OR/14/051 Introduction

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Whitbread, K. 2014. The geomorphic impact of road construction: a case study of the A9 in Scotland. *British Geological Survey Internal Report*, OR/14/051.

Overview

Natural geomorphic processes of sediment erosion, transport and deposition have received considerable research attention in recent decades because they are recognised as fundamental controls on landscape change. However, there has been relatively little attention paid to human-induced landscape change that results from excavation and deposition during infrastructure construction. By changing the form of the land surface, this anthropogenic landscape change may have considerable impacts on the operation of natural geomorphic systems with implications for associated hydrological systems and ecosystems. Quantifying the magnitude of landscape change associated with infrastructure construction is therefore important if we are to understand the potential impacts of future construction works on our environment, and to assess how our existing infrastructure affects how sediment is sourced and transported throughout our landscape.

During road construction large volumes of rock and sediment may be excavated or imported to modify the ground level, facilitating subsequent travel along the route. Although road routes may be selected to minimise the need for substantial import or export of material, most still require substantial ground modification during construction works. Man-made landforms including cuttings and embankments are therefore very common features along our road networks.

The magnitudes of ground surface change and the net transfer of material due to road construction are poorly characterised. Although construction companies commonly hold records on the volumes of material extracted or imported during their construction activities, these records are not readily accessible. Furthermore, records from different construction companies may be difficult to integrate to gain a wider understanding of the geomorphic impacts of road construction.

A spatially integrated understanding of ground surface change and net material transfer (erosion or deposition) due to road construction may be gained by comparison of historic ground levels recorded in borehole logs, in combination with digital elevation models of the modern ground surface derived from remotely sensed data.

Rational

Site investigations, including borehole drilling and trial pit excavations, are generally conducted to aid the planning of road construction works. The ground surface level at the time of drilling is recorded as the ‘start height’ of the borehole or trial pit.

Modern ground levels are represented by digital elevation models (DEMs) which are derived using satellite or air-borne radar or photographic imagery. In the case of the UK, two types of DEM are available; digital surface models (DSMs), and their derivatives digital terrain models (DTMs) that have surface features such as trees and buildings removed. These models provide three dimensional representations of the terrain at resolutions of less than 1 m vertical accuracy and c.5 m horizontal resolution (Table 1).

Table 1 DTM and DSM dataset specification[1]

	NextMap		PGA Height Data	
	DSM	**DTM**	**DSM**	**DTM**
Date raw data obtained	2002–2003		2005–2010	
Grid size	5 m	5 m	2 m	5 m
Horizontal accuracy	± 2.5 m 1 sigma (on slopes <20°)	Not specified	Less than ± 40 cm RMSE	Not specified
Vertical accuracy	± 1 m	Not specified	± 50 cm RMSE	± 60 cm RMSE

Ground surface change associated with road construction may be examined through comparison of the historic ground level recorded in the site investigation borehole records and DTMs captured after the road was built. Estimates of surface change and the volumes of material imported or removed may be made through either; a) a direct comparison of the borehole ground level and the DTM, or b) use of mathematical interpolation techniques to reconstruct an estimated pre-road DTM that can be validated using the site investigation borehole records and compared with the actual DTM. The deposition of sub-base, base and surface materials during road construction means that volumes of material excavated from cuttings will be minimum estimates.

A9 Study: testing methodologies

A preliminary assessment of ground surface change associated with road construction was conducted for two test areas along the A9 in order to assess whether the ground levels of site investigation boreholes provide an accurate reflection of the pre-road ground surface, and to compare the different methodologies for quantifying surface change and the net volume of material ‘deposited’ or ‘eroded’ during construction.

The A9 is the longest trunk road in Scotland and the major transport route connecting the densely populated Central Belt (including the cities of Glasgow, Edinburgh, Stirling and Perth) with the Highlands and the city of Inverness (Figure 1). North of the city of Perth, the A9 crosses the rural, upland terrain of the Grampian Highlands. The southern test area comprises a 30 km section of the A9 around the town of Dunkeld, extending from Luncarty to Ballinluig. The northern test are covers a 12.5 km section of the road between Daviot and Moy (Figure 1).

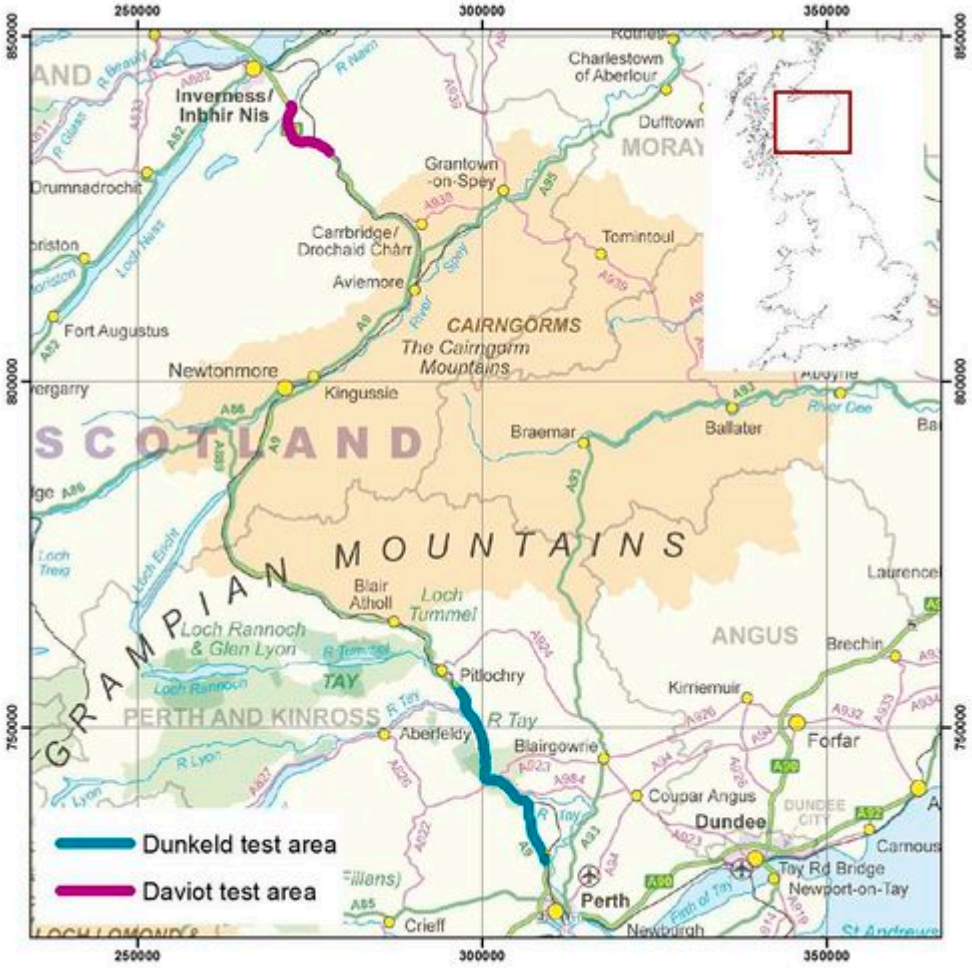

Figure 1 Location map of the two test areas along the A9. The location of the study area in the UK is shown in the inset map. Contains Ordnance Survey Data © Crown copyright and database rights 2014.

The test areas were selected for their relatively high density of boreholes and in the case of the southern test area, because of the availability of recently derived mapping data on the distribution of made and worked ground along the A9 route (Whitbread and Finlayson, 2014[2]).

Report structure

The methods used in the analysis are outlined in Methodology, followed in DEM assessment by a comparison of the different DTMs with respect to OS data to establish the most accurate DTM available for the study. The results of tests to assess whether borehole records are reliable indicators of the pre-road construction ground surface are presented in Quantifying ground surface change. In Borehole records of the ground surface ground surface change resulting from road construction is determined from borehole records and the DTM, and estimates of erosion and deposition are presented in Erosion and deposition due to road construction. A discussion of the results and their implications is presented in Discussion.

References and footnotes

1. ↑ Given on http://www2.getmapping.com/
2. ↑ WHITBREAD, K, AND FINLAYSON, A. 2014. The geology of the A9 corridor between Luncarty and Ballinluig. *British Geological Survey Internal Report*. IR/14/018.

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