

Case Study 8 Use of tyre bales in embankment core for river Witham flood defence

Construction Project: Harbour, coastal and waterway engineering

Application: Flood defence and coastal protection

Product: Tyre bales

Material: Recycled tyres

Title: Use of tyre bales in embankment core for River Witham flood defence

Date: 2003-2004

Client: Environment Agency, Anglian Region

Specification: Design was based on properties of tyre bales supplied by HR Wallingford as part of there DTI/EA funded research project "Sustainable Re-use of Tyres in Port, Coastal and River Engineering".

Summary

Flood defence improvement scheme on the River Witham near Lincoln.

The work - which commenced in 2001 near Bardney in Lincolnshire - involves raising and strengthening the flood embankments over a length of 30 km in a five to 10 year period, and the provision of erosion protection.

The project is part of a package of works to maintain/improve the standard of flood defence embankments between Lincoln and Boston.

This site posed a number of challenges. The depth of peat below the existing bank required a broad based clay bank to spread the load. To accommodate this with traditional construction methods, the existing soke dyke would have to be filled-in and a new one dug causing considerable environmental disruption. An 11kV overhead power line running alongside the soke dyke would also have to be re-routed at considerable expense.

Tyre bales provided the solution as they are approximately 1/3rd the density of traditional clay fills. This resulted in an embankment with a smaller footprint. As a lightweight fill they avoided bank stability problems and environmental damage to an adjacent watercourse that would be caused by a clay fill and meant that the power lines would not have to be relocated.

The major advantages of using tyre bales were:

- The ability to make the bank steeper meaning that the electricity pylons and the established soke dyke would not need to be moved.
- Work could be carried out through the winter unlike the clay alternative.
- The number of lorry movements needed to bring the bales to site were fewer than would have been required if the bank had built from clay.
- The bank has used ~ 1.2 million tyres in the construction, over 12% of the waste tyres that will be sent to landfill in this country this year.

Tyre bales used in the construction, each bale consists of approx. 100 scrap car tyres, compressed and strapped to form a bale.

Background

To ensure the safety and livelihood of people living in the low lying areas between Lincoln and Boston in Lincolnshire, the Environment Agency has been investigating the condition of existing flood defences to ensure that they will be able to cope with increased flooding risks caused by global warming impacts. Around half of the entire Environment Agency annual budget is devoted to flood management and flood defensive works.

The team working on the River Witham system identified nearly 50 sites where improvements were required including site no 23 near Bardney in Lincolnshire.

Geotechnical stability problems and environmental constraints at site 23, a 1600m stretch of embankment on Branston Island, led the project team, to investigate alternative fill materials to clay, which had been used for the original embankment

The key drivers were the need to avoid the relocation of an 11kv powerline behind the existing embankment and minimisation of the environmental damage to the adjacent soke dyke. The soke dyke provides a habitat for water voles and other small mammals, fish, invertebrates and flora.

Tyre bales provided the best solution as a lightweight fill. They avoided the stability problems associated with a clay embankment and resulted in an embankment with a smaller footprint, avoiding environmental damage to an adjacent watercourse.

Tyre bales also reduced the number of lorry movements as one lorry can carry a greater volume of tyre bales compared to clay.

Specification, Quality Assurance and Design

Specification

Design was based on properties of tyre bales supplied by HR Wallingford as part of a DTI/EA funded research project "Sustainable Re-use of Tyres in Port, Coastal and River Engineering". Tyre bales for testing were provided by Anglo Environmental Tyre Recycling Ltd, who became a nominated supplier for the Tyre Bales.

Initial specification questions that required research

How do tyre bales behave when saturated?

Voids fill with water; bales are negatively buoyant.

Will strapping ever decompose?

Tyres take on a deformed shape even after wire failure. A test was conducted after a bale had been strapped for 3-4 months by cutting all of the straps; the bale only exhibited a small amount of rebound and retained its shape.

What is the life of the tyre bales?

The bales are surrounded by a depth of soil so are not exposed to UV from sunlight or to extreme temperatures which can cause tyre decomposition. The design life of the embankment is 200 years.

Quality Assurance

A monitoring programme on the environmental impacts of tyre bale use in infrastructure projects is underway from the DTI and its consultant on the project HR Wallingford.

Their latest research into tyres in the marine environment for the DTI "Sustainable use of post-consumer tyres in port, coastal and river engineering" can be found at www.tyresinwater.net.

This project will be monitoring the embankments produced at the River Witham to help identify the performance and impacts of tyre bales.

Cost benefits

Advantages of using tyre bales

- No seepage prevention needed in construction.
- No need to find a substantial new clay source.
- No need to move soke dyke.

- No need to move power lines.
- Less plant and equipment required.
- Less weather dependant and allowed construction to continue through the winter months.

Environmental Benefits

The Lower River Witham catchment encompasses many important wetland habitat types that support a rich diversity of plants and animals.

There are 32 sites of Special Scientific Interest and over 100 sites of nature conservation importance.

Some of the species that live within the catchment area include:

- Marsh Harrier
- Barn owl
- Otter
- Water vole
- Fish (e.g.: spined loach) and water invertebrates (e.g.: insects)

The Witham Team understands its responsibility to the environment; it has incorporated this ideology within its environmental policy and environmental management system.

The design of any construction project such as the flood defences at the River Witham can have a significant effect on these issues.

The use of tyre bales provided not only a technical solution to a geotechnical stability problem but it also yielded important environmental benefits by not destroying an existing soke dyke ecology which would take a long time to develop in a new watercourse.

Raw Material Extraction

The use of compressed tyre bales has lead to the reduction in required primary clay use by 16,440 m³. This would have been difficult to source locally so would have had to have been transported from some distance from the site.

Transport Impacts

The use of tyre bales minimised the number of lorry movements on local roads, as they could carry more volume of fill in one load. The lightness of the material also allowed the works to be completed on site with smaller numbers of less heavy machinery.

Regulatory issues

Environment Agency is both regulator and issuing body and cannot legally issue itself with a waste management licence (WML). However the Environment Agency could not just ignore the WML issue as this would be seen as the Agency having double standards by the organisations it regulates.

To solve this dilemma it produced a quasi waste management licence going through all of the steps and procedures required by other organisations applying for a licence.

Conclusions

Technical Reasons for using Tyre Bales

Tyre Bales are a lighter material than traditional clay construction techniques leading to:

- Less material being used to construct the embankment to the design specifications.
- Reduced risk of embankment failure due to weak soils beneath embankment.
- Smaller footprint of design reducing the need for additional works.
- High friction material enabling a steeper slope batter.

Cost Reasons for using Tyre Bales

Savings for site operations including:

- Elimination of the need for a soke ditch cut and fill
- Elimination of need for safe removal and resiting of power lines

- Less plant and equipment needed to reconstruct bank
- Ability to work in winter months or in wetter weather.

Environmental Reasons for using Tyre Bales

The use of tyre bales lead directly to the prevention of damage to existing wildlife that would have occurred if the existing soke (drainage) ditch had been filled and replaced which would have been necessary if existing techniques using clay had been employed.

The embankment technique provides a genuinely useful long term application for a difficult waste stream that has few large quantity alternative recovery options in the UK at present.

Next Steps

Tyre bales can provide an alternative to more conventional fill materials. However, issues relating to potential environmental impacts from any leachate need further monitoring.

The proposed length of works is a pilot. Extensive water monitoring and geotechnical monitoring has already commenced. Monitoring on the River Witham scheme, for chemical and biological impacts will continue for a number of years.

If for any reason the trial indicates that tyre bales are not suitable, the use of tyre bales will not continue, and remedial action will be taken.

More projects are needed to further demonstrate the overall economic and environmental benefits and impacts.