GEOTECHNICAL STUDY AREA G3

BONCHURCH LANDSLIDE, VENTNOR UNDERCLIFF, ISLE OF WIGHT, UK

Plate G3 ***Bonchurch landslide, February 1995, Isle Of Wight , UK***

1. BACKGROUND

In early February 1995 a large landslide was reported to have occurred in the area known as "The Landslip", which is situated on the south coast of the Isle of Wight at Bonchurch to the east of Ventnor (see Plate G3 and Figure G3.1). The Landslip area was owned by the Local Authority who first reported the incident to its consulting engineers on 6th February 1995.

Early descriptions of the event indicated that a significant area of The Landslip had been affected by the landslide. The event was reported to have resulted in the loss of clifftop land due to the failure of a prominent rear scarp, which marked the landward extent to The Landslip, along with the considerable settlement and disruption of the slopes and amenities within The Landslip. Large quantities of landslide debris were reported to have been deposited on the foreshore, beneath the steep coastal cliffs, as a consequence of the slope movements above (Rendel Geotechnics 1995).

Although the description of the events suggested a fairly sudden slope movement, there were no reports of any casualties. The landslide did, however, result in the destruction of a number of public footpaths which form an important amenity in the area. A major concern raised after the event was the potential for further slope instability and landslide extension, particularly upslope of the rear scarp of The Landslip (Plate G3a). The Council, therefore, commissioned its consultants to inspect the site and to provide a stability report identifying recommendations for future action. The Council's consultants were instructed in February 1995 to provide a stability report and recommendations for the area affected within The Landslip in order to:

- Assess the nature and extent of recent landsliding.
- To assess the causes and impact of the event.

- To assess the potential for further slop instability, including the risk to property and the A3055 Leeson Road, inland of the rear scarp, and pedestrian access to and within The Landslip.

2. ROLE OF THE KEY AGENCIES

The key agencies involved at this location were the Isle of Wight Council as Coast Protection Authority with responsibility for management of instability issues and as Planning Authority. Further to this Southern Water Services Ltd, which has responsibility for water supply and drainage matters were also involved, particularly in relation to remedial works.

3. TOPOGRAPHY AND SITE DESCRIPTION

The Landslip, as the name suggests, is an area recognised for its past and contemporary slope instability, and which provides a unique and important setting for a wide variety of amenity interests, including geology, ecology and wildlife, and recreation. The area has a long history of slope instability and has featured on several Victorian engravings and postcards. Major landslide events occurred in 1810 and 1818 and have been reported in various 19th century Isle of Wight publications (Rendel Geotechnics 1995).

The latest instability event at The Landslip occurred shortly after the publication of the report "The Undercliff of the Isle of Wight: A Review of Ground Behaviour" (Rendel Geotechnics 1995), which was commissioned and published by the former South Wight Borough Council. This report had included detailed maps for geomorphology, ground behaviour and planning guidance for The Landslip for the first time.

Other publications and reference sources of relevance to the area included the reports and maps published by Geomorphological Services Ltd (1991), which cover the Ventnor and Bonchurch areas from the study funded by the former Department of the Environment (now DETR) entitled "Coastal Landslip Potential Assessment: Isle of Wight Undercliff, Ventnor". There are few other publications which consider the geomorphology and geotechnics of The Landslip with the exception of Chandler (1984) and Matthews (1977). Hutchinson et al. (1981) and Posford Duvivier (1991) provide geotechnical assessments for the coastal landslides at Bonchurch and Monks Bay on the coast, around 1km to the south-west of The Landslip.

The site is situated at the eastern end of the Undercliff, an ancient deep-seated coastal landslide complex believed to be many thousands of years old (Hutchinson 1965; Rendel Geotechnics 1995). The Landslip is a Site of Special Scientific Interest (SSSI) and extends around 1km along the coast from Dunnose to the north-east of Monks Bay to Boardwood Ledge to the north (see Plate G3b). The Landslip occupies the full width of the Undercliff, and varies between 190-290m, enclosing an area of around 24ha. The Landslip is elevated above a 30-40m high sea cliff, from which it rises to 100m above OD beneath a prominent rear scarp.

4. GEOLOGY

The landslides within The Landslip are developed in the Lower and Upper Cretaceous strata. These consist of over 40m of Gault Clay, underlaid by weak sandstones of the Lower Greensand and overlain by the massive cherty sandstones of the Upper Greensand and Chalk. The presence of the Gault Clay, known locally as 'Blue Slipper', provides significant weak layers upon which The Landslip has developed.

The geological structure of the Southern Downs has had a significant influence on the hydrogeology and stability of the coastal slopes (see Figure G3.2). The horizontally bedded strata of the downs dip gently to the south at 1-2° (White 1921). A shallow syncline is present within the Undercliff, the axis of which plunges gently to the south-south-east in the vicinity of Ventnor (Hutchinson 1995; Chandler 1984). The Landslip is situated on the eastern limb of the syncline, whereby the elevation of strata increases to the east which gives rise to a marked coastwise dip in the strata to the south-west.

A composite geological section for the Undercliff has not been published before. The nearest stratigraphical sections have been presented for Luccombe (Chandler 1984; Geomorphological Services 1989) and Bonchurch (Hutchinson et al. 1981; Posford Duvivier 1991). Based on these type sections and field observations, an outline geological section indicates a coastal cliff formed largely of in situ Sandrock of the Upper Greensand with deep-seated rotational landslides and mudslide developed in Upper Greensand rocks above at multiple levels within the Gault Clay.

During the reconnaissance survey fresh geological exposures were observed, including the Malm Rock (Upper Greensand) at the rear scarp, the Gault Clay around mid-slope within the landslide, and Sandrock in sea cliffs. Significantly no Chert Beds were observed at the crest of the rear scarp up to an elevation of around 180m OD. The landslide debris was entirely composed of Upper Greensand and Gault Clay debris. The Carstone is believed to be 'in-situ' beneath the basal shear surface of the Gault Clay, except at the crest of the coastal cliff where it is disturbed due to clifftop failures and slope instability above. Ledges were observed in the sea cliff which most likely correspond with the stratigraphical horizons within the Sandrock (Clay Bed 2d).

The geomorphology of The Landslip has been considered previously (Rendel Geotechnics 1995). Four main landforms may be recognised in this area namely:

1. The Chalk Downs
2. Upper Greensand bench
3. Landslide features
4. Sea cliffs

The chalk downs form the higher ground above 120m OD landward of the Undercliff. They reach an elevation of around 240m at Bonchurch Down and are characterised by a steep south-facing slope at around 35°.

The Upper Greensand bench is situated at the base of the Chalk downs between 115-120m OD. The bench was probably formed as a consequence of the removal of the overlying Chalk through solifluction and fluvial processes in the past. The removal of underlying support through landsliding in the Undercliff has resulted in stress release and the opening of joints (vents) and settlement of the Upper Greensand strata. The landslide activity in The Landslip caused the localised failure of the seaward edge of the bench exposing the Malm Rock.

The Upper Greensand bench is an important feature in the area as it marks a significant narrowing in the Undercliff coastal landslides. The Landslip is situated to the north-east of a bluff, at the seaward edge of the bench, with Bonchurch Shute (the road providing access from the main Isle of Wight coast road down into the Undercliff itself) located immediately to the south-west. Loss of support through landslides on either side of this bluff has led to settlement of the bench causing damage to property and services.

The landslide features within The Landslip are dominated by the multi-rotational failures of the Upper Greensand upon the Gault Clay. The landslides may be developed at multiple levels within the Gault Clay, although the lithological boundary between the silty and plastic Gault,

around 15m from the base of the unit, is known to form significant basal shear surfaces elsewhere in the Undercliff (Bromhead et al. 1991; Rendel Geotechnics

1995). The landslides are perched above the sea cliffs and consequently there is no passive support to the unstable slopes above.

The published geomorphological map for The Landslip indicates a number of significant landslide features in the area prior to the 1995 landslide:

1. A near vertical rear scarp in Upper Greensand.
2. A steep landslide scarp around 50m seawards of the rear scarp.
3. Large multi-rotational landslide blocks.
4. A multi-rotational degradation zone.
5. A Gault Clay scarp.
6. An active coastal mudslide.

The significance of these features is discussed below with regard to the extent and mechanisms of the landslide event of February 1995.

The sea cliffs are up to 40m high and formed of in-situ Sandrock, and where present the Carstone. They are undercut at the base through wave attack, which has led to significant cliff retreat in recent years. It has not been possible to establish accurate cliff recession rates for The Landslip although experience from sea cliffs elsewhere, which are similar in form and composition, would suggest a rate of retreat of between 1-2.5m per year. Retreat of the soft cliffs occurs through a range of processes including relatively frequent cliff falls, particle detachment and localised seepage erosion. Slope movements above the sea cliff exacerbate these processes increasing the rate of retreat of the coastline. Debris is deposited at the cliff base where it may provide temporary protection of the cliffs from wave attack prior to its removal.

5. THE LANDSLIDE EVENT OF FEBRUARY 1995

The extent of the landslide in February 1995 was largely confined to within the southern part of The Landslip. At its widest, above the sea cliff, the landslide was 400m in width and extended 260m upslope. The area affected is estimated at 40,000m² (4ha), which is much smaller than the areas affected in 1810 and 1818. Given an average depth of the landslide of around 20m, an estimated 800,000m³ of material was displaced.

The limits of the landslide broadly coincide with several morphological boundaries. The southern boundary corresponds with a formerly active mudslide which extended 130m upslope of the sea cliff into The Landslip. The northern boundary likewise corresponded with another formerly active mudslide which extended 90m upslope of the sea cliff. The inland extent of the landslide arcs between these former mudslide, extending a further 90m upslope at its apex and consequently did not affect the full width of The Landslip. The Undercliff rear scarp was only partially affected by the landslide, in the south-west, where cliff failure caused the retreat of the Undercliff rear scarp into private land by around 10m over a length of 20m.

The extent and scale of the landslide led to widespread damage mainly within The Landslip itself but with minor slope instability in adjacent areas. However, the landslide also had an impact on adjacent areas, the most notable being the deposition and run-out of debris on the foreshore and the localised collapse of the rear scarp. The latter led to the loss of private land used for grazing above the rear scarp of The Landslip. The retreat of the scarp occurred through several cliff falls at the time and subsequent to the initial landslide event.

Although not directly adjacent to the major landslide in The Landslip, an extension of damage to property and services due to ground movement occurred in February in and around the property Northcourt at Bonchurch Shute. The area is situated on the other side of the bluff

formed on the Upper Greensand bench referred to earlier and separates The Landslip area from the Undercliff to the south-west. The extent of damage included notable arc cracking and settlement of the road carriageway and private land and moderate to serious damage to several properties. Settlement of the foundations at Northcourt has led to a significant worsening of structural damage to the extent that continued safe occupancy of the building had to be reassessed.

6. MONITORING STRATEGY

The installation by the Council in 1991 of an automatic weather station at Ventnor has been of practical value in trying to assess the relationship between antecedent rainfall and ground movements within the Undercliff. It was noted that very significant rainfall totals (approaching 275mm for January/February 1995), which was almost twice the average expected for that period, was largely responsible for this event.

The Council was particularly concerned about the potential for further landsliding, which could affect nearby properties. As a result a two-tier monitoring system was put in place; first a manual inspection system was undertaken on a regular basis along the rear scarp and within The Landslip itself and second two tiltmeters with telemetric links to the Council offices and to the Police Headquarters were installed in an appropriate location between the landslide and residential development. The equipment, located outside a property called “The Retreat”, near the top of Bonchurch Shute, also comprises one settlement cell and one crackmeter.

Because of the amount of residential development in the area and the possible effect of instability on a well-used public highway, two thresholds are provided with a direct line alarm system to the Police who provide 24 hour cover in the event of civil emergencies. The Council continues to review and assess ground movement readings from this and other locations and to monitor the situation both along the rear scarp and within The Landslip itself, particularly during and after wet periods.

7. CURRENT STATUS AND APPROACH

A major concern arising from the landslide in February 1995 was the potential for further slope instability within and adjacent to the area affected by the landslide. With regard to the potential for further instability in The Landslip, degradation of the 1995 landslide continued to take place for some time, particularly during the winter and wet periods. Landslide potential includes the gradual creep of the deep-seated rotational slides, the development of lateral mudslides, further small scale failure and spalling from the rear scarp, conveyance of debris over the sea cliff, deposition of debris at the cliff base and removal of debris from the cliff base and retreat of the sea cliff through marine erosion. For a considerable period after the event the public footpath through The Landslip was closed and major remedial works were undertaken by the Council to reinstate the path in a more stable location.

Of greater concern was the potential extension of land instability northwards towards properties and the A3055 Shanklin-Ventnor road situated upslope of The Landslip (Plate G3c). It was considered that the built development and main road were not immediately at risk from the landslide due to the fact that the instability was largely confined to within The Landslip and that the development is set back at least 90m from the nearest instability. However, the resultant unloading of slopes within The Landslip adjacent to the boundaries of the landslide, will have undoubtedly caused a decline in stability in these areas. There is significant potential for the extension of landslide activity upslope, particularly along the northern boundary, which is at a

higher elevation due to the geological dip. The opening of cracks and joints noted soon after the landslide in February 1995 may indicate the precursor signs of such an extension of instability.

At Bonchurch Shute there is also potential for further slope instability given the extent and continuity of crack damage. The consequences are two-fold. First there is the potential for failure of the ground on the seaward side of the road, which would lead to loss of property in the

road. Given that the area at risk has no natural passive support on the downslope side, the potential for an abrupt movement cannot be ruled out which would have significant implications for the safety of local residents and road traffic. Second, gradual development and unloading of the south-west side of the bluff could have a detrimental effect on the stability of the Upper Greensand bench as indicated above.

7.1 Coastal Defence

The Isle of Wight Council, as Coast Protection Authority, has undertaken major coastal protection schemes along the Undercliff in recent years. In 1992/93 a £1.3m scheme was undertaken at Monks Bay, Bonchurch, which is seaward of the developed part of Bonchurch Village, but does not provide any protection or support for The Landslip itself. The reason for this is that The Landslip is a location that was at that time designated as a Site of Special Scientific Interest (and is now also designated as a Candidate Special Area of Conservation under the European Habitats Directive), therefore coast protection works would be inappropriate for environmental reasons.

The extent of The Landslip and the processes involved suggest that coast protection would be largely impractical and in addition the distance of property from the coast would mean that there would not be sufficient benefit cost to trigger the Government coast protection grant aid mechanism. Nevertheless coastal monitoring, a function of the Isle of Wight Council, which is undertaken around the whole of the 110km of coast, continues to take place, and the situation is continuously under review.

8. EXPERIENCE, SUCCESSES AND PROBLEMS WITH THE CURRENT APPROACH

In the light of the landslide at Bonchurch in 1995, a number of recommendations were made with respect of ground stability. These included:

1. Safety notices being erected to warn the public of the dangers in entering areas affected by landslides (eg soft ground, tension cracks, unstable clifftops, etc). Information boards which explain the geology, geomorphology and history of the area providing a medium through which dangers can be publicised.
2. The coastal footpath was reinstated to provide access to the coastal path and The Landslip for recreational purposes. However, the Council realigned the footpath to avoid the more unstable areas within the landslide and to mitigate the potential damage to the reinstated path due to ground movement that would inevitably occur from time to time.
3. Areas of ponding and seepage were drained through shallow hand-dug trenches in order to improve the drainage and stability of the area.
4. Structural inspections of several properties particularly on the seaward side of Bonchurch Shute were undertaken with regard to assessing the risks to residents of continued occupancy. The Council is in the process of updating its geomorphology, ground behaviour and planning guidance maps to reflect the instability situation arising from this event.
5. An early warning monitoring system was installed at Bonchurch Shute to safeguard the public and road traffic from the potential abrupt failure of the area. The monitoring system comprises a settlement cell and tilt meters which are linked by telemetry to the appropriate authorities, similar to monitoring systems established at other critical sites within the Undercliff.
6. The area upslope of The Landslip is being regularly surveyed to monitor for signs of instability. This comprises a combination of measurements and visual inspections alongside the automatic systems.

The experiences arising from the Bonchurch landslide illustrate the difficulties that a small coastal authority like the Isle of Wight Council can face in terms of managing its long and complex coastline. Tourism and recreation form a vital part of the Council's functions and the

'round the Island' coastal footpath network is a major asset to the Isle of Wight in terms of the local economy.

The event in 1995 has increased awareness of the importance of reviewing planning and building control applications in sensitive areas and in developing programmes for ground movement monitoring on an Islandwide basis. Event of this kind also stress the need for hazard and planning guidance maps to be reviewed and updated to take account of such events and for this reason the Isle of Wight Council have developed a geographical information system, the "Landslide Database" which contains all 21 of the 1 : 2,500 maps of the Isle of Wight Undercliff comprising geomorphology, ground behaviour and planning guidance.

9. REFERENCES

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Plate G3a ***Damage area arising from the 1995 landslide***

Plate G3b ***Landslide debris covers the sea, cliff and foreshore***

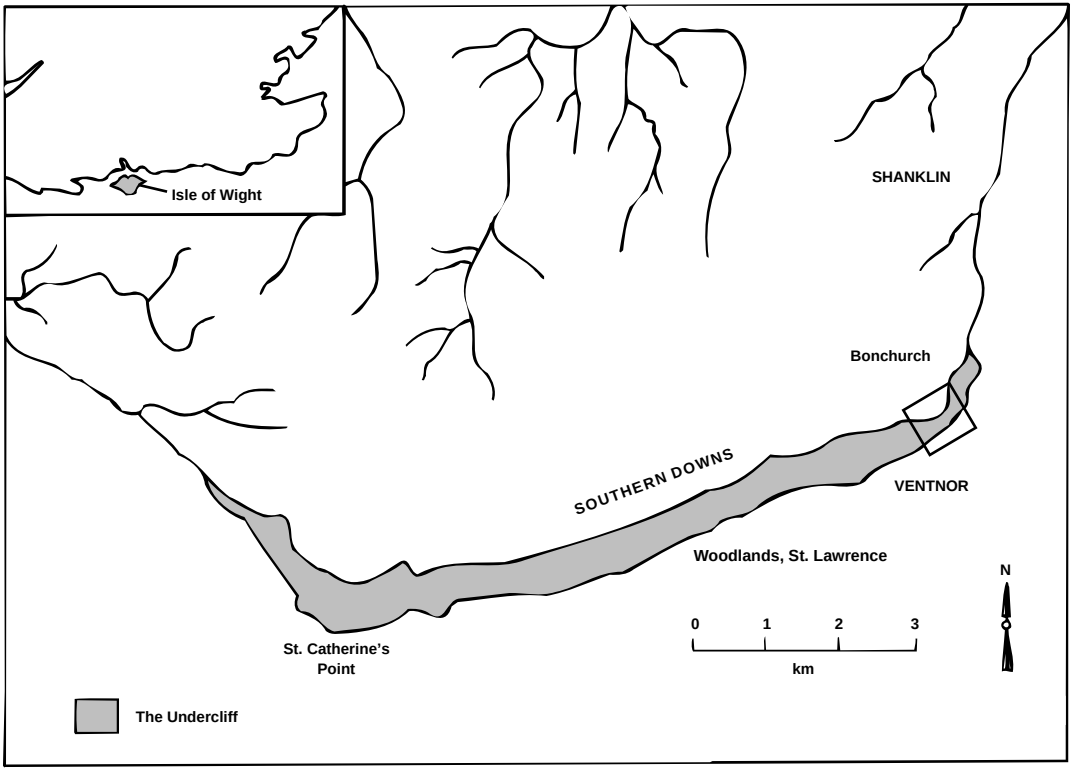

Figure G3.1 Bonchurch location map.

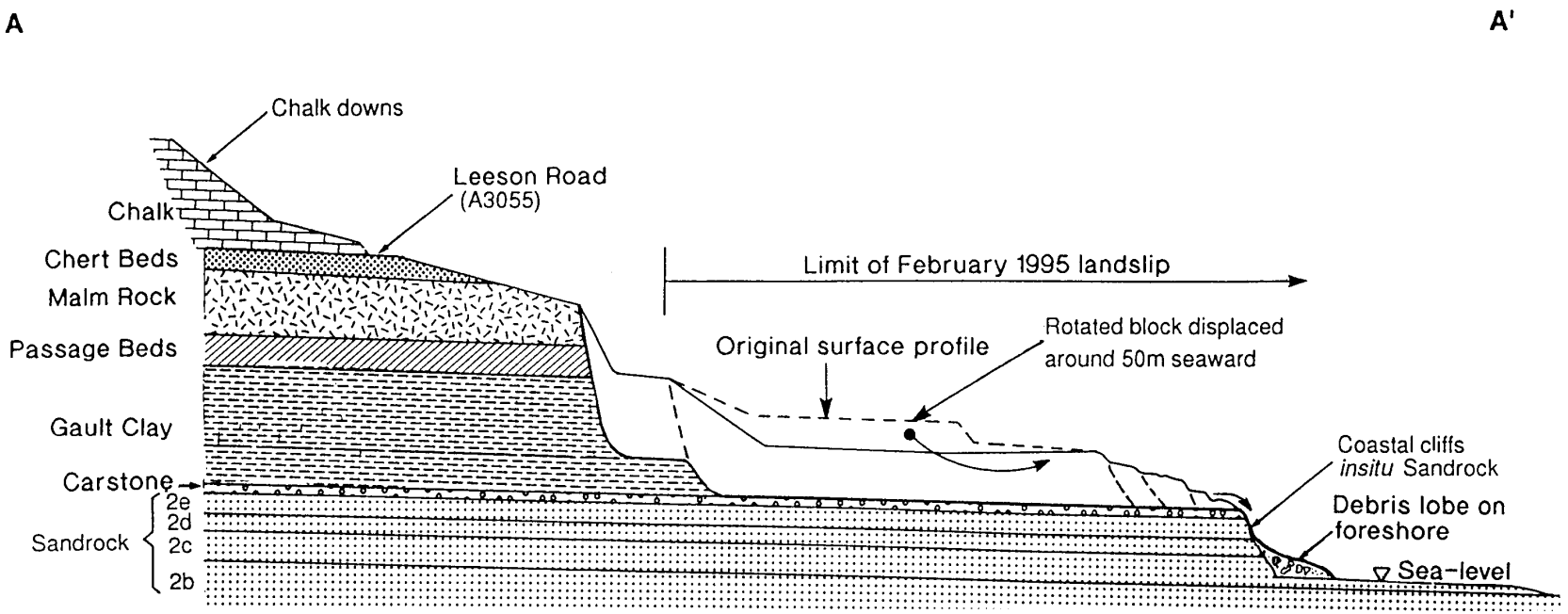

Figure G3.2 Geological cross section through the Bonchurch landslide.

Plate G3c *Bonchurch from the sea*