STRAWBALE

STRAWBALE HOME BASICS

by Kenton Shepard

Although strawbale homes have been built in the U.S. for over a hundred years, methods for their construction have changed to meet the evolving needs of their occupants.

With rising energy costs, their high thermal insulation value has made them more attractive to those wanting to reduce heating and cooling costs.

Increased sophistication of building methods and better understanding of moisture dynamics and materials technology has led to an improvement in construction techniques and a wider acceptance in mainstream building of these unique structures.

Strawbale Walls:

1. Load-bearing strawbale walls in which the bales (including the plaster interior and exterior wall coverings) support the roof and lateral (such as wind) loads.

2. Non-load bearing strawbale walls typically consist of a post and beam or conventionally-framed structure which supports the roof and lateral loads. This structure is in-filled with straw bales which provide insulation.

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

STRAW- A NATURAL BUILDING MATERIAL

Straw is the stems of cereal grains which 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,* (its "embodied energy") compared to materials used in conventional wall systems.

CONCERNS WITH STRAWBALE HOMES

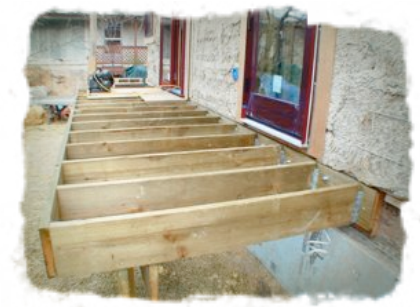
Moisture intrusion is the number one concern with strawbale homes, just as it is with conventional homes. Straw bales can provide food for mold fungi and wide-spread, long term fungal activity can destroy a strawbale home or make it a very unhealthy place to live. In addition to decay of the straw, mold is a concern because mold fungi release spores. High concentrations of mold spores in indoor air can cause health problems in people with asthma, allergies, compromised immune systems or lung disease. A number of design methods are used to keep moisture out of the straw or allow it to escape once it gets in.

FOUNDATION

1.The foundation should extend above the exterior grade far enough to keep the bottom of the exterior wall plaster a minimum of 12 inches above grade to minimize damage from splash-back and snow drift.

2. 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.

3. 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.



EXTERIOR

Roof overhangs should be extensive to protect walls from weather. Flat roofs should be avoided because they're more likely to leak than sloped roofs. The photo above shows a future deck. It's critical for deck/wall junctions to be correctly flashed and sealed.

INTERIOR

Shower stalls should be placed against interior walls.

WINDOWS

Windows should be installed so that they extend past the exterior surface of the plaster. Exterior window seals are potential points of moisture entry and should slope to help shed water. Windows should have high quality pan flashing installed beneath them.

PLUMBING

Plumbing pipes should not be routed through straw bales. Pipes should be installed in the floor, in waterproof channels designed with a clear drainage path out of the straw bale wall, or seamless tubing. This includes supply pipes for exterior faucets.

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, 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

Strawbale 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 straw where it can encourage the growth of mold.

2. Gypsum plaster has been used for many years and before drywall became 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 earthen and lime plasters are hygroscopic, (absorb and release moisture easily), walls built using these plasters can help moderate high and low swings in interior humidity. Earthen 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 fairly 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.

APPLICATION PROCEDURES

Plaster is often applied in four coats:

1. The *slip coat* is the first to be applied. It consists of a thinned clay mixture designed to be easily worked into the straw in order to provide a strong bond between the bales and the plaster.

2. The *scratch coat* is then used to build out low spots in the wall and build up the thickness of the wall surface.

3. The *brown coat* applied next adds thickness and further flattens the surface.

4. The thinner *finish coat* provides durability, color, texture, and is what you see when you look at the wall. Allowing each coat to dry completely before the next coat is applied will help prevent cracks from being transmitted from underlying coats to newly applied coats.

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 plaster is the #1 maintenance issue with strawbale homes. Cracking is a natural process with the earthen and cementicious plasters typically used to cover interior and exterior walls in newer strawbale homes. Earthen plasters shrink as they dry and they can crack as they shrink. 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 of the straw bales and are a defect requiring *immediate repair.*

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 binder (chopped straw)*

This kind of cracking is common in the scratch coat and to a lesser extent, in the brown coat. 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.) Cracks may not extend all the way to the corners and may not be continuous. 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 straw 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 rates caused by dissimilar materials absorbing moisture from wet plaster at different rates

2. differential thermal expansion and contraction rates of different materials. One method for preventing cracks resulting from different substrate materials is to staple expanded metal lath over wood framing members after the second earth coat is applied. The lath is then plastered with a coat of gypsum plaster. Once the gypsum has dried, the next plaster coat of lime or earth is applied uniformly over the entire wall.

STRUCTURAL MOVEMENT

Movement of the home structure may result from:

1. *Foundation movement caused by expansive soil and/or inadequate soil compaction*
2. *Soil consolidation from moisture*
3. *Inadequate foundation design*
4. *Seismic activity*
5. *Structure movement caused by wind or snow loads and/ or inadequate structure design*
6. *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 forming 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 Acoustic 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, creating 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

Strawbale walls are good hygric buffers. This means that 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 mold fungi become 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 strawbale homes which burn during construction are destroyed due to careless workers 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.

THE DISADVANTAGES TO BUILDING WITH STRAW BALES

Loans and Insurance

Because strawbale homes represent a relatively new construction method, lending institutions and insurance companies in some areas of the country may be hesitant to loan on or insure them. The availability of ASTM test results and the efforts of organizations like the Colorado Straw Bale Association have helped educate these industries and are good resources in applying for loans and insurance.

Building Departments

Building departments in areas of the country in which few strawbale homes exist may be hesitant in approving plans and worried about signing off on construction details with which they're unfamiliar. Confrontation does not work well with building officials. Providing them with engineering specifications or other information which will allow them to feel comfortable will help move things along and keep everyone's stress to a minimum.

Finding Qualified Contractors

Finding qualified contractors and subcontractors is crucial in new construction and remodeling. Much damage can be done by workmen who don't understand these homes.

Finding Qualified Inspectors

Finding home inspectors qualified to inspect strawbale homes is very difficult. This article is the only information available directed at home inspectors. Inspection of strawbale homes carries high liability and you should expect prices for their inspection to be about twice that of conventional homes. If an inspector offers a conventional price, that inspector does not understand these homes and will not protect you. Many inspectors won't know what they don't know.

InterNACHI is the only professional home inspection organization offering their members education about inspecting strawbale homes. Visit www.nachi.org/green for more strawbale and green building information.

More Resources:

- Watch an actual Strawbale Home Inspection: *www.nachi.tv/episode15*
- For more Green Building resources for inspectors and consumers, visit: *www.nachi.org/green*
- Visit Kenton Shepard's site at: *www.peaktoprairie.com* contact Kenton at (303) 258-8289
- Take InterNACHI's FREE Green Building course at *www.education.nachi.org*
- Visit the Colorado Straw Bale Association at:

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