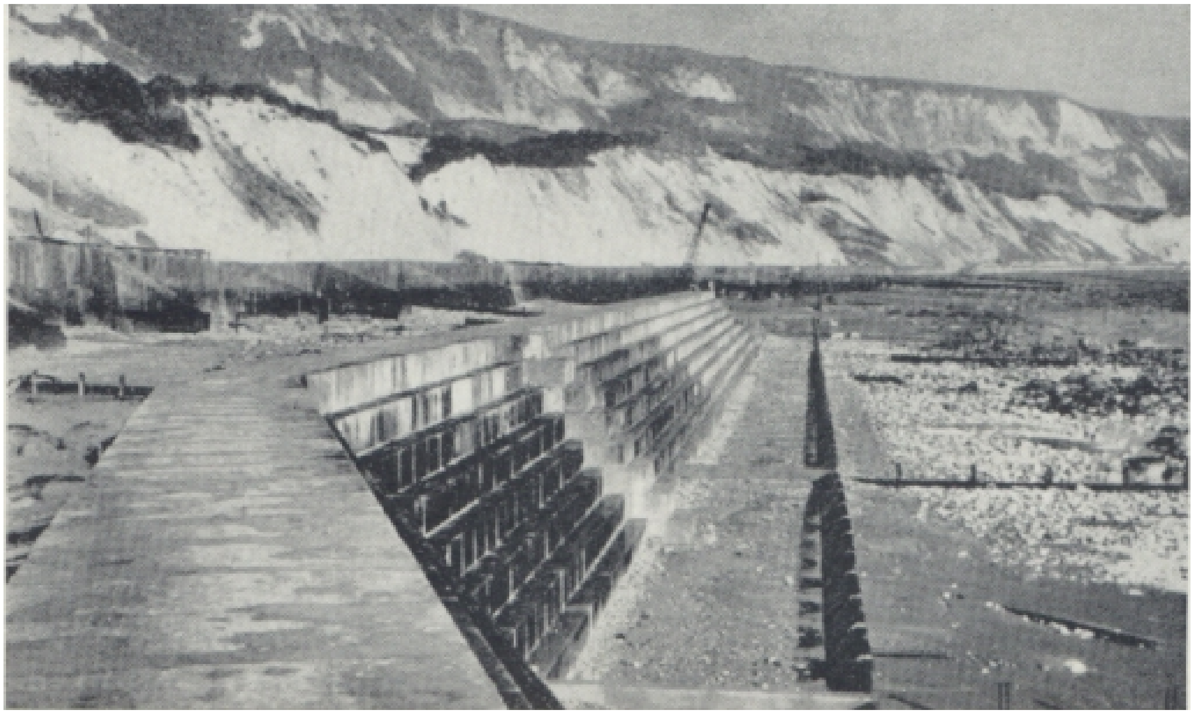
Coast Erosion Works in Folkestone Warren



Anti-erosion works on the foreshore at Folkestone Warren, looking towards Dover

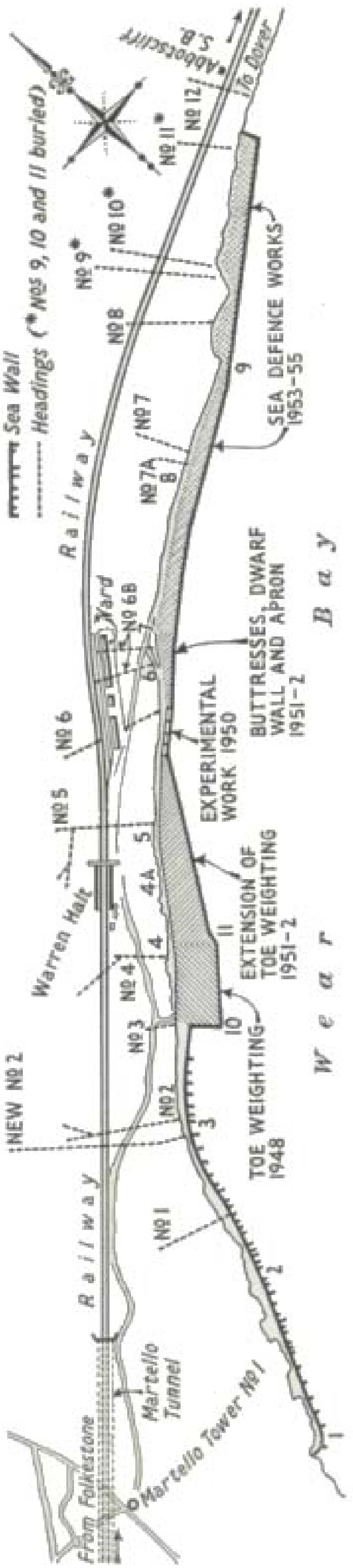
BETWEEN Folkestone and Dover, the main line of the Southern Region crosses a two-mile stretch of undercliff known as Folkestone Warren. The railway was opened in 1844, and enters and leaves the Warren by tunnels in the chalk. The area is known to have been liable to extensive landslips for at least two centuries, the first recorded slip having taken place in 1765. There were eight recorded slips in the nineteenth century, and that in 1877 interrupted railway communications for a considerable period. In the present century slips occurred in 1915 and 1936-37.

The slip which occurred on December 19, 1915, was on a large scale and involved the greater part of the Warren in a bodily movement towards the sea. The maximum displacement was about 165 ft. near the centre of the disturbance. The railway line was closed to traffic and not re-opened until August 11, 1919.

The causes of the landslips were not known until the Southern Railway sank deep test boreholes in the area in 1938 and began to apply soil mechanics tests. This work was undertaken after a slip in 1936-37 had moved the western third of the Warren lying between the railway and the sea a considerable distance forward, amounting to as much as 90 ft. at the western end. The work was continued in 1948-50 by the Southern Region, British Railways, and deeper boreholes were sunk between the railway and the cliffs.

The slips were found to arise from shear failure in the basement bed of the gault clay close to the top of the lower greensand. Rapid erosion must have taken place at the toe of the slips, before a sea wall was built along the foot of the shore line cliffs, and this removal of toe weight was a major cause of movement. An additional cause was the high level of the water table at the back of the Warren. This created pressure which helped in moving the land towards the sea.

Attempts to lower this high water table had been made previously, and a system of timbered drainage headings, running back from the top of the sea wall to varying distances into the slip, had existed for many years. None of these headings extended to the rear of the Warren, and thus they could



Plan showing the extent of the works carried out or in hand

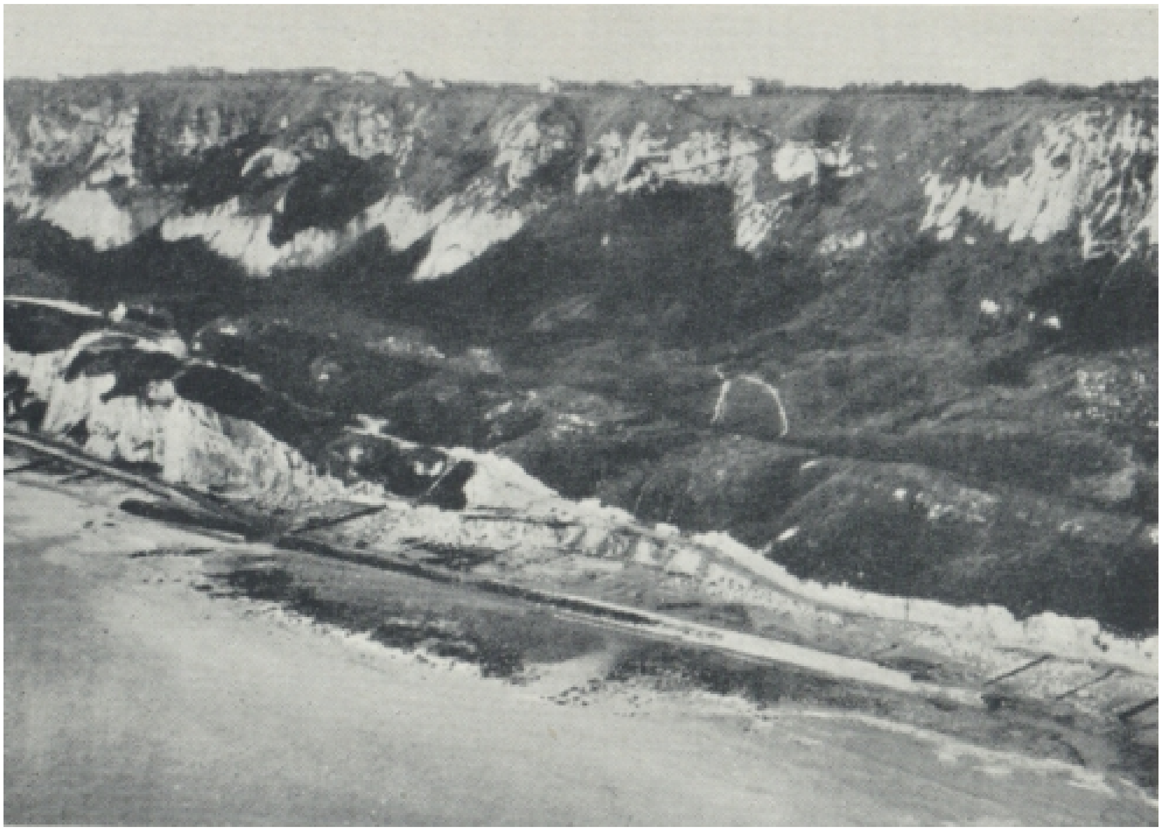
not intercept water from the high cliffs, which, with rain falling directly on to the landslip itself, forms the principal source of supply to the water table.

It was calculated that any appreciable reduction of the water head would bring about consequent relief from pressure which would in turn improve the stability of the area to a marked degree. With this in mind, a new 6 ft. 6 in. diameter drainage tunnel was driven in 1952. This tunnel is lined with reinforced concrete ring segments, and was driven by means of a shield. The geological structure encountered during the driving of this tunnel bore out the results of the previous tests, and the principal accumulation of water was found in the mixed chalk and loam which had fallen from the high cliffs. The effect of the tunnel has been to lower the water table by more than 20 ft. at the back of the Warren in that area.

To assist in replacing losses caused by erosion at the toe of the slip, and to re-establish some of the stabilising weight necessary, large masses of material have been spread on the foreshore. These are protected by a concrete wall, and the whole of the dumped material has been covered with concrete for further protection. Checks made from time to time show that this treatment has prevented further movement in that area, but a new scheme was evolved in 1950, after a slip had occurred to the east of the new works. Additional investigations into the most suitable combination of sea wall and apron for this site were made at Queen's University, Belfast, using models in a wave tank.

The works consist largely of the building of sea walls, which are, in some places, purely for protection against the action of the sea, but in others are designed to retain filling which will act as a stabilising toe weight. The walls for both purposes are of similar profile but the retaining walls are some 6 ft. higher than the others.

The most effective point at which weighting could be applied was selected as a result of the investigations which had been made, and in 1948 large-scale works were put in hand. The area chosen was some 400 ft. in width and 200 ft. in depth. As a first step two arms of precast blocks were built out from the



View of the eastern end of the defence works

The new 6 ft. 6 in. drainage tunnel driven into the cliff existing sea wall 400 ft. apart. These stood on an *in situ* concrete foundation. The blocks used were 6 ft. × 3 ft. × 2 ft. and weighed 2¼ tons each. This was the heaviest block which could be handled by the largest crane which could be brought to the site. The wall is some 14-16 ft. high and 12 ft. in depth. The crane was a tracked machine as there was at that time no road giving access to the Warren. The blocks were laid in bonded courses and were strengthened by vertical steel bars set in holes in the blocks coincident between adjacent courses. The whole was grouted with Portland cement. The wall adjoining the arms of the seaward end was provided with a stepped face towards the sea.

A filter bed of shingle to carry off surplus water was laid in the rectangle formed, and on this the main filling was tipped. The filling itself consisted of 43,000 cu. yd. of chalk which was excavated from an area near the main line. This was carried from the excavation site, some 100 ft. above sea level, by dumpers which tipped it into the enclosure. A protective covering of concrete was laid on the filling after consolidation, and consisted of slabs 24 ft. × 8 ft. with expansion joints.

To minimise the effects of scour, and as a result of the wave tank experiments, it was decided that an apron should be constructed at the toe of the sea wall. This apron is formed in reinforced concrete and is anchored, at the seaward end, to a line of steel piling. At the shore end it is bonded into the foundation of the sea wall. The piling was driven by two diesel pile hammers. These hammers are self-contained and on their own frames, and in addition are light in weight. Complete 8 ft. bays of reinforced concrete were cast at one operation in full profile, protection against the tide being provided by sheeting where neces sary.

Large scale operations were re-started in 1951, although a section of a new type of small wall had been built as an experiment in 1950 to protect the toe of the existing sea wall and had proved very successful, the design being adopted for use where protection against erosion only was required. All machinery and material for the new works was assembled on the foreshore, special ramps having been built to enable this to be done.

Bulldozer-drawn sleighs carry the pile-driving equipment and the driving of these piles is now the first operation to be undertaken, followed by the foundations of the block wall and then the wall itself. The type of filling, chalk on a shingle bed, is the same as that used for the 1948-50 works.

All concrete, both for block and other work, is being supplied from a central plant. Excavation is carried out by a mechanical excavator, assisted in clearing material away by a bulldozer. Blocks are laid by a crane-rigged crawler excavator. The conditions under which the machinery works on the foreshore necessitates heavy maintenance work, and a depot for this purpose has been established on the site. As the sea wall work is very little above low-water mark, there is constant tidal interruption and the working time in a tide is only about four hours.