

## GEOTECHNICAL STUDY AREA G4

### VENTNOR TOWN, VENTNOR UNDERCLIFF, ISLE OF WIGHT, UK



**Plate G4** *Ventnor town looking westwards, Isle of Wight, UK*

#### 1. BACKGROUND

An introduction to the general geological situation with respect to the Isle of Wight Undercliff landslide complex has been provided as Study Area G1 above. It is sufficient to say that historical records of landslide events have been collected which indicate that over the last 200 years the town of Ventnor (Plate G4) has been subjected to ground movements which have caused damage to property and services in some developed areas.

Detailed assessments of ground movement problems in the Ventnor Undercliff have been taking place since 1988 when the former Department of the Environment (DoE), now the Department of the Environment, Transport and Regions (DETR) commissioned a study of Ventnor, as part of their planning research programme, to incorporate land instability issues within the planning system. The findings of the Ventnor study were published in 1991 and since then the Local Authorities (the former South Wight Borough Council and following local government reorganisation the Isle of Wight Council) have commissioned further studies to encompass the whole of the Undercliff landslide complex over its 12km length.

The studies of Ventnor have involved:

- Determining the nature and extent of the landslide problem.
- Understanding the past behaviour of the Ventnor Undercliff.
- Formulating a range of management strategies to reduce the impact of future movement.

With respect to the town of Ventnor it is important to note that whilst some areas have been affected by landslide movement, much of the developed area of Ventnor has remained largely unaffected by major events. Thus, in many areas buildings have survived for long periods, such as Bonchurch Old Church, which is believed to be over 1,000 years old. In other locations, property damage may not necessarily reflect serious landslide problems as many of the older buildings were built with foundations and building styles quite unsuited to accommodate ground movement. Other properties were not well built or have been poorly maintained over the years. As a consequence, the landslide problems have appeared to be more serious and less manageable than they should (Rendel Geotechnics 1995).

Following extensive studies, the Council believes that there is no reason why there should not be confidence in Ventnor from a development point of view. This is true as long as sensible use is made of technical information and recommendations arising from various studies. Of course, unstable areas must be avoided where possible. However, more stable areas may be successfully developed, as long as necessary stabilization, protection and monitoring measures are adopted and the developer is willing to accept, in some locations, a higher level of risk than could be expected in other circumstances (Rendel Geotechnics 1995).

## 2. THE IMPACT OF INSTABILITY

Ground movement has been recognised as a localised problem in Ventnor for nearly 200 years with notable consequences for the town itself. In his evidence to the Royal Commission on Coastal Erosion in 1906, Mr Aubrey Strahan of the Geological Survey, provided a clear description of the situation in Ventnor that still applies in many ways today:

*“The movements appear to be continuing ... very slowly. I do not know that in the observation of any one living man these large masses of rock can be seen to have moved, but it is the experience of the surveyor and other officials in Ventnor that flights of steps which are taken straight up and down the cliff have occasionally to be lengthened. The ground, by moving downwards, leaves gaps in these flights of steps, and they have to put in occasionally a few more steps to complete the staircase”.*

Perhaps the most dramatic period of ground movement in Ventnor occurred during the winter of 1960/61. Cliff falls, collapsed walls and settlement were reported throughout the Undercliff in November and December 1960, following the heaviest autumn rainfall since records began in 1839. Cracks appeared in various parts of the town causing damage to properties, some temporary evacuation of local residents and the demolition of a number of hotels and residential properties over the next few months.

Growing public awareness of the problems has been matched by an increase in the number of reported incidents of ground movements. Within the developed areas the most notable sites have been in the upper part of the town where slow settlement seems to have been an almost continuous problem. In January 1994 movements were reported throughout Ventnor and indeed other parts of the Undercliff following a prolonged rainfall period.

Although records of ground movement in Ventnor go back as far as 1781, it is difficult to get a clear picture as to how much movement has occurred. The majority of locations (91%) have probably been moving less than 5mm a year or have not moved at all. At many sites the short-term movement rates appear to be representative of longer term trends. At some sites, particularly in the upper part of Ventnor, short-term movement rates of between 53-125mm per year were recorded (Chandler 1984), but the average trend in such locations seems to be about 28mm per year over the last 22 years.

The occurrence of ground movements within the Ventnor area has resulted in a range of problems for the local community. Judging from historical records it would appear that these problems may have increased over the last 100 years. This is without doubt a reflection of the fact that urban development itself has increased the vulnerability of the community to ground movement damage by concentrating people, resources, assets and services in the limited area

(Rendel Geotechnics 1995). Considering both the historical record and the patterns of property damage the ground movement problems within Ventnor can be divided into three broad groups:

1. Areas of very slow, intermittent ground movement where property, services and structures have remained largely unaffected by instability problems.
2. Areas of slow but significant ground movement which have caused moderate and occasionally serious damage to property, services and structures.
3. Areas of recurrent, more severe and often dramatic ground movement which can lead to problems for property, services and structures.

### **3. ROLE OF KEY AGENCIES**

Key agencies involved with ground stability in Ventnor are the Isle of Wight Council as Planning, Highway and Coast Protection Authority, and Southern Water Services, which has responsibility for sewerage and water supply works. Other service providers, including the gas, telephone and electricity industries and architects, builders, estate agents, insurers and others all have a role to play in terms of management of the Undercliff (see below).

### **4. THE STUDY AREA**

The topography and general site description of the Undercliff has already been outlined above. The town of Ventnor itself was developed in the early 1800s on an ancient landslide system known as the Undercliff. Ground movement problems are related to a number of factors such as slope instability, subsidence, heave or ground compression. Scientific studies suggest that the Undercliff was formed as a result of two phases of landsliding which took place after the last ice age around 8,000 to 4,500 years ago and 2,500 to 1,800 years ago, following major changes in climate and sea-level and consequent effects on marine erosion along the Island's southern coast.

The landslides within Ventnor are developed in Lower and Upper Cretaceous rocks. These consist of over 40m of Gault Clay (known locally as 'Blue Slipper'), underlain by sandstones (Lower Greensand) and overlain by massive Cherty sandstones (Upper Greensand) and Chalk. Of particular importance is the presence of thin clay layers within the Sandrock (Lower Greensand) which together with the Gault Clay have a very important influence on the stability of the area (Figure G4.1).

Interpretation of observations of past movements and structural damage made in the Undercliff rests on developing a consistent explanation, which accounts for all of the features (geological, geomorphological and ground movement) in a logical and scientific way. Models of landslide form have been developed based on the geomorphological within the Undercliff and these have been subsequently confirmed by borehole investigations at a wide range of sites within the town. These models allow theories of ground behaviour to be developed. Throughout the Undercliff, and indeed in Ventnor, the style of landsliding suggests a two tier system, usually involving a combination of two different mechanisms of failure at different elevations separated by the Gault Clay scarp:

Zone 1 : compound failures on the lower Undercliff slopes upon clay layers within the Sandrock.

Zone 2 : multi-rotational failures on the upper Undercliff slopes upon slip surfaces within the Gault Clay.

The evolution of the landslide models is believed to be related to the interplay of climatic changes and sea-level rise over the last 10,000 years or so. During periods of low sea-level during the last ice age the coastal slopes became fronted by large aprons of debris which would have acted as natural protection for the slopes. However the rise in sea-level after the ice melted caused parts of the apron and even the coastal slopes to be eroded away. As a result of this erosion, the slopes probably became partially destabilised and major deep-seated landslides developed on the lower section. The curved backscars of these lower landslide systems appear to have isolated a series of broad, triangular spurs. These landslides have

subsequently failed as a result of the unloading on either side caused by the movement of the earlier slides. In this way a pattern of closely-related landslide systems has developed in response to the gradual unloading of the lower parts of the landslide complex.

#### **4.1 Ground Behaviour**

The nature of the landslide hazard faced by the Ventnor community has been defined by producing maps of contemporary ground behaviour. These maps are based on a thorough review of available records, documents and reports, followed by a programme of detailed field investigation comprising geomorphological and geological mapping, a survey of damage caused by ground movement, photogrammetric analysis within the town of Ventnor and a review of local building practice. Through these methods an understanding of the following components of landslide hazard and risk has been achieved:

1. The extent of the landslide complex, systems and processes involved in its evolution.
2. The types of contemporary ground movement.
3. The magnitude of contemporary ground movement.
4. The frequency of landslide events.
5. The causes of landslide events and their temporal variation.
6. The impact of ground movement in the built-up area.
7. The nature and extent of property at risk.
8. The vulnerability of the different styles of construction to ground movement.

Provided with this information, the Local Authority has been able to develop a series of tools to assist the planning process including in particular a range of maps for geomorphology, ground behaviour and planning guidance. These maps form the basis for the development of a Landslide Management Strategy (see below).

#### **5. MONITORING**

Although the maps of ground behaviour developed for Ventnor were based on the most complete picture of the nature and extent of ground movement problems at that time, it was recognised that there was less reliable information about the precise rates of movement and the effects of specific rainfall events. As a result, an automatic surface monitoring system was installed by the Council in 1993 comprising an automatic weather station in Ventnor Park and surface movement recording stations at key points within the town.

The objectives of the monitoring are to:

1. Provide early warning in areas where ground movement could lead to the disruption of services and infrastructure.
2. Determine the rate and scale of ground movements in vulnerable locations.
3. Identify links between ground movement, rainfall and groundwater levels that can be used to develop a method of landslide forecasting.
4. Provide the necessary information to update the ground behaviour and planning guidance maps.
5. Monitor the effectiveness of landslide management strategies.

In addition to the automatic systems the Council has initiated a policy of periodic surveys of vulnerable sites and resurvey of Ordnance Survey benchmarks to monitor any changes in ground elevation throughout the Undercliff.

## 6. CURRENT STATUS AND APPROACH

1991 saw a major change in the way ground movement problems were managed within Ventnor. Prior to that date individual problems were viewed as “acts of God”: unpredictable, entirely natural events; and were addressed on a “one-off” basis. Since the publication of the results of the Department of the Environment pilot study, a range of landslide management techniques have been promoted by the Council as part of the co-ordinated Landslide Management Strategy.

The Landslide Management Strategy aims to:

1. Reduce the likelihood of future movement by controlling the factors that cause ground movement.
2. Limit the impact of future movement through the adoption of appropriate planning and building controls.

The implementation of the Strategy has required careful co-ordination, bearing in mind it involves influencing the attitudes and behaviour of the whole community; the Planning Authority, developers, insurers, lenders, property agents, builders, the statutory undertakers and not least the general public. A Landslip Management Committee meets twice a year to enhance professional and public awareness on how the Strategy is being implemented and how to monitor its effectiveness. This Committee comprises representatives from the Isle of Wight Council (Chairman) - including planning officers, Centre for the Coastal Environment and Highways - Southern Water Services Ltd, British Gas, British Telecom, Southern Electric, the Association of British Insurers, Building Employers Confederation and Highpoint Rendel the Council’s consultants (observers).

The Strategy involves a variety of approaches to address the ground movement problems by:

1. Improving ground conditions through the control of water in the ground and by coast protection measures.
2. Preventing unsuitable development through planning and building control.
3. Monitoring ground movements and weather conditions at automatic and manual recording stations.
4. Raising professional and public awareness through displays and meetings.

### 6.1 Coastal Defence

Coastal erosion has been long been appreciated to be a major factor in the long-term instability of the Undercliff. The whole of the urban frontage of Ventnor has been protected by coastal defences and it is unlikely, therefore, that marine erosion remains a significant cause of slope instability in the town provided that the defences are adequately maintained in the future. These defences provide important toe protection, supporting the landslide benches rising from the coast on which the town developed (Plate G4a).

Coastal erosion has progressively reduced the overall stability of the slopes in the past and together with other factors such as periods of heavy rainfall has promoted landslide activity.

For this reason, coast protection has been undertaken through a co-ordinated strategy developed by the Council over the last ten years with financial assistance from the Ministry of Agriculture, Fisheries and Food. In particular, defences for the town have comprised the upgrading of the Western Cliffs frontage, a 1.1km Chalk and Greensand debris cliffline, which

is protected by 30,000 tonnes of rock armourstone. The stone-faced Victorian seawalls along Ventnor seafront have also been upgraded, as has the Bonchurch frontage at Monks Bay. Further improvements have been completed at Wheelers Bay to the east of Ventnor (see Study Area of Wheeler's Bay below), as well as a major project completed between 1987 and 1988 providing upgraded coastal defences for the Eastern Cliffs between Wheeler's Bay and Bonchurch.

It is estimated that approximately £12m has been spent on improving coastal defences along the Undercliff within the last ten years. In 1996 the Isle of Wight Council developed a Shoreline Management Plan for the whole of the Isle of Wight's coastline and considered coastal defence policy options for each sub-section of the Isle of Wight's coastline. For the developed parts of the Isle of Wight Undercliff the policy is to "hold the line". This will involve a commitment to maintain or upgrade coastal defences to protect the town of Ventnor on a long-term basis (at least for the next 70 years).

## **7. EXPERIENCE, SUCCESSES AND PROBLEMS WITH CURRENT APPROACH**

Recognising that the town of Ventnor is built on a large landslide complex and that fortunately the geological setting and the style of landsliding is such that movement are often concentrated in a few locations, the Council, in partnership with a range of other interested organisations, including local residents, has adopted a Landslide Management Strategy to address the problems. The development and implementation of the Strategy involves education, physical works (eg coast protection and drainage) and monitoring, together with improved planning and building procedures which will assist in raising confidence in Ventnor from an insurance and financial development point of view. The use of sophisticated monitoring equipment for ground maintenance and rainfall will, in time, improve prediction of ground movement events and enable changes to be monitored.

A positive approach to co-ordinating the community's response to the landslide problems is regarded as essential. Indeed, to effectively reduce the impact of ground movement in the urban area, planners, developers, builders, service industries, estate agents, solicitors, insurers and property owners must liaise and recognise the needs for all parties to be involved.

The co-ordinated Landslide Management Strategies that have been developed and implemented by the Council for Ventnor are helping to minimise the risk to the community through:

1. Guiding development away from unsuitable locations.
2. Ensuring that existing and future development are not exposed to unacceptable risks.
3. Ensuring that public safety considerations are addressed in potentially vulnerable areas.
4. Ensuring that development does not increase the risk to the rest of the community.

The Council believes that it is important that the public and financial institutions are fully aware of the nature of ground conditions in Ventnor. Existing property in unstable areas will probably continue to experience damage due to ground movement; such areas should be avoided for a future development. More stable areas are likely to remain free from significant building damage and may be successfully developed, so long as necessary stabilization and monitoring measures are adopted and that developers are willing to accept, in some location, a higher level of risk than would be expected in other circumstances (Rendel Geotechnics 1995).

The work on this study of "Coastal Change, Climate and Instability" will assist in improving understanding of landslide management issues in locations such as Ventnor. As part of this project, a preferred approach to addressing instability issues is being formulated and alongside this a Best Practice Guide for a range of users is being prepared. A number of ideas developed and adopted within the Ventnor Undercliff and indeed at other key locations throughout the European Union will be included in the Best Practice Guide with the aim of improving confidence and understand in areas similarly affected by instability problems.

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**Plate G4a** *Ventnor town from the sea*



LANDSLIDE MODELS IN THE UNDERCLIFF : MODEL B

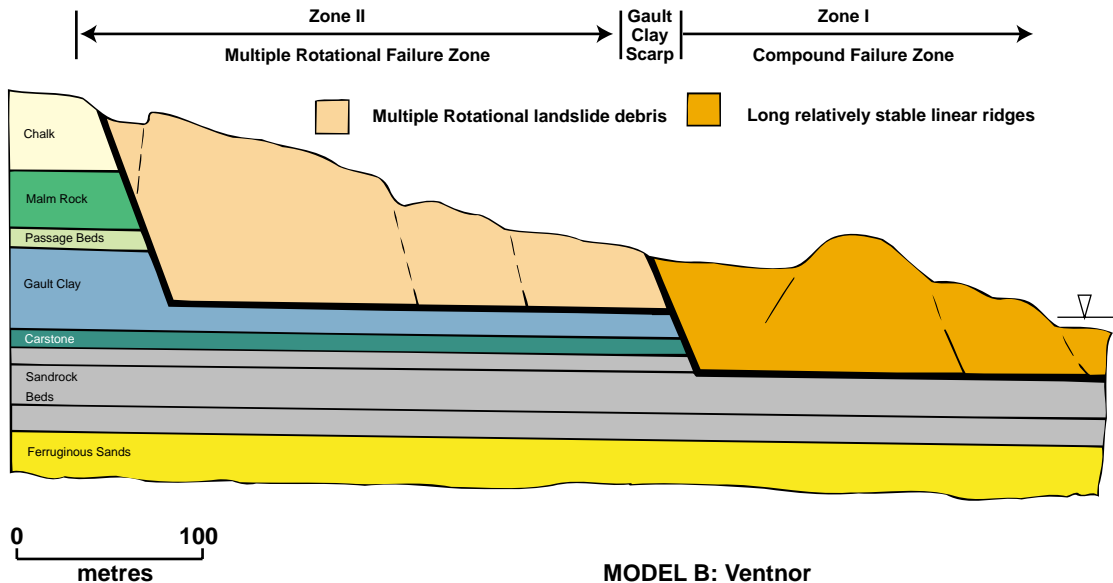


Figure G4.1 Ventnor town landslide model.