Straw Bale Building and the National Building Code of Canada

MEPP Inquiry

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Abstract

Straw bale building is a highly sustainable, low energy alternative to conventional building methods that has existed for over a century. The straw bale system, where straw bales are encased in plaster to create a wall, continues to evolve and become more and more popular worldwide. As the method becomes more and more popular, many regions and countries are beginning to adopt straw bale building codes to regulate the construction of these buildings. The National Building Code of Canada, however, currently makes no reference to straw bale building. Tests and experience have given adequate data to make design decisions with regards to fire protection, structure, thermal performance and moisture control of this technique. Inclusion of straw bale building in the building code will give rise to both advantages and disadvantages for the industry. It has been deemed that these advantages greatly outweigh the disadvantages and the process of working towards inclusion of straw bale building techniques in the National Building Code of Canada should begin immediately.

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Straw Bale Building Technique

The straw bale building technique consists of taking straw bales and stacking them one on top of another in a line to form a wall (King, 2006). The straw bales are then braced together using a metal mesh, plastic ties or a similar material (King, 2006). The straw bale wall is then coated entirely in plaster to complete the wall system (King, 2006). This is the basic principle behind the straw bale building technique.

Straw

Merriam-Webster defines straw as "stalks of grain after threshing" (Merriam-Webster, 2011). According to Straube, it's "the dead stalks of small grain-bearing cereals" (Straube, 2009). Straw is the dried stems of grain-bearing grasses (Magwood, 2005). The usable grain is cut off the stems and the stems are then dried and bundled into bales (Magwood, 2005). Straw stalks resemble tiny, hollow tree trunks and are made of the same materials, cellulose and lignin, making them quite strong and hard to pull apart (Magwood, 2005). Wheat, barley, and oat straw are the most common sources of straw in North America (Straube, 2009).

An important distinction must be made that hay isn't the same thing as straw (Magwood, 2005). Hay is made of a combination of field grasses that are cut while still green and bundled to be used as feed for animals when fresh grass or plants are not available (Magwood, 2005). Hay has a high moisture content and is highly susceptible to critters, rot and mould (Magwood, 2005). Under no circumstance should it be used in place of straw for building purposes.

Straw bales are formed by compressing straw into packages and tying strings around the packages (Straube, 2009). There are two typical sizes, 18" wide by 14" high and 24" wide by 16 or 18" high (Straube, 2009). The length of bales can vary from 32-

40"(Straube, 2009). Densities of bales can vary, but most codes in the United States have determined that a minimum density of 100kg/m3 is desirable for building (Straube, 2009).

Plaster

The plaster that coats the walls of a straw bale building not only gives straw bale buildings their beautiful appearance, it also helps enhance all of the building envelope's properties including moisture protection, thermal resistance, fire control and structural stability (King, 2006). Plaster can be made of a variety of materials, but all have three basic components: a binding agent after which the plaster is named such as gypsum, lime or earth; a structural filler, usually sand or another aggregate; and water, needed to mix the other two components (King, 2006). Plaster should be applied in a thickness of 25-75mm (King, 2006). Any ruptures that may occur in plaster over the lifetime of the building should be repaired as soon as they are discovered in order to prevent any long-term damage to the building (King, 2006).

Straw Bale Building Community

The straw bale building community is exactly that, a community. Since straw bale building materials and techniques aren't copyrighted in any way, builders are generally eager to share their techniques and knowledge with others. Straw bale building workshops are held throughout the world, where new people can come and learn about the building techniques. Organizations such as the Ontario Straw Bale Building Coalition that exist in regions worldwide facilitate events and websites for the exchange of information about straw bale buildings (Ontario Straw Bale Building Coalition, 2011).

Ontario Straw Bale Building Coalition

In Canada, the straw bale building community has organized itself into the Ontario Straw Bale Building Coalition (Ontario Straw Bale Building Coalition, 2011). There are other similar organizations around the world, such as the California Straw Bale Building Association and the Colorado Straw Bale Building Association (Ontario Straw Bale Building Coalition, 2011). The Ontario Straw Bale Building Coalition was formed for three main reasons: to provide information about straw bale building to anyone who is interested; to support the development of straw bale building knowledge and; to create a community for straw bale builders and owners (Ontario Straw Bale Building Coalition, 2011). The Coalition believes strongly in the potential for straw bale buildings to lower our dependence on non-renewable materials and fossil fuel use (Ontario Straw Bale Building Coalition, 2011).

History of Straw Bale Buildings

Although straw bale building isn't currently a widely used technique, it is one that has existed for a very long time. The oldest known straw bale building known still in existence is in Alliance, Nebraska and was built in 1903 (King, 2006). There is evidence that straw bale structures were being built as early as the mid-1800s (Knox, 1998). By the 1890s, straw bale buildings had become quite popular in regions of Nebraska and the technique stayed there, relatively undiscovered by the rest of the world until the 1980s (Knox, 1998). It is at this time that Matts Myhrman, a graduate student in architecture from the University of Arizona, gained an interest in straw bale building and set himself upon a mission to learn about the technique (Knox, 1998). He tracked down owners of straw bale houses, one by one, gaining as much insight as he could in order to build upon his knowledge (Knox, 1998). From here, the resurgence of the straw bale building movement was born (Knox, 1998).

International Straw Bale Building Registry

Greenbuilder.com, in partnership with various regional straw bale associations, hosts the International Straw Bale Building Registry (greenbuilder.com, 2001). It is an online registry where straw bale building owners can voluntarily list their property (greenbuilder.com, 2001). The registry acts as a way for straw bale owners to share their building with the world, with online listings split into houses that welcome drop-in visitors, visitors by appointment and open to participation in organized tours (greenbuilder.com, 2011). As of September 12, 2011, there were 1541 buildings registered worldwide and eighty-eight buildings registered in Canada (greenbuilder.com, 2011). Since all listings in the registry are added voluntarily, this is not at all a complete listing of all straw bale buildings in the world (greenbuilder.com, 2011). It is estimated that there could be up to ten times this number currently constructed in the world (greenbuilder.com, 2011).

Benefits of Straw Bale Buildings

There are many reasons why an owner would choose a straw bale building: the aesthetics of a plaster building, the enhanced acoustics or the inherent environmental benefits. These environmental benefits are what appeal to the majority of straw bale builders and owners. There are three main environmental benefits that are recognized as being the most significant (Magwood, 2005). These are a savings in embodied energy, the sustainability of straw as a building material, and the enhanced thermal performance of the building (Magwood, 2005).

Embodied Energy

Embodied energy refers to the energy used to produce a material and is a common measure used in comparing the environmental impact of different systems(Magwood, 2005). Embodied energy is a measure that must be carefully examined when used in comparisons because different reports will taken different processes and part of a material's lifecycle into account (Magwood, 2005). Here, embodied energy will simply consider the energy that is used directly in the creation of a building material.

Table 1 compares the estimated embodied of energy of straw bales with some common building materials. These values only account for the energy used in production of the materials (Magwood, 2005). The values are measured by weight on a per kilogram basis, making heavier building materials have a smaller value (Magwood, 2005). Straw bale, however, is both light and has a smaller a significantly smaller value, showing that its embodied energy really is much smaller than that of other common building materials.

Table 1: Common Building Materials' Embodied Energy

Material	**Embodied energy (MJ/kg)**
baled straw	0.24
fibreglass	30.3
expanded polystyrene plastic	117
cement	7.8
virgin steel	32
recycled steel	10.1
virgin aluminum	191
recycled aluminum	8.1

(Magwood, 2005)

Sustainability of Straw

Straw is considered to be a truly renewable material. While in comparison to other building materials, wood seems quite renewable, it takes many years for a tree to grow to a point where it can be harvested for useful wood. Straw on the other hand, needs just a single season in order to grow to a point where it is harvested and baled (Magwood, 2005). This single season growing time makes straw one of the few truly renewable materials used for building (Magwood, 2005). On top of this, it is estimated that enough straw is produced annually to meet all the residential building needs of North America (Magwood, 2005). Although it is extremely improbable that all North American housing will be replaced by straw bale buildings, this does show the extent to which straw is suitable for this purpose.

Thermal Performance

The thermal performance of a building refers to how much heat escapes a building during the winter months, or enters a building during the summer months, typically measured in R-value. This is what determines how much energy is required to heat or cool a building and is considered the top benefit of straw bale buildings (Magwood, 2005). Although other buildings are able to achieve the same thermal performance as straw bale buildings, it requires a much more expensive and more material intensive approach to the wall system (Magwood, 2005). Whether a person cares about impacts on the environment or is simply trying to save money on heating bills, the incentive exists to own a straw bale building (Magwood, 2005).

Technical Properties of Straw Bale Buildings

There are some common properties to all straw bale buildings that must be considered when constructing any structure. These are voids, pinning, water protection, details, and precompression.

Voids are gaps in the straw bale that can be found within bales, between different bales and between bales and windows to name a few. These voids must be filled with either a straw-clay mixture or a spray insulation (King, 2006). A continuous wall of straw bale must exist for plaster to properly adhere to the straw, so this is an important step (King, 2006). This also helps prevent any problems with firestopping and providing a continuous level of thermal and acoustical insulation (King, 2006).

In the same way that typical walls must be braced during the construction phase, straw bales must also often be braced during their stacking (King, 2006). In some instances, bamboo rods have also been pinned to the walls permanently to increase wall stiffness (King, 2006).

The saying 'a good hat and a good pair of shoes' as being important for protection from rain applies to straw bale buildings as it does people (King, 2006). Bales must be separated from the foundation by some form of moisture barrier to ensure the bales are never sitting in water (King, 2006). A standard roof can be built on straw bale buildings, but overhangs to protect the walls from rain are very important (King, 2006).

Attention must be paid to all details, including where windows and doors are added to the building (King, 2006). Windows and doors can sit on the foundation, be supported by wood or alternatively 'float' amongst the straw bales in the wall (King, 2006). Where cabinetry or other heavy pieces are planned to hang from the walls, wooden stakes are pounded into the straw bales and used for mounting (King, 2006). Grooves for conduit and pipes can be cut out of the straw using a chainsaw (King, 2006).

Straw bales are compressed heavily when baled, but will still compress more over time so should be compressed manually as well as possible before being stacked (King, 2006). After being stacked, straw bales should also be compressed together as well as possible using polyethylene or nylon packing strips (King, 2006). Compressing the bales helps prevent cracking that can occur as bales naturally compress over time (King, 2006).

Fire Protection

Fire protection is of high concern for everyone in any sort of structure. It is such an important issue that it has its own code of regulations, the National Fire Code of Canada (National Research Council Canada, 2010). The National Fire Code of Canada sets out regulations for construction; use and demolition of buildings; design, construction and conditions of use for certain elements of buildings that can present hazards; and protection measures for use of buildings (National Research Council Canada, 2010).

When it comes to design for fire protection, it is less an issue of whether or not a building can burn and more an issue of whether or not occupants can escape while a building is burning (King, 2006). Fire safety in a wall system is expressed as a function of fire resistance, meaning a measure of how long a conflagration can exist on one side of a wall before the materials on the other side of the wall ignite (King, 2006). In order for a fire to burn well, it requires a high temperature, a fuel source and oxygen (King, 2006). Since straw bales are so densely compacted, it's difficult for oxygen to flow into them (King, 2006). Because of this, in a straw bale wall fire, the outside layer of a bale will char, but the inside will typically just smoulder (King, 2006).

Many fire tests have been performed and continue to be performed on straw bale buildings, throughout the world, all of which show that straw bale buildings conform to current fire standards (King, 2006). Some think that straw bale should conform to fire code regulations and testing set out for wall insulation, but this is misguided (King, 2006). Insulation is contained within a cavity and is just one aspect of a wall. In a straw bale wall, the straw is the wall and can be thought of as being more similar to a log cabin than insulation (King, 2006). This makes tests that are made for insulation's fire resistance irrelevant when performed on straw bale walls (King, 2006).

Heat Flow

The amount of heat flowing through a wall directly relates to how much heating or cooling is required for a building. It is measured with an R-value, which is a measure of an assembly's resistance to heat flow (Building Science Corporation, 2011). In metric, the units are m2˚K hr/W and in imperial the units are ft2˚F hr/Btu (Building Science Corporation, 2011). The higher the R-value is, the more resistant to heat flow the wall is.

Walls with higher R-values are more resistant to heat escaping or entering, meaning less of a need for heating and/or cooling.

A tested R-value for a conventional wall is often much different than the actual performance of a wall due to thermal bridges (Magwood, 2005). Thermal bridges are areas where there is a break in insulation, such as at a stud in the wall. Heat flows much more easily through these areas, greatly diminishing the wall's overall ability to resist heat flow, meaning that even though a certain insulation may be advertised to have a high R-value, it's actual performance when installed in a wall will be much less. Since straw bales are so much thicker than any sort of wood support or stud within the wall, straw bale walls see much less of a thermal bridging effect, if any effect at all (King, 2006).

Although there is some debate about the actual R-value of straw bale walls, it has been shown that a typical straw bale wall will have a value of approximately RSI5 or R28 (Fugler, 2002). Typical 2X6 stud walls that are used in most buildings have a value of RSI2.5 or R19 (Fugler, 2002). The Canadian Mortgage and Housing Corporation performed a study comparing eleven straw bale houses with eleven control houses that met the standards set in the 2001 British Columbia Building Code (Fugler, 2002). The straw bale houses were actually built and their properties measured (Fugler, 2002). The equivalent 'typical' houses were modelled using HOT2000 software, a program used to model building energy use (Fugler, 2002). It was found that nine of the eleven straw bale houses used less energy for heating and on average, the straw bale houses used 20% less energy for heating (Fugler, 2002).

Structure

When examining the structure of a straw bale wall system, it must be remembered that the whole is much stronger than the sum of the parts (King, 2006). Although straw may not initially seem like it is that strong structurally, when compacted into straw bales, stacked together and sealed with plaster, it becomes a very strong wall system (King, 2006). There has never been a recorded structural failure of a straw bale building, there has, however; been difficulty in performing a structural analysis of the wall system (King, 2006). The straw bale wall system is unlike any wall system currently analysed so it doesn't conform to any of the typical analysis techniques (King, 2006).

There are two different methods of structurally supporting a straw bale building; the Nebraska or load-bearing method and the post-and-beam or non-load-bearing method (King, 2006). The post-and-beam method involves building a wood structure and roof before filling in the walls with straw bales (King, 2006). The load-bearing, or Nebraska method, named after where it originated, involves building the straw bale walls, then adding the roof, which is completely supported by the straw bale walls (King, 2006). Although all straw bales are capable of supporting the load of the building, making wooden supports a bit redundant, both methods are used due to their respective advantages (King, 2006).

The non-load-bearing method is much more common way of building for a variety of reasons (King, 2006). Firstly, the non-load-bearing method is more adaptable to different styles of buildings and makes it easier to include windows, doors and other features, which are often used for passive solar heating (King, 2006). Secondly, there is much less resistance to this method when trying to obtain a permit, mortgage and/or insurance for a new building (King, 2006). Thirdly, if there is localized damage to a part of the wall system, that area can easily be replaced since it isn't bearing any of the structural load (King, 2006). Lastly, this method allows the roof of the structure to be built before the walls, which enables the roof to be used as protection from the rain for the straw bales during the remainder of the construction (King, 2006).

There are also advantages to the load-bearing method, making it more attractive to some builders (King, 2006). Firstly, this method is considered to be more environmentally sustainable since it doesn't require wood for the structure (King, 2006). Secondly, this method of building is very quick to be completed and doesn't require a great deal of knowledge, making it ideal for post-disaster recovery situations (King, 2006). Finally, this method has been shown to perform more effectively under seismic movement as it is more ductile (King, 2006). In general, any wall that is bearing its own vertical load performs well under seismic movement because the vertical load resists and prevents the wall from overturning (King, 2006).

Moisture Control

Controlling moisture is extremely important in any building envelope, whether it be made from conventional building materials or from straw. The problems arising from moisture can include rot, dissolution, staining, mould, corrosion, freeze-thaw damage, cracking and/or swelling (Straube, 2009). In a straw bale building, moisture can cause mould growth, rot of wooden supports and corrosion of any steel parts (Straube, 2009). All of these same problems can be seen with standard wood frame construction as well (Straube, 2009).

In order for moisture to cause problems within a building envelope, four conditions must be satisfied: a moisture source must be present, there must be a means for the moisture to travel, there must be a driving force to cause moisture movement and the assembly must be susceptible to moisture damage (Straube, 2009). In an ideal world, these four conditions would all be eliminated through the building envelope design (Straube, 2009). In reality, this isn't possible from an economic or practicality view point, so the goal of building envelope design is to control moisture and reduce its risk of damage (Straube, 2009). In other words, building envelope designers accept that moisture will enter into any wall system and they need to include a way for it to exit. Wall systems are designed to be able to withstand a certain amount of moisture and with a way for this moisture to escape from the system. This is referred to as a moisture balance, meaning there is a balance between wetting and drying, and moisture isn't able to accumulate over time causing problems (Straube, 2009). Straw and wood can both typically store around 20% of their weight in water without any damage (Straube, 2009).

There are four main ways for moisture to be removed from a building system: evaporation from the outer or inner layer of the wall, drainage which is driven by gravity, transportation of vapour, and air flow (Straube, 2009). Typically, drainage provides the quickest, highest volume solution to drying and is achieved through a rainscreen principle, where there is an air space between the outer layer of the wall and the inner insulation where water can drain out of the system (Straube, 2009). This approach, however, cannot be used in the case of straw bale building because the stucco must be directly bonded to the straw in order for the wall system to be effective (Straube, 2009). For a straw bale building, moisture is removed by diffusion through the wall or evaporation from the plaster wall surface (Straube, 2009).

There are three main sources of moisture for a building closure: the condensation of water vapour moving through the wall by diffusion, precipitation, in particular driving rain, and built-in stored moisture in building materials (Straube, 2009)(Straube, 2009). In addition to this, below and/or at grade, the building enclosure can be affected by moisture coming from things such as surface run-off, melting water or high water tables (Straube, 2009). Of these, driving rain is the largest and most common problem amongst straw bale buildings (Straube, 2009). Overhangs have been proven to be very effective in reducing damage from rain and a minimum of 400mm for a one-story building or 600mm for a two-story building is recommended (Straube, 2009). Experience has also shown that joints and penetrations are very susceptible to rain damage and extra precaution, and appropriate membranes and flashings should be used in these areas (Straube, 2009). This is something not only seen in straw bale, but in all enclosures.

National Building Code of Canada

The National Building Code of Canada is developed and updated by the Canadian Commission on Building and Fire Codes (National Research Council Canada, 2010). The Commission is an independent committee comprised entirely of volunteers that was created by the National Research Council of Canada (National Research Council Canada, 2010). Codes are developed through a consensus-based approach with voluntary input from a variety of groups (National Research Council Canada, 2011). Nine standing committees review and develop changes before they are given to the public for review (National Research Council Canada, 2011). Provincial input is gathered through the Provincial/Territorial Policy Advisory Committee on Codes (National Research Council Canada, 2011). The first National Building Code of Canada was published in 1941, with it being updated periodically since that time up to the present (National Research Council Canada, 2010). At any time, anyone can submit a suggested change to the Building Code of Canada by filling out a form available on the National Research Council's website (National Research Council Canada, 2010).

The provinces and territories have the power to regulate the design and construction of new buildings, as well as their maintenance and fire systems within the buildings (National Research Council Canada, 2011). The national building, fire and plumbing codes were created as model codes and it is the decision of each province and territory as to whether or not, or how much of the model code they will enforce (National Research Council Canada, 2011). In New Brunswick, Manitoba and Saskatchewan, the building, fire and plumbing codes are all adopted province-wife with some modifications and additions (National Research Council Canada, 2011). In Newfoundland and Labrador, the fire and building codes have been adopted province-wide with some changes, and there isn't a province-wide plumbing code (National Research Council Canada, 2011). The Northwest Territories, Yukon and Nunavut have adopted the building and fire codes territory-wide and Yukon also enforces the plumbing code (National Research Council Canada, 2011). Prince Edward Island has adopted the plumbing and fire codes province-wide, while the building code is the jurisdiction of individual municipalities (National Research Council Canada, 2011). Alberta and British Columbia enforce their own building, fire and plumbing codes that are very similar to the national codes (National Research Council Canada, 2011). Ontario has building, fire and plumbing codes that are based on the national codes, but have significant differences in content and scope (National Research Council Canada, 2011). Quebec has building and plumbing codes that are very similar to the national codes with some additions, and major municipalities enforce the National Fire Code (National Research Council Canada, 2011).

Straw bale in other countries

The resurgence of straw bale buildings in the 1980s began in the United States and has since spread worldwide (King, 2006). Today, there are straw bale buildings that have been built in many countries (King, 2006). In different countries, straw bale building owners have gone through different processes in order to gain permission to build their straw bale building, raging from building in a region where no building code or permitting process exists, to areas where fully enforced straw bale building codes exist (King, 2006).

United States

The first straw bale building code was introduced in Tucson, Arizona, United States in 1996 (King, 2006). This code acted as a pioneering document for the industry and many of the other straw bale building codes now in existence have been based on this initial code (King, 2006). This initial code has also acted as a learning experience, with other jurisdictions observing where the code is too prescriptive or alternatively, not prescriptive enough (King, 2006).

International Building Code

In the United States, the majority of the states enforce the International Building Code, which is developed by the International Code Council (International Code Council, 2011). The International Code Council and International Building Code is younger than the Canadian version, with the Council being created in 1994 in response to a desire for unified codes (International Code Council, 2011). The Council is a non-profit organization and to date has published thirteen different codes, among them the International Building Code, International Fire Code and International Plumbing Code (International Code Council, 2011).

International Green Construction Code

Since 2009, the International Code Council has been developing the International Green Construction Code (International Code Council, 2011). The second draft version of the code is currently under review and the final version is scheduled to be published in March 2012 (International Code Council, 2010). This code is striving to create a model code for green building technologies in both new and existing buildings (International Code Council, 2011). Straw bale buildings have been included in the current version of the code, meaning they will more than likely be included in the final published version. Section 507 of the code is dedicated to straw bale construction and outlines a standard for bale properties, moisture control and structure (International Code Council, 2010). The straw bale section was added to the code after a proposal was submitted by the California Straw

Building Association and architect Martin Hammer (California Straw Building Association, 2011).

Australia

In Australia, straw bale buildings are permitted according to the Building Code of Australia (King, 2006). They are classified as an 'Alternative Building Solution' (King, 2006). As such, they need to adhere to 'performance requirements' or shown 'deemed to satisfy' the provisions of the code for building construction (King, 2006).

Belarus

Belarus was the first jurisdiction outside the United States to publish a straw bale building code in 1999 (King, 2006). The code includes requirements for the quality, moisture content and density of the straw bales used (King, 2006). Straw bale can only be used for insulation infill, meaning no load-bearing structures, only post-and-beam style structures (King, 2006).

China

There is currently no straw bale code in China, but hundreds of straw bale homes have been built in China, due in large part to the work of American architect/builder Kelly Lerner (King, 2006).

Czech Republic

In the Czech Republic, all structures, whether they be a large building or just a small shed, require drawings, a technical report, a fire safety report and statements from local governments regarding utilities in order to obtain a building permit (King, 2006). All building materials used must also have been tested and received an 'agreement protocol', but such a certification for straw bale doesn't currently exist (King, 2006). Two permitted straw bale buildings have been built in the country and they required specialists to vouch for the quality of the straw bales in order to get around the tested materials requirement (King, 2006).

Denmark

The Danish Building and Urban Research Institute has published a sixty page document outlining all testing and design guidelines for straw bale construction (King, 2006). It is an extensive document that was published in 1994 (King, 2006). Although it isn't a building code, having been published by the highest building authority in the country, it is a very useful tool to take to building officials when attempting to get a permit for a straw bale building (King, 2006).

France

In France, it is illegal to not grant a building permit purely due to a building material choice, so straw bale buildings are able to easily obtain permits (King, 2006). Builders have trouble, however, getting insurance for their buildings (King, 2006). It is believed that this would be eased by the introduction of a DTU, the French equivalent of a building code, for straw bale buildings (King, 2006).

Germany

In February 2006, Germany adopted a straw bale building code, becoming the second straw bale code adopted outside of the United States (King, 2006). The code is however, a bit restrictive and it only allows straw bale to be used in an infill insulating capacity (King, 2006).

United Kingdom

In the United Kingdom, there is a set of National Building Regulations which act more as a guideline than as a prescriptive code (King, 2006). Each region has a Local Authority Building Control Department which enforces these regulations (King, 2006).

There is no mention of straw bale building in the regulations, but straw bale permits are obtained without problems (King, 2006). Private enterprises are also now able to give permits and ensure buildings meet the regulations (King, 2006). With this rule, a single company is able to specialize in a certain type of building and give building permits across the country, regardless of location (King, 2006).

Ireland

The system in Ireland is very similar to the system in the United Kingdom, with the Irish Building Regulations acting as a guideline for all buildings in the country (King, 2006). Architects and designers bear most of the responsibility in ensuring the building meets the regulations and there hasn't been much trouble obtaining permits for straw bale buildings (King, 2006).

Italy

Italy's building code is quite rigid and has no mention of straw bale buildings, but straw bale buildings have successfully received permits and been built in the country (King, 2006).

Japan

The Japanese building code does not mention straw bale buildings, but straw bale building permits have been obtained (King, 2006). Tea rooms, garden rest places and rooms less than ten square meters do not require a permit and can be built from any building material, including straw bale (King, 2006).

Mexico

Not all areas of Mexico require a building permit in order to build, so straw bale buildings are being built in areas where permits are not required (King, 2006).

Mongolia

Many straw bale buildings, including health clinics, have been built in Mongolia with government approval (King, 2006). Work has been done on trying to create a national straw bale building code, but working with the bureaucracy of the country has proven difficult and the code has yet to be implemented (King, 2006).

The Netherlands

Building officials are generally enthusiastic about ecological building projects in the Netherlands so straw bale buildings don't receive much opposition when trying to obtain a building permit (King, 2006). Building officials do, however, require documentation and an explanation of the building process when applying and codes from other countries act as a good source for this process (King, 2006).

New Zealand

There is currently no straw bale building code in New Zealand, but the Building Research Association of New Zealand and the Building Industry Authority have both created advisory bulletins for straw bale construction (King, 2006). Architect Graeme North also published an article titled 'Guidelines for Strawbale Building in New Zealand' (King, 2006). These three documents are used as informal guidelines for straw bale buildings in the country (King, 2006).

Russia

There currently isn't any acceptance for straw bale building in Russia, but there are straw bale advocates in the country who would like to see it put on the National Building Materials List (King, 2006).

Inclusion in the Code

The inclusion of straw bale building in the National Building Code of Canada has both positive and negative impacts on the straw bale building industry. Although the National Building Code is simply a model building code and each province would enforce any information regarding straw bale at their own discretion, its inclusion in the code would become a nation-wide standard for straw bale buildings, regardless of whether the code is enforced or not.

Advantages of Inclusion

The major advantage of straw bale building being included in the building code is that there is then a set standard for the building practice. Currently, straw bale buildings are built to a different standard in different areas, depending on the criteria that the building official requires for a building permit. This in turn makes the work of the building official much easier because there is a standard for them to follow, as opposed to simply following precedent set in other areas. Currently a building official may require drawings from an engineer or architect, among other documents, in order to grant a building permit for a straw bale building. Having set criteria to follow in the building code will prevent these extra documents from needing to be produced.

Inclusion will also promote the construction of straw bale buildings. Not only will the initial addition to the building code bring straw bale building to people's attention, but their inclusion will make people feel more at ease with the process. The inclusion will make the concept of straw bale building seem less foreign causing more people to be willing to build their house with the sustainable material. This will also make it easier for building owners to obtain mortgages and insurance for their straw bale buildings.

The status of straw bale building in relation to building codes for various countries was mentioned above and, as was listed, many countries and/or regions have implemented some sort of code or standard with regards to straw bale building. If Canada were to not adopt any sort of provisions with regards to straw bale building, it's possible that it will fall behind other countries in terms of sustainable building standards. The inclusion of a straw bale building standard could also pave the way for other sustainable or alternative building practices to make their way into the code and Canada could, alternatively, become a world leader in sustainable building.

Disadvantages to its Inclusion

The large disadvantage to adding straw bale building to the National Building Code of Canada currently is that the current building methods may not be the ideal methods and enshrining these in the code will hinder the process' development. The building process is still continuing to evolve and there is a concern that including a process in a building code will stifle the industry's innovation. Further, the process for adding standards to the building code is a long and often costly one. The addition of straw bale building to the code, and any subsequent changes due to the process' evolution, could potentially require a lot of experts' time and taxpayers' money.

Recommendations

Add Straw Bale Building to the National Building Code of Canada

After examining the above listed advantages and disadvantages to straw bale buildings' inclusion in the building code, it has been deemed that the advantages highly outweigh the disadvantages and straw bales buildings should be added to the National Building Code of Canada. As it can take many years for a change to the building code to come into effect, the process of working towards inclusion should begin now. Ideally this process would involve the formation of a committee that examines whether there are any gaps in technical testing knowledge so these tests can be conducted as soon as possible. This committee would also work towards creating a code that isn't too prescriptive and doesn't hamper the development of improved straw bale building techniques. The code could build upon other codes that have been implemented in other countries throughout the world.

Smaller Scale Code

In many regions of the world, straw bale building codes and standards either exist, or started as codes in a smaller region, such as a municipality, before developing into larger national codes. This same concept could work here in Canada. A straw bale building code would be implemented in a municipality or town, perhaps in Ontario where the Ontario Straw Bale Building Coalition is active. This code could then be used to evolve into a larger scale code for inclusion in the National Building Code of Canada.

Straw Bale Education

Greater education is needed surrounding straw bale building, both on the academic and public awareness front. The education of architects, engineers, designers and builders needs to be expanded to include straw bale building and other environmentally sustainable techniques. There also needs to be an increase in public awareness of the availability of alternative building systems like straw bale, as well as their advantages over traditional techniques.

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