Ecological Engineering 36 (2010) 697–702

Contents lists available at ScienceDirect

Ecological Engineering

journal homepage: www.elsevier.com/locate/ecoleng

The use of air bricks for planting roadside vegetation: A new technique to improve landscaping of steep roadsides in China's Hubei Province

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ARTICLE INFO

Article history:
Received 16 September 2009
Received in revised form 8 December 2009
Accepted 17 December 2009

Keywords:
Air bricks
Planting techniques
Landscape conservation
Vegetation cover
Vegetation restoration

ABSTRACT

Road construction is an important cause of environmental degradation, particularly in mountainous regions. However, re-establishing vegetation cover at the construction site can mitigate these problems, particularly on steep roadside slopes. In the present study, we developed two new planting techniques to increase vegetation cover on these slopes, in which planters fill the holes in air bricks (i.e., bricks with large holes that pass through the full depth of the brick) with soil, then plant grass or herbaceous species in the soil. Two variants of this technique (one in which the air bricks form a stairstep pattern, and another in which they form a smooth slope) were tested in an area with a warm climate near Shennongjia (Hubei Province) between 2006 and 2008. The new planting techniques promoted root growth, the development of a continuous vegetation cover, and the production of merchantable seeds compared with the conventional planting technique. This suggests that the air brick technique is more suitable for the study area, where the natural soils are thin, and may prove suitable for similar areas elsewhere in the world. The provisional results, based on 2 years of research, suggest that the new techniques represent a potentially valuable alternative for vegetation restoration, landscape conservation, and road maintenance/management in mountainous zones during and after highway construction. The techniques have strong potential for use in other areas. In addition, they provide a good example of using ecological engineering to increase vegetation cover on steep roadside slopes.

1. Introduction

Roads are a widespread feature of most landscapes, and high road densities create large ecological impacts by altering landscape patterns and interrupting ecological flows (Pauwels and Gulinck, 2000; Cao et al., 2006; Liu et al., 2008). Road construction is a major cause of environmental degradation, particularly in mountainous regions, where re-establishing a protective vegetation cover to protect steep roadside slopes is a challenging task. The impacts are particularly severe in mountainous regions, where the fragmentation caused by roads is pervasive and landscape structures are significantly altered within multiple vegetation types at a variety of ecological scales (Sari et al., 2002). Although the presence of roads and the associated traffic flows are primary sources of landscape fragmentation, the actual ecological impact of this fragmentation depends on a number of variables, including the species composition of the surrounding vegetation and animal communities and the road design characteristics (Jaarsma et al., 2002, 2006).

As a result of China's rapid economic development and growth, an extensive road network is being constructed in many regions (Xu et al., 2006). By the end of 2006, the total length of all classes of road had reached 1.9 million km, including 45 000 km of motorway (high-speed roads), and village roads had reached a total length of 1.5 million km (Li and Shum, 2001; Guo et al., 2007). The total in all classes of road is expected to expand to 2.5 million km (including 100 000 km of motorway) by 2010 (Guo et al., 2007). Because more than two-thirds of the area that will be accessed by these roads is in mountainous regions of China, this aggressive construction has the potential to cause great environmental damage. Environmental protection during highway construction is thus a significant challenge for China's national road development program.

Road construction can create extensive surface disturbance, with correspondingly serious adverse impacts on the surrounding environment, especially where the soil is highly susceptible to

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0925-8574/$ – see front matter.
doi:10.1016/j.ecoleng.2009.12.012

erosion, where the vegetation cover is poor or where the ecosystem is fragile (Xu et al., 2006). Increased awareness of the need for environmental protection has led to widespread adoption of revegetation of roadside slopes (e.g., Grace, 2000; Fransen et al., 2001) around the world and in many parts of China. In ecologically fragile mountainous regions, bare stone walls along the steep uphill side of a road have been used to hold soils in place, particularly where thin soils make vegetation restoration difficult. In 2006, we undertook a study to explore the potential for revegetation of steep roadside slopes by planting grasses or herbaceous species. The study took place in the Shennongjia region of China's Hubei Province. We compared two new methods with an existing (conventional) method on steep slopes with the goals of sustaining the functional characteristics of the landscape, protecting the slope above the roads, and improving the visual and other characteristics of the road area.

2. Materials and methods

Planting grass species in air bricks (bricks with large holes that pass through the full depth of the brick) has frequently been used on steep slopes and to provide green space around buildings and bridges in China. This technique uses the air bricks as "flowerpots" (Deng and Wu, 2004). Based on these successful uses of the technique, we tested two new planting techniques that used air bricks and assessed their usefulness for establishing vegetation cover on steep roadside slopes.

2.1. Experimental design

The study was conducted in the famous Shennongjia tourist area (110°03′05″–110°33′50″E, 31°21′20″–31°36′20″N) in western Hubei Province. The test area had a mean annual temperature of 15.9 °C (ranging from −16.8 °C in January to 43.1 °C in August), average annual precipitation of 1155 mm, and a range in elevation from 178 to 1169 m. The study area included a total of 53 km of class II paved road.

Three species that had previously been shown to be suitable for planting in the area were planted in 2006 and assessed in 2007 and 2008. In the conventional planting technique that is used in the study area (Fig. 1, top), soil and stone excavated during construction of the road is piled on the steep slopes along the uphill side of the road, and seeds are planted in soil that fills the gaps between large rocks. We developed two new planting techniques that used air bricks as alternatives to the conventional approach. The air bricks used in this study were 20 cm wide by 40 cm long by 20 cm deep. In both techniques, workers fill the holes with surface soil (not with the coarse fragments of broken rock produced during excavation of the road's bed) and plant the seeds of grass or herbaceous species in the soil 2–3 months before the road construction, then arrange the bricks on the slope along the uphill side of the road. Two different brick patterns were tested: a stairstep pattern in which the holes were oriented vertically and the bricks overlapped to form a series of stairs or tiers (Fig. 1, middle) and a smooth slope pattern in which the holes were oriented roughly perpendicular to the slope to form a smooth, continuous surface (Fig. 1, bottom). The space between the air bricks and the steep retaining wall beside the road is filled with the soil and stone excavated during the construction.

In 2006, we planted three grass or herbaceous species (*Festuca arundinacea* Schreb., *Lespedeza dahurica* Turcz., and *Trifolium repens* L.) as single-species plantings and as three mixed-species plantings (*F. arundinacea* with *T. repens*, *F. arundinacea* with *L. dahurica*, and *F. arundinacea* with both *T. repens* and *L. dahurica*). We selected a total of 12 sampling sites distributed along the whole length of the road, with the goal of covering the full range of slopes and site conditions

Fig. 1. Illustrations of the conventional technique (top) and air brick planting technique with a stairstep pattern (middle) and a smooth slope (bottom).

in the study area. At each sampling site along the road, we established one 5 m × 10 m plot for each treatment (i.e., three single-species plots and three mixed-species plots), with the plots randomly arranged. The distance between sampling sites ranged from 3.2 to 5.5 km, but at each site, the plots for the six treatments were established side by side, with no space between them. To determine which treatment offered the greatest economic benefits (primarily as a potential source of merchantable seed, since biomass was not recovered during maintenance activities such as mowing) and which technique provided the most effective revegetation, we recorded the seed germination rate, total biomass, the cover ratio,