DRAFT

Building Green in Cleveland

An appendix to the City of Cleveland Residential Code
to guide the creation of residential living spaces
that minimize long-term impacts on the environment

Prepared by The HouseMender, Inc. for the Cleveland EcoVillage Project,
a partnership of the Detroit-Shoreway Community Development Organization
and EcoCity Cleveland.
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Comments are appreciated on this draft document.
Please send suggestions to the contacts listed on the following page.

Project background

This green building code appendix is an initiative of the Cleveland EcoVillage, a development project in the Detroit Shoreway neighborhood on the west side of Cleveland. Since the EcoVillage aims to demonstrate advanced techniques of green building—such as energy efficiency, passive solar design, nontoxic building materials, considerations of life-cycle costs, and alternative forms of wastewater treatment—the project organizers wanted to make sure that the City of Cleveland residential building code would not impose unnecessary restrictions on high-performance design. So the project commissioned this unofficial "green appendix" to the new code that the City is planning to adopt. The appendix offers guidance to those wishing to build in a more environmentally responsible manner. It is only advisory at this point, but it is hoped that the ideas will eventually become a standard part of the code. The project is working with City officials to make that happen.

For more information

The Cleveland EcoVillage is a partnership of the Detroit Shoreway Community Development Organization and EcoCity Cleveland. For more information:

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Additional information about the EcoVillage project can be found on the Web at www.ecocitycleveland.org.

Acknowledgements

This appendix was researched and written by Jim LaRue of The HouseMender, Inc. David Rowe of the Detroit Shoreway Community Development Organization and Manda Gillespie of EcoCity Cleveland managed the project. Peter Yost of Building Science Corporation conducted a technical and editorial review of the contents. David Beach of EcoCity Cleveland helped to edit the final document. Special thanks to Linda Hudecek, director of Community Development for the City of Cleveland and Robert Vilkas, Building and Housing commissioner for the City for their encouragement and suggestions during the development of this work.

Disclaimer

While every effort has been made to provide accurate and authoritative information, this appendix should not be construed as professional advice. If expert assistance in architecture, engineering or other building profession is needed, please seek qualified professional services.

How to read this appendix

The following chapters parallel the format of the 1999 Ohio Residential Code, which the City of Cleveland is now considering for adoption. **Quotations from the official code are printed like this**, and then ***"green" guidelines are included like this to provide additional ideas that the green builder should consider***.

These materials will be updated regularly, and persons wishing to provide new information for consideration should bring it to the Building and Housing Offices at City Hall or to the staff of the Cleveland EcoVillage project.

Contents

Introduction

Residential building codes have played a major role in promoting the integrity of structures and protecting the health and safety of occupants. Over time, the scope of residential building codes has grown to reflect broader issues, such as how the home and its occupants relate to the environment (energy codes being a prime example).

In the last 20 years, we have become more aware of the profound environmental impacts of home construction and operation. Vast quantities of raw materials are required for home construction. These materials must be shipped to a place where they can be made into useable building products, with significant transportation costs and impacts on the environment. The manufacturing process often requires large amounts of energy and produces air pollution and other harmful waste by-products. Some building materials are made with hazardous chemicals that can harm human health and the environment. Once built, the energy efficiency and maintenance requirements of a house cause ongoing impacts. And finally, when a house is no longer useable or economically viable, it has impacts when it's torn down and taken to a landfill.

Equally profound is the growing realization that the building of residential structures is not just about using alternative materials that are environmentally friendly, but it is about system thinking and integrating building systems to achieve significant reduction in the environmental impact of building. How a building system handles moisture, temperature and pressure differences (both inside and out) is critical for everything from energy savings to avoidance of mold growth. How we connect all these elements together is as important as the materials themselves.

This appendix to the City of Cleveland residential code is one attempt to address this new reality in residential building. The appendix is prepared as a guide for those who wish to practice green (or sustainable) building. It contains information for both prospective homeowners and builders—and for everyone else who wishes to harmonize human habitats and natural systems.

Cleveland building officials, like their counterparts in more and more cities around the country, want to encourage the best quality building possible. By incorporating the concepts of green building, the city hopes to encourage the creation of residences that are healthier, more economical, and environmentally friendly. This is a big step toward the building of a more sustainable city.

A Word About the Codes We Use

There are two basic types of code for residential building construction: prescriptive code and performance code. A prescriptive code tells the builder and the code official *how* to build with exacting direction. A performance code tells the builder and code official *what* the building should achieve and leaves the exacting directions out. Some builders take comfort in the clear and unambiguous nature of prescriptive codes; others prefer the discretion and freedom of professional judgment that performance codes offer.

In an effort to bring some uniformity to the codes and to take into consideration climactic differences across the United States, three code bodies have evolved over time:

- Building Officials and Code Administrators National Building Code (BOCA), which is used in the Northeast and Midwest;
- International Conference of Building Officials Uniform Building Code (ICBO), which is used in the West;
- Southern Building Code Congress International (SBCCI), which is used in the South.

In September l999, these three bodies joined to create the International Residential Code (IRC), which was published in January of 2000. The consolidation of code work into a common code means that a level playing field is being developed so that all the players in the residential housing industry—city planners, architects, developers, city building officials, builders, and prospective homeowners—will increasingly be using the same language and the same guidelines. The timing could not be better for attempting to expand the code by incorporating what we are learning about how to make our living spaces more environmentally friendly.

Each state adopts a code, which it can adapt to meet the needs of its climate and geography. Then county and municipal governments, while having to adopt all the content of the state code, can make amendments to that code based on an even finer definition of climate and geography.

Presently the City of Cleveland still uses an earlier version of a collective residential code known as the Council of American Building Officials (CABO) One and Two Family Dwelling Code (the l989 version). The City Council will soon consider adopting the l999 Ohio Residential Code, which is based largely on the l998 International One-and Two-Family Dwelling Code, the precursor to the 2000 International Residential Code.

Increasingly, building departments around the country are moving toward more performance-based code. A performance code permits carefully documented experimentation in building science to occur. This is essential if new green building methods are to be developed and tested—and if standards are to be expanded to protect the larger environment. Both prescriptive codes and performance codes must observe "the minimum requirements to safeguard life or limb, health and public welfare," but green building attempts to recognize the many additional impacts residential buildings have on occupants and the environment over the life of the structure. At this time, we cannot be sure how the tension between prescriptive and performance code will be played out, but we do know that we cannot stop the evolution of residential building.

The health of our city and the region requires us to be vigilant in our protection of the environment and diminishing natural resources, for a failed environment can become a threat to life, health and the public welfare of its residents. It is clearly a public welfare issue, and it is encouraging that Cleveland is welcoming the thoughtful and careful experimentation in green or sustainable residential building by those seeking to create living space for our residents in this city.

A Green Building / Sustainable Building Strategy

> Green building is all about science—physics, chemistry, and biology. It's really about ecology because ecology is about physics, chemistry, and biology. Green building is all about systems and integration. That's because ecology is all about systems and integration of physics, chemistry and biology.
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> Building is about shelter and creating boundaries between people and the environment. Green building is about creating optimized boundaries between people and the environment. Optimized means performing like Nature's most basic element, the cell. Cells have membranes and even walls that relentlessly observe the laws of physics and chemistry, selectively permitting and excluding passage of all manner of things into and out of the cell, all in an effort to create a secure and comfortable environment. Green buildings accomplish the same optimized selective boundaries for light, heat, moisture and would-be invaders. For the cell and the green building, optimized selective boundaries require the expenditure of energy, but as little as possible. So optimizing is about energy, too.
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> Green building is even more about energy because of really striking indirect effects. There is no shortage of energy, just limited access. The particular circumstances of our planet mean that more energy strikes the earth each day than the whole earth knows what to do with. It's the stored forms we currently use—coal, oil, natural gas, and even hydroelectric—that carry heavy duty environmental consequences. Optimal energy use in buildings is a combination of how much we use for producing and then operating our buildings. The best way to accomplish the former is to use as little of a material as possible—efficient design—for as long as possible—durability. The best way to accomplish the latter is to think like a cell-set up optimized boundaries.
>
> Green building is largely about how well and how long buildings perform. And buildings lacking an integrated systems approach will most often do neither. We need to design, construct, operate, and maintain buildings in the same way that nature builds cells—with efficiency, elegance, and unerring deference to the natural laws of physics, chemistry, and biology. A green architect or builder must be a student of science first; great buildings will follow.
>
> —Building Science Corporation (www.buildingscience.com)

Green architects, builder, and building officials must learn to become building scientists. Each site where a house is being built is a laboratory where we are learning how to build in concert with nature and human needs. To help guide this new learning, the authors of this appendix relied on two documents that are products of years of hands-on experience in residential building in the U.S and Canada.

The first work is *Builder's Guide To Cold Climates,* which offers "a systems approach to designing and building homes that are healthy, comfortable, durable, energy efficient and environmentally responsible." This book was funded by the U.S. Department of Energy, Building Science Corporation, and The Energy and Environmental Builders Association. The second guide is *Builder's Manual*, published by the Canadian Home Builders Association. This green building appendix will continually reference these works as it develops over time.

Both of these works are a superb combination of basic building science and practical, hands-on methodology for accomplishing green building. Every builder who is developing plans for residential green buildings is encouraged to use these books as a reference.

What does green building require in the development of guidelines, standards and codes for the City of Cleveland? It calls for a continuing effort in the following areas to achieve ever-higher levels of performance in every residential building rehabbed or constructed in the city:

- Save Energy—design and build energy-efficient buildings.
- Recycle Buildings—utilize existing buildings and infrastructure instead of developing virgin land.
- Create Community—Design communities to reduce dependence on the automobile and to foster a sense of community.
- Reduce Material Use—Optimize design to make use of smaller spaces and utilize materials efficiently.
- Protect and Enhance the Site—Preserve or restore local ecosystems and biodiversity.
- Select Low-impact Materials—Specify low-environmental impact, resource-efficient materials.
- Maximize Longevity—Design for durability and adaptability.
- Save Water—Design buildings and landscapes that are water-efficient.
- Make the Building Healthy—Provide a safe and comfortable indoor environment.
- Minimize Construction and Debris Waste—Return, reuse and recycle jobsite waste.

Source: *Environmental Building News*, http://www.buildinggreen.com

A Strategy For Selecting Building Materials

The very best of building materials, applied improperly or without consideration of what building science tells us, can actually produce a worse product than a poor material installed properly. With this is mind, we will be increasingly interested in how builders have been able to address the following matters when specifying building materials for their residential green building projects:

- Energy use: will the material in question have a measurable impact on building energy use?
- Occupant health: might products in this application affect the health of building occupants?
- Durability and maintenance: are products likely to need replacement, special treatment, or repair multiple times during the life of the structure?
- Hazardous by-products: are significant toxic or hazardous intermediaries or by-products created during the manufacture?
- Energy use: how energy-intensive is the manufacturing process?
- Waste from manufacturing: how much solid waste is generated in the manufacturing process?
- Resource limitations: are any of the component materials from rare or endangered resources?
- Impacts of resource extraction: are there significant ecological impacts from the process of mining or harvesting raw materials?
- Transportation: are the primary raw materials located a great distance from your site?
- Demolition waste: can the material be easily separated out for reuse or recycling after its useful life in the structure is over?
- Hazardous materials from demolition: might the material become a toxic or hazardous waste problem after the end of its useful life?
- Review of the results: go over any concerns that have been raised about the products under consideration, and look for other life-cycle impacts that might be specific to a particular material.
  (from *Environmental Building News*: http://www.buildinggreen.com).

Chapter 1: Administration

The Administration chapter in the code defines the relationship between the jurisdiction where the residence is being built and the owner/builder/developer during the building process. It defines the purpose of the code, its scope and who in the jurisdiction is responsible for seeing that all the codes are enforced. It spells out the procedures to be followed that will permit the building officials to see the project at appropriate times to determine if the work is progressing consistent with the code. It also outlines the legal penalties to be assessed if the owner/builder/developer does not observe the codes or rulings by building officials.

The l999 Ohio Residential Code (ORC) states in 102.1 Minimum Standards:
"The purpose of this code is to provide minimum standards for the protection of life, limb, health, property, environment and for the safety and welfare of the consumer, general public, and the owners and occupants of residential buildings regulated by this code."

Green building or sustainable building code attempts to insure healthier living spaces that have a minimum negative environmental impact both during their construction and while they are occupied. There are increasingly strict regulations to protect our environment from the side effects of automobile manufacture and use and we are now becoming increasingly aware of how the creation of building materials, the construction of homes and the operation and maintenance of these homes can have some negative impact on the occupants, the rest of the citizenry and the environment itself.

The purposes described in the ORC can easily be considered to cover the concerns of green building. It is a new emphasis that clearly fits under the umbrellas provided by the purpose statement in 102.1 Minimum Standards.

The following are some issues addressed in the 1999 ORC Chapter 1:

1. Permits are required for all significant residential building work and a critical part of obtaining most permits is a detailed site plan (ORC: 111.3). In addition to the usual plot plan requirements to detail how the lot sits in relation to other properties and what buildings are already on the site that may be demolished, ***green building is concerned that the orientation of the site (N,S,E,W) is noted for possible solar uses, that shade trees and other natural vegetation that could help with summer cooling or reduce winter wind effects be identified and that a demolition plan which includes deconstruction and recycling options for all the existing building materials be included.***
2. Inspections of the building during the construction process are critical. There is a rough-in inspection done before walls are backfilled or closed in. These inspections tend to deal primarily with the structural placement of things. Green building brings some new dimensions to these inspections, which are covered in more detail in other sections of the code, but the following are some examples of

some additional green building concerns about inspections during the building/remodeling process.

ORC 113.1 Foundation inspection:
"Inspection of the foundation shall be made after poles or piers are set or trenches or basement areas are excavated and forms erected and any required reinforcing steel is in place and prior to the placing of concrete. The foundation inspection shall include excavations for thickened slabs intended for support of load bearing walls, partitions, structural supports or equipment and special requirements for wood foundations."

Green building adds that examination of moisture and water control measures taken to protect the foundation from a variety of types of moisture entry be included. Moisture control is critical to reducing the amount of moisture entering the living space so the chance of molds developing is reduced and dust mite levels are more effectively controlled.

ORC 1132.1.2 Plumbing, Mechanical and Electrical Inspection
"Rough-in inspection of plumbing, mechanical and electrical shall be made prior to covering or concealment, before fixtures are set and prior to framing inspection."

Green building standards for rough-in inspection include air-sealing of all openings cut through any framing or surfaces during the process of installation and air sealing of electrical receptacles and ductwork with effective, long lasting sealants. Every effort should be made to have heating run pipes or ducts placed inside the building envelope and not in the exterior walls or unconditioned spaces. When this is not possible, measures should be taken to insure effective insulation of the exposed parts of the delivery systems. A ventilation system that addresses the air change needs of the entire structure is roughed-in with all its ductwork effectively sealed.

ORC 113.1.3 Frame and Masonry Inspection
"Inspection of the framing and masonry construction shall be made after the roof, masonry, all framing, fireblocking, draftstopping, and bracing are in place and after the plumbing, heating and electrical rough inspections are approved."

Green building is equally concerned with the fire and structural concerns that are the focus of this inspection, but is also concerned that the exterior envelope in a building also be inspected for proper air and moisture sealing of the exterior surfaces of the structure.

Green building actually adds another layer of inspection concern for it recognizes that a building is a system that can be affected by just about

everything that is done anywhere in the structure. Holes left by plumbers running their waste stacks to the roof can be places where significant heat loss can occur and warm moist air can escape into a cold attic where it can condense and generate mold. Green building is not afraid of inspection, indeed, it welcomes it, but it is concerned that the inspection incorporate the concerns that eventually make a house last longer, be healthier for the resident, and have the least impact on the environment while it is in use and when it is eventually dismantled.

To this end, green building welcomes performance testing of the building envelope, using blower doors, duct blasters, and room pressure testing. Building knowledge and technique has been significantly advanced by such testing, for it simply demonstrates where there is air leakage so it can be corrected before the building process proceeds any further.

Chapter 2: Building Definitions

All building codes include a chapter on building definitions that are a "dictionary" of words used in the writing of the codes. It is an attempt to help everyone who uses the codes be on the same page. The same is true for green building. To help articulate new concepts represented by sustainable or green building there are some new words and phrases now commonly used in the field. Below is a sampling of these new terms being used in residential construction, beginning with the definition of green or sustainable building.

green building: The first Green Builder Program in the United States was created in l991 in Austin, Texas. Pliny Fisk, the man behind that program defined green building or sustainable building in a most helpful way when he wrote:

> "Sustainability", according to *Webster's American Heritage Dictionary*, is to "keep in existence; maintain." As it relates to the world we live in, sustainability means meeting our present needs without compromising the needs of future generations. The sustainable approach recognizes the interaction of natural and technological systems on our planet, and seeks to minimize the adverse impacts of our everyday lives on the systems that support all life.
>
> Sustainability implies that we look at and understand our **local** environment in terms of climate, natural resources, and human resources and improve our relationship with them without jeopardizing their future usefulness. Recognizing the nature of the interdependence of the human and natural environment is a key concept toward understanding sustainability. A sustainable approach encourages people to become a part of the natural flows and cycles of our world and not seeking to overpower them.
>
> "Thinking globally", the Green Builder Program is designed to help Austin homebuyers "act locally" by offering environmentally sound residential building choices."

acceptable indoor air quality: air in an occupied space toward which a substantial majority of occupants express no dissatisfaction and in which there are not likely to be known contaminants at concentrations leading to exposures that pose a significant health risk (ASHRAE 62-1989 revision)

active solar heating: heat from the sun is absorbed by collectors and transferred by pumps or fans to a storage unit for later use or to the house interior directly. Controls regulating the operation are needed.

active solar water heater: heat from the sun is absorbed by collectors and transferred by pumps to a storage unit. The heated fluid in the storage unit conveys its heat to the domestic hot water of the house through a heat exchanger. Controls regulating the operation are needed.

agricultural by-products: products developed in agriculture that were not a primary goal of the agricultural activity. The most commonly used as a building product is straw, which is used in wall panels or as bales in a technique called straw bale construction with the bales used as building blocks. The straw bale construction method was common in the plains states at the turn of the century and is currently being revived in Europe and the U.S.

agricultural fiber: agricultural fibers (i.e., cotton) are just recently being introduced for use as insulation materials.

asbestos: a mineral fiber that has been commonly used in many building construction materials for insulation and as a fire-retardant. Invisible fibers of asbestos can be inhaled and have been connected to lung diseases and cancer.

brownfields: abandoned, idled, or under-used industrial and commercial facilities where expansion or redevelopment is complicated by real or perceived environmental contamination.

building related illness: the term "building related illness" (BRI) is used when symptoms of diagnosable illness are identified and can be attributed directly to airborne building contaminants.

built environment: refers to human-built structures such as single family homes.

carbon dioxide: a naturally occurring greenhouse gas in the atmosphere, concentrations of which have increased (from 280 parts per million in pre-industrial times to over 350 parts per million today) as a result of humans burning coal, oil, natural gas and organic matter (e.g., wood and crop wastes). It is attributed with being a major contributor to global warming.

carbon monoxide: a colorless, odorless gas that comes from incomplete combustion of gas stoves, fireplaces, kerosene appliances, tobacco smoke, and automobile exhaust. Proper ventilation is important to prevent negative health effects such as fatigue, dizziness, nausea and even death.

cellulose: the fibrous part of plants used in making paper and textiles. Most building products with the word cellulose imply that paper was used in the manufacture.

cellulose insulation with borates: cellulose insulation is made from recycled newspaper. The borates provide fire and vermin protection. Most cellulose insulation now uses chemical fire retardants as opposed to the natural borates. Environmentally sensitive persons should avoid cellulose insulation that contains newspaper ink, which can cause allergic reactions. There are cellulose insulation products made without inked newspaper.

cementitious foam insulation: a magnesium-oxide based material blown with air to create an inert, effective insulation. It is especially good for people with chemical sensitivities.

certified sustainably managed: some certifying organizations have been established that oversee the harvesting of wood for lumber. The underlying guidelines are for preservation of a diverse sustainable forest that exhibits the same ecological characteristics as a healthy natural forest.

chlorofluorocarbons (CFC's): a family of chemicals used in refrigeration, air conditioning, packaging, insulation, or as solvents and aerosol propellants. Because CFC's are not destroyed in the lower atmosphere they drift into the upper atmosphere where their chlorine components destroy the earth's protective ozone layer.

composite materials: a complex material made up of two or more complementary substances. They can be difficult to recycle. Plastic laminates are an example.

Composite materials are best applied in situations where they can be removed for reuse (not requiring remanufacture).

composting: a process whereby organic wastes, including food wastes, paper and yard wastes, decompose naturally, resulting in a produce rich in minerals and ideal for gardening and farming as a soil conditioner, mulch, resurfacing material, or landfill cover.

daylighting: a method of illuminating building interiors with natural light so that the use of artificial lighting is reduced in the day time. Common daylighting strategies include the proper orientation and placement of windows, use of light wells, light shafts or tubes, skylights, clerestory windows, light shelves, reflective surfaces, and shading, and the use of interior glazing to allow light into adjacent spaces.

deciduous: trees and plants that shed their leaves at the end of the growing season.

demand control ventilation: ventilation provided in response to actual number of occupants and occupant activity.

design charrette: the charrette process is focused workshop(s) which take place in the early phase of the design process. All project team members meet together to exchange ideas, encouraging generation of integrated design solutions.

domestic hardwood: deciduous trees that grow in the U.S.; this is the only type of wood in the U.S. where on a general scale the growth of new trees easily exceeds the removal rate.

dust spot efficiency: the dust spot efficiency test is a semi-quantitative measure of a filter’s collection efficiency for fine particles---those associated with smudging of the interior surfaces of buildings. Upstream and downstream paper target filters collect particles and the opacity (light transmission) is measured.

earth sheltered design: home design that is partially or totally below ground, either by digging into existing topography or filling over parts of the structure. Earth sheltered design uses the constant temperature of the soil to improve energy efficiency and can be beneficial for us on hilly sites to decrease maintenance and environmental impact.

earth's thermal energy: a short distance below the surface, the Earth maintains a mostly constant temperature very close to the human comfort range. This can be used advantageously for geothermal heating systems.

electromagnetic fields: electric and magnetic fields are common in nature and in all living things. Electric power produces fields that have a possible association with health risks.

embodied energy: embodied energy accounts for all energy expended for production and transportation plus inherent energy at a specific point in the life cycle of a product.

energy modeling: a computer model that analyzes the building’s energy-related features in order to project energy consumption of a given design.

environmentally preferable: products or services that have a lesser or reduced effect on human health and the environment when compared with competing products or services that serve the same purpose. This comparison may consider raw materials acquisition, production, manufacturing, packaging, distribution, reuse, operation, maintenance, or disposal of the product or service.

fossil fuel: a fuel, such as coal, oil and natural gas, produced by the decomposition of ancient (fossilized) plants and animals.

energy recovery ventilator (ERV): a mechanical device that draws stale air from the house and transfers the heat or coolness in that air to the air being pulled into the house. This can help reduce energy costs and dilute indoor pollutants.
exterior grade plywood: uses phenol formaldehyde (a volatile organic compound) as an adhesive that is released in much smaller amounts compared to urea formaldehyde used in interior grade plywood and particleboard.
formaldehyde: colorless, pungent smelling, toxic material used as an adhering component of glues in many wood products. It can cause respiratory problems, cancer, and chemical sensitivity.
fly ash: the ash residue from high temperature combustion processes. Electric motor plants using western coal produce a non-toxic fly ash that because of its very high calcium content can be a substitute for Portland Cement (the common bonding material in concrete).
fuel cell: a technology that uses an electrochemical process to convert energy into electrical power. Often powered by natural gas, fuel cell power is cleaner than grid-connected power sources. In addition, hot water is produced as a by-product that can be utilized as a thermal resource for the building.
full spectrum lights: these lights come closer to the natural light spectrum and are considered more healthy.
geothermal heat exchange technology: in winter, geothermal heat exchange technology utilizes heat from subsurface water and soils to heat buildings; in summer, this technology extracts heat from the building into subsurface water and soils for cooling.
greywater: wastewater that does not contain sewage or fecal contamination and can be reused for irrigation after simple filtration.
harvested rainwater: the rain that falls on a roof and is channeled by gutters to a storage tank or cistern. The uses of this water are dependent on any pollutants that may be picked up from the roof surface.
heat recovery systems: building mechanical systems that capture waste heat from another system and use it to replace heat that would otherwise come from a primary energy source.
high quality duct system: this option avoids the potential of significant heating and cooling losses, as well as avoiding potential health threats caused by depressurizing or pressurizing a house. All ducts are sealed using a fibrated latex mastic and fiberglass tape. Inner and outer linings of the duct are both sealed. The air handler, support platform and return plenum are sealed air tight at the joints. Duct tape is not used in any part of the system. No ductwork is run inside of the building envelope walls. The system can be performance tested to ensure proper installation.
hydrochlorofluorocarbon (HCFC): HCFCs are generally less detrimental to depletion of stratospheric ozone than chlorofluorocarbons. HCFCs are generally used to replace CFC's where mandates require CFC's to be eliminated. A total ban on all CFC's and HCFCs is scheduled effective 2030.
indigenous materials: to reduce transportation cost and increase viability of the local economy, building materials that are mined, manufactured or fabricated in an area close to where building will take place is always preferred.

integrated pest management: a coordinated approach to pest control that is intended to prevent unacceptable levels of pests by the most cost-effective means with the least possible hazard to building occupants, workers and the environment.
kilowatt hour: a measure of electric usage equivalent to the use of 1,000 watts for one hour.
kitchen recycling center: a built-in section of the kitchen cabinetry that allows convenient separation of recyclable materials.
lead: a harmful environmental pollutant that is typically in the home in lead-based paints and in lead solder used in plumbing before l978. Lead is toxic to many organs and can cause serious damage to the brain, kidneys and nervous system.
life cycle assessment: the comprehensive examination of a product's environmental and economic aspects and potential impacts throughout its lifetime, including raw material extraction, transportation, manufacturing, use and disposal.
life cycle cost: the amortized annual cost of a product, including capital costs, installation costs, operating costs, maintenance costs, and disposal costs discounted over the lifetime of a product.
low biocide: many paints have added fungicides and pesticides. A low-biocide paint does not include such additives.
low-e windows: "Low-E" (low emissivity) windows reflect heat, not light, and therefore keep spaces warmer in winter and cooler in summer.
low pressure drop high efficiency air filters: extended surface pleated air filters that allow greater air filtration without a significant increase in horsepower requirements.
material safety data sheet (MSDS): forms that contain brief information regarding chemical and physical hazards, health effects, proper handling, storage, and personal protection appropriate for use of a particular chemical in an occupational environment.
methane: (CH4) An odorless, colorless, flammable gas that is a major component of natural gas; it is a more powerful global warming agent than carbon dioxide.
nitrogen oxide: (NO) a colorless, poisonous gas. It is a by-product of gas combustion.
outgas: the emitting of fumes into the air; there are numerous building materials that have chemicals in them which outgas, when exposed to high temperatures, moisture and/or ozone levels.
ozone: 1. *stratospheric ozone*: in the stratosphere (the atmosphere layer beginning 7-10 miles above the earth), ozone is a form of oxygen found naturally which provides a protective layer shielding the earth from ultraviolet radiation's harmful effects on humans and the environment. 2. *ground level ozone*: ozone produced near the earth's surface through complex chemical reactions of nitrogen oxides, volatile organic compounds, and sunlight. Ground level ozone is the primary component of smog and is harmful to humans and the environment.
particulate matter: solid material that escapes from combustion processes and which can be inhaled causing potential health problems.
passive design: in home construction, the building design and placement permits the use of natural processes such as radiation, convection, absorption, and conduction to support comfort levels.
passive cooling: the building's structure (or an element of it) is designed to permit increased ventilation and retention of coolness within the building components. The intention is to minimize or eliminate the need for mechanical means of cooling.

passive heating: the building's structure (or an element of it) is designed to allow natural thermal energy flows such as radiation, conduction, and natural convection generated by the sun to provide heat. The home relies solely or primarily on non-mechanical means of heating.
passive ventilation: passive ventilation relies typically on using both convective air flows that result from the tendency of warm air to rise and cool air to sink and taking advantage of prevailing winds. Many passive ventilation systems rely on the building users to control window and vents as indicated by site conditions and conditions within the building.
passive solar water heater: a water heating system that does not require mechanical pumps or controls to create hot water for domestic use.
pervious paving: paving material that allows water to penetrate to the soil below; this reduces the amount of water that needs to be treated by the water system and increases the water in the aquifer.
photovoltaic panels (PV's): photovoltaic devices use semiconductor material to directly convert sunlight into electricity. Power is produced when sunlight strikes the semiconductor material and creates an electrical current.
post-consumer recycled content: post-consumer material is a material or finished product that has served its intended use and has been discarded for disposal or recovery, having completed its life as a consumer item.
pre-consumer recycled content: pre-consumer material is material diverted from the waste stream following an industrial process, excluding reutilization of materials such as rework, regrind or scrap generated in a process and capable of being reclaimed within the same process. Synonyms include post-industrial and secondary material.
radon: a radioactive, colorless, odorless gas that occurs naturally. When trapped in buildings, concentration build up, and it can cause health hazards such as lung cancer.
R-value: a measure of the thermal resistance of material, especially insulation.
recycling: the series of activities, including collection, separation and processing, by which products or other materials are recovered from the solid waste stream for use in the form of raw materials in the manufacture of new products other than fuel for producing heat or power by combustion.
renewable energy: energy resources such as wind power or solar power that can keep producing indefinitely without being depleted.
"sink": gases and vapors often adsorb, and particles deposit, on surfaces such as carpet, drywall, etc. These surfaces are known as "sinks"**—**contaminants can be re-emitted from the sinks at a later time.
smart house: consists of programmable electronic controls and sensors that can regulate heating, cooling, ventilation, lighting, appliance and equipment operation in an energy conserving and climatically responsive manner.
stack-effect: the phenomenon in a building or building component caused by wind pressure and temperature differentials which results in air being drawn through some components of a building and out others creating a continuous pattern of air flow.
sulfur dioxide: a colorless, extremely irritating gas that is a primary cause of acid rain.
thermal bridge: a highly conductive element such as a metal channel in the building envelope that penetrates or bypasses the less conductive element such as insulation, and acts as a thermal short circuit through the insulation system.

thermal buffer: a space or other element that reduces the heating and cooling load on another space located between the space and the exterior.
thermal by-pass: an opening between a conditioned and unconditioned space that heated or cooled air can move through, therefore violating the air tightness of the building envelope.
thermal envelope: the shell of a building that essentially creates a barrier from the elements. A highly insulated thermal envelope allows maximum control of interior temperatures without outdoor influence.
thermal flywheel: a space or other element such as a solid masonry wall that collects heat during one period and releases it during another in a repetitive pattern.
volatile organic compounds (VOCs): VOCs are chemicals that contain carbon molecules and are volatile enough to evaporate from material surfaces into indoor air at normal room temperatures (referred to as off-gassing). Examples of building materials that may contain VOCs include, but are not limited to: solvents, paints, adhesives, carpeting and particleboard. Signs or symptoms of VOC exposure may include eye and upper respiratory irritation, nasal congestion, headache and dizziness.
wind power systems: wind power systems convert the energy of the wind into electricity. Surplus electricity is often stored in a battery storage system for later use, or the power is passed back to the utility essentially making the meter go in reverse.
xeriscape: creative landscaping for water and energy efficiency and lower maintenance. The seven xeriscape principles are: good planning and design; practical lawn areas; efficient irrigation; soil improvement; use of mulches; low water demand plants; good maintenance.

Chapter 3. Building Planning

The Building and Planning Chapter defines the parameters that will guide the construction of any residential dwelling in the given municipality. It's primary foci are all the basic design issues, including climactic and geographic design criteria, loads that are permissible on the structure, location on the lot, interior space requirements, sanitation matters, windows and lighting requirements, emergency and safety considerations, restrictions regarding certain building materials, termite control requirements, radon protection and importantly, a section that permits the use of alternative building systems and materials. There are numerous points of potential for green building input during this phase of construction, but as presently articulated there is very little specific attention paid to such matters in this chapter.

ORC Section 301.2 Climatic And Geographic Design Criteria

This section requires that certain climatic and geographic criteria be observed. The following maps and charts are included in the code: state and national climatic zones, winter design temperatures, seismic risk map, concrete weathering probability map, basic wind speed map, snow load map, termite infestation probability map, decay probability map and EPA radon zones.

Green building fully affirms all measures that support the creation of structures that are in harmony with the climatic and geographic conditions prevailing in the area where the residence is being constructed. Green building adds a map defining the solar exposure and cloud cover likely to occur in a given area so that the use of solar systems can be seriously calculated and another map defining the average rainfall so water conservation and water control measures will be included in the planning. Though the Cleveland area is not prone to serious flooding, green building advocates flood-resistant construction codes to protect from 100-year flood possibilities.

ORC Section 302: Location On Lot

The primary concerns here are the dimensions of the lot and how close the building will be to lot lines. ***Green building promotes the idea that the orientation of the structure on the lot demonstrate that every effort has been made to facilitate the use of the southern exposure and the opportunity to use solar heat sources and light and to avoid unnecessary heat gains from such exposure.***

ORC Section 303: Light, Ventilation and Heating

The light issue has to do with the amount of window to be provided. ***Green building promotes the optimal amount of natural light (daylighting) including light tubes, skylights, and conventional windows, etc. and adds a concern for the orientation of the windows so solar gain and loss are considered.***

The ventilation section begins to touch on the broader issue of ventilation of the whole house and this is a matter in which green building would fully concur. ***There are at least four ventilation strategies that green builders use to achieve the standard outlined in this section and there is considerable debate regarding the amount of air change***

needed and how to best achieve it. This code section permits experimentation and provides a basis for future discussion of this issue. Whatever ventilation system is used, green building requires it be possible to test to determine if the appropriate air change is actually being achieved. The heating issue in this section is simply the requirement that there must be a heating system that can achieve a temperature of 68 degrees in each habitable room. How this is done is reserved for a later chapter on mechanicals.

ORC Section 303.4 Stairway Illumination

This section has to do with being sure there is lighting in the stairwells from either a natural or artificial source. ***Wherever artificial light will be on for an extended period of time (as is often the case on stairways) green building calls for the use of compact fluorescent bulbs to reduce energy costs.***

ORC Section 306.1 Toilet Facilities

This section only addresses the issue that a toilet, sink and tub and/or shower be provided. ***Green building strongly supports the federal regulation requiring a 1.6-gallon toilet and requires that each water faucet and showerhead be a water saver or fitted with a water saver device. A scald-proof shower control is also installed. The option of using greywater is always considered, provided the greywater is not in any way connected to potable water sources and it can be tested and treated locally to avoid any health risk.***

ORC Section 308 Glazing

The focus here is on safety dimensions of glass used in a residence in a variety of ways. ***Green building insists that all windows used be approved by the National Fenestration Rating Council (NFRC) (see energy section).***

ORC 309 Garages

The concern here is the potential fire hazards in an attached garage. ***Needless to say, green building affirms these measures that fully compliment another concern, namely, the possibility of carbon monoxide (CO) fumes entering the living space from the garage. Green building always prefers the use of a detached garage as first choice, then specifies air sealing of any attached garage from the residence (including the basement) and includes either a passive or active vent in the garage to exhaust auto emissions. Heating and hot water tanks systems should not be located in a garage because of the potential for the ductwork to pick up back-drafted flue gases and carrying them into the house. Only sealed combustion heating equipment should be used in this area.***

ORC 311.2 Type of Lock and Latch

For green building, this is another accessibility issue. The use of lever handles on exterior doors makes it safer for a person with a disability to open the door from either direction.

ORC 313 Ramps

Green building is certainly supportive of accessibility measures, but it also has a concern with the environmental appearance of a residence, and when possible, creates landscape walkways so they can serve as a "natural ramp" from the ground to the landing level; lifts from ground level to landing level are acceptable where space limits the creation of a ramp and/or walkway.

ORC 317 Smoke Detectors

In addition to smoke detectors, a green home always has a CO detector and the CO detector is a device with a digital readout panel that indicates at all times whether any CO is being detected.

ORC 318 Foam Plastic

This code is concerned with plastic insulation and the potential hazards from fire should it burn. It is also concerned with the issue of termites using foam insulation as a pathway into the house framing (if it is wood) (also see Section 323 re: protection against termites). ***Green building is in complete agreement with these measures and is also concerned that foams not outgas CFCs and recycling issues related to foam waste during construction and deconstruction. Builders should be able to describe how they will be disposing of waste from the building project and how much of it can and will be recycled.***

ORC 319 Insulation

This code is primarily dealing with the fire retardancy of insulation and not its insulating properties (see chap. 11 for insulating properties). ***Green building is in full agreement with these concerns, and advocates strongly that insulation not be blown into wall cavities where old electrical wiring is present until that electrical wiring has been evaluated and corrective measures taken to avoid a fire hazard.***

ORC 321.1 Moisture Vapor Retarders

Moisture getting into the wall cavities where it can condense in cold weather and cause paint peeling and wall damage is the concern of this code. Keeping a wall cavity from moisture damage can take a number of different forms. ***The use of vapor retarders is a subject of some debate. Check the two reference manuals for appropriate applications of these materials.***

ORC 322 Protection Against Decay

The primary concern here is with the potential for wood failure if the wood gets wet and rots. ***Green building shares this concern, and adds another, namely, the potential for mold growth when wood or any other cellulose-based material gets wet that could be potentially harmful. If pressure-treated wood is used to avoid wood rot, green building would require the use of non-CCA treated wood because of the potential hazards of the arsenic that leaches out from the CCA when it is used. CCA has recently been banned as an acceptable building material.***

ORC 323 Protection Against Termites
This section focuses on three concerns: one, the use of termiticides, the ability to always be able to visually see if termites are present and the use of pressure-treated wood in framing to protect a structure from termites. ***Green building is greatly concerned with the use of termiticides to protect a residence from termites due to the soil gases that can enter the residence and create a potential health hazard for the family. The emergence of foams that have a termiticide in them is an option currently being tested. Green building affirms the latest Integrated Pest Management procedures that have been developed. If termiticides are being used, the inclusion of subslab ventilation for radon may help reduce the termiticide soil gases from entering the living spaces.***

ORC 324 Radon (this section was deleted in the l999 ORC, though a map of radon zones is included in 301.2(8). ***Green building strongly opposes deleting this section from the Cleveland code even though radon levels are commonly below action levels in this area. Also green building has begun to recognize that radon is only one of many soil gases that can enter living spaces with potentially harmful consequences. Termiticides and lawn chemicals are two other sources of soil gas. As we become more aware of soil gases and their specific effects, it is likely this section will become known as "soil gas control methods", with radon being a subheading.***

ORC 326 Alternate Materials and Methods: This is the place in the l999 ORC that alternate materials and methods are recognized. The body of building knowledge and the number of building materials that is available for the construction and remodeling of homes is overwhelming. The ORC recognizes that the code must be prepared to deal with these new building techniques and materials. The ORC states:
"The provisions of this code are not intended to limit the appropriate use of materials, appliances, equipment or methods of design or construction not specifically prescribed by this code, provided the building official determines that the proposed alternative materials, appliances, equipment or methods of design or construction are at least equivalent of that prescribed in this code in suitability, quality, strength, effectiveness, fire resistance, durability, dimensional stability, safety and sanitation……In order to document the viability of alternatives, there is a testing requirement set in this section.

ORC 326.3 Tests
"Determination of equivalence shall be based on design or test methods or other such standards approved by the building official. The building official shall be permitted to accept as supporting data to assist in this determination duly authenticated reports from BOCA Evaluation Services, Inc., ICBO Evaluation Services, Inc., SBCCI Public Safety Testing and Evaluation Services, Inc., and National Evaluation Services, Inc., acceptance of documents from the U.S. Dept. of Housing and Urban Development or from other approved authoritative sources for all materials or assemblies proposed for use which are not specifically provided for by

this code. The cost of all tests, reports and investigations required under these provisions shall be paid by the applicant."

These provisions provide both a challenge and an opportunity to green building work, for it makes it possible to use a variety of environmentally friendly systems and materials, provided there is sufficient support documentation for what is being attempted. There are growing number of accrediting bodies emerging (e.g., the National Fenestration Rating Council that tests windows using rigorous standards) that can provide the necessary support for building techniques and materials. A list of these organizations can be found at the end of this appendix.

Chapter 4: Foundations

The foundation chapter deals primarily with the stability of soils, proper drainage, damp-proofing and waterproofing and the integrity of the design and construction of the footers and foundation walls appropriate to the conditions. A major concern of green building is energy efficiency in residential building operation. The insulation of foundation walls has received much attention over the past few years. In the ORC there are clear references to the use of insulating materials as they relate to foundation walls and their construction. There is currently no mention of interior insulation methods. Builders planning to use insulation on the interior or exterior of their buildings should check the two reference books for details for the most effective methods of installation. A new subsection on foundation wall insulation may be created to give more specific guidance in this matter. This is a clear demonstration of the way green building concerns will gradually simply be part of the national codes. In addition, green building is concerned with how much it costs the environment to produce the materials we use to build our foundations. The CO2 emissions from the production of cement are enormous. On the other hand, the growing use of fly ash, a by-product of burning coal for power plants (which also results in heavy CO2 emissions), as a substitute for cement used in concrete is making use of a previously discarded material that is actually enhancing the quality of the concrete.

ORC 401.3 Drainage

This is concerned with surface water drainage so the foundation is protected from water. ***Green building fully subscribes to these standards, but is also concerned that as much water as possible be absorbed by the soils on the property so that there is less water having to be handled through the municipal storm system and there is more water makings its way into the aquifer. A growing number of more permeable materials for such things as driveways, walkways and patios are being developed. See the reference manuals for further consideration of these matters.***

ORC 402.1 Wood Foundations

This code permits the construction of wood foundations. ***Wood foundations were an early idea of green building enthusiasts because it is made of a renewable resource (wood), and is more easily and effectively insulated. The use of pressure-treated wood below grade has been a concern because of the potential for leaching of arsenic from the chemicals used to treat the wood. The appearance of less toxic treatment chemicals reduces this concern somewhat.***

ORC 403.3 Insulated Footings (Frost Protected Shallow Foundations)

The frost-protected shallow foundation is another innovation (imported from Sweden) by green building designers that is now fully incorporated in this code.

ORC Footer Moisture Barrier

This is not presently in the code. ***Building scientists actively pursuing green building concerns, have begun to recommend the installation of a moisture barrier (capillary break) on top of the footers before the walls are poured or laid to reduce the migration***

of moisture through the footer and into the living space; it eliminates one more source of moisture problems.

ORC 404.4 Insulated Concrete Form Foundation Walls

This is another green building concept that is now fully incorporated into the codes. ***A continued concern of green building is the nature of foams (do they contain HCFCs or other chemicals that could be a problem during manufacture to eventual deconstruction).***

ORC 405.2.2 Moisture Barrier (for slabs)

This code calls for a polyethylene sheeting over the subslab gravel in the basement or under a slab before the concrete floor is poured. ***This is a measure also long advocated by green building scientists because it greatly reduces the chance of moisture wicking up through the concrete floor where it could contribute to mold growth on any cellulose containing products that are often placed on basement floors.***

ORC 409 Foundation Waterproofing and Damp-proofing

All foundations require a combination of damp-proofing materials applied to the exterior of the foundation walls and a water control system to carry water away from the foundation. ***Green building fully supports such measures, but it has some concerns with the nature of the products used on the walls as damp-proofing and the chemicals used to lubricate steel forms in the fabrication of concrete foundation walls. The chemical composition of these materials needs to be carefully evaluated so there is not a direct hazard for the occupants from contact with these chemicals or indirect contact via soil gases that are created by these chemicals. In response to this concern, there are a growing number of alternatives coming to the market for contractors to use, including vegetable oil lubricants for concrete forms to replace fuel oil lubricants now commonly used.***

ORC 409 Crawlspace

The traditional crawlspace has been treated as an unconditioned space that sometimes has some insulation in the flooring above it, plastic sheeting on the soils to reduce moisture, and several vents to the exterior around the perimeter. ***For years, green building scientists have advocated that the crawlspace be treated as a conditioned space for both energy savings and resident comfort. Now this code permits the crawlspace to be considered a conditioned space "when the ground surface is covered with an approved vapor retarder material, the space is supplied with conditioned air, and the perimeter walls are insulated."***

ORC 409.3 Removal of Debris (from a crawlspace)

Green building enthusiastically supports this measure because the potential for all manner of mold growth on debris (especially cellulose product) in a crawlspace is great. With duct work and other openings from such a space into the living space, the potential health hazards are great.

Chapter 5: Floors

The primary emphasis of this chapter has to do with the structural strength of framing and surfaces for floors in a residential structure, including attic floors that may need to be strong enough to handle mechanical equipment placed on them. Green building brings a number of concerns to this subject: developing new ways of framing that maintain the integrity of the structure, but reduce the materials needed; the use of wood from certified forests; and using manufactured wood products that have a minimum of VOC outgassing after they are installed.

ORC 501 General

Green building has supported the development of Optimum Value Engineering (OVE) because it has provided new strategies for framing a residential structure that make it just as strong, if not stronger, while using less building materials.

ORC 503 Floor Sheathing

Most of the sheathing used in floor construction is a type of oriented strand board (OSB); it is best to seek FSC-certified sheathing for such usage. ***(See list of green building certifying organizations at end of this appendix)***

ORC 504 Pressure Preservatively-treated Wood Floors (on ground)

Green building promotes the use of non-CCA type pressure-treated wood because of the potential for leaking arsenic into the soils and the chance of creating soil gases that enter the living space and create a health hazard.

Finish Flooring: Finish flooring is not addressed in the codes, but green building strongly advocates its inclusion because ***the materials used (especially coatings) can be a health issue due to VOCs included in these products and green building also promotes the use of wood from certified forests.***

Chapter 6: Walls

The focus of this chapter is the structural integrity of the exterior walls of a residential structure, whether the primary material used is wood, steel, or masonry (in its numerous forms). Of note is the appearance of Optimum Value Engineering options for doing framing with wood and the inclusion of insulating concrete form wall construction. Optimum Value Engineering permits the use of less wood members when they are properly configured so they do not compromise the strength of the structure. Insulating concrete form wall construction meets energy efficiency concerns with concrete even as it is poured. Not yet included (but being considered) is straw bale construction, which is becoming increasingly popular in some parts of the country. While labor intensive, this type of construction comes as close to being the perfect green built structure as any because its fundamental building component (straw bales) is so simply created from an abundant source and its finish surface (clay mixed with straw) is also in abundant supply. Moreover, both materials are available almost everywhere very close to where the straw bale construction will take place.

This chapter includes windows and doors for their structural integrity only, not their water tightness or energy efficiency (see Energy Conservation).

ORC 602.3.3 Top Plate

In this section, a double top plate is called for which is the common way to wood frame a wall, but this code affirms an exception, which is consistent with OVE standards. It permits a single top plate if it is properly secured to other wall sections with metal plates. ***Green building also advocates that all floor joists, rafters and trusses that sit on top of an OVE single top plate wall, be spaced so they rest directly over a stud in the wall beneath it, thus assuring that loads are fully transferred through framing members and less stress is experienced by any top plates (commonly called in-line framing).***

ORC 613 Insulating Concrete Form Wall Construction

The green building concern with energy efficiency of concrete walls is met by the fact that there is foam insulation on both sides of the wall that dramatically stops heat transfer through these walls, which normally would have a very low R-value. But green building has three additional concerns with concrete for wall construction: One, use fly ash in the concrete to the maximum amount permitted by research and experience, two, no HCFCs should be used in the foams, and three, carefully assess the use of termiticides. Since termites have learned to use foam insulation on the exterior of concrete as a path into the structure where they can do damage, the matter of termiticide use reappears. There are some new foams with termiticides in them and at issue is whether there is any leaching of these products into the soils and whether they can contribute to soil gas problems for residents. Also, some of the materials being used as termiticides (such as borates) break down when wet and are not longer useful. A new generation of safer termiticides is beginning to appear.

Chapter 7: Wall Covering

This chapter addresses the surface materials applied to the exterior and interior of the building walls. The guidance of this chapter addresses many of the concerns of green building, but green building is always concerned that wall assembly construction be evaluated in its entirety and not piece by piece. While these sections address the matter of keeping water out of the walls, green building science is also concerned with the "drying capacity" of walls in the event moisture does get in, and how to control the potential damage this moisture can do. The energy efficiency of the wall is not addressed in this chapter (see Appendix C), so some of the moisture issues affected by how well a wall is insulated are not addressed here.

Green building is also concerned with the nature of materials used, not just so they are not compromised by moisture, though that is a first concern, but also to evaluate the environmental consequences of manufacturing, using and discarding certain building materials over time. Vinyl siding, which has become a primary exterior surface material, is the focus of much debate that has not yet been resolved in either the laboratories or the courts. As more information becomes available, it will help make informed decisions regarding the use of such a material.

OBC 702 Interior Covering

Green building is very concerned with the use of drywall and the potential for problems if moisture can get into the wall cavities. Drywall can quickly become a host for molds if moisture is not controlled. Green building prefers that drywall on the interior of the exterior walls be sealed to the framing. In addition, green building calls for the use of air sealed electrical receptacle boxes bonded to the back of the drywall, the caulking of all electrical wiring holes and other openings through the stud framing. The wall surface in tub and shower areas receives special treatment to reduce the chance of moisture entering those wall cavities.

If drywall is installed over foam that is part of an insulated concrete foam wall construction system, furring strips are installed on the foam first to keep moisture from wicking into the drywall via the foam. If wood paneling is installed that has the potential for seams between panels to open, a sealed subsurface is attached to the framing before the paneling is installed.

OBC 703 Exterior Covering

Once again, green building is concerned with the drying potential of an exterior wall and treatments that address it.

OBC 703.2 Weather-resistant Sheathing Paper

If Styrofoam sheathing is used, it is not necessary to use a weather-resistant sheathing paper as long as the horizontal and vertical seams of the Styrofoam are properly flashed or sealed.

OBC 703.3.1 Horizontal Siding

If installing wood siding, green building will install furring strips on top of the felt paper or on top of the Styrofoam with a vent space at the top and bottom to act as a drying space for moisture that enters under the siding. The siding will be primed on all edges before it is installed as well.

ORC 703.7.3 Flashing (for masonry veneer)

Green building is not only concerned with the letter of the codes, but their full implementation as well. It is not uncommon for masonry veneer walls to be improperly flashed at their base, allowing wind-driven rain to enter via the mortar joints, drain down behind the brick to be trapped at the sill plate of the exterior walls. The result can be rotted wood, mold in the basement living spaces or rusted metal sill plates. It is also not uncommon to have the landscapers grade soils higher than the weep holes in a veneer wall so water cannot exit and similar problems to occur.

Flashing of Window and Door Frame Openings:

One of the worst leak areas in any home, but especially in new homes, is where the windows and doors are fastened to the framing. It is important to flash the window and door jambs and sills so that any water that gets in through the siding cannot get in through these seams where it can do damage to the windows and the doors as well as to the walls. This flashing is installed after the sheathing has been applied on the exterior and seals the seam where the sheathing joins the window/door opening.

A common material used for this work is one of the "ice guard" products with a sticky back that is commonly used along roof eave edges and under many roof flashings.

Chapter 8: Roof-Ceiling Construction

This chapter addresses the structural requirements for the building of roofs so they will effectively handle the loads (especially snow, in this climate) they will be required to support. Roofing is an important focus of green building because of the moisture issues that can destroy a roof if it is not constructed properly, the heat loss and gain that can occur through its surface, the amount of large framing materials required to construct it, and the ventilation issues that must be addressed. A green building scientist reading this chapter would amend the content at a number of places to highlight these other dimensions affecting roof construction.

ORC 802.1.3. Fire-retardant Treated Lumber

Because of the hazards of disposing of pressure-treated wood, green building recommends not using it any more than necessary. Pressure-treated wood in a roof is not leaking chemicals into the soils around a house, but it can still be a problem when it is finally discarded after demolition. The ACQ chemical is less a problem than the traditional CCA treated wood, but green builders choose not to use pressure-treated wood for this purpose, assuming that the shingles or other surface materials will provide adequate moisture protection. The same argument holds for the use of pressure-treated wood for sheathing on roofs as called for in ORC803.2.1.2.

ORC 802.6.2 Engineered Wood Products

This section deals with not notching engineered wood products so their strength is compromised. ***Green builders advocate the use of engineered wood products for roof framing because it means not using large dimension wood frame members to frame a roof.   Engineered flooring members, particularly open web trusses, more readily accommodate efficient duct design and layout.***

ORC 802.9 Trusses

This section focuses on the structural integrity of trusses. ***Green building has two additional concerns: a raised heel truss permits a greater level of insulation to be installed in an attic space without compromising the ventilation required. It is a minor addition to any truss configuration that helps improve the energy efficiency and function of the roof structure. Because trusses can experience "truss uplift"(when the bottom chord of a truss, in stress with upper chords, raises up in the middle causing cracks between the interior walls and the ceiling), it is important that the drywall on the interior be installed so the truss can rise without affecting the drywall. (See reference for dealing with this in Builder's Guides.)***

ORC 803.2.3 Installation (Roof Sheathing)

This section deals with the requirement to install sheathing with staggered joints. ***Green building recommends that as much as, but not more than a "nickel width" space be placed between all edges of the sheathing, so the sheathing does not buckle from any moisture it may absorb (a common problem).***

Chapter 9: Roof Coverings

Roof surfaces are the focus of this chapter. The underlayments, the flashings and the variety of roof surface materials available are covered by these codes. Green building is concerned not only with how to effectively keep the interior dry and effectively help the water run off the roof, but how snow melt is controlled and the environmental friendliness of each of the materials used in roofing today.

ORC Flashings

This section of the code deals with the use of flashings where a roof meets a house wall, a parapet or chimney (step and counter flashings), and valley flashings, flashings around plumbing stacks, skylights and other openings in the roof surface. ***Green building calls for an additional measure to flashing work to greatly reduce the chance a flashing would ever leak, by placing self-adhering polymer modified bitumen under each metal flashing before it is installed.***

ORC 903 Asphalt Shingles

Green building uses shingles that include a recycled paper base and, if an old asphalt roof surface is being removed, the waste materials from this work and the waste from the new shingles will be taken to a place where it can be recycled into asphalt road construction materials if such a waste site is currently available. A 30-year shingle is recommended

ORC 903.1 Self-adhering Polymer Modified Bitumen Sheet

Green building advocates that not only should this material be used along eave edges and valleys but also down over the fascia board behind the gutters to keep water from heavy rains or ice backup from entering the connection between these two surfaces.

ORC 905 Metal Roofing

This section addresses the appropriate conditions for use of metal roof surfaces, including roof pitch. ***Green building is concerned about the tremendous amount of energy required to create metal roofing. Aluminum would be preferred over steel, but metal roofing materials are more durable (with proper installation and maintenance) than asphalt and most are recyclable. It is important that metal not be mixed in the installation process because of the galvanic reaction that can cause metals to deteriorate. Green building is always faced with ambiguous situations. This is one of those. Eventually keeping millions and millions of tons of asphalt out of landfills by using metal roofs is an attractive idea, but our experience with metal roofs in this generation is too new to fully support its use at this time.***

Chapter 10: Chimneys and Fireplaces

Green building is concerned with indoor air quality and energy cost. Fireplaces have traditionally been very energy inefficient and often have been the source of significant back drafting from wood byproducts that contain known carcinogens. Recently, gas fireplace units, which are not vented to the exterior, have been approved for use in residential structures. These units add the problem of excess moisture that is given off when gas burns, which can push the interior of a residence into a too high relative humidity level and increase the chances of mold growth.

Masonry chimneys built for one generation of heating equipment and now used for more efficient units, often experiences damage to the interior of the chimney in addition to normal wear and tear. The requirement to install liners in chimneys when operating efficiencies change has reduced this problem, but the problem still remains in many older homes. The presence of debris (such as dislodged masonry materials, leaves, and animal carcasses) can block the exhaust flues of furnaces and hot water tanks so toxic flue gases are backed up into the living space.

ORC 1001.14 Masonry Chimney Cleanout Openings

These codes call for the inclusion of cleanout openings in the chimney for both fireplaces and furnaces/hot water tanks. ***Green building calls for the inclusion of a wire screen on top of chimneys to reduce debris buildup.***

ORC 1006.2 Exterior Air Supply

This code specifies that all combustion air for factory-built or masonry fireplaces shall be equipped with an exterior air supply. ORC 1006.2 states: "the exterior air intake shall be capable of providing all combustion air from the exterior of the dwelling. The exterior air intake shall not be located within the garage, attic, basement or crawlspace of the dwelling." ***The basic rule for green building as it relates to the construction and use of fireplaces is that no interior air be used for combustion and that all fireplace units vent directly to the exterior (no unvented gas fireplace units).***

Chapters 11-28: Mechanical Heating/Cooling/Ventilation

ORC 1100 Mechanical Administration

These are the codes that "regulate the design, installation, maintenance, alteration and inspection of mechanical systems that are permanently installed and utilized to provide control of environmental conditions within buildings." ***See the Builder's Guides for more complete delineation of detail for these code references.***

ORC 1200 Mechanical Definitions

This code includes several pages of definitions related to mechanical work; green building terms that may be new to this field are included in the definitions included in Chapter 2.

ORC 1300 General Mechanical System Requirements

Green building requires that the following concerns be addressed in the codes which regulate mechanical installation:

- ***Require the use of the optimum energy efficient mechanical equipment feasible for any given building and the budget will allow (e.g., see "Specification of Energy-Efficient Installation and Maintenance Practices for Residential HVAC Systems at www.CEEforMT.org/resid/rs-ac/hvac.php3).***
- ***Make every effort to move toward the total elimination of the use of interior air for combustion air; have all fuel-burning equipment get its combustion air from the exterior.***
- ***Use no unvented fuel burning appliances for two reasons: one, the obvious attempt to reduce the production of carbon monoxide and carcinogenic byproducts in the air and two, avoid the excess moisture that the combustion of fuel produces.***
- ***Develop an appropriate air change ventilation plan that is energy efficient and effective; eliminating the use of interior air for combustion would dramatically reduce the number of air changes required and their subsequent cost.***
- ***Air seal ducting that delivers heat and cooling and the return air so that all the air intended for a given site is delivered there.***
- ***Properly size heating equipment and delivery systems so optimum comfort is achieved with the minimal equipment necessary.***

ORC 1400 Heating and Cooling Equipment

These are the codes that regulate the safe installation of heating and cooling equipment. All this work assumes that the ASHRAE standards are being applied and that the requirements created by the manufacturers of heating/cooling equipment have been observed.

ORC 1500 Electric Resistance Heating

Green building's concern with electric resistance heating is the cost of doing so. While electricity is 100% efficient at point of use for heating, it causes considerable pollution

in its production (CO2 emissions and nuclear waste) and the cost for use as a heat source is significant.

ORC 1600 Vented Floor, Wall and Room Heaters

Green building takes strong exception to the inclusion of unvented room heaters in this chapter of the OBC, Section 1604.1, which states: "not more than one unvented room heater shall be installed in a bedroom or bathroom. An unvented room heater installed in a bedroom shall have a maximum input rating of 10,000 Btu/h (2930 W). An unvented room heater installed in a bathroom shall have a maximum input rating of 6,000 Btu/h (2344 W). Unvented room heaters shall be equipped with an oxygen-depletion-sensitive safety shutoff system." There are two issues for green building with these devices: one, even though this equipment has been approved by the American Gas Association as safe, the potential for CO poisoning is still present and two, the amount of moisture produced by gas burning is large and can be a major contributor to moisture problems that can produce molds. Green building strongly advocates against the use of unvented appliances.

ORC 1700 Ventilation Air Supply

This chapter simply notes that ventilation required is covered in Section 303 and ductwork is covered in chapter 19. See section 303 for green building concerns related to ventilation. ***See the Builder's Guides for a more detailed delineation of at least four types of ventilation system to be used in a residential structure.***

ORC 1800 Exhaust Systems

This chapter deals with such matters as clothes dryer exhaust, range hoods, installation of microwave ovens, overhead ventilation hoods. ***Green building strongly supports this code's requirements regarding range hoods (it promotes their being vented directly to the exterior and that it not be vented into an attic or crawlspace; a recirculating range hood can only be used where other proper ventilation is in place and servicing the same area).***

ORC 1900 Duct Systems

Green building advocates against the use of exterior walls for the installation of ductwork or the use of floor joists for return air for the primary reason that, the organisms, especially mold, that can grow in these cavities on a cellulose material like wood can result in mold spores being distributed throughout the living space. Green building also does not advocate the use of underground ductwork to deliver heated air to the living space of a residence. The potential for soil gases to infiltrate these systems and mold to grow in them is too great. Also, if they have been poorly installed (poor grade so water pools in them or seams are not tight) moisture can enter the system and the ductwork becomes a humidification system that can do significant damage to the house. Duct sealing is a concern for green building because it means a more energy efficient and effective heat delivery system. The ORC section 1901.3.1 on joints and seams should be more specific in its requirements for duct sealing; green building requires the use of mastic on every duct seam. Poor quality materials that do not last

very long reduce the long-term effectiveness of a heating system. Green building strongly supports this section's requirement regarding where return air can be drawn from.

ORC 2000 Combustion Air

Green building advocates "buildings of unusually tight construction." Green building affirms such construction for energy conservation reasons but recognizes that a tighter building presents challenges that must be addressed. One of these is where combustion air comes from in such a structure. ORC 2001.1.1. states: "In buildings of unusually tight construction, combustion air shall be obtained from outside the sealed thermal envelope." Green building advocates this for all construction, loose or tight.

ORC 2100 Chimneys and Vents

This chapter deals with the safe and effective ventilation of combustion heating appliances and green building is certainly affirming of any efforts to do that.

ORC 2200 Special Fuel Burning Equipment

This includes ranges and ovens, open top gas boiler units, outdoor gas cooking appliances, clothes dryers, vented decorative gas appliances, gas lights, and sauna heaters. **G*reen building concerns with this equipment are three: one, what equipment is necessary and what equipment should have to pay a mitigation fee because it is for casual use such as saunas and fireplaces; two, no interior air should be used for combustion for fireplaces; and three, no unvented appliances should be used.***

ORC 2300 Boiler/Water Heaters;

This chapter covers boilers, hot water tanks used for both heating and domestic water use, floor heating systems, water heaters used for just domestic purposes and pool heaters. ***Again, one green building concern is: what is necessary (e.g. pool heaters)? Green building affirms the use of water heaters for both domestic use and heating because it reduces the up front cost and long-term cost of installation and replacement of equipment.***

ORC 2400 Refrigeration

Green building has several concerns with this kind of equipment. One, that it use environmentally friendly refrigerants (no CFCs and not even HCFCs if alternatives are available); two, that the builder demonstrate that the use of cooling will not compromise the wall structure so moisture entering wall cavities from the exterior will not condense on the back of drywall in the now cooled interior walls and that wall coverings (especially vinyl and foil) do not serve as vapor barriers to moisture from the exterior resulting in mold growth in the drywall and behind the wallpaper.

ORC 2500 Hydronic Piping

This chapter addresses the kind of piping that can be used for hot water/steam systems, the fittings that are approved and some installation measures. ***Green building affirms the use of ground source heat pumps; this is not presently covered in the ORC code.***

ORC 2600 Gas Fuel Piping

Green building, of course, subscribes to every code measure that ensures the proper installation of and continuous effective maintenance of gas fuels, but it is continually reminded that the use of gas fuels is ultimately a dead end because it is a nonrenewable resource. The use of natural gas is a sign of work yet to be done in the area of renewable energy sources.

ORC 2700 Special Piping and Storage Systems

This chapter focuses on fuel oil and the proper installation of lines and equipment to handle it. ***As with the gas fuel piping, green building is reminded that fuel oils are a non-renewable resource and there is a need to develop alternative fuels for the future. This leads to the next chapter, which begins to address this issue.***

ORC 2800 Solar Systems

This chapter is an excellent example of how green building content can be incorporated into the existing prescriptive code, not as green building, but as a clearly accepted and useful building system that needs to be done in an effective and carefully regulated manner. It is also an example of content being added to the code that does not require that the content be implemented, only that the code be observed if it is implemented. You are not required to use hot water heating, but if you choose to do so, there is a code that guides its proper installation. The goal of green building is that there be as many environmentally friendly alternatives as possible that ultimately find their way into the prescriptive code because of the clear field evidence of their usefulness and effectiveness and the best ways to achieve the same.

Chapters 29-38: Plumbing Code

The plumbing code has been deleted from the l999 Ohio Residential Code. The following statement defines that action: "All one, two and three family dwelling structures shall comply with the Plumbing Code approved by the Ohio Board of Building Standards," which is a full book of codes devoted completely to plumbing matters. All plumbing work is carefully monitored and inspected, and the codes and practices are the product of many years of experience. ***Green building concurs with all the plumbing code as it relates to the effective and safe installation of equipment to handle water and waste in a residential structure. The issues that green building advocates in the plumbing field are attempts to find ways to more effectively conserve water (1.6 gal. toilets and 2.5 gal. shower heads are Federal regulations now in effect), more cost effective ways to deal with human waste both inside and when it leaves the residence; how to reduce the amount of storm water that is needing to be treated because it ends up in the storm sewers and runs through treatment plants; rain harvesting and placing more water back into the aquifer are two strategies being actively explored in a number of cities here and abroad; green building would also completely affirm any efforts to keep backflow from occurring in the potable water system because of the hazard of polluting residential drinking water. There are a number of devices available to do this, but they are not yet required by code.***

Chapters 39-48: Electrical Code

The electrical code has been deleted from the l999 Ohio Residential Code. The following statement defines that action: "The provisions of the National Electrical Code, NFPA 70, as referenced and adopted by the State of Ohio, shall be incorporated herein and shall govern the installation, testing, and operation of the electrical systems of one, two and three family dwellings within this jurisdiction. All electrical work is carefully monitored and inspected and the codes and practices are the product of many years of experience.
There are several issues for green building regarding electrical work:

- ***The use of recessed light fixtures in cathedral ceilings or other unconditioned spaces should not be permitted unless the fixture has an IC rating that keeps moist air from escaping into cold spaces in the winter time where it can condense and cause significant damage to roof and other framing members.***
- ***The use of airtight electrical boxes in the exterior envelope of residential structures is an important green building consideration.***
- ***Green building is concerned with energy efficiency and any measures that can be taken to reduce the amount of electricity required to operate the residence. The use of compact fluorescent fixtures and Energy Star appliances are significant measures that can be taken.***
- ***If alternate energy sources (such as solar) are used to produce electricity, green building is interested in being able to feed what will not be used back to the power company and thus lower the electrical bill of the homeowner.***
- ***Green building strongly supports the electrical code sections that are developing to guide the safe and effective installation of photovoltaic grids on residential structures.***
- ***There has been a continuous concern about electromagnetic fields both outside and inside the home, but no definitive research ha yet been conducted that can clearly demonstrate the affects of these fields on the health of individuals exposed to them.***

Appendices to Code

The appendices included at the end of building codes serve at least two purposes. First, they are informational (and are designated as such) and help guide code observations but are not strictly code measures. Second, they are new code areas that have not yet found their way into the organization of the existing code but are enforceable code measures where relevant to a particular residential construction system.

The following is commentary from a green building perspective on the appendices found in the l999 Ohio Residential Building Code.

Appendix A: Manufactured Housing Used As Dwellings

The primary purpose of this appendix is to define the regulations for placement of a manufactured home on a site. It does not address the issues of how it is constructed. ***Green building finds manufactured housing potentially consistent with all its goals because it creates a modest living space, a more resource-efficient structure, and increasingly a more energy-efficient one.***

Appendix B: Swimming Pools, Spas and Hot Tubs

The primary purpose of this appendix is to define the regulations for barriers to be constructed to protect children, animals and others from inadvertently falling into one of these units and drowning or suffering other injuries. ***Measures that strongly encourage or require a higher standard of resource efficiency for resource-intensive luxury or recreational items such as spas, hot tubs, and heated pools are consistent with green building objectives. Examples include solar water heating, PV assist systems, and "off setting" mechanisms (see discussion at end of this section).***

Appendix C: Energy Conservation

The l999 Ohio Residential Code places Energy Conservation is in the appendices of the code where it says: "All one, two and three family dwelling buildings and structure(s shall comply with the Ohio Basic Building Code for energy conservation." Presently the Ohio Basic Building Code uses as a standard the l995 Model Energy Code, which was produced by the three national code bodies. In l995, the three code bodies turned their oversight on energy conservation over to the International Residential Code body that was beginning the first International Code. The new 2000 International Code has an updated version of the l995 Model Energy Code, and it will be updating this energy code every three years from now on. The l999 Ohio Residential Code chose not to use this update at this time.

It is useful to know that the Energy Star rating program that was created by the U.S. Department of Energy (DOE) and the U.S. Environmental Protection Agency (EPA) recognizes the Model Energy Code, now the 2000 International Residential Code, as the performance code builders can use as the <u>minimum</u> standard. A one-star rating would be the minimum standard and a five-star rating would be the highest. All builders who want to have their residential structures rated by Energy Star standards must allow their structure to undergo rigorous testing at the builder's expense. The number they reach will determine the level their units are awarded. The number is determined by another program that does the testing called Home Energy Rating System (HERS). If HERS rates a house with an 86 or higher, it is designated an Energy Star five-star rating. Generally, to reach a five-star rating, it is necessary for a builder to achieve percentages of energy efficiency 30% higher than the basic standard.

Green building strongly supports attainment of a five-star Energy Star rating with every house built and seeks to incorporate at optimum levels as many of the energy efficiency measures as can be afforded. While each edition of the International Residential Energy Conservation Code will move closer to the five-star standard and broaden areas to be addressed (such as ventilation, combustion safety and moisture control strategies,) so the bottom-line prescriptive standard is always on the rise, a five star rating will likely always remain a performance code standard.

Both the l995 Model Energy Code and the 2000 International Energy Conservation Code address several areas: the building envelope, including window ratings; mechanical systems used for heating and cooling, including the ductwork and piping required to deliver heating and cooling; water conservation; and renewable energy. The International Code has also begun addressing the variables in various building systems, such as steel and concrete, when they are used instead of wood. The codes are clearly committed to energy conservation, and their focus is increasingly comprehensive and integrated. But the level of commitment is an issue. What is required in the prescriptive codes (the l995 Model Energy Code) is considerably less than what can be achieved for minimal additional cost. Therefore, two matters are critical for green building: that the existing prescriptive energy conservation standards be actively enforced and that the door be open for performance code work at a much higher level to provide the basis for future prescriptive measures.

Another issue that has begun to be addressed in other cities is excessive energy use that is not regulated by the codes is part of a new home. Snowmelt systems, spas, and heated pools are examples. One city, rather than prohibit such usage, now requires the installation of on-site renewable energy systems to cover the energy needs of such additions, or it charges a mitigation fee based on the system's energy use over a 20-year period multiplied by twice the marginal cost of locally available wind power. The money collected from this fee is used to invest in the development of renewable energy in the city. This is a creative way to further green building and develop an effective infrastructure for the development of renewable energy sources.

Example of Minimum Prescriptive Standards for Home Building Systems

There are numerous and increasing numbers of building systems used to create residential housing. This green building code appendix does not attempt to declare any building system as *the* system of choice. Rather, it requires that any system wanting to call itself green or sustainable prepare minimum standards — standards that meet the fundamental requirements of the general green or sustainable building.

The following is an example of minimum prescriptive standards proposed for straw bale construction. Those sections preceded by questions marks indicate that these are issues yet to be resolved for our climate and conditions. This material is a work in progress.

Minimum Prescriptive Standards for Straw Bale Construction

SECTION 9901: PURPOSE

The purpose of this document is to establish minimum prescriptive standards of safety for the construction of structures that use baled straw as a non-load bearing material.

SECTION 9902: SCOPE

The provisions of this document shall apply to all structures utilizing straw bales in the construction of wall systems. Load bearing structures shall not be limited to any particular class of building or structure.

SECTION 9903: DEFINITIONS

For the purpose of this document, certain terms are defined as follows:

STRAW: is the dry stems of cereal grains left after the seed heads have been removed.

BALES: are rectangular compressed blocks of straw, bound by strings or wire.

FLAKES: are slabs of straw removed from an untied bale. Flakes are used to fill small gaps between the ends of stacked bales.

LAID FLAT: refers to stacking bales so that the sides with the largest cross-sectional area are horizontal and the longest dimension of this area is parallel with the wall plane. Strings or wire are on the top and bottom faces of the bale and therefore are not exposed.

LAID ON-EDGE: refers to stacking bales so that the sides with the largest cross-sectional area are vertical and the longest dimension of this area is horizontal and parallel with the wall plane. Strings or wire are exposed on the side faces of the bale facing the interior and exterior of the building.

SECTION 9904: MATERIALS

9904.1.1 Type of Straw: Bales of various types of straw, including, but not limited to, wheat, rice, rye, barley, oats and similar plants, shall be acceptable if they meet the minimum requirements for density, shape, moisture content and ties.

9904.1.2 Shape A: Bales shall be rectangular in shape.

9904.1.3 Dimensions: Bales used within a continuous wall shall be of consistent height and width to ensure even distribution of loads within wall systems. A standard bale is generally 14 in. x 18 in. x 36 in.

9904.1.4 Ties: Bales shall be bound with ties of either string or wire. Bales with broken or loose ties shall not be used unless the broken or loose ties are replaced with ties that restore the original degree of compaction of the bale.

9904.1.5 Moisture Content: Moisture content of bales, at time of installation, shall not exceed 20% of the total weight of the bale. Moisture content of bales shall be determined by one of the following:

9904.1.5.1 Field Method: A suitable moisture meter, designed for use with baled straw or hay, and equipped with a probe of sufficient length to reach the center of the bale, shall be used to determine the average moisture content of 5 bales randomly selected from the bales to be used.

9904.1.5.2 Laboratory Method: A total of 5 samples, taken from the center of each of 5 bales randomly selected from the bales to be used, shall be tested for moisture content by a recognized testing lab.

9904.1.5.3 Common Sense Method: If 5 bales randomly selected from the bales to be used are broken apart and the center of the bales "feels" dry, then it can be safely assumed that the moisture content is less than 20%. This can be confirmed by the supplier.

9904.1.6 Density: Bales in non-load bearing structures shall have a minimum calculated dry density of 25 lbs. per bale. The calculated dry density shall be determined after reducing the actual bale weight by the weight of the moisture content, as determined in section 9904.1.5. The calculated dry density shall be determined by dividing the calculated dry weight of the bale by the volume of the bale, or a general approach to straw bale consistency may be exercised as follows:

9904.1.6.1 Consistency: If the bale supplier is made aware of the end use of the bales, then by appropriate harvesting techniques he will be able to supply consistent density bales.

9904.1.7. Custom-size Bales: Where custom-made partial bales are used, they shall be of the same density, same strong or wire tension, and, where possible, use the same number of ties as the standard size bales. Custom bales of various sizes can be supplied by the bale supplier if sufficient notice is given.

SECTION 9905: Construction and General Requirements

9905.1 General: Bale walls, when covered with plaster, drywall or render shall be deemed to have the equivalent fire-resistive rating as wood frame construction with the same wall finishing system. This is based on tests done in l993 in New Mexico, USA, in accordance with ASTM –E for bales laid on edge.

9905.2 Wall Thickness: Nominal minimum bale wall thickness shall be 18 in. for bales laid flat and 14 in. for bales laid on edge.

9905.3 Wall Height: ??????Bale walls shall not exceed one and half story in height and the bale portion shall not exceed a height to width ratio of 6.5 to 1 (for example, the maximum height for the bale portion of a 450 mm thick wall would be 2925mm) with the ground story floor and half wall above being tensioned independently of each other.
Exception: In non-load bearing exterior end walls of structures with gable or shed roofs, an approved continuous assembly may be required at the roof bearing assembly level.

9905.4 Unsupported Wall Length (????) The ratio of unsupported wall length to thickness for load bearing bale walls shall not exceed 16:1 (for a 450 mm thick wall, the maximum unsupported length allowed is 7200 mm). A timber box section structure or other equivalent structure must be securely attached to the footing in a self-supporting mode to enable a run of wall to exceed that distance.

9905.5 Allowable Loads (?????) The allowable vertical load (live and dead load) on the top of load-bearing bale walls shall not exceed 2000 kilograms per square meter (psm) and the resultant load shall act at the center of the wall. Bale structures shall be designed to withstand all vertical and horizontal loads as specified in Load Bearing Tests carried out in accordance with the BCA. See attached notes.

9905.6 Footings:

9905.6.1 General: Footings shall be sized to accommodate the total thickness of the bale wall and load-bearing structure, as well as the load created by the wall and roof live and dead loads. Footing (stem) walls which support bale walls shall extend to an elevation of not less than 8 in. above adjacent ground at all points. the minimum width of the footing shall be the combined width of the bale and the load-bearing structure it supports.

9905.7 Wall Assembly Anchorage

9905.7.1 General (?????) Vertical reinforcing bars with a minimum diameter of 12 mm, embedded in the foundation a minimum depth of 150 mm, and extending above the footing a minimum of 300 mm may be used at wall ends or at corners if necessary. Two per bale per minimum one bale from end of wall or corner.

9905.7.2 Intersecting Walls: (????) Walls of other materials intersecting bale walls shall be attached to the bale wall by means of one or more of the following method or an acceptable equivalent:

1. Wooden dowels at least 25 mm in diameter of sufficient length to provide 300 mm of penetration into the bale, driven through holes bored in the abutting stud, and spaced to provide one dowel connection per bale.
2. Pointed wooden stakes, at least 300 mm in length and 100

mm by 50 mm at the exposed end, fully driven into each course of bales, as anchorage points.

3. Bolted or threaded rod connection of the abutting wall, through the bale wall, to a steel nut and steel or plywood plate washer, a minimum of 150 mm square wall and a minimum thickness of 6 mm for steel and 12mm for plywood, in at least three locations.
4. Brick ties laid in mortar joints and attached to the bale wall as per methods 2 or 3.

9905.7.3 Wall Anchor System:

9905.7.3.1 General: Bale walls and roof bearing assemblies shall be anchored to the footings by methods which are adequate to resist uplift forces resulting from the design wind load.

9905.7.4 Moisture Barrier (?????) A moisture barrier shall be used between the top of the foundation and the bottom of the bale wall to prevent moisture from migrating through the footing into the bottom course of bales. This barrier shall consist of one of the following:

1. bituminous waterproof coating;
2. rubberized aluminum over an asphalt emulsion
3. sheet metal flashings, sealed at joints;
4. other approved building moisture barrier. All penetrations through the moisture barrier, as well as all joints in the barrier, must be sealed with asphalt, caulking or an approved sealant.

9905.7.5 Stacking and Pinning: Bales in non load-bearing walls may be laid either flat or on-edge and stacked in running bond where possible, with each bale overlapping the two bales beneath it. overlaps shall be a minimum of 12 in. Gaps between the ends of bales which are less than 6 in. in width can be filled by an an untied flake snugly into the gap.

The first course of bales shall be laid impaling the bales on the vertical bars or threaded rods, if any, extending from the footing. When the fourth course has been laid, bamboo stakes at least 15 mm in diameter and long enough to extend through all four courses (1400 mm) shall be driven down through the bales, two to each bale, located so that they do not pass within 150 mm of, or through the space between the ends of any two bales. The layout of these pins may approximate the layout of the vertical bars extending from the footing if used.

As each subsequent course is laid, two such pins long enough to extend through the course being laid and the three course immediately below it, shall be driven down through each bale.

This pinning method shall be continued to the top of the wall. In walls seven or eight courses high, pinning at the fifth course may be eliminated.

Only full-length bales shall be used at corners of load bearing walls. Staples, made of 12 mm or larger rebar formed into a "U" shape, at least 450 mm long with two 250mm legs, shall be used at all corners of every course, driven with one leg into the top of each abutting corner bale. In lieu of staples, corner bales may be tied together, by a method approved by a structural engineer.

9905.7.9 Openings and Lintels

9905.7.9.1 General: All openings in load bearing bale walls shall be a minimum of one full bale length from any outside corner.

9905.7.9.2 Openings (?????) Openings in exterior bale walls shall not exceed 50 per cent of the total wall area based on interior dimensions, and where the wall is providing resistance to lateral loads.

9905.7.9.3 Lintels: Wall load present above any opening shall be carried, or transferred to the bales below by one of the following:

1. a structure frame
2. a lintel: Lintels shall be at least twice as long as the opening is wide and extend at least 24 in. beyond either side of the opening. Lintels shall be centered over openings and shall not exceed the load limitations of section 9905.5 by more than 25 per cent.

9905.7.9.4 Attachment of framework: All door and window box frames shall be attached to the bale walls with wooden dowels or equivalent no smaller than 1 in. in diameter. These shall be driven through the sides and top of the frames no less than 12 in. into the bales, and spaced no more than 36 in. apart, with a minimum of two per section of frame.

9905.7.10 Moisture Protection: (????) All weather-exposed walls shall be protected from water damage. An approved building moisture barrier may be used to pro tect at least the bottom course of bales, but not more than the lower-one third of the vertical exterior wall surface, in order to allow natural transpiration of moisture from the bales. The moisture barrier shall have its upper edge inserted at least 150 mm into the horizontal joint between two courses of bales, and shall extend at least 75 mm below the top of the foundation. Bale walls shall have special moisture protection provided at all window sills, unless full cover is supplied by a verandah or equivalent. This shall consist of an extended sill with appropriate drip drainage in accordance with B.C.A. Unless protected by a roof, the tops of the walls shall also be protected. This moisture protection shall consist of a waterproof membrane, such as asphalt-impregnated craft paper, polyethylene sheeting, galvanized metal flashing or other acceptable moisture barrier, installed in such a manner as to prevent water from entering the wall system at window sills, openings or at the tops of walls.

9905.7.11 Wet Areas (???) Straw bale walls in wet areas shall Be made moisture proof by the following methods:

1. Applying a moisture barrier to the interior face of the bale wall before final rendering.
2. Sealing the interior face of the rendered bale wall with an approved sealant.
3. Applying an approved physical barrier, such as tiles or equivalent , to the interior face of the rendered bale wall.
4. Attaching a timber or other framework to the interior face of the rendered bale wall with a minimum air gap of 75 mm to which approved wet area sheathing is attached. This shall be finished off as per methods 2 or 3. At all times due attention shall be paid to joints and corners, with appropriate flashing in accordance with B.C.A.

9905.7.12 Wall Finishes: Interior and exterior surfaces of bale walls shall be protected from mechanical damage flame, animals and prolonged exposure to water. Bale walls adjacent to bath and shower enclosures shall be protected by a moisture barrier. (????)

The joint between the bottom of the wall render and the top of the stem wall will be reinforced to ensure that it is water proof and not liable to cracking. Cement render shall be reinforced with galvanized woven wire netting or an acceptable equivalent. Such reinforcement shall be secured by attachment through the wall at a maximum spacing of 600mm horizontally and 500 mm vertically, using baling twine or an equivalent stitched through the bale wall. Where bales abut other materials the plaster/render shall be reinforced with galvanized expanded metal lath, or an acceptable equivalent, extending a minimum of 300 mm into the bales. Earthen and lime-based plasters may be applied directly onto the exterior and interior surface of bale walls without reinforcement, except where applied over materials other than straw, or where the bales have been laid on edge. Weather-exposed earthen plasters shall be stabilized using a method approved by the building code.

Cement render would consist of a 4-6:1:1 mix of sand, cement and lime.
Lime render would consist of 3-4:1 mix of sand and lime putty.
Plaster would be as per manufacturer's instructions.
Earthen renders would consist of a suitable sand/clay mix and stabilized with an appropriate medium when necessary.

9905.7.13 Electrical (?????) All wiring within or on bale walls shall meet all provisions of the building code. Wiring shall be run in approved conduit systems, mounted on the bale wall with wire ties and rendered over. Outlets shall be securely attached to wooden stakes driven a minimum of 300 mm into the bales or an acceptable equivalent.

9905.7.14 Plumbing (????) Water or gas lines within the bale Walls shall be encased in a continuous pipe sleeve to prevent leakage within the wall. Where pipes are mounted on bale walls, they shall be isolated from the bales by a moisture barrier. Where a sleeve is to run through an external wall, its outer end shall sit lower than its inner end, thus allowing any leakage to drain to the outside.