CARBON COST

Straw Bales V Natural Limestone

Craig White the Managing Director of Modcell recently made the claim that after conducting research with the building research establishment, straw bale houses could be considered carbon neutral or even carbon gain.

How true is this comment or is it head in the sand! We take a look at the carbon cost of producing straw bales for those not familiar with farming practices straw is the stalk of wheat left after the combine harvester has removed grain which lies to the top. Wheat is purposely grown from seed for financial gain as at October 2019 the value of the straw, £42 per ton represented around 23% of the total value, the wheat representing 77% is it fair then to consider 23% of the carbon input costs to be attributed to the straw? This would seem entirely logical.

Here is some useful facts about growing wheat ref the agricultural and horticultural development board. It takes 15 passes over the land with agricultural machinery to grow each crop. There is a significant carbon cost with each pass.

(Picture of tractor pulling cultivator)

The tractor passes of field operations are as follows;

- 1 x Min Till cultivator
- 1 x rolling
- 1 x Conventional drill
- 3 x Distributors of solid fertilizer
- 7 x Spray applications
- 1 x Combining
- 1 x Baling

Total = 15

In addition to considerable fossil fuels associated with running the tractor a significant problem is nitrates. Nitrous oxide (N20) occurs in fertilizer manufacture and is 300 times as powerful as Co2 (carbon dioxide) nitrous oxide is also relevant to the breakdown of nitrates within the soil.

Pesticides are sprayed on to the crop several times, pesticides are toxic chemicals they can contaminate water soil and turf they are harmful to insects, birds, fish and many other organisms. Farmers actually spray glyphosate on to crops two days before harvest to kill the crop and ripe the wheat so called crop management includes spraying fungicides. Fungicides kill fungi spores on the crop. They are limited to the decline of bumble bees. Addition carbon costs include road transport and residue field management.

The world health organisation international agency concludes that glyphosate is probably carlogenic (cancer causing) to humans. Is straw a by-product that is destined to be wasted?

If Straw had no other uses then the argument for a low carbon building material would be stronger. The reality is however that straw in the UK is in high demand for the following purposes.

1. Livestock bedding
2. Erosion control (blankets and wattles)
3. Dairy cow feed
4. Mulch for locking in moisture horticulture and agriculture
5. Pulp manufacture
6. Mushroom farms
7. Gardening planters

For every ton of straw unavailable for the above an alternative has to be found. The carbon cost of winter wheat is estimated at 361kg Co2/tonne at 23%. The straw element would equal 83kg per tonne.

Limestone

Laid down naturally 200 million years ago limestone was formed as a sediment on the sea bed. The thickness is typically between 5 meters and 25 meters. At shallow depths the limestone is often fractured providing a natural dry stone or construction walling with thickness varying from 50mm to 180mm. These beds may continue throughout the holes depth or may have formed in bigger block typically 300mm, up to 1.2m in thicknesses. The thinner beds are extracted from the ground manually or by diesel excavator then cropped by hydraulic driven cropper powered by a small petrol or diesel engine.

The larger blocks are extracted by large tracked excavators hauled to a sawn yard by dump truck or HGV lorry off loaded by forklift truck diesel driven. Sawn into varying thickness slabs by water cooled diamond toothed saws and then cropped by hydraulic cropper and tumbled in a rotary cylinder.

Taking this one step at a time the excavator 33 tonnes in weight can move up to 300m3 of material an hour, overburden clay soil etc, The overburden being all that lies between the surface and down to the top (head) of the rock. Extracting block is more challenging especially large block, this can vary between 20 and 100 tonnes per hour. That's an average of 60 tonnes per hour. The carbon cost of running the excavator is 10.15 Co2 per gallon of diesel burnt (4.75 gallons per hour), the carbon cost per tonne of stone extracted is therefore 10.15 kgs Co2 X 4.75 gal = 48.21kgs Co2. Divide this by 60 tonnes extracted + 80kg Co2/tonnes. The overburden has to be removed and stoned after the stone is exhausted; the overburden and soils are replaced, and the land being returned to agriculture. The carbon cost of removing and replacing soils and overburden are as follows;

- Average depth to be removed 4m
- Average depth of stone liberated 12m – based on 300T/per hour
- The cost of moving /replacing overburden is 2.6kg Co2 per tonne divided by 12m3
- Depth of stone = 0.22kg Co2
- .80 add . 22kg Co2/T

The Dump Truck

Bell articulated diesel burn 2.63 gallons/hour, the dump truck is deployed to move all material from the excavator to the storage heaps at surface. The dump truck works in tandem with the excavator for the same hours. Knowing the carbon cost of the excavator is 1.02kg Co2/ton the dump truck is 44% more fuel efficient than the excavator. Its' carbon cost can be treated at 1.02kg less 44% = 0.57 kg Co2/ton. The processing machinery (diamond saws, cropper tumbler). The carbon cost of diesel used of during processing has been divided into tonnage of output for each ton produced: 2.1 gallons of diesel is consumed. At 10.15 kg Co2 per gallon this = 21.42.

The carbon cost of finalised walling stone can therefore be summarised as follows:

Excavation of stone blocks (including allowance for restoration)

- 1.02kg per tonne extracted
- .57kg the dump truck

These figures must be double in order to account for waste in processing

- 2.04 excavator
- 1.14 Dump truck
- 1.7 Processing

Total = 24.6 kg Co2 per finished ton or 30% of the carbon used in producing straw

The carbon cost of the tractor/excavator and other equipment used is both procession is considered similar. Natural stone can be laid dry but often is associated with mortar. Limestone mortars use very little cement. In fact a cement free lime mortar can be used, consisting of lime. Straw bale construction often requires timber or steel frame supports steel being or extremely high carbon cost.

Since both products require road transport in order to deliver the final product to destination this has not been assessed.

A down side of building in stone is that it may be necessary to build an inner skin wall in order to maintain strength the two being connected with aluminium ties. The inner wall may be built from hollow concrete block in order to reduce Co2, a low carbon alternative could be rammed earth or unfired clay blocks. The plus side is that the masonry alternative take us less space leaving more floor space. The load bearing qualities are much higher without relying on steel or timber. Downsides of straw includes the following;

- Can't be used under damp proof course
- Inconsistent sizes and properties
- The walls are limited to light weight fittings
- A limited amount of experienced builders
- Fairs badly in floods
- Constant shelter required during construction
- Expensive to remedy damp ingress and rot
- The projected thermal qualities seen to vary widely from 20 to 50 a valve

SUMMARY

When all the agricultural activities are taken account of the real carbon cost of straw is probably in the order of 83kg per tonne in carbon cost. It should also be noted that there is a significant additional cost when taking pesticides and nitrates into account. Further carbon costs should be considered in connection with steel supports, timber rating, and plater and paint use. Natural sawn and cropped limestone is calculated to cost 24.6Kg Co2 per ton but requires an insulation and an inner wall. There are a variety of suitable insulation that ae carbon gain such as cork slabs, wood/wool boards, flax etc. Sheep's wool or hemp will insulate to a high r valve; Sheep's wool is carbon gaiss hemp is described as carbon gaiss with no pesticides and very little (if any fertilizer). Hemp or sheep's wool would provide an R value of 28 in a 200mm cavity.

For this exercise we will assume an insulation of carbon zero. This leaves the inner masonry wall hollow, concrete blocks would be in the order of 40kg Co2 per ton, rammed earth or clay would be similar to aggregate statistics at 4.28kg Co2 per ton. The cost of building in stone therefore estimated at 24.6kg Co2 per ton. This is a third of the carbon cost of straw bale constructions. Is natural limestone sustainable? Yes, there are billions of tons across England. It is also being formed in hard water areas. A final thought is of cost. Straw bales are extremely cheap to buy, they are also very wide and take up a significant amount of the available space in a building project. Space is not cheap and can vary between £3,000 ad £5,000 per square metre in rural areas.

If walls of 400mm are adopted as an alternative to straw bales, typically 500mm in width, the space saved is 5.6sq metre or 56 Sq feet. Assuming a 2,000 sq foot property, the additional space represents £16,800 (at our lower value). This will go a long way to provide alternative materials