Loadbearing, Infill and Hybrid methods

There are two main ways to design and build strawbale houses, and a variety of hybrids in between. At one end of the spectrum is the Nebraska style, or loadbearing – the original and simplest method. At the other end of the spectrum is the framework or infill style, a method that was developed in the late 1970s. In the former, the bales are used as structural blocks, insulation material, and a key for plaster. In the latter they are only used as insulating material, and often also as a plaster key.

Loadbearing

In this technique the bales are used as structural blocks and take the weight of the floors and roof; there is no need for any other structural framework. They are placed together like giant bricks, pinned to the base plate (a continuous timber plate that sits on top of the foundations) and to each other with coppiced hazel, and a continuous rigid timber ring beam on top spreads the floor and/or roof loads around the building and across the width of the wall. For two-storey houses, the floor joists at first-floor level are attached to the ring beam before building up the straw walls again beneath the roof. The roof plate (a continuous plate that sits on top of the walls and under the roof) is fastened to the bales with coppiced hazel and may be strapped down to the foundations, depending on local weather conditions and the weight of the roof. The roof is constructed on top of the roof plate, following straw bale design principles.

This is the original way to build with straw, pioneered by Nebraskan settlers in the USA in the late 1800s. It is simple, flexible in design, has great thermal performance and is cost-effective. The potential for empowerment through working together on a shared project is one of the great advantages of this type of building, as it is such an accessible building method: pretty much anyone can do it, and it's a lot of fun!

The load-bearing style is a simple, straightforward building method, easy for non-professionals to design following readily comprehensible basic principles. Designs from one-room to two-storey homes can be created using a simple step-by-step approach. Curves and circles are easy to achieve, though at some extra cost due to more complicated timber work. And as the straw is very forgiving, total accuracy in plumb is not necessary, but wilder variations can be brought back into shape easily! Self-builders love it because it's fast, fun and fulfilling! However, most of the larger loadbearing buildings now being built in the UK and Ireland are actually pre-compressive, hybrid loadbearing styles (see below).

Infill (also called post and beam or timber frame)

This is another way of building with straw, developed in the USA in the late 1970s, as their construction industry was by then familiar with timber framing as a practice. In this method, the weight of the roof is carried by a timber, steel or concrete framework; the bales are simply infill insulation blocks between the posts, and a key for plaster; they are not used structurally. You might make this choice because you like the look of timber and you want to use its beauty in your design, or because you are going for something really ambitious with large openings and spans, and a load-bearing building just won't do it. This method also has the advantage of giving peace of mind to clients and those professionals (architects, engineers and building inspectors)

who aren't quite ready to accept just what straw can do as a building material. It is often the preferred option for architects, as the structural concepts are not innovative and rely on an already-established method of building, therefore the risk associated with using a new technique is minimised. There is no need to satisfy oneself of the capacity of the bales to take the roof weight, since the framework does this. This method requires a high level of carpentry skill and uses substantially more timber than a load-bearing design, so has significant cost and environmental implications.

When designing a timber framework to have straw as an infill material it is really sensible to have somebody who understands how straw works to work with the framework designer; this means that all sorts of practical difficulties can be eliminated before you ever get on site. This type of building needs to be designed with the dimensions and properties of the bale as the first consideration, but what usually happens is that the building is designed as per standard framework techniques, and the bales have to somehow fit within that. Because of the nature of the straw, it *is* possible to solve most practical problems on site, but doing so can detract from the ease of build and the fun – if, for example, you're having to make little parcels of straw, or sew packets on to the front of posts and so on just to get around the fact that the frame wasn't designed with the straw in mind.

Post size and location

From a design point of view it is best to use small-dimension timber notched into the centre of the bales. This makes stabilising the straw more efficient, and it also means that there's no possibility of air leakage around posts, as there is not a flat join between straw and timber, but obviously then you don't get the benefit of seeing the timber as part of the design. Ideally a post would be small enough to be notched in between the strings of a bale, 100 x 100mm or 100 x 150mm. This gives strength to the straw/frame component and allows for much less timber to be used than if a framework alone was being used. Posts would be spaced apart by combinations of whole or half bale lengths, and beam heights would be set to match compressed bale heights.

Using large posts

It's common to use 200mm x 200mm (8" x 8") posts for a frame, but fitting the bales around these can be difficult due to the location of strings. Posts of this size cannot be notched into the centre of a bale, so the ideal location for them is to protrude into the building, removing the corner of each bale against a post and re-locating the string. However, if the posts are located on the inside of the building, and the bales are essentially wrapped around the outside edge, then we have the problem of how to stabilise the straw with nothing fixed above it. Tricky! This type of design usually results in a lot more timber than would have been necessary for a standard timber frame building, simply because the straw itself hasn't been taken into account properly in the design, so more timber is required for a plate below the straw and to cover the top of the straw to make a connection with the framework.

An issue with infill building is how to stabilise the straw ready for plastering. Originally, this was done by using external pins, fastened to the base plate and wall plate inside and outside the wall. These long pins would be sewn together with baling twine through the body of the bale using about two stitches per bale: as you can appreciate, this is an enormous amount of work. Because this adds time and expense to the job, other methods of stabilising the straw have been devised, which are discussed under compression.

On the plus side, all of the timber work can be prefabricated and brought to the site for assembly, which will help keep costs down, and very large open spaces can be created using specially designed roof trusses that sit on the posts. However, these advantages can also be incorporated into loadbearing hybrid techniques.

Compressive frame

In an attempt to combine the best of both the above methods, what has been called the compressive frame method was developed by amazonails, who often designed hybrids that used a frame on the south side and loadbearing straw for other elevations. A true loadbearing design cannot use lots of glazing, desirable to increase heat gains from the sun, and must therefore incorporate a version of framework. The two main drawbacks to the framework method of straw bale building are the difficulty of stabilising the straw enough for plastering and the extra cost associated with using a secondary frame of timber as well as the structural straw. A better idea is to make a building as much like a loadbearing one as possible, reducing the amount of timber used, and adding compression to the straw infill part of any framework.

The basic idea of this method is the same as for the pre-compressed load-bearing method: that is, using various means to hold the floors and roof out of the way while the straw is installed, dropping these elements down on to the walls and then pre-compressing the walls beneath them. In framework techniques the floors and roof are held up using posts that remain a permanent part of the building, rather than temporary props. The main design challenge is to incorporate rigid and flexible elements into the same structure.

Lightweight frame

This method uses the structural properties of the bales to enhance those of a lightweight timber framework. The frame is so minimal that it could not stand up alone, and requires temporary bracing and props to give it stability until the straw is in place. The straw is an essential part of the structural integrity of the building, more so than the timber, and it works together with the timber to carry the load of floors and roof. Small timber posts, usually 100mm x 50mm (4" x 2"), are located at intervals and either side of window and door openings and are designed such that the timber wall plate or roof plate, at first floor and/or roof level, can be slotted down on to the posts once the straw is in place and the bracing and props are removed, allowing the bales to be pre-compressed manually using various different methods. This could be by ratchet straps, or threaded rod can be used, depending on the design. Compression of the straw bale infill walls is essential to achieve enough stability of the walls for structural integrity and so that they can be plastered. In two-storey buildings the first floor needs to be lowered before the first-floor walls are installed so that the posts have free movement through the wall plate. The posts do not become fully structural until the walls have been compressed and then the timber is permanently fixed to the wall and roof plates.

Hybrid and other methods

There are many types of straw buildings that use a combination of ideas from the above techniques, or use new ideas. Being so simple, using straw allows for invention during practice. For instance, it’s possible to build well-insulated load-bearing walls to protect your house on the cold north side and combine this with a framework method on the south, allowing for lots of

windows to maximise solar gain. The two-storey house that won the Grand Designs Eco-Home of the Year Award 2008 was designed like this. All it takes is a bit of ingenuity with the design to make the rigid parts work with the flexible parts.

Other methods have been used at different times around the world too. For instance, 30 years ago in Canada, Louis Gagné pioneered a bale building method using cement mortar between the bales, called the Mortared Bale Matrix. The bales were used much more like bricks, stacked in vertical columns so the cement mortar, in effect, formed posts between each stack and the whole building was cement-rendered inside and out. This approach is rarely used now because of the knowledge of simpler, more environmentally conscious and more enjoyable methods, but it is occasionally practised, particularly in France, through the French connection between Quebec and Europe.

Building in a wet climate

Over the years, the main disadvantage of the load-bearing technique – namely how to keep the straw dry throughout the whole building process despite the sometimes prolonged wet weather of the UK and Ireland – has been dealt with. Ways we can address this issue are as follows.

- Prepare everything in advance (prefabrication) so the whole building goes together quickly once you start, like building with Lego. The vulnerable time of exposure to the weather, and the need to keep it covered, can be reduced to a few weeks.
- For small buildings, build underneath a marquee or large tent.
- For larger buildings, increase the height of the scaffolding (needed to build the walls and roof), add a temporary roof over the top, and cover in the sides. This level of protection is required for the lime render anyway, so it can be cost-effective to protect the whole building, ensuring there will be no time lost due to the weather for any aspect of the building, not just the straw, at any stage.
- Use the floor and/or roof as the main weather protection, together with sheeted scaffolding.

There is still as great a need to weatherproof the building if it has a framework as if it is loadbearing. There is a common misconception that framework buildings protect the straw better during construction – this is not necessarily the case! Having a roof overhead does not protect the first few courses of bales as they are under construction, rain does not often fall only vertically, unless there is no wind! Also, the hardest part of a straw building to protect is the straw that surrounds a post, as rain above the post will run down it, taking moisture directly into the heart of a bale. Be warned!