, but has the ability to approve materials for all of Canada rather than just provincially. This is the method that most major manufactures of products use (NRC, 2014).

Despite the OBC making room for either of these agencies to approve building materials, an issue remains. These approval agencies require significant capital investment and testing to be approved. For example, submitting an application to CCMC can cost between $5000 and $10000, with each revision costing over $1000, in addition to the laboratory testing that will require additional costs and a year or two to be approved (NRC, 2014). Therefore, no corporate business is going to undergo the process to approve alternative materials that will not generate a profit. Ultimately, individual home builders are prevented from engaging in this process due to the lengthy and expensive testing and approval process.
5.1.2 Other Options (Stamped/Informal Economy)

The most common approval method for homes constructed with alternative materials is to have a design professional, such as an architect or engineer, stamp and approve the design. Individual home builders choose this option because it removes liability from the municipality in the case of injury or damage, therefore satisfying the building inspectors, and provides opportunities for innovative designs and materials to be used on a case-to-case basis. Although this approval option is a step in the right direction for the OBC in allowing alternative designs, it is still prohibiting the opportunity for communities to construct affordable and efficient housing. First of all, because the designs need to be stamped on a case-by-case basis each individual home would need individual drawings stamped and approved. Second, it can be difficult to find a design professional who is both willing to stamp individual drawings of an alternative nature and at a cost reasonable for individual home owners. In the majority of cases where homes made with alternative materials the home builders either are design professionals themselves, have familial ties with design professionals, or are part of a larger organization or community where those skills are easily accessible.
CHAPTER 6: CASE STUDIES

6.1 Bancroft Rammed Earth

Located in Bancroft Ontario is one of the oldest rammed earth homes in Ontario. Construction was completed in 1990 on a 10+ acre piece of property (personal communications, October, 2014). The design was inspired by Michael Reynolds’ “Earthship” designs, which were discussed earlier as “rammed earth encased in steel belted rubber” (Fig. 3) (Reynolds, 1999). The spaces between the tires are filled with a straw-clay mixture, a layer of chicken wire, and covered in adobe. Since its construction 25 years ago, the only major maintenance of the building envelope has been adding additional layers of adobe over some cracks in the interior walls. This is a natural occurrence in Earthship designs as the earth berm behind the load bearing wall, which acts as a thermal wrap, settles. Not only did the structure cost less than $100,000 to construct (including energy, water, appliance, and additional heating infrastructure), but the structure is not connected to municipal hydro or utility services. Therefore, there are no additional costs after construction aside from general maintenance.

This case study is particularly applicable to this research because it is an extremely unconventionally built home and was the first one approved and constructed in Ontario. There are hundreds of Earthships constructed around the world and the design is gaining very significant traction and legitimacy, particularly in developing nations that are poverty-stricken, and in volatile locations such as earthquake and flood zones. Due to the Earthship’s design it is
almost being completely immersed in the ground and renders it nearly indestructible (Reynolds, 1999). Considering the range of functions these dwellings provide, one might think they would not be visually appealing, however, they are often also great works of art (Fig. 4). Although many Earthships now exist in Ontario and around the world, with their design and practicality being proven in a variety of climates Ontario’s prescriptive code still does not recognize it as an acceptable form of construction. The only means in which these buildings gain approval is through independent approval from a building and construction professional, which as previously discussed is a barrier to most individuals. The individuals who own the Bancroft home are fortunate enough to have familial ties with engineers who were able to stamp their drawings and oversee construction pro bono.

6.2 Tillsonburg Rammed Earth and Guelph Straw Bale

The rammed earth home located near Tillsonburg is of the same design concept as the structure previously discussed located in Bancroft. However, this structure is much newer and was only completed last year (Fig. 5). These individuals also found an architect to stamp their drawings, relieving the municipality of any liability, and were able to being construction with little hassle. Two other buildings of the same conceptual design are also being constructed in the same area. While precedent is not a factor in municipal decisions regarding home construction, now that officials are more familiar with the differences in this design concept from conventional homes the process by which approval is granted has become much more streamlined (Personal communications, March 2015).
A similar instance was noted in a conversation with a couple near Guelph who constructed a straw bale home (personal communications, January 2015). They were the first in the area to build a home with alternative materials that required the approval of another design professional. Even after their drawings were approved some building officials in the area had difficulty conceptualizing and understanding components of the structure where it differed from conventional knowledge. This created some barriers for the homeowners which required more time and money to overcome. Ultimately the structure was completed and in speaking with one of the building officials in the area it appears that the experience the municipality gained working with that case would allow a much easier process for future individuals who sought to construct similar homes. Therefore, when it is completed once within a municipality and involved individuals become more familiar with alternative designs and the conceptual barriers from individual misunderstandings are less of an issue in future builds. No photos are included due to the structure appears as a very ordinary home, only with thicker more insulative walls.

While a number of benefits were mentioned by the owners of these homes, such as the satisfaction of constructing their own dwelling, and the low or non-existent mortgage and utility costs there are drawbacks to these types of designs. As previously mentioned, these homes replace material intensity with labor intensity. That means there is a lot more work by the homeowner that goes into constructing these homes which may require time or skills out of reach for the typical family. Moreover, due to the custom nature of these homes maintenance is often left to the homeowner to find a solution. Other factors mentioned as potential drawbacks are the resale value of these homes, and potential for structural issues not present in conventional homes. For example, the owners of the straw-bale home expressed how detrimental it might be if the
plastering of the straw bales were not done correctly leaving the potential for mice, moisture, or mould. Such issues not only are concern for the health of occupants but may undermine the structural integrity of the building.

6.3 The Canelo Project

The Canelo Project is a non-profit organization founded by Athena and Bill Steen in Southern Arizona. Founded in 1990, the project aims to develop “ways of living that connect us to others and the natural world” through “an ongoing exploration of living, growing food and building that creates friendship, beauty and simplicity” (Seyfeng, 2010, p.7629). The project is located on a 40 acre Oak woodlot and contains the Steens’ adobe family home, a guesthouse, and more than a dozen small straw bale buildings which have, over the years, been constructed by participants of straw bale workshops. Seyfeng (2010) emphasizes the principles of localization of materials and reduced ecological footprint both in initial construction and long-term operation of the building. Possibly the most important aspect of the Canelo project are the community-oriented lifestyles to promote equitable sharing of resources. The low-cost, accessible materials inherently provide opportunities for low-income and socially excluded groups: “People who might otherwise be excluded become directly and enthusiastically involved” (Steen et al., 1994,p. 21).

Steen et al. (1994) also makes note that while straw bale homes can be more efficient, not all alternatively constructed buildings are sustainable or environmentally conscious. This highlights another important aspect of the Canelo project which focusses on collective action and a reversal of individualism. Not only was this echoed in the previously in this document when discussing
affordable housing, but is repeated in numerous other articles as well (Reynolds, 1999; Crabtree, 2006; Wilson, 1996). Ultimately, there are a number of interacting concepts that are catalysts for developing strong and resilient communities: use of inexpensive and easily accessible materials promote low resource and high labour intensity to construct homes, these homes can be constructed by members of the community by each other and for each other which develops lasting social relationships, and these social relationships create support networks when individuals in the community are in need, ultimately building resilience by facilitating communication and exchange.

Of course, one of the potential issues of living in these types of communities is the opportunity for conflicts to undermine the social fabric of the community. This is of particular concern if the community built homes together and only a small number of individuals possessed particular skills vital to the construction or maintenance of the buildings and those individuals leave. In this respect, there may be some security in having the ability to depend on global workers whom no relationships are required to use their services.
CHAPTER 7: RECOMMENDATIONS

7.1 For Ontario

There are clear and reasonable arguments for the enforcement of the building code, such as assurance of public safety (personal communications, January 2015). However, there are a number of researchers who view building code as a mechanism which maintains the status quo and is prohibitive of innovation (Foxon, 2002; Eisenberg, 2005; Hoffman & Henn, 2009; Choguill, 2007; Seyfeng, 2010). Much of these views on building code stem from the prescriptive nature of codes which allow for very little flexibility. Ontario should be commended for the inclusion of innovative options in its code by allowing other design professionals to stamp drawings and remove the liability from the municipality. While this provides opportunities to build innovative structures, it may still be seen as exclusive as the initial upfront cost may be too much for individuals or families seeking affordable housing.

Although a number of researchers believe codes to be prohibitive and a barrier to innovation, many practitioners believe current practices are adequate to manage the global and regional social and environmental issues faced today. Morton et al. (2011) examined the perceptions of building industry representatives concerning the adequacy of current practices to deal with climate change. Their results showed that most respondents, particularly those with the highest seniority in building industry organizations, thought current practices to be adequate. Thus, individuals studying social and environmental impacts from housing developments are
concerned with current practices, yet most individuals who oversee and participate in the industry believe practices to be adequate. Although it is not uncommon for industry representatives to claim their current practices are acceptable while a number of other groups disagree, it is of concern when the industry itself has the greatest ability and greatest unwillingness to change.

The building industry and its supporting legislation could arguably be characterized as an industry suffering from technological “lock-in”. Technological lock-in can apply to technical systems or institutions where a singular approach dominates despite alternative and superior solutions (Leidl et al., 2010). The following are examples supporting this characterization: codes and standards prescribe what materials are used and how, these materials require large capital investment to be approved and thus require return on investment, these materials have been shown to be more financially and environmentally costly in comparison to alternative materials, however the alternative materials are not accepted by the code without additional investment or transfer of liability to a design professional, and ultimately “business as usual” is maintained. Hoffman and Henn (2010) offer a number of other individual, organizational, and institutional level perspectives which may act as barriers to the implementation of new and innovative approaches to building. Furthermore, Tensbrunsel et al.’s (1997) paper which suggests suboptimal outcomes can result from adherence to standards due to a tendency to direct attention toward the law itself and away from the purpose behind the law. Tasker-Brown (1991) proposes a framework to formulate strategies to make communities more sustainable in which field practitioners ask themselves: (1) What makes a community sustainable, (2) Can we achieve
sustainable community development with our present tools and practices? (And if not, what tools are needed?), and (3) Are there initiatives from which we can learn? Seriously addressing these questions may threaten current practices by questioning conventional methods and systems, and their applicability to the uniqueness of individual communities. It is recommended that legislators examine the degree to which technological ‘lock-in’ may be affecting alternative construction outcomes and adopt a similar framework to Tasker-Brown’s into the building code to allow greater flexibility and innovation by its next revision, which is in 2017. Furthermore, it is recommended that a training program be required for building officials to address polarities in attitudes and perceptions highlighted by Morton et al. (2011) while also addressing issues highlighted by Tensbrunsel et al. (1997) whereby officials unquestionably adhere to prescriptive codes rather than thinking about the purpose behind the codes.

7.2 Community Land Trusts (CLTs)

Community Land Trusts (CLTs) were developed in the 1960s by the Institute for Community Economics (ICE), a community development organization located in Springfield, Massachusetts. The ICE defines CLTs as: “a private non-profit corporation created to acquire and hold land for the benefit of a community and provide secure affordable access to land and housing for community residents.” (Housing Strategies Inc, 2005, p.3). The distinguishing features of a CLT are its non-profit status, grass-roots designed governance structure, dual ownership of land, perpetual affordability, and a range of housing types and tenure options.
There are a number of examples of CLTs in Canada, and at least one in Ontario (Colandco Cooperative Homes Inc). However, none of the case studies explored the potential for alternatively constructed housing. Each CLT explored is unique in its structure of tenure and the types of housing offered, such as: condominiums, single-detached, or shared amenities. However, considering that housing constructed with alternative building materials can equate to short and long-term affordability through greater efficiency and lower material costs perhaps CLTs may benefit from seeking more than just different organizational structures.

The Housing Strategies Inc. (2005) document examining CLT success factors in Canada shows that CLTs face challenges of building broad community understanding and support for the initiatives, obtaining necessary funding to cover operating expenses, and a lack of capacity within the sector. Moreover, three interconnected recommendations were made to CLTs: foster greater community support, provide education and outreach, and create new and strengthen existing community partnerships (Housing Strategies Inc, 2005). The inclusion of alternatively constructed homes may aid in the successful development of CLTs through diversification and opening up potential partnerships with other social movements through the practical application of appropriate technologies. For example, those who live in alternatively constructed homes may further improve resiliency and affordability through other community actions such as organic or alternative agriculture or alternative forms of servicing such as off-grid electricity or solar hot water. Not only is there an opportunity to improve affordability, but incorporating a number of multifaceted, resilient, and community driven initiatives may act as demonstration projects for community education and outreach, as well as provide a sense of place for residents of the CLT.
(Roseland, 2000; Haugton, 1996; Boothroyd & Davis, 1993; Steen et al., 1994). The recommendation is CLTs or other community oriented groups and projects use alternatively constructed buildings to satisfy the recommendations made by Housing Strategies Inc. (2005). These buildings could be a means of fostering community support by bringing together individuals for an exciting project, a unique education opportunity for the surrounding community which will draw in visitors and also create opportunities to create new partnerships. Furthermore, when organizations such as CLTs, NGOs, or other passionate groups gather to complete these projects it creates greater momentum and possibility for other similar projects.

7.3 For NGOs

During the discussion of alternative materials it was noted that in order for materials to be written into the OBC one of two organizations would need to be involved: BMEC for Ontario, or CCMC for national approval. Many of the low-cost, locally available materials discussed here have not been put through this process presumably due to associated costs and the inability to profit from the sale of materials such as rammed earth, straw bale or cord wood. The exclusion of these alternative building materials from the OBC means that individual homeowners or builders must have their drawings approved and stamped by a design professional, which increases initial costs.

The interconnected nature of housing to a number of wider social and environmental issues indicates it may be in the interest of a number of different organizations to advocate for alternatively constructed homes. In fact, some NGOs are already involved in the housing sector:
the WWF released a report titled *Warm Homes, Not Warm Words* that examines the monetary and environmental cost of heating homes and potential solutions (WWF, 2014). Other organizations who focus on poverty, or food and water security may also be interested in affordable, efficient housing. It is recommended that NGOs and other community organizations collaborate, and work together with government to begin the process with BMEC or the CCMC to have alternative materials tested, approved, and written into the code. This should take place before 2017 when the new building code is released.

### 7.4 For Further Research

There is a significant amount of further research that could be done to explore the barriers to alternatively constructed homes and related issues. First, a variety of further empirical research is recommended to provide greater consensus that alternatively constructed homes can be beneficial to homeowners and builders. While lifecycle and EE assessments highlight the environmental benefits of using alternative as opposed to conventional materials in homes, the idea would be better received if the economic implications were more clear. Therefore, it is recommended an analysis be completed to compare the cost of materials and labor in an alternatively built home versus a conventional style home. It is very likely the cost of materials in a conventional home would be more costly than in an alternatively built home, but the alternative home would require much more time and specialized labour. Determining whether the increased labour costs would be offset by lower material costs has yet to be explored and would be vital to the implementation of alternatively built homes on a larger scale. Furthermore, it
would be interesting to examine the final sale prices and operating costs of both styles of homes to calculate the return on investment.

Additionally, further research may provide more rigorous analysis of the interactions between the building industry and the OBC to better understand the specific processes which prevent innovations from percolating into standard practices. This additional research may be accompanied by exploring potential partnerships between various organizations who may be willing to put alternative building materials through the CCMC or BMEC approval process. Furthermore, as an expansion of this idea on focussing solely on alternative building materials, there is significant work to be done on examining the barriers to other alternative living solutions and system components in housing. For example, rainwater use in laundry, space and water heating with off-grid solar applications or compost, indoor grey water and aquaponics systems and other innovative systems that can be applied to homes. These other systems components are other practical ways of improve affordability of homes and increase the resilience of communities by providing opportunities to produce and consume energy and food locally.

CHAPTER 8: CONCLUSION

The building code, ultimately, is a protection against liability for the municipality and to ensure public safety. As such, Building Officials may be held personally responsible for negligence if structural issues occur. While the Ontario building code allows for some flexibility for alternative
materials, the process of gaining approval can often be costly. In order for materials to be approved by the Canadian Construction Materials Centre (CCMC) or Building Materials Evaluation Committee (BMEC) is costly and time consuming due to requirements for laboratory testing, applications fees up to $5000, and the bureaucratic process. Often, individuals opt to have their designs approved and stamped by an authorized professional such as an engineer or an architect. While this process is often much easier, it does not eliminate the barrier of an initially high upfront cost and may require unexpected changes to the design.

From discussions with current owners or previous builders of homes with alternative building materials it is clear that having a third party professional approve plans is the only reasonable method for individual home owners to construct homes from alternative materials. In most of these cases, the owners were privileged in that they had a personal relationship with a design professional which reduced concerns of costs. It is concerning that the process to incorporate alternative materials, which have great potential to be more locally sourced, benign to the surrounding environment, less costly, and more durable and efficient is so exclusionary to the vast majority of the population when affordable housing and poverty are such prevalent social issues. This is especially concerning with the many examples of alternatively constructed homes not only throughout Ontario, but throughout Canada and internationally. Clearly, these alternative options are functional but not fully adopted by the construction hegemony.

This document highlights that housing, and many related issues, not only are generated by cumulative social, environmental and economic pressures, but that the solutions and processes in
which to achieve these solutions are equally as complex and multifaceted as the problem itself. Briggs (2007) would certainly classify this and related issues as wicked problems. A number of suggestions have been made regarding potentials for future research, as well as actions to begin to address the issues associated with housing construction. Moreover, there are a number of other avenues in which similar research to this document can be conducted that may not be connected to housing directly, but ultimately contributes to the same social, economic and environmental issues.
APPENDIX

INTERVIEW GUIDE

For Practitioners

1. Why do standardizations exist in the building code?
2. Do standardizations create any problems?
3. Considering many of the social/environmental/economic issues we face today, is the current policy framework appropriate? Why?
4. Does the current policy framework allow for flexibility and innovation?
5. What other building materials have you had experience with?
6. What was the process for getting these alternative materials approved?

For Homeowners

1. What impacts, if any, did standardized building codes have on the process of the construction of your home?
2. From your experiences, do you believe the current codes are appropriate for the construction of homes in Ontario?
3. In your experience, were building practitioners flexible and receptive to the unconventional design of your home?
4. What made you choose the material and design of your home? Why choose this style rather than a conventional home?
5. What were the lessons you learned from going through the process of building your home?
LIST OF TABLES

Table 1. Lifecycle analysis of an average steel framed versus wood framed dwelling (Harris, 1999)

<table>
<thead>
<tr>
<th>Material</th>
<th>Embodied energy kWh/m²</th>
<th>Renewable resource?</th>
<th>Scrutiny of raw materials</th>
<th>Local extraction disruption</th>
<th>Indoor effects (Toxicity)</th>
<th>Recycling potential</th>
<th>Energy GJ</th>
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</thead>
<tbody>
<tr>
<td>Standard</td>
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<td>117.7</td>
<td>10.6</td>
<td>98.4</td>
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<td>64.4</td>
<td>19.1</td>
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Table 2. Lifecycle analysis of conventional building materials in homes (Harris, 1999)

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<thead>
<tr>
<th>Material</th>
<th>Embodied energy kWh/m²</th>
<th>Renewable resource?</th>
<th>Scrutiny of raw materials</th>
<th>Local extraction disruption</th>
<th>Indoor effects (Toxicity)</th>
<th>Recycling potential</th>
<th>Energy GJ (Resistance per 100 mm)</th>
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<tbody>
<tr>
<td>Brick (Fletton)</td>
<td>300</td>
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<td>High</td>
<td>Dust if exposed</td>
<td>Low-med</td>
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<td>Timber (local oak)</td>
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<td>Dust if exposed</td>
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<tr>
<td>Crushed granite aggregate</td>
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<td>Aluminium</td>
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<td>High</td>
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<td>n/a</td>
<td>Low</td>
<td>2.5</td>
</tr>
<tr>
<td>Mineral wool</td>
<td>230</td>
<td>Non-renewable</td>
<td>Common</td>
<td>High</td>
<td>Dust if exposed</td>
<td>Low</td>
<td>2.22</td>
</tr>
<tr>
<td>Synthetic finishes</td>
<td>High</td>
<td>Non-renewable</td>
<td>Common</td>
<td>High</td>
<td>Asthma etc.</td>
<td>Low</td>
<td>n/a</td>
</tr>
<tr>
<td>Plastics</td>
<td>47,000</td>
<td>Non-renewable</td>
<td>Common</td>
<td>High</td>
<td>None</td>
<td>Low-med</td>
<td>0.625</td>
</tr>
</tbody>
</table>
Table 3. A list of household items and a corresponding number of VOCs found to be contained in each. (Wallace et al. 1987)

<table>
<thead>
<tr>
<th>Materials</th>
<th>Number of compounds identified</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cleansers and polishes</td>
<td></td>
</tr>
<tr>
<td>Chlorine bleach scouring powder</td>
<td>51</td>
</tr>
<tr>
<td>Liquid detergent</td>
<td>35; 29*</td>
</tr>
<tr>
<td>Steel wool soap pads</td>
<td>34</td>
</tr>
<tr>
<td>Liquid detergent</td>
<td>54</td>
</tr>
<tr>
<td>Furniture wax</td>
<td>80</td>
</tr>
<tr>
<td>Stainless steel polish</td>
<td>82</td>
</tr>
<tr>
<td>Glues</td>
<td></td>
</tr>
<tr>
<td>Carpet glue</td>
<td>111</td>
</tr>
<tr>
<td>Wallpaper glue</td>
<td>18</td>
</tr>
<tr>
<td>Floor and wall coverings</td>
<td></td>
</tr>
<tr>
<td>Smooth carpet</td>
<td>30</td>
</tr>
<tr>
<td>Textured carpet</td>
<td>21</td>
</tr>
<tr>
<td>Ceiling tile</td>
<td>29</td>
</tr>
<tr>
<td>Sheetrock</td>
<td>49</td>
</tr>
<tr>
<td>Pesticides</td>
<td></td>
</tr>
<tr>
<td>Insecticide</td>
<td>14</td>
</tr>
<tr>
<td>Insecticide (spray can)</td>
<td>13</td>
</tr>
<tr>
<td>Insecticide (solid)</td>
<td>45</td>
</tr>
<tr>
<td>Rodenticide (solid)</td>
<td>49</td>
</tr>
</tbody>
</table>

* Two determinations.
LIST OF FIGURES

Lifecycle Map of CO$_2$ production for Hempcrete construction

Fig 1. Map depicting the process by which CO$_2$ production was calculated for hempcrete/hemp-lime wall construction (Ip and Miller, 2012)
Fig 2. Figure shows one influential model of the determinants of health that illustrates how various health-influencing factors are embedded within broader aspects of society. (Mikkonen & Raphael, 2010)
Fig 3. The construction of a rammed-earth tire wall (Top), and the completed product (Bottom). (Cook, 2015)
Figure 5. A few photos taken from inside the Phoenix Earthship in Taos, New Mexico. This is one of the first earthships designed by founder, Michael Reynolds (Biotecture, 2015)
Figure 5. A photo of the indoor planter cell of the earthship near Tillsonburg which is currently producing pineapples and bananas.
GLOSSARY

**BMEC**: Building Materials Evaluation Committee; a provincial committee that evaluates the efficacy of alternative building materials and is able to approve materials so they can be written into the OBC.

**CCMC**: Canadian Construction Materials Centre; a national organization that evaluates building materials and who's approval is necessary in order for a material to be used nation-wide.

**CLT**: Community Land Trust; a type of land trust, usually held by a non-profit corporation, that emphasizes land stewardship, while also allowing for other activities such as gardening, affordable housing, commercial buildings or other community assets.

**EE**: Embodied Energy; a means of evaluating the amount of energy contained within a material from initial manufacturing and processing to the time it is utilized.

**LCA**: Life Cycle Analysis; a means of evaluating the total efficacy of a material which may include EE, by-products associated with production, or the durability of a material.

**NGO**: Non-Governmental Organization; an organization that is neither part of government, or a for-profit corporation and is organized by ordinary citizens to address a certain subject or issue that citizens feel are not currently being addressed, or adequately addressed, by government or the private sector.

**OBC**: Ontario Building Code; the building code the governs construction in the province of Ontario

**UFFI**: Urea Formaldehyde Foam Insulation; an insulation dating back to the 1930’s and used extensively until the mid 1970s when the health concerns associated with formaldehyde became more widely known.

**VOC**: Volatile Organic Compound; organic chemicals that tend to evaporate from liquid or solid materials and then enter the surrounding atmosphere. Many VOCs are known to cause harm to human and environmental health.
REFERENCES


