Proceedings of the Institution of Civil Engineers
Geotechnical Engineering 000
xxx 2002 Issue x
Pages 1–3

Paper 12896

Received 00/00/0000
Accepted 00/00/0000

Keywords:
developing countries/recycling of materials/retaining walls

Alberto S. F. J. Sayão
Associate Professor, Catholic University of Rio de Janeiro, Brazil

Luciano V. Medeiros
Associate Professor, Catholic University of Rio de Janeiro, Brazil

Ana C. C. F. Sieira
Doctoral Researcher, Catholic University of Rio de Janeiro, Brazil

Denise M. S. Gerscovich
Associate Professor, Catholic University of Rio de Janeiro, Brazil

Vinod K. Garga
Professor, University of Ottawa, Canada

Retaining walls built with scrap tyres

A. S. F. J. Sayão, L. V. Medeiros, A. C. C. F. Sieira, D. M. S. Gerscovich and V. K. Garga

A technique for building gravity retaining walls using scrap tyres is presented. This technique has been used successfully for stabilising natural slopes in Brazil. Experience with a 60 m long, 4 m high soil–tyre retaining wall in Rio de Janeiro is documented. The wall was built in horizontal layers, with scrap tyres tied together with rope or wire and filled with available local soil. Construction was monitored by displacement gauges and pressure cells in four cross-sections with different materials or dimensions for the wall. A 2 m soil surcharge was placed on the backfill, and the displacement responses at the four sections were compared. It is shown that the soil–tyre wall can be considered as an attractive alternative for slope stabilisation, because it combines the mechanical strength of tyres with the low cost of building materials such as local soil and scrap tyres.

1. INTRODUCTION

Production of scrap tyres has been growing steadily over recent decades. At present world production is approaching about 800 million annually. It is estimated that there are approximately 3 billion used tyres deposited in reclaimed areas. As a result, rigid restrictions on disposal procedures for scrap tyres have been imposed by many countries. Storage of scrap tyres poses an undesirable problem, because vast landfill areas are required and there is a great potential for fire danger and insect proliferation, particularly in tropical environments.

Reuse of scrap tyres in engineering projects is therefore becoming an attractive solution for these environmental concerns. Many different applications in engineering have been reported:[1,2] artificial breakwaters, impact barriers, slope protection, soil reinforcement and retaining walls.

A comprehensive study on the use of tyres for soil reinforcement and retaining walls in France has been documented,[1] including reports on the behaviour of soil–tyre walls up to 650 m long. In Canada, research with scrap tyres has been reported.[3]

In Brazil, the reuse of scrap tyres in gravity walls was first considered in the mid-1990s, with a research project by the Catholic University of Rio de Janeiro (PUC-Rio) jointly with the University of Ottawa, Canada, and the Geotechnical Engineering Office of Rio de Janeiro (Geo-Rio). The main objective was to provide a low-cost alternative for slope stabilisation in densely populated areas in developing countries. This is ongoing interdisciplinary research, which also includes aspects of social studies in low-income communities where the technique was to be first introduced. Several governmental agencies, such as the State University of Rio de Janeiro, the Health Department, and the Secretary of Environment, were also involved in this project.

This paper focuses on the construction procedures for building gravity retaining walls with scrap tyres.

2. RESEARCH DETAILS

To investigate the geotechnical behaviour of soil–tyre gravity walls, a fully instrumented retaining wall was built, 60 m long and 4 m high.[4] Tyres were placed side by side, in successive horizontal layers, and tied together to make a mat. This layer of tyres was then filled with locally available soil. Approximately 15 000 automobile tyres 0·60 m in diameter and 0·20 m thick were used for building this wall. Tyres with one sidewall removed (Fig. 1) were also used, and proved to provide better conditions for soil compaction. The retaining wall was built with four different sections (each 15 m long), with the following characteristics:

(*a*) section A: entire tyres, tied together with a 6 mm thick polypropylene rope
(*b*) section B: cut tyres, with the same cross-section and rope connections as in section A


Fig. 1. Entire and cut tyres

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(*c*) section C: cut tyres, with the same cross-section as in A, tied with a 2 mm thick plastic-coated galvanised zinc wire
(*d*) section D: cut tyres, with a thinner cross-section, tied with the polypropylene rope.

Compaction of soil inside the tyres was carried out manually with a vibratory plate. The wall's backfill was made out of compacted soil at optimum water content. Locally available material, a gneissic sandy silt residual soil, was used. It is important to note that soils with poor geotechnical characteristics may be used, because the soil role in this gravity structure is primarily to provide weight. Upon completion of the wall, an additional 2 m-surcharge soil load was placed on top of the backfill. Fig. 2 shows a typical cross-section of the soil–tyre wall.

Field instrumentation comprised inclinometers and pneumatic pressure cells in all sections of the soil–tyre wall. Fig. 3 shows various construction stages. The external face of the wall may be protected with vegetation or with a thin layer of shotcrete. This protection is recommended not only for aesthetic reasons, but also to minimise soil erosion in the face tyres and reduce the risk of fires.

Figure 4 presents profiles of horizontal displacements measured after the placement of soil surcharge in sections A, B and C.

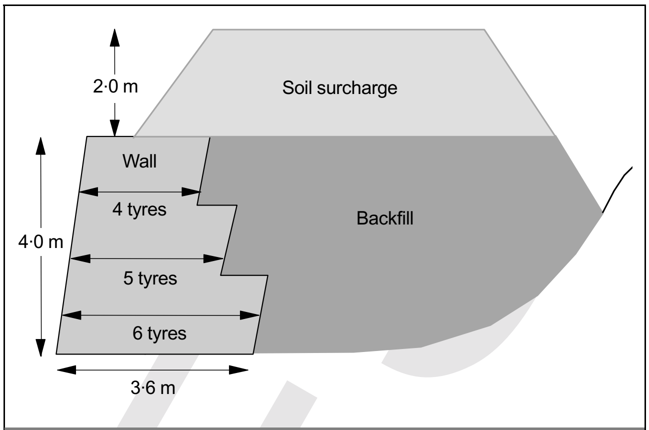

Fig. 2. Schematic cross-section of soil–tyre retaining wall

Measurements in section D indicated that installation problems might have occurred, and these results were therefore disregarded.

It can be seen in Fig. 4 that movements of the soil–tyre wall were kept within reasonable limits in all three sections sections. The largest displacements were observed in section A, which was built with uncut tyres connected with rope. Note also that the minimum flexibility of the wall was achieved when cut

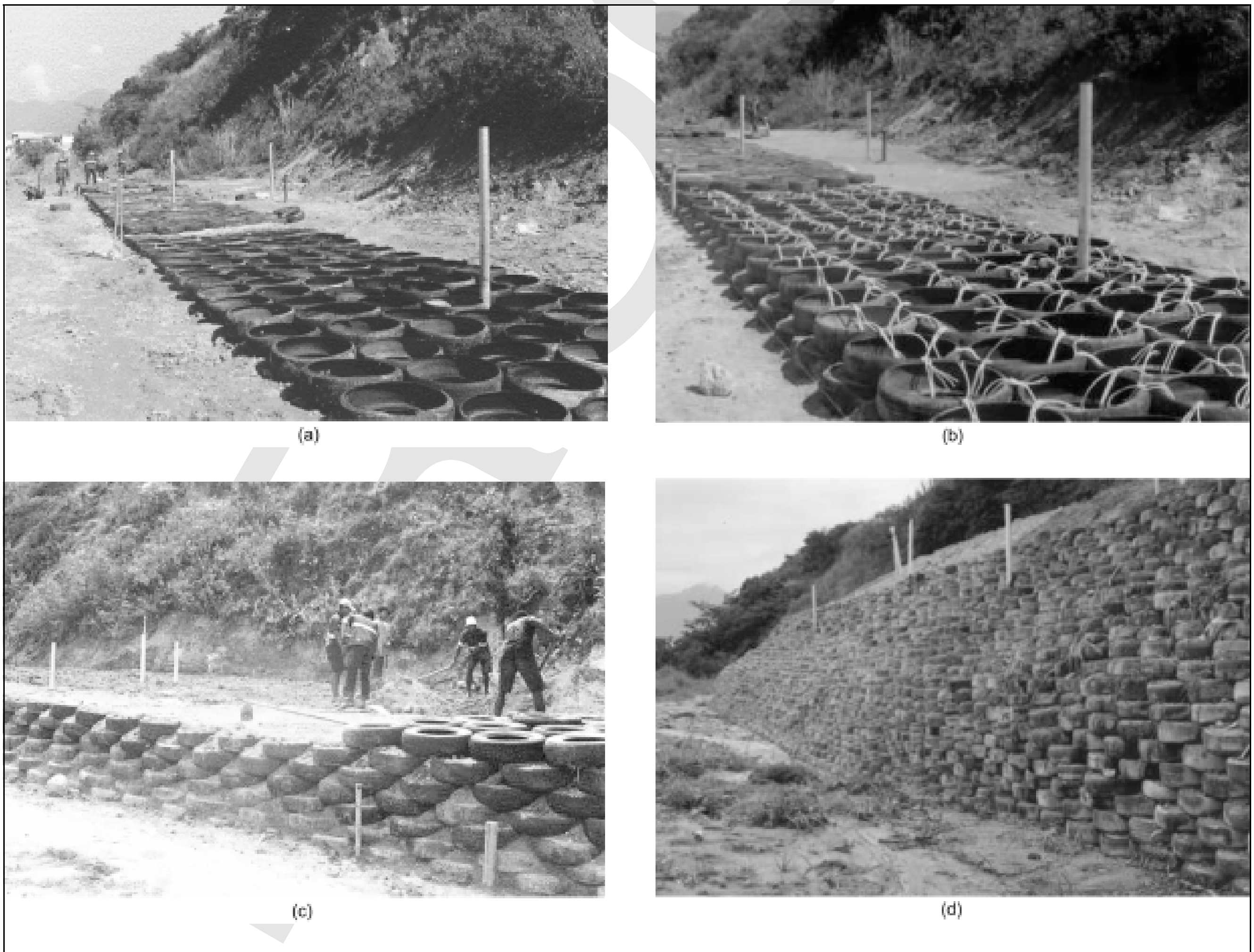

Fig. 3. Construction of soil–tyre retaining wall: (a) start of construction; (b) cut tyres with rope; (c) during construction; (d) end of construction

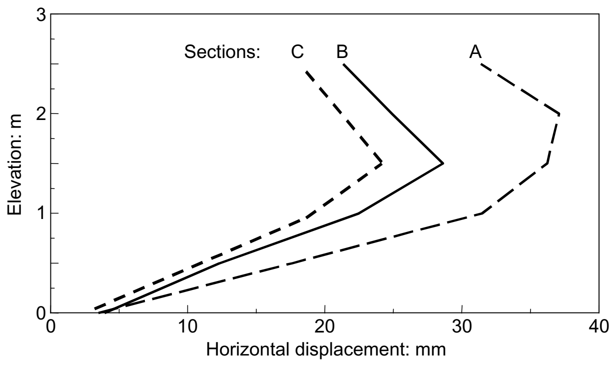

Fig. 4. Horizontal displacements after the placement of soil surcharge

tyres were tied with plastic-coated wire (section C). The wall built with cut tyres therefore proved to be less deformable than those with uncut tyres, although the removal of a tyre's sidewall requires a special cutting machine. Moreover, the closer tightening of tyres with wire resulted in a significant reduction of the horizontal displacements, when compared with tightening with rope. However, the rope is less expensive than the wire.

Detailed analysis of instrumentation results and comparisons between field behaviour and numerical predictions for all sections of the wall have been reported elsewhere.[5,6]

3. CONCLUSIONS

The use of scrap tyres is a feasible and low-cost engineering technique for building gravity retaining walls. Thanks to the tyres' mechanical properties and construction procedures, the soil–tyre wall structure is more flexible than conventional concrete or geosynthetic reinforced walls, although observed lateral displacements were kept within reasonable limits. The technique requires only local soil, scrap tyres and polypropylene rope (or galvanised wire), with no need for materials such as cement, steel or aggregate. The wall can be constructed manually or with light compaction equipment. Transportation costs are usually low, because scrap tyre deposits are available in urban areas. Removing one tyre's sidewall proved to be advantageous, because it facilitates construction and allows a stiffer structure than when using uncut tyres. After this work, several soil–tyre retaining walls have recently been built in slope stabilisation projects in Brazil.

4. ACKNOWLEDGEMENTS

The work described herein has been funded by IDRC (International Development Research Centre, Canada) and by Geo-Rio (Geotechnical Engineering Office of Rio de Janeiro, Brazil). Mr Luis O. Vieira and Mrs Marcia H. Andrade from Geo-Rio participated actively in all field activities. The authors thank CNPq (Scientific and Technological Research Council, Brazil) for granting research assistantships. Thanks are also due to AEERJ (Association of Engineering Companies of Rio de Janeiro) for awarding the first prize for MSc research in civil engineering in 1998.

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