Compression of Straw Walls

As strawbale building has become more professional, ways have been developed to speed up and improve techniques to make them more appropriate for the modern building site. Most buildings of any size are built using pre-compression techniques for the straw, whether they are loadbearing or infill.

Ideally we would choose the densest bales to build with, in order to reduce the amount of settlement that occurs due to the loading of other bales, floors and roof. Construction-grade bales will compress up to 10mm (almost half an inch) per bale, whereas more fluffy bales will compress further. Lighter roofs may not compress the bales to their fullest extent. Windows and doors in load-bearing systems should therefore have at least 75mm (3") settlement gap left above them. During settlement, this gap is maintained by folding wedges of timber with which you can gradually reduce the gap as the building compresses. Imagine a piece of 100mm x 50mm (4" x 2") timber cut along a diagonal line on the wider face from corner to corner. If you now stand these on edge, you can slide one along the other. This has the effect of reducing the height of the timber whilst keeping the edges parallel. This is a pair of folding wedges! These wedges would be used in all places where settlement needed to occur.

Walls can be pre-compressed by using heavy duty ratchet straps at 1-2m (3'3"-6'6") intervals along the wall, fastened to or through the foundation, to give even pressure on the walls, and using the wall plate to spread the load across the width and length of the wall. You can appreciate that putting the walls under the amount of pressure required to compress the bales, particularly when using construction-grade bales of very high density, requires a lot of force. This means that whatever you fasten the ratchet straps to at foundation level needs to be very strong. For commercial house building, this is a design detail that needs to be added in at the earliest stages. It's best to add a physical fixing point at or through the foundations.
If you have access to lifting equipment, a really great way of creating compression quickly is to lift one-tonne sacks of sand up on to the corners of the wall plate.

At compression, there is a dramatic change in the stability of the walls, and instead of being flexible stacks they become remarkably solid and reassuring to work on. This is the moment at which sceptical mainstream contractors become infused with bale frenzy themselves and decide they do want to build more straw bale houses after all!

Methods for holding compression straps

- Leave a hole in the foundation by placing a piece of water pipe into the foundation that can be removed later. A metal pin can be inserted through this to protrude 100mm (4") from each face, so that compression straps can be hooked round them. This pin can be removed after use and the hole plugged.
- Fix anchor bolts into the foundations internally and externally to take compression straps. Ensure that they are fixed close enough to the wall so that they can be plastered in, or that they can be removed later.
- Drill holes in the base plate large enough to take the hooks of the straps, ensuring that the walls are heavy enough to prevent uplift.

Tie-downs
These are NOT used to create compression. They have two functions:

- a means whereby the roof structure can be fastened down securely to the foundations, after compression has been applied, to prevent uplift when subjected to strong winds
- a device to keep the walls in compression so that ratchet straps can be removed, and the walls and roof above can be constructed.

Tie-downs, also called strapping, are usually polyester, or sometimes metal with an adjustable fastener so they can be tightened as the walls compress. Remember to trim the walls before attaching the tie-downs, as it gets more difficult afterwards. The tie-down generally goes underneath the base plate or under the foundations, up and over the wall plate, and is fastened on both sides of the wall with a tensioning buckle.

Tie-downs aren't always necessary. In two-storey houses, for instance, the ground floor doesn't need to be tied down, because it won't move with all that weight on top of it, and the roof plate can be tied down to the first floor. If the roof is sufficiently heavy, there is no need to tie that down at all either, unless you are in an area that experiences high winds. When you plaster the tie-downs in you need to make sure that they are covered really well, either with a wide strip of hessian scrim about 300mm (1') set into the body coat, or by using long-straw-rich plaster over the tie-down.

Strapping can be fixed to the timber base plate that is laid on top of the foundations, as long as the walls are heavy enough to prevent the base plate from lifting.

Methods for compressing loadbearing buildings

All loadbearing designs are compressive, it's just a matter of whether you let the building structure itself compress the bales, or whether you help it along so you can build faster. It's still perfectly feasible to allow the floor and roof weight to compress the walls without using pre-compression and for smaller or self-build types of building you may find it unnecessary. Traditionally, in load-bearing buildings the roof weight would compress the bales over a period of about six weeks, but by pre-compressing the straw, settlement caused by the roof and floor loads can be controlled and encouraged to happen much more quickly. Now that straw is becoming a mainstream building material it is necessary to be able to construct load-bearing buildings fast and simply using pre-compression.

Buildings need to be carefully designed so that pre-compression is physically possible, and as much as possible of the timber work of the building should be prefabricated, because this speeds up the actual time of the build and therefore its vulnerability to the weather. The base plate, first-floor ring beam and joists, roof plate and roof can all be made ready in advance.
Various methods of pre-compressing straw walls have been used around the world since at least 1994. The idea is to force settlement of the bales and maintain the pressure by the use of tie-down straps, fastened over the top of the wall and down to the foundations, until the straw is stabilised. When you see this happen, it transforms a very flexible wall into a solid, strong, extremely *impressive* structure in a few moments! (No-nonsense builders, previously sceptical of this new-fangled building material, have become instant advocates at this point in the build and have been found showing their friends round and boasting about their

building's credentials.) Methods include rubber tubes placed on top of the walls, fastened down with chains and then filled with air (first used in Canada), industrial-strength ratchet straps, placed over the top of the walls and fastened to the foundations, and then ratcheted down tight (as used in California) or pairs of threaded rod attached to either side of the wall and base plates and screwed down (used in Australia).

Using temporary posts and beams

The wall plate and first floor can be built directly on top of temporary posts and beams, usually 4 posts and 2 beams are required per house. The floor will need a temporary stem wall to be built centrally along its length to create a pitch for heavy-duty tarpaulins that waterproof the floor and cover in the sides of the building to give the straw protection from driving rain. The scaffolding should be sheeted on the outside for the same reason. The straw is now installed and the posts and beams are removed by raising the floor with acrow props and taking the timber columns out, leaving the floor resting on the walls, which are then compressed by the weight of the floor itself; alternatively, you can use ratchet straps that go through the floor. The weight of the floor itself and the walls and roof above are usually enough to stabilise the building without the need for permanent tie-downs (these would be needed at this level only if this was a single-storey building with a lightweight roof, or there were severe winds).

Once the ground-floor walls are complete, the roof plate and roof are constructed above the first floor, on to more posts and beams, and temporarily held in place while the first-floor walls are constructed. At this stage, the roof provides waterproof covering over the building and sheeted scaffolding protect the sides from driving rain. Again, the walls are compressed using ratchet straps over the roof plate.

The timber used for the props is designed so that it can have a second use as part of the building later on. There has to be some flexibility in the building schedule to make sure that certain critical points of the build take place during dry weather, e.g. putting the roof on, as this obviously requires the straw walls to be uncovered, but these stages should not require more than one or two days to complete. This method was used to build a two-storey semi-detached house at Ralegh's Cross in Exmoor and it worked extremely well.

Using the window and door fixing posts

In many loadbearing designs, the fixing posts for the doors and windows can be used as temporary props. They need to be left long for this purpose, as the wall plate must be high enough to allow room for the straw to be installed below it. Once the fixing posts are in position, a temporary cap of timber of is placed on top of them, wide enough to support the width of the wall plate. The wall plate is constructed in sections and lifted onto these caps, fixed together securely, and the floor or roof is then constructed on top. This is weather proofed and then the straw is installed. Once completed, the wallplate is lifted just enough to be able to remove the caps. This can be done by placing a horizontal timber underneath the plate beside a cap, and using an acrow prop either side to lift. A version of this method was used to build the Outback Centre in Halifax in 2011.

An alternative to this method is to use temporary timber battens underneath the wall plate and fixed to the scaffolding boards around the outside.

Using a crane

If the budget allows, floors and roofs can be prefabricated off-site, or constructed on-site next to the building. Either method has the advantage of enabling the roof to be built at ground level, thus saving on labour, time and scaffolding costs. The roof is not completed at this stage, so as not to be too heavy, only finished up to the vapour-permeable

(weatherproof) layer. A crane is used to lift the first floor, and temporary posts and beams (or scaffolding) are placed beneath it for support, leaving enough room to install the straw underneath. It's an effective but expensive method and was used to build the North Kesteven straw social housing in 2009.

Methods for compressing infill/framework buildings

It is sensible to create compression on the bales even when they are only being used for infill rather than for structure. This is because compression strengthens the wall structure, making the frame and straw work together, and firms up the straw surface that will be plastered. It is best to think through the method of compression to be used at the design stage, as there are various practical problems to be addressed that need to be solved by the method of construction. For instance, in general it is more difficult to compress a stack of bales once there is a beam above it, as this beam gets in the way of physical installation.

The frame should be designed with the floors and roof about 100mm (4") higher than their finished level, held out of the way by various means, and then, once the straw has been installed, to lower the floor and/or roof on to the walls, often using their weight to stabilise the straw without the need for pre-compression straps. This gives a covered space inside the building in which to store straw, but still means the sides of the building need to be protected from rain.

There are many different ways this can be done, and you can be sure that your engineer can think of very complex ones! It should, however, be kept as simple as possible, and can be done using folding wedges of timber on the shoulders of mortice and tenon joints, or threaded rod of some description, metal shoes for the posts, etc. If you do end up with lots of metal in the walls (which is expensive), the straw will need to be protected from its coldness by wrapping the metal in hessian or something similar, because cold metal could cause warm moist air to condense on to it, thus causing potential damp problems.

Sworders Ltd, a fine-art auctioneers based in Stansted Mountfitchet, built its new saleroom using this method in 2008.

How to compress when there is a physical barrier above the straw

In infill designs there is usually a beam above the stacks of straw that connects the frame together, sometimes between floors, or this could be part of the roof structure. This barrier, if not designed well, can make it very difficult to install the straw. It also makes it difficult to insert pins into the wall, as the beam or roof gets in the way.
Ideally, the barrier above the straw should be at a height that is the same as the exact height of a full number of compressed bales. However, if this is the case there is an obvious problem: the bales cannot be compressed until they are in place, and the last bale cannot be put in place unless it and the bales below are compressed! This is one of the reasons why infill designs are more costly to build than loadbearing, as there is more complicated work to do with the straw. Nevertheless, there are always solutions, and below are some of them. Whatever method you use, it's important that you stabilise the bales somehow before plastering.

1. Use a temporary metal compression plate at one bale below full height
2. Use a bottle jack beneath the beam above and then insert the last bale
3. Add a timber compression plate that is strapped down permanently.

1. With larger frames, the straw can be pre-compressed between each post by using a metal plate on top of the last but one bale, placing ratchet straps over this and under/through the foundation, compressing the straw, adding the last bale, and then removing the straps and metal plate. This allows the bales to decompress slightly, which has the effect of compressing the last bale inserted. It sounds fairly straight forward but can be pretty hard to do in practice!
2. If the frame is strong enough then bottle jacks can be used to compress the straw downwards from the beams of the frame, rather than using ratchet straps tied to the foundations. To do this a solid metal plate needs to be placed on top of the straw, and the jack extended between this and the top beam of the frame. Then, if the frame has been designed correctly, a whole bale will fit in the space you have created, between the jacks, and you can carefully pull out the metal plates as you remove the jacks.
3. Alternatively, you can design the frame so that you have a timber plate at compression level, which remains permanently in the wall. Again, the straw beneath can be compressed using bottle jacks or ratchet straps, and then the timber plate is fixed permanently to the posts either side. It may need to be held in compression using tie-down straps until the whole wall has been built, and then these straps can be removed. You can carry on building above the compression plate, and add more than one plate if the wall is particularly high. In general, you would need a compression plate every 4th course of bales.