Papers

Landslide behaviour impact and management at Ventnor, Isle of Wight

by R Moore, EM Lee and AR Clark[1]

Introduction

During the extremely wet winter of 1960/61 parts of Ventnor, on the south coast of the Isle of Wight, were affected by ground movement. A number of properties were damaged beyond repair, some of which had to be temporarily evacuated. The Ministry of Housing & Local Government offered financial assistance to those affected and around £78 000 of insurance claims were made. This was not, however, the first time Ventnor had experienced trouble from ground movement. Indeed, it has long been recognised that the town was built upon a massive ancient landslide complex known as the Undercliff. Over the last 100 years at least 50 buildings have had to be demolished because of ground movement and Chandler and Hutchinson (1984) estimated that between 1960 and 1980 landslide damage costing over £1.5M occurred in the town.

In 1988 the Department of the Environment commissioned a study of the landslide problems in Ventnor as part of its planning research programme. One of the aims of this study was to identify ways in which ground movement information and an understanding of landslide processes could be used to assist local planners in making decisions on the most effective use of land. It was recognised that once there was a detailed understanding of the nature and extent of the landslide problems, management strategies could then be formulated to reduce the consequences of future movement.

The assessment of landslide hazard at Ventnor, Isle of Wight has necessitated the development of a new method for assessing the ground behaviour of an existing landslide complex. The scale and complexity of the landslides dictate that conventional engineering solutions to contemporary instability problems are unlikely to be cost-effective; localised engineering treatments aimed at reducing the magnitude and frequency of movements and their impact on the community are considered more realistic. The results of the study have been published in a Technical and Summary report (Lee & Moore 1991; Lee et al 1991a) and have led to a wider public and professional awareness programme and the development of the Undercliff Landslide Management Strategy.

The study area

The Undercliff on the southern coast of the Isle of Wight (**Figure 1**) is an extensive ancient landslide complex, on parts of which

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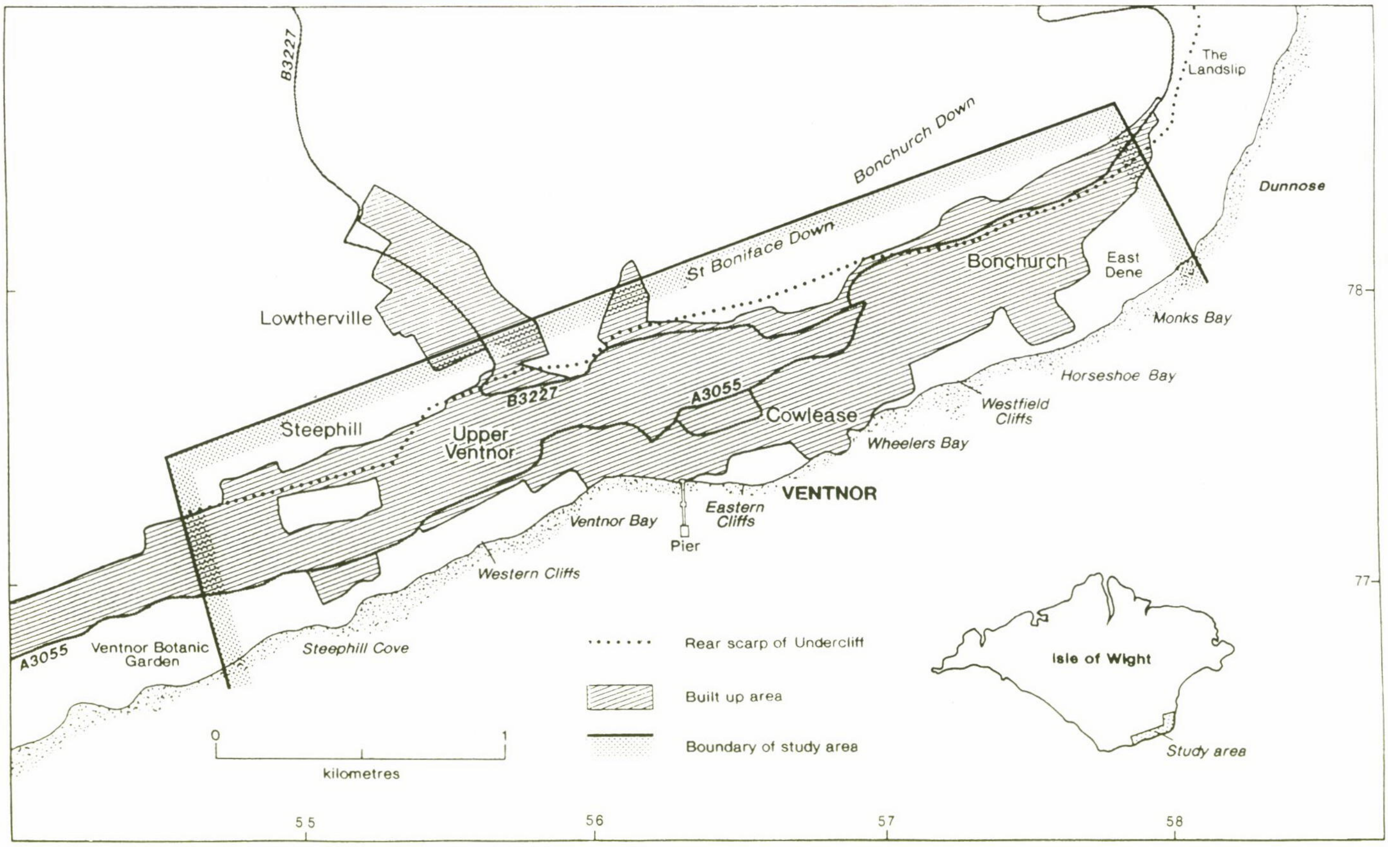
Figure 1: Location of study area.



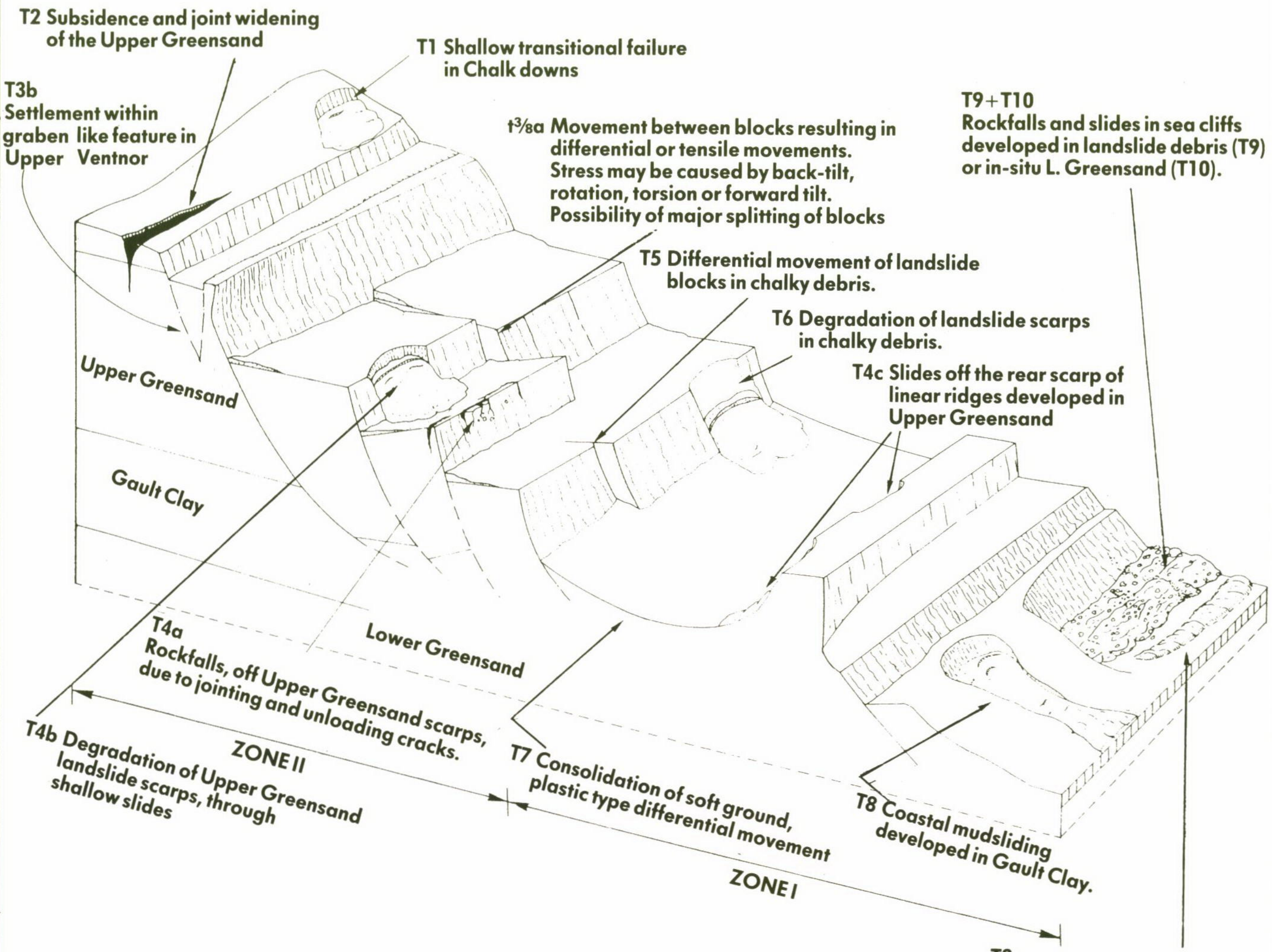


Figure 2: Types of contemporary ground movement in Ventnor.

the town of Ventnor and the village of Bonchurch are situated. The landslides within the Undercliff are developed in Lower and Upper Cretaceous rocks. These consist of considerable thicknesses of Gault Clay underlain by sandstones of the Lower Greensand and overlain by massive cherty sandstones of the Upper Greensand and Chalk.

Although there remain many uncertainties about the variation in thickness and composition of the bedrock units and the broad structure of the Undercliff, it is clear that the geological setting exerts a primary control on the development of landsliding (Hutchinson 1991). The sequence of seaward dipping (1° - 2°) over-consolidated Gault Clay overlain by a massive but well jointed caprock of Upper Greensand gives rise to a geological setting which is particularly prone to landsliding. The presence of thin argillaceous layers within the Lower Greensand Sandrock together with the Gault Clay have a major influence on both the hydrogeology and stability of the area.

The present form of the Undercliff represents the product of at least three main phases of mass movement activity over the last 8000 years, together with the effects of continuing modification by contemporary processes. However, the Undercliff should not be viewed as a simple uniform system, as both the form and the intensity of landslide activity appears to have varied along its length. The combination of spatial variability in the geological framework (both structure and lithology) and a variety of mass movement environments (both through time and space) has been manifest by a wide range of landslide types (Lee and Moore, 1991; Hutchinson et al 1991).

Ground behaviour mapping

Detailed geomorphological maps were produced at 1:2500 scale and accompany the technical report (Lee & Moore 1991). These maps reveal the scale and complexity of the landslides in a clearer way than could have been achieved by conventional subsurface investigation and at a fraction of the cost. Once the framework of landslide units had been established it was possible to relate building damage and movement rates to clearly defined units. From this understanding of ground behaviour it was possible to develop landslide management strategies that reflected variations in stability rather than a blanket approach to the problem.

A search through historical documents, local newspapers from 1855-1989, local authority records and published scientific research, revealed nearly 200 individual incidents of ground movement in Ventnor over the last two centuries. The various forms of movement that have occurred are summarised in **Figure 2** and include first time failures of the Chalk Downs, subsidence and joint widening within the Upper Greensand (vent formation), blocks of material moving en-masse along pre-existing shear surfaces and the degradation of pre-existing landslide features by a variety of processes such as mudslides and spalling of scarp faces.

While the most serious damage to property has occurred in areas affected by the largest movement rates the situation is not a simple case of extensive damage to property in unstable areas and no damage in more stable areas. Often it is not clear whether some of the reported problems with building were a direct result of ground movement or simply due to poor building construction. It is clear, however, that in many areas the type of damage reflects a range of ground movement forms; these include differential vertical and horizontal movement, rotation, torsion, forward tilt and ground heave.

Understanding the geomorphology of the landslide complex at Ventnor has proved the key to understanding the nature and pattern of contemporary movements, and formed the basis for a 1:2500 scale ground behaviour map. The map summarises both the nature, magnitude and frequency of contemporary processes and their impact on the local community, being a synthesis of the following information:

- the extent of different landslide features which form the Undercliff at Ventnor (eg multiple rotational slides, compound failures and mudslides):
- the nature of different landslide processes which have operated within the town over the last 200 years;
- the location of ground movement events recorded in the last 200 years;
- the recorded rates of ground movement;
- the intensity of damage to property caused by ground movement;
- the causes of damage to property as a result of ground movement (eg torsion, rotation and heave);
- the relationship between past landslide events and antecedent rainfall.

Landslide management

In the past there has been an ad-hoc response to specific landslide events in Ventnor, concentrating on emergency action as required; repairing buildings where possible and condemning any properties damaged beyond repair. Such 'crisis management' responses after the event are common reactions, throughout the world, to infrequent problems. However, in Ventnor, where ground movements are a recurrent problem, there is a clear need for a coherent and systematic strategy for managing the landslide hazard.

The ground behaviour map clearly shows that the problems resulting from ground movement vary from place to place according to the geomorphological setting. This forms the basis for landslide management strategies that reflect the variations in stability rather than a blanket approach to the problem.

Since the publication of the DoE study the local authority has approved an outline Undercliff landslide management strategy the objectives of which are:

- to reduce the likelihood of future movement by controlling the factors (both natural and man-induced) that cause ground movements;
- to limit the impact of future movement through the adoption of appropriate planning and building controls.

The DoE study identified that considerable benefit can be gained by reducing the frequency and magnitude of ground movement events through small-scale engineering works designed to improve the stability of the landslide system. This work would best be directed towards coastal protection to prevent toe erosion or unloading of the landslide complex, groundwater management and improving the infrastructure throughout the Undercliff (some structures have been poorly maintained and neglected to the extent they have become dangerous) and thereby improve confidence in the area. Potentially the most serious destabilising

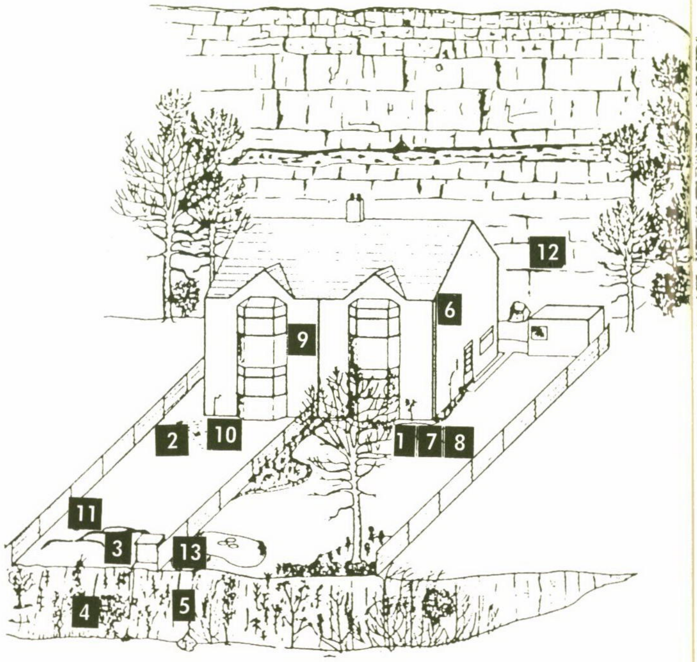


Figure 3: Suggested good home maintenance practices.

factor associated with development in the Undercliff has been the artificial surcharge of groundwater from septic tanks, leaking water pipes, drains, sewers and swimming pools etc.

It was recognised that there were considerable opportunities to prevent future damage to new development by incorporating the knowledge of ground behaviour within the existing planning framework. For this purpose a 1:2500 scale planning guidance map was produced which relates categories of ground behaviour to forward planning and development control. The map indicates that different areas of the landslide complex need to be treated in different ways for both policy formulation and review of planning applications. Areas were recognised which are likely to be suitable for development, along with areas which are either subject to significant constraints or mostly unsuitable. Advice was also provided on the level of stability information which should be presented with planning applications in different areas.

The mapping at Ventnor has clearly revealed that the landslide system is too large-scale and complex to be resolved by conventional engineering solutions that would also be prohibitively expensive. However, available knowledge indicates that many of the problems can be reduced if the local community comes to terms with the situation and learns to live with the landslide. Control of construction activity is considered to be especially important in preventing instability with particular emphasis placed on:

- the avoidance of inappropriate cut and fill operations which should be carried out only after due consideration of the geomorphological setting of each site:
- the timing of earthmoving operations which should be restricted during the winter months when slopes appear to be more prone to failure;
- the establishment of a code of practice for open trench excavations, such as for the maintenance of gas and water mains.

Because it is known that movements in Ventnor occur during specific rainfall and groundwater conditions, it is vital that a major effort should be directed towards preventing water leakage from

DON'Ts

1 Don't block or alter ditches or drains.
2 Don't allow water to collect or pond
3 Don't shift your water or soil problems downslope to your neighbours.
4 Don't landscape the slope without notifying the Local Authority.
5 Don't clear vegetation off slopes without replanting.

DO's

6 Check roof drains, gutters and downspouts to make sure they are clear.
7 Clear drainage ditches and check them frequently during winter
8 Make inspection during winter – this is when problems can occur.
9 Watch for water back-up inside the house at sump drains and toilets, since this indicates drain or sewer blockage.
10 Watch for wet spots on the property
11 Consult an expert if unusual cracks, settling or land slippage occurs inform Local Authority of any problems.
12 Regularly inspect scarp slopes for potential rockfalls or loose debris.
13 Regularly inspect swimming pools and ponds for leaks and repair if necessary.

service lines and sewers. It was recognised that the flow within the sewerage and water supply network should be monitored to identify areas of leakage which could then be quickly repaired. Soakaways, French drains and other natural percolation methods of disposing of surface water need to be avoided, with storm water outfalls taken down to sea-level before being discharged. The importance of preventing water leakage into any landslide system cannot be over-emphasised and at Ventnor it is believed that such an approach is likely to be the most cost-effective way of reducing the occurrence of damaging ground movement events. In addition, good maintenance practice by individual homeowners can be a significant help as neglect can result in localised instability problems **(Figure 3)**.

Getting the message across

The importance of getting the message across to the public was recognised by the DoE and South Wight Borough Council. At the same time as the results of the study were published, seminars were held to discuss the implications with the Association of British Insurers; town, borough and county council members and statutory undertakers; local estate agents, surveyors and solicitors; and the press. A free public information leaflet was produced which advised the residents on what the survey revealed and what they should do to control the problems, emphasising the need to prevent water leakage. South Wight Borough Council also funded a three month public awareness programme during which time a shop was rented in the High Street and manned by two of the consultant's team who had carried out the study. Display boards and maps explaining the results of the study were mounted on the walls. Over 2000 residents visited the shop where they were free to discuss any fears or problems.

Conclusions

The DoE study has demonstrated that an understanding of ground behaviour in an urban landslide system can be achieved through geomorphological mapping, coupled with extensive archive research, surveys of damage and land use, and photogrammetric analysis. It was found that ground behaviour mapping was best based on individual geomorphological units rather than landslide systems. This gave a better impression on the mechanics and dynamics of the landslide system as a whole. This is especially important in complex landslides such as those at Ventnor where there are interactions between landslide sub-systems.

It is important that the landslide problems faced in Ventnor are kept in perspective. The town is built on a massive landslide complex and as such the whole area should be viewed as potentially unstable ground. Fortunately the geological setting and the style of landsliding is such that movements are often concentrated in a few locations, and that intervening areas have shown negligible or no movement. Thus in many areas buildings have survived for long periods, such as Bonchurch Old Church, which is believed to be over 1000 years old. In addition, many properties are so poorly built with foundations and building types completely unsuited to accommodating ground movement, the landslide problems have appeared to be more serious and less manageable than they should be.

It is felt that there is good reason for confidence in Ventnor from a building insurance or financial development point of view so long as sensible use is made of the technical information presented by the DoE study and from future monitoring exercises, and that the Undercliff Landslide Management Strategy is implemented. Of course, unstable areas must be avoided where possible, but conversely more stable areas can be successfully developed, provided precautionary measures are adopted, where needed and the developer is willing to accept, in some locations, a higher level of risk than would be expected in normal circumstances.

Acknowledgements

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