Straw Bale Home Basics

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Although homes have been built in the US using straw bales for over a hundred years, methods for their construction have evolved to meet the changing needs of their inhabitants.
Building Science is the study of how buildings are affected by moisture, temperature changes and air movement.

Rising energy costs have encouraged the construction of homes designed to minimize air leakage. Tighter building envelopes affect the way moisture produced by activities such as bathing and cooking accumulates inside homes and in wall assemblies. Straw bale homes are no exception.

Home system types must be combined in ways that work well to keep the home safe and comfortable. When a home is built using methods that minimize air leakage, ventilation must be increased to avoid accumulating excess moisture in the home interior and in wall assemblies.

Pre-purchase or pre-sale inspection of straw bale homes requires basic knowledge of commonly-used straw bale construction techniques, some special instruments, a working knowledge of Building Science and some research into what methods are appropriate for various climates.

There are two types of straw bale homes:

1. *Load-bearing* straw bale walls (including the plaster interior and exterior wall coverings) support the roof and lateral (such as wind) loads.

2. *Non-load bearing* straw bale walls typically consist of a post and beam structure which supports the roof and lateral loads. This structure is infilled with straw bales which provide insulation.

Exterior and interior wall coverings are plastered using cement/ stucco, earthen plaster, lime, or some combination of these. Plaster should be applied directly to the straw.

CONCERNS WITH STRAW BALE HOMES

Moisture Intrusion of the Straw Bales

Moisture intrusion is the number one concern with straw bale homes, just as it is with conventional homes. Because straw bales can provide food for decay fungus, wide-spread, long term fungal activity can destroy a straw bale home.

In addition to decay of the straw, decay fungus are a concern because mold fungus release spores. High concentrations of mold spores in indoor air can cause health problems in infants or the elderly, people with compromised immune systems, lung disease or allergies.

Preventing Moisture Intrusion

A number of design methods are used to keep moisture out of the wall cavity or allow it to escape once it gets in there...

1. Foundation
    a. The foundation should extend above the exterior grade far enough to keep the bottom of the outside wall plaster a minimum of 12 inches above grade to minimize damage from splashback.
    b. The bottom of the lower course of bales should be a minimum of 3 inches above the interior finish floor. This will help prevent soaking the bales if the floor should flood.
    c. The lowest course of bales should rest on a waterproof material which will provide a *capillary break* (such as plastic sheeting) to prevent bales from wicking up moisture from below.
2. Exterior
    a. Roof overhangs should be extensive to protect walls from weather.
    b. Flat roofs should be avoided because they're likely to leak.
    c. Windows should be installed so that they extend past the exterior surface of the plaster. Whether windows are installed to the exterior or inset from the exterior wall face, high-quality pan flashing should be installed under the windows. Any sills should slope and extend past the exterior face of the plaster.
3. Interior
    a. Shower stalls should be placed against interior walls.
4. Plumbing
    a. Plumbing pipes should not be routed through straw bales. Pipes should be installed in the floor or in waterproof channels designed

with a clear drainage path out of the straw bale wall. This includes supply pipes for exterior faucets.
If pipes must be routed through straw bales they should be contained within watertight (preferably seamless) conduit which is sloped to the exterior.

5. Moisture barriers or retarders
   Wall plasters should be applied directly to the straw bales. No plastic, polymer or other barriers or retarders should be installed in wall assemblies. In addition to trapping moisture in the wall cavity, installing a barrier will limit the shear strength of the wall assembly, which relies on good adherence of the plaster to the straw.

PLASTER BASICS

Straw bale homes are typically plastered with one of four different types of plaster...

1. Stucco-cement is a cementicious material. Although in the past it has been the material of choice, difficulty in repairing cracks and low permeability to water vapor are causing it to be seen by many as inferior to earthen or lime plasters. Low permeability may result in moisture becoming trapped in the wall cavity where it can encourage the growth of decay (mold) fungus.

2. Gypsum plaster has been used for many years and before drywall become the interior wall covering of choice, interior walls of most conventional homes were covered with gypsum plaster. Because it is relatively soft and water soluble its use is limited to interior applications.

3. Earthen plasters are composed of various combinations of clay-based earth, lime, sand and chopped straw. Other additives such as mica, various fibers and pigments for color are often added.

   Because clay in earthen plasters is *Hygroscopic* (water absorbing), earthen walls can help to temper interior humidity.
   These plasters act as a barrier to water in its liquid form, but will allow water vapor to pass through so that moisture is not trapped within the walls.
   Cracks or changes can be more easily repaired or blended when using earthen or lime plasters.

4. Lime plasters have been used around the world for centuries. They are made from limestone which has been heated and powdered. When mixed with sand, water and fiber and allowed to cure it hardens, providing durability and acting as a barrier to water in its liquid form, while remaining permeable to water vapor.
   Lime plasters are easily repaired and have anti-microbial properties.

Application Procedures

Plaster is often applied in three coats...

1. The *scratch coat* is worked well into the straw to provide a good bond between the plaster and straw. It is used to build out low spots in the wall and build up the thickness of the wall surface.
   Sometimes, a thinner layer of diluted plaster called a *slip coat* will be applied first in an effort to get better penetration into the straw.
2. The *brown coat* applied next adds thickness and further flattens the wall surface.
3. The thinner *finish coat* provides durability, color, texture, and is what you see when you look at the wall.

Allow each coat to dry...

Allowing each coat to dry completely will help prevent cracks from being transmitted from underlying coats to newly applied coats.

Mist before applying mud...

The straw or plaster substrate should be misted with water before a fresh coat is applied. This will help prevent a dry substrate from sucking the water out of newly applied plaster. If the new coat loses too much water to thirsty substrates, it may not bond or cure properly and the result can be an easily eroded, abraded or detached layer.
New coats will need occasional misting for a couple of days after they are applied and all coats should be protected from the sun and wind as they cure.

CRACK DIAGNOSTICS

Cracking is a natural process with the earthen and cementicious plasters typically used to cover interior and exterior walls in straw bale homes. They shrink as they dry - they can crack as they shrink.
Cracking plaster is the #1 maintenance issue with straw bale homes.

Cracks through the finish coat should be repaired to prevent increasing damage from the freeze/thaw cycle. Hairline cracks are not a problem, but should be monitored and repaired if they widen.

Cracks through multiple coats may allow moisture intrusion and are a defect requiring immediate repair to prevent moisture intrusion of the straw-filled wall.

Sagging or Weight Cracks

If the heavy, wet plaster has not bonded well to the straw or mesh to which it has been applied, gravity will begin to pull it toward the floor...

1. in parts of the wall where it has been applied thickly to fill in low spots.
2. if the plaster has been mixed with too much water.
3. if the plaster has been mixed with inadequate amounts of fiber (chopped straw).

This kind of cracking is common in the first coat and to a lesser extent, in the second.
These cracks will often extend across a section of thick plaster and take the shape of a frowning or smiling mouth.

If you see this kind of cracking in a finish coat it may mean that...

1. cracks in underlying coats were not allowed to cure completely before subsequent coats were applied.
2. cracks in underlying coats were not filled completely when subsequent coats were applied.

Inadequate Plaster Mix

While excessive amounts of binder in the plaster can cause cracking, too little binder can cause the plaster to be weak or crumbly. Especially with earthen plasters, additives are often used to modify or augment the qualities of the clay/sand mix.

Improper Curing

When the wall surface is covered with extensive, spidery, multi-directional vein-like cracks, the reason is probably improper curing due to inadequate hydration (moistening) during the drying process.
Dry plaster will suck the moisture out of any wet plaster applied to it before the wet plaster has a chance to hydrate completely, causing the bond between coats to fail.

Inadequate hydration can be caused by...

1. exposure to sun and wind causing rapid evaporation.
2. inadequate wetting of the straw before applying plaster
3. inadequate wetting of dry plaster before additional coats are applied.
4. inadequate wetting of plaster coats as they are curing.

If cracks are wide and close together and plaster detaches when it is tapped or scraped, the bond to the underlying material has failed and the entire coat in problem areas needs to be removed and a new coat properly applied.
If cracks are widely spaced and narrow, it may be possible to simply patch them.

Shrinkage Cracks

The most common type of cracking in the clay, lime and cementicious plaster wall coverings of straw bale homes is caused by the shrinkage of the plaster as it dries.
Cracks often run diagonally between the longest diagonal distance in a wall (for example lower left to top right) and may not extend all the way to the corners. Some shrinkage cracks also emanate from the corners of doorway and window openings.
Very thin cracks can be left alone, but cracks which can admit moisture to the wall cavity should be repaired.
Cracks in stucco/cement may have to be widened to be repaired properly.

Different substrates

Plaster applied over different substrates, such as straw and wood, may crack where different materials meet for two different reasons...

1. differential curing caused by dissimilar materials absorbing moisture from wet plaster at different rates.

2. differential thermal expansion and contraction rates of dissimilar materials.

Structural movement

Movement of the home structure may result from...

1. foundation movement caused by
    a. expansive soil
    b. inadequate soil compaction
    c. excessive moisture in the soil
    d. inadequate foundation design
    e. seismic activity
2. structure movement caused by
    a. wind loads
    b. inadequate structure design
    c. Poor construction practices

These cracks also often appear at the corners of doors and windows or at the upper and lower corners of the structure, but may appear in other areas, depending on the nature of the problem.
You may be able to apply some of the guidelines for diagnosing poured concrete foundation problems to determining the cause of the cracks you see in plaster walls. This is where having a copy of the original plans and/or photographs of the construction process may help.

PAINTS and SEALERS

Paints that form a membrane which is impermeable to moisture vapor should be avoided in order to prevent sealing moisture into the walls. Other paints such as lime paint and silicate paint are an appropriate final application.
Typically, non-toxic pigments are added to the final finish plaster or can be applied with washes using a brush or roller.

Sealers such as siloxane can be used to reduce moisture intrusion, improve durability while maintaining good vapor permeability to allow moisture in walls to escape.

The ADVANTAGES to BUILDING with STRAW BALES

High thermal insulation value

Straw bale wall assemblies provide an R value somewhere between 30 and 36 according to authorities such as the California Energy Commission and Oak Ridge National Laboratories. Actual R values will very depending on how well voids within walls are filled. A typical 2x6 exterior wall assembly with fiberglass insulation is approximately R-22.

High sound insulation value

In conventionally-framed buildings, framing members act as sound bridges, transmitting sound through walls. Because straw bales are non-rigid, they dampen sound rather than transmitting it, making for an a wall with highly effective acoustic insulating characteristics. This is one area in which loosely compressed straw bales are superior to tightly compressed bales.

The Ability to Store Water

Both the interior and exterior plaster and the straw bales are capable of absorbing and later releasing large amounts of water while remaining below the levels at which decay fungus are active. This means that it takes more water to bring these walls to the point at which mold will start to grow than wall assemblies that have less water storage capacity. Because of the high permeability of the straw bale/plaster wall assembly, it is able to efficiently release this water through evaporation (and to a lesser extent, diffusion).

Fire Resistance

The majority of straw bale homes that burn are lost during construction due to careless subs igniting loose straw. Once straw bales are sandwiched between plaster, wall assemblies are extremely fire resistant. Because the straw inside walls is compacted there is little oxygen available for combustion.

Properly constructed, plastered straw bale walls can withstand temperatures of 1800 degrees F. for up to 2 hours with little or no damage. Fire resistance varies with straw bale density, the effectiveness with which interior wall voids have been filled and the type and thickness of the plaster.

Walls plastered with earth and cement/lime have now passed 1 and 2 hour fire rating tests respectively during full-scale ASTM e-119 tests.

Natural building material

Straw is the stems of cereal grains that have had the seed heads removed. It contains no toxic glues or resins, it's relatively inexpensive and often locally available. It's comparatively benign to work with, no trees are cut to provide it, and very little energy is required to cut, bale and deliver it (embodied energy) compared to materials used in conventional wall systems.

The DISADVANTAGES to BUILDING with STRAW BALES

Most problems relating to building straw bale homes can be traced to the fact that there is much less experience with them and that methods involving innovative techniques and ideas about what works best for a given climate are still changing.

Lack of Qualified Professionals

Designers, building officials, general contractors, sub-contractors and home inspectors are often ignorant of good building practices unique to straw bale homes. This can lead to difficulties in getting plans approved, problems being built into homes which are sometimes difficult to identify and/or correct both before and after the home is complete and a lack of qualified pre-sale and pre-purchase home inspectors.

Problems obtaining financing

The main concern of mortgage lenders is resale value. If they should have to foreclose on the property, they want to feel confident that they can recover the cost of the loan by selling the home. Areas with a larger percentage of straw bale homes will be more likely to have financing available. This condition may also improve with time.

A couple of companies offering construction, mortgage or green system loans for systems such as photovoltaic and hot water systems in Boulder, Colorado are:

Colonial Savings
2500 30TH STREET #300
BOULDER, CO 80301
(303) 443-4427

Heritage Bank
3002 Bluff St
Boulder, CO 80301
(303) 413-0700

Problems obtaining insurance

There are companies who will write fire insurance policies on homes containing straw bales, such as Farmer's Insurance, but at this time (Sept. 2006), many insurance companies will not. is. Difficulty in finding coverage will depend to some extent on the area in which the home is located. Availability will probably change with time.

For more information :

The Last Straw http://www.thelaststraw.org
Quarterly magazine, comprehensive, covering straw bale and natural building.
Colorado Straw Bale Association http://www.coloradostrawbale.org/
extensive green links http://www.dcat.net/resources/links.php#straw
Ecological Building Network http://ecobuildnetwork.org
Non-profit organization developing educational programs for and promoting green/sustainable building.
Straw bale testing results are available through this site.