Material change for a better environment

Case study

Tyre bales in an embankment for residential development

This case study relates to the manufacture of tyre bales and their first use in house building in GB; to secure an embankment for the construction of new houses in a residential area on the outskirts of Inverness. A 100 metre embankment utilised approximately 21,000 tyres weighing 160 tonnes.

Key facts

- This case study relates to the first use of tyre bales in house building in Great Britain.
- Tyre bales were used as an alternative to concrete and brick retaining walls in the construction of an embankment to support new residential housing.
- Improved drainage and slope stabilisation were achieved.
- Costs savings of up to £25,000 were estimated.
- A 100 metre embankment utilised approximately 21,000 used car and light commercial vehicle tyres, weighing 160 tonnes.
- Environmental impact was reduced through the displacement of virgin aggregates and energy-intensive cement and bricks, and through reduced emissions from the transportation of materials. The application also assists the creation of markets for recycled tyres which can no longer be disposed of to landfill in the UK.
- Cost and environmental benefits for the use of tyre bales in civil engineering projects are likely to be greater in the Highlands of Scotland, the location of this project, due to the limited availability of lightweight aggregates and the greater transportation distances.

Background to the case study

The compression of whole tyres into bales offers one of a number of ways of putting post-consumer tyres to beneficial use and reducing the use of primary materials, typically virgin aggregates. Displacement of aggregates is beneficial to the environment, since it reduces quarrying.

Conversion of post-consumer tyres into bales is currently a process which is managed under the Waste Management Licensing Regulations 1994. In Scotland, subject to limits on the amounts involved, the process of baling of waste tyres is deemed to be an exempt activity under the Regulations. However, the transport of whole tyres and tyre bales requires a Waste Transfer Note as specified by the Environmental Protection (Duty of Care) Regulations 1991, as amended.

Once manufactured, the specific use of bales in construction is generally accepted by the waste regulators in the UK as a low risk activity. Studies to date have indicated that leachates are well within regulatory limits and fire risks are acceptably small. In England and Wales, regulators are not actively pursuing licensing applications for this use of tyres. In Scotland the use of tyre bales in certain specified civil engineering works is an exempt activity under the Regulations.

This case study relates to the manufacture of tyre bales and their use to secure an embankment for the construction of new houses in a residential area on the outskirts of Inverness.

Tyre bales in Scotland

Northern Tyre Recycling Ltd (NTR) is a tyre recycling company located near Dingwall, Inverness in the Highlands of Scotland. The Company, which has been operational since 2000, is an importing agent for tyre baling machines into the UK. It works closely with the Scottish Environmental Protection Agency (SEPA) and holds a full waste management licence covering its operations.

NTR operates a collection service, picking up all categories of used tyres, from motorcycle, car and light commercial vehicle (van) tyres to heavy truck and agricultural tyres. Collections are from garages and tyre fitters across the Highlands and the Scottish Islands. Whilst the feedstock for the majority of bales produced by NTR originates from these collection rounds, a number of local councils have now started to supply tyres brought in by the public to their civic amenity sites.

The location of NTR is important since there is a limited supply of lightweight aggregates in the Highlands and this has opened up the market for tyre bales. Where tyre bales are used as a substitute for aggregates there is a substantially reduced transport cost. This proven cost saving has encouraged local civil engineers to try tyre bales for various applications. The low bulk density of tyre bales is contributing even further to transport savings since the volume of tyre bales per truck load is greater than for the equivalent load of virgin aggregates. This can reduce the number of designated journeys by as much as 50%.

The majority of tyres collected, and used in the bales, are from passenger cars and light vans. Some larger commercial and agricultural tyres are mixed with the car and van tyres in each bale. However, these are used sparingly, say two per bale, in order to maintain the integrity of the bale and to limit its weight.

Specification and manufacture of tyre bales

Technical Specification

During 2007 a Publicly Available Specification (PAS) document of tyre bales will be released. This PAS 108:2007, "Specification for the production of tyre bales for use in construction", will specify the minimum technical and quality requirements for tyre bales when used for construction applications.

The table below summarises the size, density, permeability and other technical characteristics of bales used in the construction project described in this case study, and details the number and weight of the tyres.

Description	Units
Size of bale	1.5 X 1.2 X 0.7m
Bulk volume of bale	1.26 m^3
Weight of bale	0.75 - 0.8 tonnes
Bulk density of bale	0.64t/m^3
Approximate number of tyres per bale	100 – 110 tyres
Permeability (bale)	0.14 - 0.04m/sec
Aggregate equivalence	300 mm
Binder strand material	Galvanised high tensile strength wire
Binder strand diameter	4 mm
Approx. number bales used in this project	200 bales
Approx. weight of total tyres used	160 tonnes
Approx. number of car/van tyres used	21,000 tyres

In-use characteristics of tyre bales

A historical concern of users of tyre bales is that the imbedded energy of the bale will be released when the wires corrode and break after some years of use. There have also been concerns over decomposition of tyres in the ground. Trials carried out in America and in the UK have, however, shown very small expansions of bales when wires break. This in especially true for bales used as aggregate replacement since they generally are buried under a significant layer of soil. The fact that there is only a minimal expansion is due to the destruction of the original tyre shape during the compression.

Tyre bales used in road construction in America in 1985 did not show any sigh of decay when dug up in 1999. Tyre bales which are kept away from ultra violet radiation, such as in the project described in this case study, are expected to last over a very long time.

Manufacture of tyre bales

Northern Tyre Recycling has the ability to use all types of tyres in their manufacturing process, from small motorcycle tyres to large truck and agricultural tyres. The baler itself is mounted on a truck for mobility. Where arisings of more than 3,000 tyres are found, the company can move the baling process to the site to minimise transportation costs. To date, NTR has baled tyres at nine different sites in the Highlands and on the Scottish Isles.

The size of the bale is determined by the chamber size of the baler and the length of the wrapping wires or straps. All major baling companies in the UK are presently using the same standard baling equipment. Between 100 and 110 tyres are placed into the bale chamber to produce one bale.

The tyres used by NTR are usually taken directly from the collection lorry into the baler to avoid unnecessary double handling and storage. This practice also provides a better working environment for the baler operators by minimizing the amount of lifting.

The process starts with the empty bale chamber where the galvanized wires are placed in designated gaps in the chamber bottom. Three van tyres are then positioned in the bottom of the chamber to increase the strength of the bale side.

Start of a new bale, showing wires and tyres in the bottom of the chamber

The bale making process is continued by filling the chamber with tyres in layers in a herringbone pattern and compacting each layer.

The hydraulic compactor compresses the tyres with a load of about 65 tonnes pressure for 10 to 20 seconds per cycle. Some 6-8 compactions are carried out until the bale is finished. The baler is usually operated by 2-3 men and can make between 4-5 bales per hour.

Bale in loading

When the bale chamber is full, the press is left in the down position and the high tensile galvanized wires are put in position around the bale by use of a quick lock mechanism.

Bale in compression and wire locking

The finished bale is then expanded to its maximum size when the pressure is released, removed from the baler and stored.

Finished bale removal

Tyre bales in an embankment for residential development

Application and benefits

This case study relates to the first use of tyre bales in house building in the UK, specifically to secure an embankment for the construction of new houses in a residential area on the outskirts of Inverness. The new houses are located on a hill side overlooking the city. Because of the steep slopes in the area, measures to minimise erosion and land slides were deemed necessary.

Conventional construction would have been through the use of a drained brick wall with a 600 mm concrete base to secure the embankment.

Tyre bales in position at the site

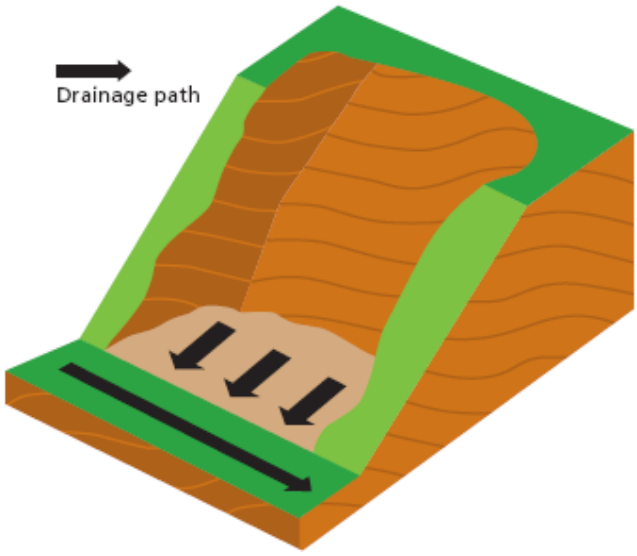
The above picture shows the embankment built on two layers of tyre bales. The total embankment length is 100 metres and comprises 190-200 tyre bales.

The use of tyre bales has a number of significant advantages compared to the alternative of a drained brick wall. These are:

- They provide good drainage and good stabilisation at the same time;
- They provide significant cost savings;
- Tyre bales in embankments provide a potentially large, low risk market for recycled tyres where the long life of modern tyres can be put to positive use;
- The use of tyre bales results in large raw material savings and the displacement of concrete, which is energy intensive;
- There is reduced need for transportation;

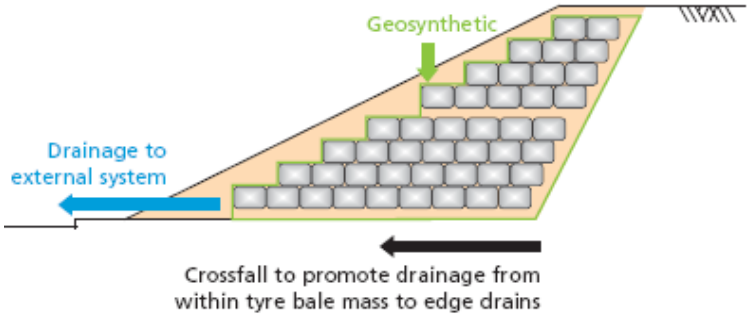
Drainage

The high permeability of tyre bales facilitates the design of drainage systems in civil engineering applications. The following schematic picture shows a typical drainage path in a steep sloping area.



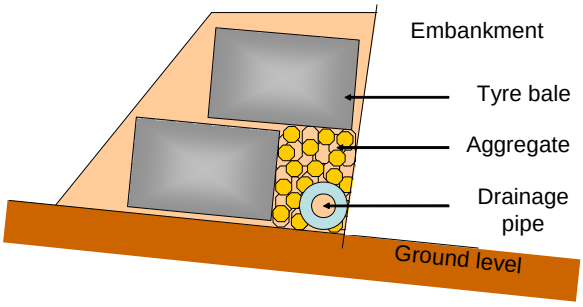
Source: PAS108

The following picture shows how tyre bales can be used to build a large scale embankment in which water drains without any increased risk of land-slides. The tyres are laid on, and covered with, a geosynthetic membrane to minimise water ingress through the surface of the embankment. The membrane is then covered with topsoil.



Source: PAS 108

The same principle, on a smaller scale, was used for the embankment in Inverness (see diagram below). Only two layers of tyre bales were used. The lower layer was back-filled with aggregate in which a drainage pipe was embedded: both layers were laid at a slight angle in order to direct water flow towards the drainage pipe. The pipe discharges to a water course at the rear of the site. In this instance a membrane was therefore not required.



Embankment construction

Because the construction project at Inverness was the first of its kind in the UK, some initial "learning by doing" was evident for the construction site workers, the machine operators and the site management, and the first 30 metres of the embankment took as long to complete as the last 70 metres. The attachment of a "grab" to the digger, by which the tyre blocks could be moved and manoeuvred easily, speeded up the process.

To complete the works, the tyres will be covered with topsoil, graded to attain the required slope, and finished with appropriate landscaping.

Comparison between the tyre embankment and a brick retaining wall

Time & Manpower

- It took a crew of three men, using one digger, four days to build 100m of embankment.
- It would have taken an estimated three weeks and up to 10 men to make a 100m drained brick wall with a concrete foundation.

Environment

- Approximately 21,000 tyres were used in the 200 bales in the embankment. The use of bales displaces energy intensive raw materials, such as concrete and bricks, and decreases transport needs.

- The indirect carbon emissions from concrete and bricks are substantially higher than for tyre bales. Also, the transport distances and demand would have been considerably higher for a brick wall.

Cost benefits

There are a number of components to the cost benefits of tyre blocks in embankments. These are in labour and equipment, transport and raw material savings. A total benefit of up to £25,000 is estimated for this project, as detailed below.

Labour savings

The estimated labour and equipment cost of using tyre bales in this embankment is:

One digger with driver	@ £600 per day, plus
3 operators	@ £100 per day.
Total time	4 days
Total cost	**£3,600**.

The building of a brick wall is estimated at:

One digger with driver @ £600 per day for 5 days, plus	
10 men @ £100 per day for three weeks.	
Total cost	**£18,000**.

As this very approximate calculation shows, the labour and equipment savings from using tyre bales in this particular embankment are in the order of £14,000.

Transport savings

Transport savings are more difficult to estimate than labour. They are likely to be much smaller than the labour savings. In this project it took NTR five articulated truck loads to get the tyre bales to the site. The builder could not make any real estimates of the transport costs that would have been incurred in delivering materials for the brick wall, but believed that they would have been slightly higher.

In other projects, where the tyre blocks are substituting for “pure” aggregates as in road and landfill construction, the transport savings will be more substantial.

Raw material savings

The price charged by NTR for the bales was £1,100. This can be compared to estimates in excess of £10,000 for bricks, mortar and concrete for a 100m drained brick wall.

Stored tyre bales

Environmental benefits

The use of tyre blocks in embankments will benefit the environment in several ways:

- **Creation of market for recycled tyres.** In this short 100m residential embankment, approximately 21,000 tyres have been used. This form of recycling puts the long life of modern tyres to a beneficial use.

- **Displacement of energy intensive raw materials**. Concrete and bricks as well as virgin aggregate have been replaced. This implies decreased carbon emissions and less pressure on virgin quarried materials.

- **Decreased transport needs**. The need for transport of building materials has decreased both by choosing a local tyre bale supplier and by the ability to send a higher volume with each transport load. Less transport leads to lower carbon emissions.

Details of parties

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