SPECIAL NOTE: I recently had a conversation with a bunch of my readers and it got me very excited to share some of the basic information that I think everyone interested in building a load bearing straw bale structure should know…..

"What Are the 10 Things I Would Share With Anyone Interested in Building a Load Bearing Straw Bale Structure?"

The "Essentials of Load Bearing Building" Report
Version 1.1

From the desk of Andrew Morrison
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I have 10 tips and techniques I am going to share with you…. But first I want to explain what load bearing construction is for those of you who don't know and show you WHY building a load bearing straw bale structure is something <u>anyone</u> can do.

You've seen the beautiful photographs, you've read about the amazing health and energy saving benefits of straw bale, and you may have had the opportunity to visit or stay in a straw bale house. No doubt about it, straw bale building is becoming more and more popular worldwide and perhaps you've decided that this is **THE** way to build your dream home.

At this point you will need to make a fundamental decision about which type of straw bale building you want. The two choices are:

1. Load Bearing Straw Bale, or
2. Post and Beam Straw Bale Infill

Most straw bale homes are built as post and beam infill, but load bearing construction reflects back to the original straw bale structures in Nebraska. For that reason, load bearing construction is often referred to as "Nebraska Style."

What's the difference?

The biggest and most obvious difference between Post and Beam Straw Bale Infill Construction and Load Bearing is that **no structural system is used to augment the strength of the bales** in the load bearing method. The walls, formed entirely of straw bales, are the only structural system used to support the load of the roof assembly. **Another difference is that load bearing construction is much easier for people with no construction experience!**

There are many advantages of load bearing construction

- The environmental impact of load bearing structures is less due to the minimal use of wood. The only wood required for a load bearing home is found around windows and doors in what are called “bucks” and in the roof framing and toe ups. (Unless, of course, you build on a wood floor system.)
- It lends itself to the owner builder who can build this type of structure with limited building skills.

You can do it

Straw bale construction can be ideal for the person who is interested in building their own house. For some this may be a daunting task, but I want to reassure you, it's easier than you think to build your own straw bale house, especially if you choose to do it using the Load Bearing Straw Bale Building method.

Homeowners and people wanting to build their own house like the idea of load bearing construction because **little carpentry skills are required** to build a home. It is important to have enough skills to construct a simple roof and some window and door bucks, but the majority of the intricate details of home construction are replaced with **simple block building techniques.**

If you ever built with Legos™ as a kid then you can build a load bearing straw bale structure!

Load Bearing is Fun and Community Based!

As opposed to in-fill construction, no notching of the bales is needed because there are no posts or beams to notch around. This **speeds the process of stacking the bales** and is ideal for a workshop or bale wall raising party. This makes the construction of the home **fun and community based**, which is something many homeowners appreciate.

In this report I want to give you a basic understanding of what it takes to build a load bearing structure. If you haven’t ever built before, I recommend that you practice on a

small structure like a garden shed or studio before tackling a full size home construction project.

Here We Go…. The 10 Things I Would Share With Anyone Interested in Building a Load Bearing Straw Bale Structure

Tip #1: Load Bearing Straw Bale Requires Special Design Considerations

It is important that you pay attention to some basic design rules prior to building your load bearing straw bale structure. This is particularly important when it comes to planning out the door and window openings. Here's what you need to know about the 3 basic ratios of load bearing:

1. Due to the use of the bales as the structural component of the home, the openings in the walls are limited to 50% of the wall surface area. Although this sounds somewhat harmless, when applied, it means that you have to be very precise with the type and placement of your windows.
2. You also have to pay attention to how high you make your walls. There is another important ratio to pay attention to: **The ratio between wall height and wall thickness.**

> The height of the structure is limited by a width to height ratio of 5.6:1 under most codes. In construction terms, this means that a 23" thick wall has a maximum wall height of 10 '8." In addition, load bearing structures are limited to single story; however, a loft design can be utilized if the roof pitch is steep enough.

3. Another ratio in load bearing construction that needs to be considered is the **"unsupported wall length"** which cannot exceed a ratio of 13:1 for a 23 inch wide wall. This ratio basically means that you cannot have any more than 25 feet of unsupported wall length in any direction. This is fine as long as the interior partition walls are spaced appropriately and used to offer perpendicular support to the bale walls.

Tip #2: Foundations

There are basically 3 different foundation options open to you:

a. Slab Foundation

b. Concrete Stem Wall

c. Raised Floor System

Slab Foundation

If you're building a structure on a slab foundation, very few differences exist between a post and beam and load bearing system. But pay attention to this:

Create the foundation with enough depth and room to handle the width of the bales as well as the foundation bolts placed through the toe ups.

Stem Wall Foundation

If, however, you are building on a stem wall foundation with a separate slab floor (often the system used when placing an earthen floor), you will have to form the foundation wide enough to support the full width of the bales you use. That can mean a concrete stem wall that is 18" – 24" wide.

Raised Floor System

Another option is a raised floor system like that used over basements. It should be installed in the same way that one would in a post and beam structure. Be sure to account for the extra weight of the bale walls in the floor joist engineering.

Tip #3: Pay Attention to Your Toe Ups

Toe ups are used to raise the bales off of the floor as well as to secure the bales to the foundation. By raising the bales off of the ground, they are safely removed from any minor floods caused by leaking appliances or plumbing. The second job of the toe ups is to provide nailing for the welded wire mesh. I typically use 4 X 4 dimensional lumber for my toe ups. The toe up can then become part of the shear system of the building if engineered as such. Once in place the toe ups are bolted to the concrete foundation

It's important that you know the width of the bales you will be using before you install the toe ups. I add one inch of width to the bale width when determining my interior toe up lay out. In other words, if the bales are 18" wide, I mark the layout so that the interior face of the toe up is 19" from the exterior face of the mudsill. I then snap a chalk line to represent the interior edge of the toe ups. This yields a straight and precise line for the edge of the toe up, making installation quick and accurate. Be sure to account for the door openings when laying out the toe ups!

Tip #4: Bale Compression – Using Compression Straps

Unlike Straw Bale Infill Construction, it is necessary to add special straps underneath the toe ups before they are tightened to the foundation. The straps are used to secure the bales to the toe ups and ultimately to the foundation.

When the straps are tightened, a box beam (more on this later) placed on top of the bales will act as a cinch and will **compress** the bales into their final position. If the

bales are not pre-compressed, they will have a tendency to sag over time under the weight of the roof assembly. So this step is essential!

Because the straps tend to get in the way of the construction while raising the bales and straightening the walls, I run a short section under the toe ups, typically extending about 3' up each side of the wall, which is then rolled up and secured by rubber bands at each location. I lay the straps about every 2' along the length of the wall making sure that I am not laying them in window or door openings.

Once in place and perpendicular to the toe ups, I tighten down the toe ups to hold the straps securely in position, and add either clean gravel or insulation in between the toe ups.

Tip #5: The Box Beam

A box beam is used on top of the bales to provide a surface to mount the roof assembly and to help evenly compress the bales before the roof is installed. Here's a tip that you must pay attention to:

The box beam should be built immediately after the toe ups are installed. Build the box beam as a mirror image of the toe ups. Build it to the exact dimensions so that when placed on top of the bales, it will be easy to find the plumb location of the box beam and ultimately to tighten up the walls in a plumb position.

The only place where an exact copy of the toe ups is not used is in door openings. Because the door openings need to be spanned by the box beam, do not stop the construction of the box at the openings that are created in the toe ups.

It is important that the box beam be built in sections so that it can be easily lifted into position and assembled on top of the bales. Once the bales are in place and checked for plumb, raise the sections of the box beam to their respective locations and nail the sections to each other at every union.

Of course, since we have yet to raise the bales, all you can do now is build the box beam with precision, label each piece for its respective location, and place the pieces to the side.

Tip #6: Window and Door Bucks

In a load bearing building you will have to build special frames for all your windows and doors. These are called "bucks" and need to be created before you being the baling process. A buck acts as the framing member that anchors the window or door firmly to the building. Without the buck, there is no way to secure the windows and doors to the

bales. It is important that the bucks be square to ensure proper window and door operation.

I always build bucks that are deeper than the window or door they will support so that I have space on the buck to attach wire mesh to during the shaping phase of the construction. A simple 2x6 box is often enough to create a window buck and a 2x8, 3 sided box (no bottom) is adequate for a door buck. More elaborate bucks can be created in order to aid in the bale shaping process if so desired.

Be sure to add braces that keep the buck square. You can either use bracing inside the buck itself or use plywood scraps nailed to the face of the buck at the corner to hold it in place. Whichever you use, be sure to place the bracing in an area that will not impede the baling process.

The buck should be fully anchored to the building with mesh and dowels before the braces are removed and the window installed. For that reason, I usually install the bracing just inside the exterior plane of the buck where the window or door will eventually sit.

Once your window bucks are built and braced, number them so that you know where they go in the structure and place them around the building in the general area of their final position. The door bucks should be installed at this time. Stand them on the floor system and nail them to the toe ups. You may need to temporarily brace them in position until enough bales are installed around them to firmly anchor them in place.

Tip #7: Keeping Your Load Bearing Structure Plumb

Contrary to popular belief, load bearing structures need to built as plumb and square as a wood framed building. Consider that the bales are the wall system. Now consider that the wall system, if built out of plumb, is not actually bearing directly on the points below which have been designed to hold them. Instead, the walls are pushing out to the sides and placing stress on the corners and other supporting areas of the structure like any partition walls, which were never designed to carry such loads.

In order to build a load bearing structure plumb, reference must be given. Without it, a series of bales stacked on each other will eventually slip out of plumb. This is because the eye, although very competent at maintaining a plumb or level line is fooled by the odd shape of the bales and the bulges that are commonly found on the ends of bales.

To compensate for this, the eye tends to tell the brain to build out rather than straight. The result is a wall that gradually grows longer and a corner that gradually flares out as you go up in courses. Be sure to plumb your corners with wood braces before you start stacking bales.

Tip #8: Building Your Walls
a. Safely Securing the Bales Together

The bales need to be stacked in what is called *running bond*. This means that the bales are stacked like bricks so that no two courses have joints that line up with each other (remember the legos™!)

Start in one corner and work in one direction all the way around the structure while building the initial corner in two directions or build the walls out entirely in two directions from the starting corner. If you have several people helping with the bale raising then build out in two directions so that more people can actively place bales; however, if your labor force is small, it is best to work in one direction and focus on completing the home in sections.

As you approach another corner or turn in the wall, be sure that a full bale is used on the bottom course. The full bale should either run in line with the current wall or perpendicular to it. Do not use small sections, less than ½ of a bale, in the corners, as a weak corner will develop.

If you find that a full bale or half bale will not fit in the corner and a small piece will need to be added, place the full bale in the corner first and then add the small stuffing behind it, towards the bulk of the wall. In that way, the running bond will still apply, and the full bale will maintain the strength and integrity of the corner. Be sure to pay attention to the corner braces so that the walls go up plumb from the beginning.

Don't Use Rebar except in one special area!

Each course of bales needs to be attached to the one below and the one above. In the past, builders would drive rebar pins into the bales to tie them all together. Today, I secure all of the bale courses to each other by using welded wire mesh on both sides of the walls once they have been fully raised. The one place that still requires rebar is in the corners. Rebar staples, not pins, should still be used to tie the corners and thus the walls together.

b. Stacking the Bales

Stacking bales is very satisfying. In fact, it can be so exciting that you might not want to stop, even when you are supposed to install a window buck. Make sure that everyone involved in the bale raising is aware of the window locations and that the bucks get placed in the wall before the bales get stacked too high.

The easiest way to add bucks is to place them on top of bale courses in the proper location. Once in place, secure them by adding bales on either side of the opening

while maintaining the running bond pattern. If the bucks do not stay in place, nailing a wide piece of plywood to the bottom of the sill will help it stand up. The plywood can be left in place once the window buck is secure.

Tip #9: Installing Your Box Beams and Keeping Your Walls Plumb!

The walls may be weak at this stage, especially if they reach the maximum height for bale walls per the width to height ratio given earlier. The bracing in the corners will help strengthen the walls, but the major push at this point is to install the box beams on top of the bales.

Because the sections were labeled and properly laid out around the structure this stage of construction is a simply assembly line. Hoist the sections of box beam to the top of the wall and assemble them with nails and plywood. Be sure that as you nail them together, the corners remain square.

Because the box beams are a mirror of the toe ups below, keeping them square will insure that the whole building stays square and, ultimately, plumb. Once the box beam is fully assembled, line up one edge of the box beam perfectly with the section of toe up directly below it. This is used as the baseline for the building, and confirms that the walls, if in line with the toe ups and box beam, will be plumb.

To make minor adjustments in the walls, use a soil tamper or home made "persuader" (large wooden sledge hammer) to hit the bales into position. The weight of the box beam will help secure the wall; however, be careful not to hit the wall too hard and knock it over. It is best to do this in pairs with one person on the inside of the house and one on the outside. Choose a side that will represent the perfect plumb line and stick with it. For example, if the person on the outside of the house holds the plumb stick, then all checks for plumb shall happen on the exterior of the building, all the way around. Work the bales from one corner, around the building and back.

When satisfied with the position of the bales, add the remaining strap material up and over the box beam and attach it to the small sections previously installed at the toe ups.

Tip #10: Strapping, Compressing, and Wire mesh
a. Strapping and Compressing the Bales

The strap material serves two purposes. The first is to compress the bales. This is important to reduce cracking in the final plaster and to increase the overall strength of

the structure. In most cases, the bales will not compress more than a couple inches. Be sure to compress them as far as they will go so no further settling will ensue.

The other purpose of the straps is to adjust the box beam into a level plane all the way around the structure. This is important for the roof framing. If the box beam is out of level, the roof framing will be difficult, even for a seasoned carpenter. Therefore as the straps are tightened watch the level of the entire box beam. This is where working from one corner out is important.

After the majority of the compression has been made, the final adjustments can be made incrementally. By starting in one spot and marking it as the baseline for the rest of the house, the box beam can be lowered evenly creating a perfectly level base for the roof assembly.

The strap material may have a tendency to stretch over time when exposed to direct sun. For that reason it is important to check the straps and check the box beam for level one last time before the welded wire mesh is installed.

This is also the time to adjust your bales one last time and have at them with a weed whacker. The smoother your walls are now, the easier they will be to plaster.

b. Attaching the Wire Mesh

Welded wire mesh is a very strong and versatile product. It is used as the lateral shear strength of the building, to shape bales, and to attach the bales to the toe up and the roof. Once the mesh is installed, any adjustments to the strapping will cause the mesh to bow and buckle which makes the finish plaster difficult to place so it's important to do that last check on the strapping prior to installing the mesh.

Start installing the mesh on the exterior of the structure by nailing it to the box beam and then stretching it to the foundation toe ups. Be sure to install the mesh tightly running from the top of the building to the bottom. Wrap the mesh around each corner to strengthen the corners. Don't forget to remove the temporary corner bracing first! After the entire exterior has been installed, adjust the window and door bucks to insure they are perfectly plumb. Check them for level once again and then attach the mesh to the face of the bucks.

Once the entire exterior is wrapped in mesh, focus should turn to the roof assembly. A detailed explanation of roof construction is outside the scope of this report. It is vital that the roof be installed as soon as possible to fully load the walls and to protect the bales from inclement weather.

Finishing It Up On the Interior!

After the roof is complete, move to the inside and perform any of the necessary interior work, such as electrical, before adding the interior mesh.

If there are interior partition walls in the structure, they'll need to be installed at this time. In general, it is best to support the roof only on the load bearing walls because the wood partitions will not accept any settling whereas the bales may still continue to settle even if only in minute amounts. The differential settling will cause cracks in the plaster.

With all of the interior work complete, the shaping of the bale openings and the interior mesh work is priority number one. Once the mesh and shaping are complete, use bale needles to sew the mesh through the wall to the mesh on the other side.

Tying the two mesh planes together strengthens the walls and ties the entire structure together. This is a vital step for anchoring the bales to one and other and for the overall strength of the building. Use baling twine to tie the mesh every 24" on center, both directions, or more if required by your local inspector. Use a Miller's Knot to tie the twine tight to the bales. After the mesh is fully secured, the structure can be plastered. The sooner the structure is plastered, the sooner it is protected from fire and weather.

That's It!

I hope you have found this information useful. I wish I had a report like this when I built my first load bearing building way back when!

Obviously this report is more of a rough outline than a true end-to-end guide. My goal was to open your eyes to the possibilities of load bearing and clear up some of the misinformation I see so much of nowadays.

If you want to learn more about how to actually build your own load bearing straw bale structure then please check out my best-selling Step-by-Step How-To Load Bearing DVD Production.

This DVD production is unlike anything else that has been seen in the world of straw bale construction… it is structured like a 6 day workshop, with me as your host and guide! It takes you through every step of the load bearing process from the bare earth of the site through to getting the building ready for plaster. It takes all this and systemizes it into clear, easy to follow steps that are arranged in a true step-by-step fashion.

Check out the DVD at the following link:

http://www.StrawBale.com/Load-Bearing

I have created a short online video preview of the Load bearing DVD. Check it out at this link:

http://www.StrawBale.com/LB-Video

That's it for now….now it's time for you to build that straw bale house you've been dreaming about!

Happy Baling,
Andrew

Andrew Morrison
Straw Bale innovations, LLC

P.S. Remember…It's not rocket science. Once you get the techniques down on a small structure you'll be moving onto bigger and better buildings before you know it!

P.P.S. I really want to hear your comments and questions…go to my blog now and post them. Here's the link: http://www.StrawBale.com/blog