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Discussion: Physical modelling of in-ground waste repository capping systems

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1. Contribution by D. M. Tonks, E. M. Gallagher, W. H. Craig and N. Shaw

It is good to see this interesting centrifuge work published (Richards and Powrie, 2011). It helps to build confidence in the performance of caps for repositories and landfills generally and gives valuable data concerning those differential settlements that may be accommodated. The contributors' comments are in the context of current design work on capping for a major repository in the UK and the value of such studies thereto. Further comments are also given on the Craig and Gallagher studies cited.

The work demonstrates that even a relatively low specification cap, 600 mm impermeable barrier without geomembrane, can accommodate considerable differential settlements, up to 2 m in some test circumstances. Flexibility of this layer is clearly important; further study of the strains and properties of the cap components will assist in design optimisation.

It is reassuring that such caps may maintain virtually 100% integrity up to substantial deflections and strains, and indeed important to note that beyond this may allow virtually all (of available) water to infiltrate. A design aim is clearly to identify the area of a cap that may be at risk and prevent such possibilities.

The 'knife edge' differential settlements modelled are relatively extreme, but could model effects of steel containers and suchlike. The work shows the importance of suitably engineered transitions over hard edges. Infill materials can substantially spread deflections and improve cap resilience.

Craig and Gallagher (1997) gave limited details of quite extensive studies for BNFL, unpublished to date, also to simulate performance of a repository cap under differential settlements, leading to shear movements. The present paper has led the present contributors to re-examine this with a view to presenting further information in due course. A 875 mm clay layer within about 3 m total cap thickness withstood significant displacements; but by 500 mm, significant distress to the impermeable barrier was evident (Figure 10). Introducing infill materials significantly increased the resilience. The addition of a low-grade geomembrane over the clay substantially improved performance and prevented tension rupture from propagating through the clay (Figure 11). The work was not taken to a stage where quantitative deductions could be made, but demonstrated a methodology that could give at least conservative indications of resilience of the cap. Recently, assessments have been undertaken of conditions that will enable movements within cap layers to be kept small, typically less than 1% strain, whereby performance of the natural liner components will be very little changed and unlikely to be compromised with respect to its intended design functions. The Craig and Gallagher works gave some helpful data on strains; the present contributors hope to add more on this in due course. The more recent work by Viswanandham is also proving of value and these contributors are encouraged to reaffirm the potential value of centrifuge work in this area (Viswanadham and Jessberger, 2005; Viswanadham and Mahesh, 2002; Viswanadham and Muthukumaran, 2007; Viswanadham and Rajesh, 2009; Viswanadham and Tripathi, 2006).

Modern repository caps are being designed to very high standards, with many component layers (in the case of the contributors' work, 12), each having identified key functions, acting together to maintain a very high level of integrity and durability. It is to be hoped that this publication will encourage further such studies to increase knowledge and improve prediction of cap performance under the variety of movements they are designed to withstand.

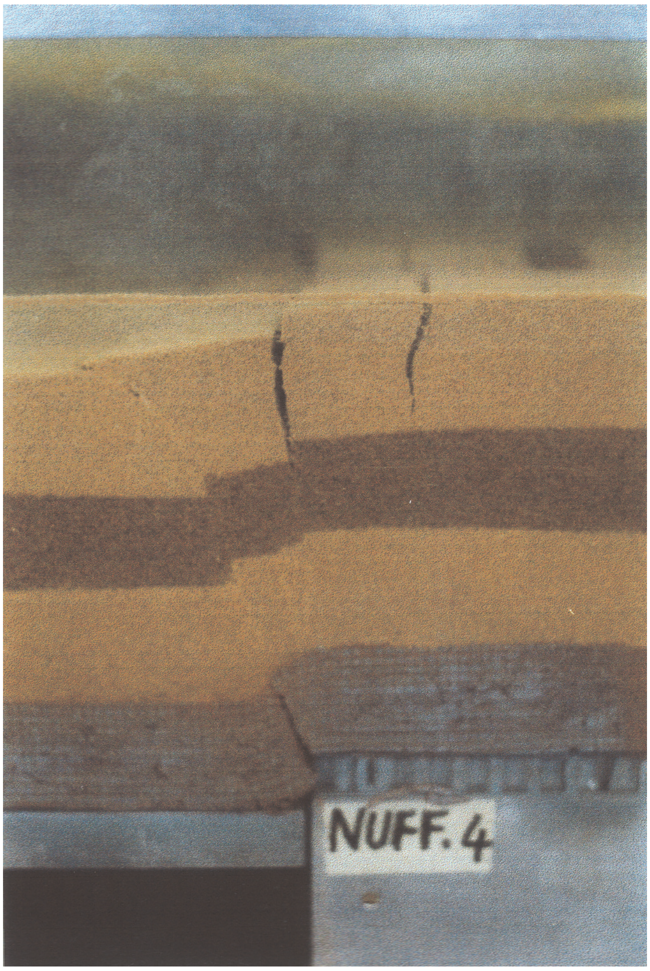

Figure 10. Clay barrier, 500 mm displacement

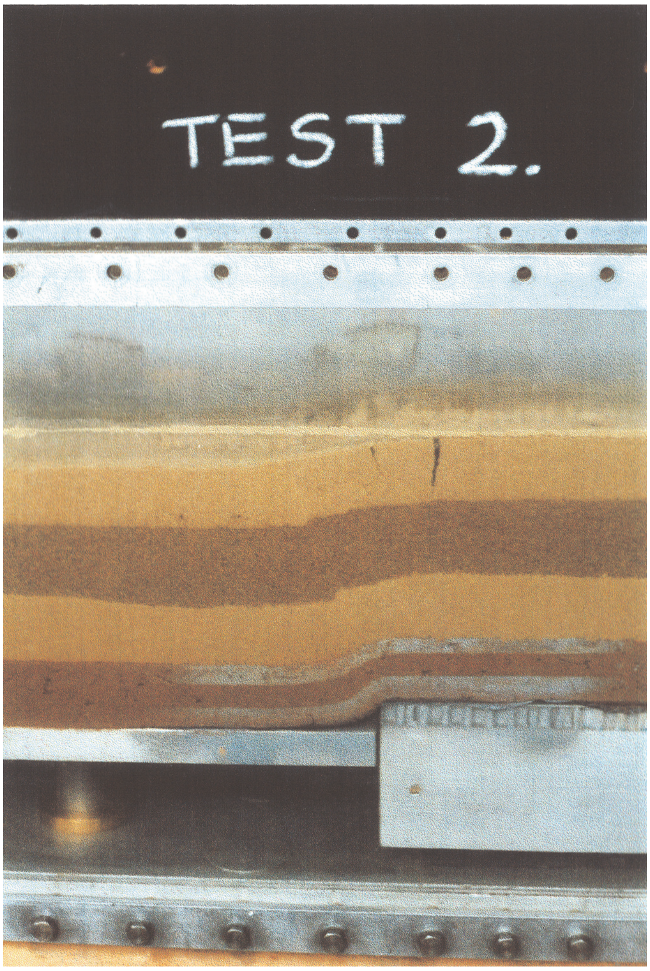

Figure 11. Clay with geomembrane, 500 mm displacement

2. Authors' reply

The authors thank the discussers for their interest and for their contribution, which adds some useful evidence. They agree that the 'knife edge' or step drop modelled in their centrifuge tests is somewhat extreme: it was intended to represent the effects of waste settlement at the edge of a rigid-walled containment vault, or the collapse of a stack of the half-height steel ISO freight containers now used to dispose of low-level radioactive waste at Drigg. These tests were intended to represent a cautious or very long-term condition for the cap, after any geotextiles within it had degraded. Nonetheless, the authors agree that the incorporation of a geotextile would be of benefit in improving the performance of the capping layer in the event of relatively short-term settlements occurring over the first 100 years or so; and the discussion contributors' tests provide some valuable evidence of this. As the contributors point out, a real cap is likely to have many layers fulfilling different functions (e.g. supra- and sub-cap drainage, capillary break, human intrusion barrier, animal intrusion barrier etc.) making it difficult to model at a small scale. The authors' tests were aimed primarily at identifying the geometric factors affecting resistive layer performance: it would be very interesting to see the results of tests replicating the effects of other layers, and the present authors look forward to the publication of the discussion contributors' test data.

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