CONCISE HISTORY OF
EARTH MOVEMENT
SANDGATE

In 1827 a landslip occurred in Sandgate extending from the Church at the foot of the Undercliff to the Eastern end of Encombe house. This area was later drained.

In 1893 another landslip occurred extending from the eastern end of the Coastguard Cottages to the Military Hospital behind Helena House. In this slip 68 houses were damaged, 24 beyond repair. The land dropped ten feet in places with chasms 3 to 6 feet wide. It occurred at low water of Spring tides after heavy rain. Photographs in Public Library.

The Local Authority, Sandgate Local Board of Health, on the advice of the Local Government Board in London, called in Baldwin Latham, engineer, of London. He advocated a deep drain along the lines of the main fault of the slip. Its purpose was to protect all the houses in the area. Sewer laying was suspended until the drain was complete.

The slip occurred on 4th March. On 24th March the Clerk to the Local Board wrote the Local Government Board mentioning an Act of Parliament as one means amongst several of paying for the drain. On 26th April the Local Board resolved to ask the Sandgate Landslip Relief Fund committee to contribute towards the cost of the drain, to "make Sandgate safe for the future". Latham's Report received on the same day.

Letters to a London newspaper announcing the opening of the appeal fund dated 6th and 9th March say it is for the relief of the distress of the inhabitants and make no mention of the drain. When Latham was engaged the Local Board had every intention of carrying out any remedial work he might advise as a normal public work to be paid for and maintained out of the rates.

The Relief Fund agreed to meet the whole cost of the drain, at a meeting on 19th May. On 24th May, the fund totalled £8400. The final total of the fund was £8741 and of this sum £5286 was paid out in "Grants to Sufferers". This does not include the sum contributed towards the drain, £2450.

Latham's Report is addressed to the Sandgate Local Board of Health. The Specification makes the contractor responsible only to them. The final accounts of the Relief Fund report the drain as satisfactory to them and to the engineer and make no mention of being satisfactory to the Relief Fund. There is no report of the Relief Fund Committee inspecting the drain. The Appeal Fund was NOT launched to raise funds to pay for the drain.

The Local Board failed to take powers to maintain the larger part of the drain which was laid across the lands of small private owners. That is, they gave it away. They had no power to do so. It has not been maintained.

Folkestone Corporation, who as successors to Sandgate Urban District Council hold both Local Board and U.D.C. Minutes, state that the two volumes covering the 1893/94 period are missing.

Substantial movement took place in and around Encombe House between 1951 and 1958 and was duly recorded in Halcrow's 1959 report. In 1960 and in 1962 outline planning permissions were granted in respect of the Encombe estate without stipulation of precautions against earth movement. Later in 1962 Soil Mechanics Specialists Reports were stipulated and permission was made conditional on

> "any recommendation of the specialists being undertaken as part of the approved scheme of development".

The report accepted by Folkestone Corporation in satisfaction of these stipulations was Halcrow's report of 26th April, 1960, two years before, and prepared neither for the developers nor for the Corporation but at Dr. Leader's request. This report made two recommendations:-

(1) that "...it would be unwise to build on or close to any of the lines of the 1893 landslip".

Halcrow's report of 1967 shows that the Corporation have allowed five houses to be built over such lines.

(2) "Should any increase in the rate of ground movements be noted...this office should be consulted".

When therefore after the movement of October, 1966 the Corporation became alarmed at the clear evidence of continuing increased ground movement they should have made the developers consult Halcrows at the developers' expense instead of calling them in themselves at the ratepayers' expense, as they did in July, 1967. Further, had the planning permission been properly worded, the developers would have had to pay for the three bore holes, the cost of which has been thrown by the Corporation on the ratepayers AND the £35,000 drain, some part of the cost of which the Corporation now seek to pass off onto householders.

The 1960 report amounted to only 2¾ pages but in that small compass contained eight references to the 1893 landslip or its effects and six references to Halcrow's report of 1959. It was clearly quite unsuitable as a basis for a £200,000 development in a dangerous area and the Corporation should have insisted on seeing the 1959 report or, more wisely, demanded an up to date report. The Borough Engineer stated in December, 1967 that he had not got a copy of the 1959 report and expressed interest when shown extracts from it. As stated above, it contained a list of incidents proving recent earth movement. It also stated that underground erosion was the main cause of recent disturbances. Folkestone Corporation allowed 8000 tons of earth to be dumped over the drain put in by the Local Autority in 1893 to stop just such erosion. Did Halcrow's authorise the use of the 1960 report and confirm that it was suitable for the purpose to which the Corporation put it? In February, 1969 the Corporation refused to supply a copy to a householder on Encombe whose house was cracking, moving and tilting on the grounds that it was "confidential".

Engineers all agree that in this type of unstable ground, common around the Kent coast, the aim should be to reduce weight at the back of the slip and increase the weight on the toe. At Encombe 8000 tons was taken off the sites above the Esplanade, near the toe, and dumped in the old Water Garden at the back of the slip over two branches of the Sandgate U.D.C. drain. The Sandgate Society's research has shown a clear link between low tides and landslips especially if the ground is very wet. On the first occasion on which abnormal rainfall coincided with very low tides, in late October, 1966, the present movement began.

In July, 1967 the Corporation asked Halcrows to report on ground movement in the Sandgate area. Halcrows issued a preliminary report on 9th October and in December the Corporation resolved that owners affected should be notified and the report made available to persons interested. Owners affected were NOT notified. Solicitors making searches for prospective buyers were invited to purchase the report. Loss of sales began. Halcrows' final report came out in January, 1969 advocating a drain costing up to £35,000. At a meeting between the Corporation and owners in that month Mr. Muir Wood, of Halcrows, agreed that the proposed "new" drain was no more than a relay of parts of the Sandgate U.D.C. drain of 1893 without change.

Folkestone Corporation with Ministry of Agriculture approval suggested a drainage scheme under the Land Drainage Act under which owners would pay. The Sandgate Society took Counsel's advice and suggested a scheme under a different section of the Act under which the Corporation would have powers to pay. At the Society's suggestion a meeting took place at the Ministry of Agriculture in London in July at which all parties were represented. The Ministry turned both schemes down. The Society then asked the Corporation to suggest to the Ministry of Housing that the work should be done under a Coast Protection scheme, adducing their evidence of a tidal link.

The Ministry have now approved this suggestion in principle but with a suggestion that householders deriving benefit should contribute.

Ministry of Housing and Local Government Circular No.41/62 of 20th August 1962

/states...

states at paragraph 2:-

"Coast Protection Authorities are therefore advised that from now on no more works schemes should be made for the purpose of recovering compulsory contributions from private interests".

and at paragraph 5:-

"...the Minister reminds coast protection authorities of the powers in the Act to obtain contributions by agreement. He considers that such contributions should be sought where appropriate, e.g. when works will protect substantial properties such as hotels, holiday camps, etc."

and at paragraph 6:-

"Indeed it may be that in some cases a private and commercial undertaking is the sole interest involved and in such cases local authorities will no doubt consider whether it would be more appropriate for them to.... make a contribution towards the cost of coast protection work carried out by other parties".

The Sandgate Society asserts that all the householders now asked to contribute are "private interests" as exempted by paragraph two and further that these householders are NOT either a hotel, holiday camp or a private and commercial undertaking involved as the sole interest.

Folkestone Corporation as successors to Sandgate U.D.C. must admit to full knowledge of the 1893 disaster and the official action taken to prevent a recurrence. Tipping of the 8000 tons of earth took place nearly a year before the first purchaser bought his plot on Encombe. There is therefore no excuse for the Corporation's failure to place an entry on the Register to the effect that relaying of the U.D.C. drain would be necessary and that they proposed to ask owners to contribute. No entry having been made, the remedy provided by the Act applies and the proposed charge is invalid.

Society research has revealed that movement is not confined to the "Green Belt" area covered by the Town Clerk's warning letter.

They have evidence of movement in the new Moore Barracks on the edge of the cliff top, which cost the taxpayer £1,500,000.

The Minutes relating to the proposed development at "Latchgate", Sunnyside Road contain the following:-

"...the Committee, having in mind the problems which had arisen at Encombe (a short distance to the east of "Latchgate") considered that a report should be made by Sir William Halcrow & Partners..."

(Note:- Actual distance 1550 feet, over a $\frac{1}{4}$ mile.
Sandgate Society)

and

"...the applicant be requested to obtain from Sir William Halcrow & Partners a report on the suitability of this site for the proposed development and any measures necessary to maintain the stability of the development and the adjoining land and property".

The Minutes relating to the proposed development in the Undercliff refer to

"...the works (if any) necessary for reinforcing the foundations of and strengthening the proposed buildings and such other works (including works of drainage) as may be necessary in relation to the site and the adjacent roads, lands, buildings including those in the Undercliff, the Crescent, Gough Road and Sandgate High Street, and the drains, sewers and other services in connection therewith...".

Clearly, the Corporation consider the whole area from the east end of the Undercliff to beyond Sunnyside to be dangerous. This area coincides roughtly with the combined area of the 1827 and 1893 landslips. The Society's map of Public Utility failures (of which there have been sixty since October, 1966) shows evidence of movement from one end to the other of this area.

/There...

There is no justification whatsoever for demanding contributions from owners as the present movement is due solely to inadequate sea-defences and the Local Authority's neglect of their own drain.

September, 1970.

Coastal Landslides of Kent EN 35/65

cliffs have an average inclination of about 37 to 38° and consist of the Folkestone Beds underlain by Sandgate Beds. They are now fronted by the broad terrace of beach material which has accumulated since the early 19th century behind the Folkestone Harbour works, and appear relatively stable.

Before the building of the harbour, these cliffs were under active marine attack and suffered frequent landslips. One took place a little west of Folkestone Parish Church on about 20th September 1785. This slip, which was perhaps in the region of 228357, was about 130 ft long and sank 40 ft over a period of several days, raising a reef in the sea at its foot (Lyon, 1786). It would thus appear to have involved base failure in the Sandgate Beds.

KD87. Folkestone, Leas and Radnor Cliffs (226356 to 206352)*
TR 23 - Fig. 17.

Throughout this 1¼ mile length of coast, there is a general increase of cliff height towards the west to a maximum of about 180 ft at Radnor Cliff (c. 212353). West of there, the slopes fall to the Enbrook valley. The cliff is formed chiefly of the Folkestone Beds overlying the Sandgate Beds, both having a gentle easterly dip of a degree or two. The upper cliff slopes are scarred by a succession of vegetated old slip corries, commonly about 100 yards across, and vary in average inclination between about 37 and 45°. West of about 212352, the Hythe Beds rise into the cliff foot.

This length of coast is fronted throughout by an undercliff which increases slightly in width towards the W., to a maximum of roughly 100 yards. It has been produced by ancient landslipping as was recognised, for example, by Ireland (1828-30, vol. 2, p. 169). That this involved deep-seated rotational failures of the Sandgate Beds and the underlying Hythe Beds may be inferred from the attitude of the reefs of ragstone in the foreshore. These probably consist of Hythe Beds and are all somewhat disturbed, with landward dips in excess of 30° being reported in the reefs to the W. of Mill Point (221351) (Smart, Bisson and Worssam). The Reverend John Sackette (1716), incumbent of Folkestone Parish Church, reports a gradual diminution in width of the undercliff at a point between Folkestone and Sandgate, which he makes clear was not due to direct marine erosion. It is possible that this phenomenon was the result of slow slip movements affecting the cliff above the undercliff, probably in the region of 221354.

On Sunday, 8th March 1801, just after 10 a.m., a considerable landslip took place in the cliffs about ¼ mile W. of Folkestone, carrying away the cliff-top footpath to Sandgate, but causing no damage to persons or buildings (Anon, 1801). Topley (1875, p. 316) considered that landslipping on this length of coast was encouraged by the removal of stone from the offshore reefs for harbour construction. This practice has now long ceased and the seaward face of the undercliff is protected throughout by a sea wall and groynes. In the January or February of 1897, considerable falls were reported from 'the face of the cliffs at Folkestone' (Anon, 1897). This probably refers to Leas Cliff.

The only movements to be reported from this length of cliff during the present century have taken place in the vicinity of Leas

Cliff Hall (224355). This structure is founded on mass concrete footings in the in situ Folkestone and Sandgate Beds forming the steep, upper cliff. It is not responsible for the movements of the adjoining ground and has not been damaged by them. Since the completion of the Hall in 1928, a slow downslope movement of the talus sloping down from the seaward face of the building has taken place. By 1954 the talus below and to each side of the Hall had moved downwards about 2 feet, exposing the top of the seaward row of footings. In 1941, associated movements in the foot of this cliff damaged the sea wall between groynes Nos. 3 and 7 (respectively 420 feet E. and 240 feet W. of the centreline of Leas Cliff Hall), with maximum movement occurring between groynes Nos. 3 and 4 (respectively 420 feet and 230 feet E. of the centre of the Hall) (Soil Mechanics Ltd., 1955).

In January 1955 there was a more sudden, downward movement of 2 to 3 feet in the talus seaward of the Hall, accompanied by heaving and cracking of the undercliff (occupied by the Lower Sandgate Road) and damage to the sea wall and groynes. Subsequent examination showed that the movements in the talus extended from about 580 feet E. to 180 feet W. of the Hall centreline. The movements affecting the undercliff and the sea defences were of closely comparable extent (Soil Mechanics Ltd., 1955). The upper cliff of Folkestone Beds has been unaffected by these movements.

Comprehensive investigations of these movements have shown them to derive from a renewal of movement in an old multiple (double) rotational slip which originated chiefly through the incompetence of the Sandgate Beds. This slip is probably typical of those by which this length of Undercliff was formed (Soil Mechanics Ltd, 1955; 1956; and 1957). Further movements in this vicinity took place in 1957-58 (Smart, Bisson and Worssam).

The extreme W. end of this length of coast, where the ground falls to Enbrook (209353 to 206352), consists chiefly of Sandgate Beds with the Hythe Beds at their foot. This area is reported to be free from landslips (Smart, Bisson and Worssam).

KD88. Sandgate (206352 to 190349)* TR 23 and 13 - Figs. 17 and 18.

This mile-long length of coastal slopes rises generally to heights of between 200 and 250 feet and has an average inclination varying between about 12 and 20°. The slopes are capped by the Folkestone Beds, which form a fairly steep scarp. The irregular slopes beneath this consist of the Sandgate and Hythe Beds, with the Atherfield Clay at their foot. They are occupied by a complex of old and recent landslips, upon which the town of Sandgate is largely built.

Offshore reefs of ragstone between about 194349 and 200350 dip landwards at angles of between 16 and 53°. They consist probably of Hythe Beds and betoken earlier deep-seated rotational slips involving this bed and probably also the underlying Atherfield Clay (Smart, Bisson and Worssam).

In the 19th century two large landslides took place at Sandgate, which together affected practically the whole area of the town. The first, in 1827, involved a 500 yard length of the E. part of the area, extending from the church at 20433524 westwards to Encombe House

MINS-129/1

LATCHGATE, SUNNYSIDE ROAD, SANDGATE PLANNING APPLICATIONS

(From Folkestone Borough Council Minutes)

4.9.68 T.P.App.13. 1. Town Planning-21.8.68-outline application deferred.

"...and the applicants be informed that the application will be favourably considered (i) upon production of a report by soil mechanics' consultants upon the stability of the site satisfactory to the Council, (ii) details of the foundations for the buildings as shown by such report to be required to ensure stability of and prevent possible damage to any buildings to be erected on the land through ground movement and..."

68/133a erection of 28 2-bedroom self contained flats in 2 blocks each 4 storeys in height....

4.12.68 F.76.164 2. Town Planning-20.11.68-letter from applicant received.

"The Borough Engineer submitted letter from Mr.J.Coley requesting that his amended application for the erection of 28 flats on the above site should be considered. He suggested that the Committee should impose appropriate conditions on the grant of permission, requiring a satisfactory report on soil investigations and any necessary precautions to be taken to strengthen the foundations and structure of these proposed buildings.

The Borough Engineer stated that Mr.Coley had already instructed a soil mechanics' firm to investigate soil conditions on the site and they had submitted an interim report, a copy of which had been supplied to him.

After hearing the advice of the Town Clerk and the Borough Engineer, the Committe, having in mind the problems which had arisen at Encombe (a short distance to the east of Latchgate), considered that a report should be made by Sir William Halcrow & Partners, consulting engineers, who had lengthy experience of soil conditions in this area, on the soil conditions before they considered Mr.Coley's application for development of this site."

RESOLVED-That Mr.Coley be informed of the Committee's views in the matter and that he be requested to obtain from Sir William Halcrow and Partners a report on the soil conditions of the above site, its suitability for the proposed development, and on any works which should be undertaken to strengthen the foundations and structure of the proposed buildings and services and otherwise."

5.2.69. T.P.App.4 3. Town Planning-15th January, 1969. Outline application deferred)

68/133b-"Latchgate", Sunnyside Road-Erection of 28 two-bedroom flats in 2 blocks each of 4 storeys and 35 car parking spaces.. ....in order that the following information may be provided by the developer:-

(a) To what extent the development is likely to affect the overall stability of the slipped ground in the vicinity and

(b) Whether the existing drainage system may be relied upon to function for the life of the proposed development or whether it will require maintenance or modification.

5.3.69. F.92.204c 4. Town Planning-19th February, 1969.

The Town Clerk reported that a number of objections to the development of this site had been received.

RESOLVED-That consideration of the undermentioned application be deferred and the applicant be requested to obtain from Sir William Halcrow & Partners a report on the suitability of this site for the proposed development and any measures necessary to maintain the stability of the development and the adjoining land and property.

68/133b Outline-Erection of 28 flats with 35 car parking spaces.....

MINS. 129/2 &3

LATCHGATE, SUNNYSIDE ROAD, SANDGATE PLANNING APPLICATIONS (From Folkestone Borough Council Minutes)

5. Town Planning-19th March, 1969.

2.4.69. F.99

Further to minute 204(c) of the proceedings of this committee of 19th February last, the Town Clerk informed the Committee that the applicants for development of the above site had requested the opportunity of making representations in support of their application for outline planning permission for development of the site by the erection of 28 flats. The Chairman had agreed to the request and the developers were in attendance.

The Town Clerk outlined the history of the application for outline planning permission and reminded the Committee of their concern that any development on the site should not be adversely affected by the soil conditionsx which were known to exist in that area.

The applicants were then invited to the meeting and addressed the members at length. The following points were made by the applicants:-

(a) The concern of the Committee was very much appreciated and the applicants were just as anxious as the Committe were that the proposed development should not be adversely affected by the soil conditions resulting from the landslip at Sandgate in 1893.

(b) The applicants had, at the request of the committee sought the advice of soil consultants who had advised that development on the scale proposed was feasible. The Committee had, however, requested that Sir William Halcrow & Partners should advise and they (Halcrows) had suggested further soil investigations.

(c) The applicants were anxious to comply with the reasonable requirements of the Committee but considered it only reasonable that they should have an assurance that the Committee would grant outline planning permission, if the advice of the soil consultants proved favourable. The applicants had already been put to considerable expense, which was likely to increase and in these circumstances they suggested that the committee could safeguard their position by imposing appropriate conditions on the grant of outline planning permission.

The Committee then discussed the matter generally with the applicants who subsequently withdrew from the meeting.

RESOLVED-That in pursuance of the Town & Conuntry Planning Acts 1962 to 1968, ...the application.specified hereunder be granted....

68/133b The erection of 28 flats with 35 car parking spaces...

(1) The plan attached ...
(2) The siting...
(3) The applicants shall obtain a written report from such specialist soil consultants as may be agreed with the Council, or, in default of agreement, as may be determined by the Minister of Housing & Local Government, advising on the suitability or otherwise of the site for the proposed development, and if such consultants consider the site suitable therefore, on the works (if any) necessary for reinforcing the foundations of and strengthening the proposed buildings and such other works (including works of drainage) as may be necessary in relation to the site as may be essential to ensure (so far as practicable) the stability of the buildings, roads and services proposed to be erected, constructed and laid on the site and shall on receipt of such report submit the same to the Council for their consideration.

Reasons:-

(iii) To ensure that the best specialists advice is secured on the soil conditions exisiting on the site, the possibility of soil movement, the suitability of the site for the development proposed and the precautions necessary to ensure the stability.....

(4) The applicants shall carry out such works for reinforcing the foundations of & strengthening the proposed buildings & such other works in relation to the site as may be agreed with the Council, following consideration of the consultants report, or, in default of agreement, as shall be determined by the minister

P.T.O. FOR 129/3

Mins. 129/3

(iv) To ensure, as far as practicable, the permanent stability of the proposed buildings, roads and services on the site, and that no damage thereto or to any adjacent property shall occur in case of subsidence or land movement on the site.

FEB/69 A. Todd. see last page

Ex 88

From Mrs.L.Rene-Martin to the Sandgate Society Committee.

I am very grateful that you hav asked me to be present at your meeting 7.2.69 and I deeply regret that through unavoidable circumstances I am unableto attend. I append:

GENERAL OBSERVATIONS AND SOME VERY PERSONAL REACTIONS

To the Council's attitude to the residents in the affected area of 'Pay or be damned i.e. accept the consequences' I would like to point out that some unfortunate householders are already damned, others in lesser degree. Mr.Muirwood' comment on the Mayor's performance was BELLIGERENT.

We ask ourselves why we, the residents old and new, should compensate:

1. The Council and its servants for neglect of a perfectly good land drainage scheme. At the Civic Centre Meeting 8 July 1968 the Council said they had 'no powers of inspection' WHY?

2. The Planning Authoirities for failing to stipulate elementary precautions and the maintenance of ths vital drainage complex on what is well-known to be a treacherous and water-logged terrain; and for 'errors of judgement'.
At the July Meeting, the Council said that there had been 'no justification for refusing palnning permission' WHY?

3 The develloppers for blatant indifference to the hazards of the terrain, and who bulldozed on, while the Council turned a blind eye to their disregard of some of the planning stipulations.

Surely we, the innocent residents (particularly those at the bottom of the hill who are feeling the main brunt) are the ones who are morally entitled to 'compensation' or at the very least A MORE SECURE FUTURE.

It is up to our legal advisor(s) to say whether there is any legal redress, or legal means of forcing the issue to make the Council responsible.

The Council have all along tried to localise the matter and keep it to the realms of private property.

Since December 1966, my efforts have been directed to brining the matter into the area of public property where the Council cannot escape responsibility. This is instanced in my letter of 30 December 1966 to the Ministry of Transport, inmy letter of 3.8.68 to the Folkestone Herald, and my telegram of 28 August 1968 to the Mayor, urgently begging a 3rd test boring on Esplanade which had not originally been contemplated.

1967 Halcrow Report
We may also well ask why Halcrows were asked to confine their report to a limited sector of private property, an area which excludes the public sector, the main trunk road, the promenade and sea defences, and the former land drainage system at Encombe and beyond, besides a large area of Sandgate which also bore the brunt of the 1893 landslip and, in the event, could be affected again.

The Mayor has said that the past is now history and what we have to think about is the present. It is obvious however, that the present is being looked upon, on a piecemeal basis, and that Halcrows might well have further views outside the terms of their narrow brief.

88/2

1 I would further like to report to the Committee, that Mr.Muirwood (Halcrows) recognised me on the station platform afer last Thursday's meeting, and quite voluntarily forwent hsi first-class compartment to travel second-class with me.

2 During the journey, I could not of course put any direct questions to him. I could however throw out a few general comments, and pick up any hints he dropped in his replies.

3 Entirely of his own accord, he raised the matter of the Wilberforce garages, and asked what was beingdone about the water flowing into and out of the garages. The Council had not approached him about this, nor asked him to suggest ways of bringing it within his scheme. It did not come within his scheme and he seemed to think the matter merited serious attention. Halcrows had a limited brief

4 When I expressed my utter astonishment that Planning Consent should ever have been given on the terrain, he said there was very little one could do once the area had been designated a 'Development area'.

5 Mr.Muirwood had personally seen the Chairman of the Abbey National in 1958, to whom he expressed surprise that the chair man of a building society should buy a property without a survey first. 'If you had asked my opinion' quoted Mr.Muirwood ' I'd have told you that you would need not only an umbrella but galoshes as well.'

6 Mr.Muirwood also did a report for Dr.Leader who had ideas of building a hotel on the site. SEE 97/12/3, 586.

In 1958, Mr.Alman Borough Engineer, passed the article (by Bledine) from Nature on the 1893 landslip to Mr.Muirwood, in connection with the report he was making for the Abbey National.

Ex52 (In "1893") Mentioned in H59 (to Abbey Natl B/S) on p1 (para 8)

R-M in phone call of 31/1/69 said M Wood said:- Errors of Judgement in past. C'cil facing up to situation. C'cil had been feeble!

Buchanan Report showed as "Landslip Area".

If want further reports from us, cheap way to get them is to ask the C'cil to get them & let someone put up the cash for the drain & let work go ahead. To admire field. Has there been any difficulty in selling houses?

R.M — "yes - up to 6 sales lost".

1.2.69 CONFIDENTIAL

3

88/3

FOR THE COMMITTEE'S CONSIDERATION

Move 1
Put it to the Council to obtain a loan (interest-free if possible from Min. of Housing, Public Works Loan Commissioners, Emergency Fund or other source -- so that Halcrow £ 35,000 scheme be put int effect with least possible delay while discussions on who shall pay and how much, are going on.

Move 2

Insist on immediate action to stop the water behind and within Wilberforce garages from flowing into ground and causing further water-logging of subsoil. This is a continuing menace to Wilberforce Road, the main trunk road, public services, and the residential area. Most of the water is coming out of ground at bottom of tip. See 36 (1) Town and Country Planning Act 1962.

Move 3
Ask Council to prepare an estimate of maximum contributions that could be expected from Transport Authorities, Coast Protection (Kent County Council and rates); Kent River Board and Local Council's special contingencies.

Move 5
If private contributions were expected to exceed a sum of xx pound (total contribution for the affected area) indicate to Council that we would have no alternative but to press for a Public (or Ministerial) Enquiry into the whole affair. This would also involve the residents in large fees for Counsel. But Folkestone Council might not welcome the spotlight of publicity either.

Move 4
The matter of individual contributions could only be considered after Sandgate Society have received these estimates.

Move 6
Should the Council refuse to act on Move 1 or 3, without some prior undertaking on the part of residents to contribute a share, then Council together with Sandgate Society should draw up a suitable formula for everyone to sign without prejudice. The formula might stipulate that any levy on residents would not absolve the Council from past neglect or future maintenance of any works carried out. All works to be vested in the Council.

Move 7
If any special parliamentary questions, or powers are needed, keep Costain* in picture so that he can give us advice, and contact appropriate Minister, as necessary. For instance, necessary powers of inspection for Council.

Move 8
In view of the increasing work that is falling to the Honorary Solicitor, a small fighting fund should be set up out of which to defray expenses, and the increased burden.

* Note : I have been in contact with Costain on landslip matters since 10 April 1967 and would continue ti keep contact with him should the Committee so wish.

88/4

EXCERPTS FROM TOWN AND COUNTRY PLANNING ACT 1962 (.19?/62)

17 (1) Local Planning Authority ....

a) may grant planning permission either unconditionally or subject to such conditions as they think fit, or
b) may refuse planning permission

... that authority in dealing with the application shall have regard to the provision of the development plan, so far as material to the application, and to any other material considerations

18 (1) Conditional grant of planning permission

... or requiring the carrying out of works on any such land, so far as appears to the local planning authority to be expedient for the purposes of or in connection with the development authorised by the permission;

19 (IV) Regr - open to Public
28 Powers of Control

36 (1) Proper Maintenance of waste-land etc:

If it appears to a local planning authority that the amenity of any part of their area, or of any adjoining area, is seriously injured by the condition of any garden, vacant site or other open land in their area, then, subject to any directions given by the Minister, the authority may serve on the owner and occupier of the land a notice requiring such steps for abating the injury as may be specified in the notice to be taken within such period as may be so specified.

CARE

101 (4) Right to Compensation (when planning permission is revoked)

Compensation under this Part of the Act shall not be payable in respect of the refusal of permission to develop land, if the reason or one of the reasons stated for the refusal is that the land is unsuitable for the proposed development on account of its liability to flooding or to subsidence

See 88/6

As far back as December 1966, the Council could have stopped development on the Encombe Estate, under this clause, without having to indemnify the developpers. Why did they not do so?

~~The~~ The County Council Development Plan approved 1958 shows the area between Seafront and Camp as a development area. It does not contain any 'hatching' to show that the area is scheduled for development within 5-20 years. I cannot find any later map, but you could easily see it at Local Planning Office —

PTO

If you don't want to go — ask
someone like Leslie Bennett to drop in
and see maps of development areas,
and amendments to 1958 plan.

[illegible]. 4.2.69

7421 Engineering aspects of coastal landslides

A. M. MUIR WOOD, MA, FICE, FGS*

Much has been written about the investigations and analyses of particular coastal landslides, usually in the form of a reconstruction of events leading to a failure which has already occurred. This account attempts, however, to relate the engineering solutions to the typical problems presented by incipient landslides. Investigation and analysis appropriate to undertaking economic remedial works are discussed and the importance is emphasized of considering the geotechnical and the coastal erosion aspects in association. Certain coastal forms lend themselves towards providing solutions based predominantly on control of littoral drift or on other means of diverting the destructive forces of the sea. Examples are given of such instances. Investigations should be preceded by critical observation and should be designed not only to test hypotheses relating to the nature of the instability but also to permit evaluation of the benefit to be expected from alternative possible forms of remedial works. The basic nature of the remedial works is usually simple but considerable subtlety arises in applying an economic scheme appropriate to specific local conditions, to suit geology, geohydrology and their variations.

Introduction

This Paper is an attempt to describe the most significant engineering problems, and their appropriate solutions, relating to coastal landslips. The sea is the principal cause of instability and to prescribe the appropriate cure it is necessary to understand not only the mechanics of the landslip but also the mechanics of the sea.

2. It is a truism to state that no two coastal landslips are the same; it is nearly true to say that no two coastal landslips are even similar. The principal factors which determine the nature and extent of each coastal problem are set out in Table 1. Of these factors, probably the historical one alone needs further immediate explanation. As will be described subsequently, the history of previous instability and the past rates of erosion by the sea will largely determine the present condition of the coast; in consequence, topography and the historical sequence of events have to be reviewed together.

3. Presented with a situation of coastal landslips that require to be stabilized, the technical objective, with a responsive eye to amenity, must be to obtain the greatest benefit for the minimum cost. To do so, it is necessary to identify and understand the several factors and, most important, to understand how they operate in association. Only then is it possible to explore and develop the most efficient remedial measures. A solution which treats the problem as a whole or in a composite manner may be more efficient and permanent than one which provides a series of separate countermeasures to each individual factor.

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Table 1. Principal factors affecting coastal stability

Topography	Geology and hydrology	Historical factors	Marine factors
Height of cliff Profile of undercliff Profile of foreshore Profile of inshore area Vegetation on undercliff Coastal features	Geological structure (dip, strike, faulting, folding) Stratigraphy including consistency of deposits Presence of intrusions Fissuring patterns (of competent strata) Geotechnical properties of ground, their dependence on time and other factors Rainfall, percolation and run-off (seasonal variations) Permeability of ground Ground water flow Chemical and physical properties of ground water	Rates of recession Isostasy (normally only of importance for long term processes) Factors affecting rates of recession Previous remedial works	Tidal range and currents Wind and wave climate, including effects of reflexion, refraction and diffraction Littoral drift Sediment transport

4. As a coast recedes, a process of constant rejuvenation of the coastal features occurs. As a consequence, the coast provides the scene for all types of landslip which are seen elsewhere generally in isolation or as relicts of geological history. The rate of recession itself may be an important factor in determining the type of landslip that develops in a certain type of ground forming the coastline.

5. Before considering typical problems and the appropriate remedies, we should start by defining the zones of an unstable coast. Proceeding from the land towards the sea, we may identify these zones:

(*a*) *The high cliff.* The zone unaffected by coastal slips, apart perhaps from slight structural strains resulting from release of loading against the face of the cliff or from shear forces set up by the motion of slipping.

(*b*) *The undercliff.* The exposed area affected by slipping which is situated above the area subject to sea action.

(*c*) *The foreshore.* Here defined as the area above low water washed by the sea, in the present context extended to the upper limit of breaking storm waves.

(*d*) *The inshore area.* The zone of breaking waves immediately seaward of the foreshore, where waves provide the greatest source of energy affecting erosion and sediment transport.

(*e*) *The offshore area.* The zone seaward of the inshore area, where energy available for sediment transport is derived partly from wave damping and partly from shear forces set up by currents; the rate of expenditure of energy per unit area of bed is considerably lower here than in the inshore zone.

Rock slopes

6. Coastal landslips are not confined to soft ground and there are particular factors that affect the stability of rock slopes. The analysis by Hoek[1] provides

an excellent and logical approach to the rock mechanics; special features arise however at the coast from the effects of waves at the foot of the slope or cliff. Quite apart from questions of local erosion, accentuated by the presence of mobile material on the beach, there is a possibility of high pressures being set up in fissures by breaking waves.[2] The direction of fissure planes will control the significance of such wave action.

7. In stabilizing coastal slopes in soft rock, support is needed at the base, provided in such a manner as to break up waves to avoid high local pressures. Since soft rocks will continue to erode down to a wave platform, formed at approximately the level at which storm waves begin to break, any type of protection should take account of this continued drop in level of the foreshore and inshore areas. Figure 1 indicates a practicable type of protection for such a situation where a chalk cliff is exposed to attack. It is of some interest in that at this particular situation the rate of recession may be accurately estimated since the chalk cliff seen beyond the groyne in the photograph has remained stable since 1881. The annual rate of recession was locally about 25 cm per year until protection was provided first by a formal wall in 1947 and later by the illustrated revetment in 1967, when the wall was becoming undermined.

Fig. 1. View of Groyne 52 at Seaford with adjacent revetment

Earth slopes

8. Skempton and Hutchinson have described the various types of natural landslip.[3] Each type is represented in coastal landslips. The types and their preferred ground conditions are set out in Table 2.

Table 2. Types of coastal landslips

1.	*Falls* Rock, also dry cohesive ground which is subjected to rapid basal erosion
2.	*Rotational slides* Circular—rare in nature and confined to soft homogeneous clays Non-circular—transitional in type to compound slides Shallow—common in weathered clays
3.	*Compound slides* Commonly with inclined or sub-circular back and the base depth determined by a firm underlying stratum, in cohesive and granular soils
4.	*Surface flows* Normally confined to mud slides and flows, saturated or semi-saturated fine material, activated by surface water, ground water or sea spray (here a mud slide is used to describe sliding movements with horizontal motion of less than 10 m/day, a mud flow for more rapid movements with a high water/soil ratio)

9. Apart from special instances of pumping from depth, ground water will usually flow towards the sea and, for whatever types of ground and type of slip, control of drainage will normally be an essential factor except in a dry climate. An immediate problem then arises as to the extent to which the drainage may be combined with protection against the sea and here we must deal with two specific types of condition:

(i) where long term deterioration in strength of the ground is going to cause continued recession of the undercliff even though the toe position may be retained;

(ii) where weathering, sensitivity, and other causes of chemical or physical deterioration may be ignored.

In dealing with the first of these conditions, either material improvement must be achieved in the overall stability of the undercliff or protective works must be confined to the foreshore, accepting that further limited falls and slips on the undercliff will continue to occur, with concomitant damage to works on the undercliff. This latter approach must assume that further recession of the top of the cliff may be tolerated; and is practicable only where the continuing deterioration will not jeopardize the stability of the works constructed on the foreshore. Where, on the other hand, further deterioration is not a risk, there is greater freedom in the disposition of remedial works.

10. There are certain typical causes for long term deterioration:

(*a*) Sensitive clays[4] (not normally found in Britain), where the open structure is caused by the leaching and consequent base exchange affecting normally consolidated marine clays after these have been lifted above sea level.

(*b*) Related to ground water flow. Locally there may be an increase with time in ground water or in piezometric levels but these will be isolated phenomena with specific causes. A more common consideration is the effect of erosion caused by the continued flow of ground water through permeable material. The most serious type of failure of this nature is likely to be associated with piping, particularly likely to occur where a bed of sand is immediately overlain by more competent and less permeable ground.

(*c*) Over-consolidated clays (which may include material classified as soft shales, silt-stones or mudstones). These materials may deteriorate in strength for two reasons: the first concerns the reduction of overburden through geological time and whether the material has regained equilibrium under the loading of the cliff; secondly, in the undercliff there will again be a reduction in overburden and in lateral loading so that further swelling of the material will take place before the equilibrium state of water content is attained, possibly affected by fissuring and shear movements.

11. Stiff clays provide some of the most interesting problems of coastal stability and there are several features of these clays to be considered. Skempton and Hutchinson[3] indicate some approximate figures for the strength reduction of London clay as a function of time. Another approach to the same question concerns the angle at which a clay cliff in given circumstances stands in relation to the rate of erosion by the sea. There are evidently many factors that complicate any direct association between undercliff slope and the present rate of erosion, including water, fissuring and the past types of failure.

12. It appears probable that progressive failure provides at least a partial explanation of the initiation of deep slips where a stress analysis alone would suggest that peak values of ϕ' (angle of shearing resistance in effective stress terms) should be adequate to resist failure. Progressive failure is normally discussed in relation to locally exceeding peak values of ϕ' and thus leading to an overall diminution of strength, but the high shearing stresses in the vicinity of incipient surfaces of sliding may also lead to local softening of the clay from the migration of interstitial water. A phenomenon of this nature could be indicated by the development of reduced pore water pressure until the softening process is completed and, as mentioned below, such has recently been detected at Folkestone Warren. A consideration of the geometry of the situation, the levels of stress and the swelling characteristics of the clay could help to indicate an approximate time scale for such a softening process. It is relevant here to observe that railway cuttings in London clay have often failed some 100 years after their original formation and this at least provides an order for the time scale.

13. It can readily be shown that for failure to occur in an undercliff subjected to the most extreme set of adverse circumstances (short of high artesian pressures from below) the average ground surface slope in the direction of sliding must be greater than about $\phi'r/2$ where $\phi'r$ is the angle of residual shearing resistance in effective stress terms. However, if a coastline is receding rapidly on account of erosion by the sea, the most highly stressed zones in the ground structure will also be receding inland at the same rate and progressive

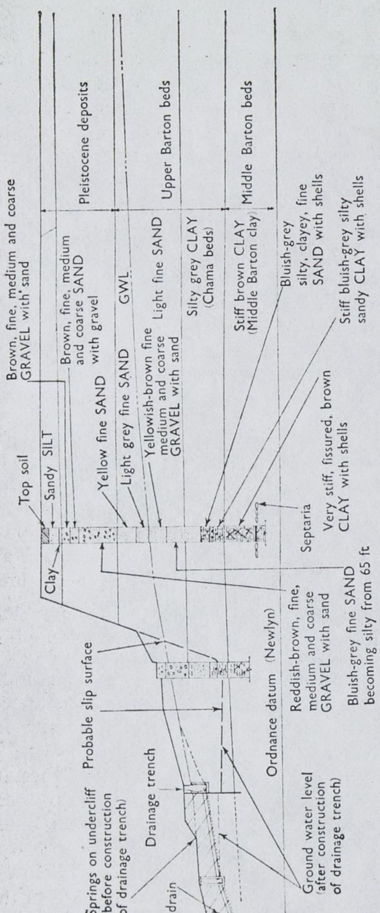

Fig. 2. Typical cross section at Barton-on-Sea undercliff indicating surfaces of sliding and remedial work

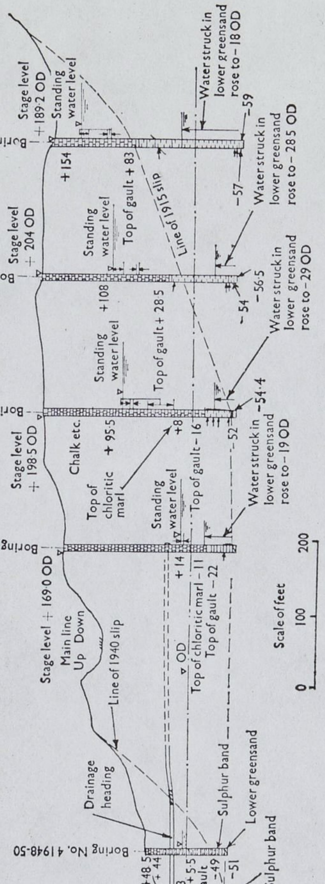

Fig. 3. Typical cross section at Folkestone Warren indicating surfaces of sliding and remedial work

failure of the type described above will not then have time to develop at any one locality. On this account, deep slips are unlikely to occur in very steep cliffs of clay which are only found at situations of high rates of recession; these will tend to fail by surface slipping provoked by weathering and by the development of high water pressures in fissures opened on account of lateral release of ground loading.

14. Another feature that will tend to cause deep slips is the presence of a fairly competent stratum in the upper cliff above the clay. Slight release of support that will occur at the face of the cliff, on account of creep or of release of lateral land, will lead to the opening of fissures running approximately parallel to the face of the cliff and to consequent tilting of slices of the upper cliff. Partial unlocking of adjacent rock faces across fissures will cause consequential increase in the load to be carried by the clay at the face of the cliff.

15. Once deep slips have occurred, then subsequent stability will depend upon the preferential paths for further movement and the residual strength of the clay. Figures 2 and 3 illustrate the types of solution for the two cases of surface slipping and of deep slips. The solution of Fig. 2 depends upon the capability in the long term of building up a good beach but accepts that some local erosion will occur until this is achieved, causing settlement of the revetment which may be readily restored without impairing its function as filter and protection to the face of the clay. Figure 3, on the other hand, represents the far more massive structure required to provide toe weighting to stabilize a deep slip where the natural beach cannot be relied upon to make any appreciable contribution in such a respect. Many problems in stabilizing cliffs tend to polarize towards the two basic types of solution, the one light, flexible and tolerant to further deterioration, the other massive and provided with adequate apron and toe to permit erosion to occur over an appreciable period without undermining the structure. The latter is naturally more expensive than the former in first cost and each type should entail consideration of the likely coastal evolution after the works have been constructed, a factor too often overlooked in the past.

16. Coastal mud slides may be caused by internal erosion (usually associated with surface springs) or by surface weathering in association with some external source of water. A mud slide is generally shallow by comparison with its width or length and a simple initial analysis of a mud slide on a steady gradient may be carried out as illustrated by Fig. 4. We are here considering a saturated material of vertical thickness h on slope θ with an effective piezometric line h_w above the base of the mud slide. The material is assumed to be non-cohesive and to have an effective angle of shear ϕ'. Where ρ_s is saturated unit weight of the material, ρ_w that of water, limiting stability requires that

$$h\rho_s \sin\theta = (h\rho_s - h_w\rho_w)\tan\phi'\cos\theta \quad \text{or} \quad \tan\theta = \tan\phi'(1 - h_w\rho_w/h\rho_s) \qquad (1)$$

From equation (1) it is apparent that the factors which may be manipulated to increase stability for a given value of θ concern the reduction in h_w or increase in h or a combination of both. For a fairly permeable material ($k = 10^{-6}$ cm/s corresponds to an average rate of vertical percolation from rainfall of about 40 cm per annum), apart from mud flows that result from torrential rain, the water must come from springs or from local surface concen-

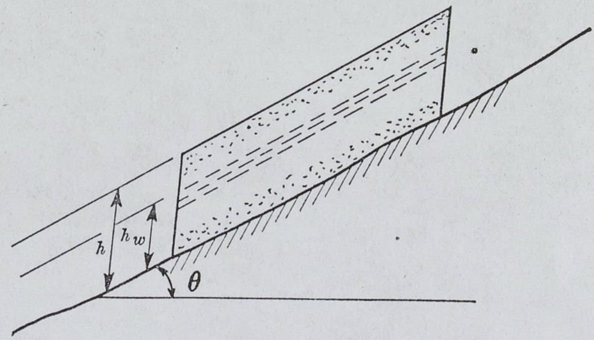

Fig. 4. Reference diagram for long wide shallow mud slide

trations. For instance, where a mud slide or mud flow occurs in a gully formed in the surface of a less permeable material, the remedy must be to divert or to stop the flow of water. Figure 2 indicates a drainage system used for such a purpose. For a fine silt or clay, k will be such that normal surface precipitation may suffice to cause stability. A solution here may be to provide a blanket of granular material to increase the effective stress on the base, possibly combined with drains down the slope to reduce h_w, at least in the close vicinity of each drain, the zone of influence depending on the permeability of the ground. Movement will not normally cease immediately and the type of drain must therefore tolerate some distortion and extension. Partly perforated PVC pipes with long collars provide a possible choice, set in a suitable granular surround which satisfies Terzaghi's requirement for a filter material (see § 40). Unless the gradient decreases towards the toe of a mud slide, some support will be required here, possibly combined with protection against the sea. Many mud slides are seasonal and an inspection in the summer when evaporation may possibly exceed precipitation will reveal only to the experienced eye the signs of instability indicated by profile, vegetation and by surface structure and cracking. Many a tendering contractor has regretted his favourable impression of a halcyon summer day.

17. At the East Cliff, Folkestone, mud slides have occurred periodically in the weathered Gault clay above the sandstone of the Folkestone Beds. Here, a cut-off drain has been provided to intercept ground water entering the area of the mud slide, and also transverse drains have been set at intervals down the mud slide. After observation of a year's performance it may be decided to complete the work with a permeable blanket and a toe wall supported on the rock ledge with outfalls projecting through it like gargoyles to discharge down the face of the lower rock cliff.

Coastal forms

18. Particularly interesting conditions of coastal instability arise where the coastline is composed of an undulating sequence of soft and hard rocks. An

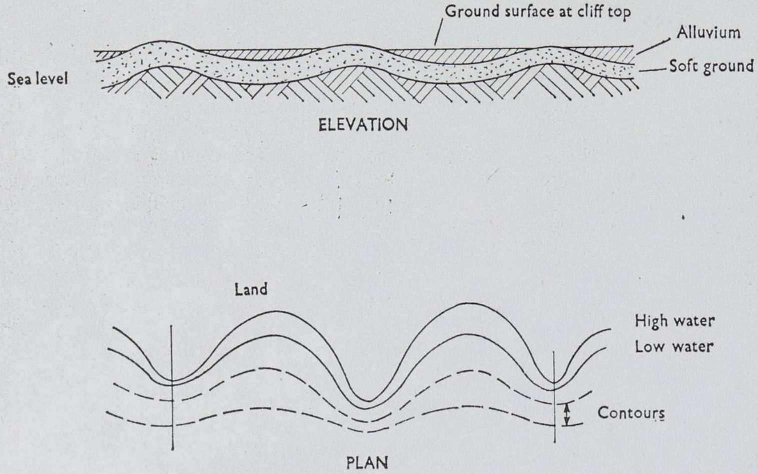

Fig. 5. Plan and elevation of a coastline of folded rock with softer material above

example of such a coastline occurs between Sunderland and Seaham where magnesian limestone of the carboniferous series has a number of folds, whose axes are approximately transverse to the general coastline, overlain by softer limestone and glacial deposits. Figure 5 illustrates such a coastline diagrammatically in plan and elevation.

19. The harder rocks form promontories at their exposures with natural bays between and a crenulated coastline results. As the toe of the soft ground of clays and sands is attacked by the sea towards the centre of each bay so do slices of the face of the cliff collapse on to the beach.

20. The conventional reaction to a condition of this nature is to provide protection to the soft parts of each bay. However, examination of the history of such a coastline will often show that the bays maintain a fairly regular shape and that the rate of recession of the coast is controlled by the rate of attrition of the promontories. The soft ground, if unprotected, would account for a far more rapid recession of the bay. This then points to the rational countermeasure as entailing the provision of reinforcement and spurs at each headland rather than protection around the perimeter of the bays. It is unfortunate that it is not at present possible from first principles to determine the equilibrium shape of a crenulated coastline, largely because of the complexities of littoral drift and of onshore/offshore movement of material. However, for the case in discussion, it is reasonable to assume, unless erosion rates have shown marked recent fluctuation, that the shape is sensibly in equilibrium and that the reinforcement of the promontories should serve to improve the beaches in the bays, sufficient to confer full protection to the vulnerable cliff.

21. The following factors materially affect the build up of beach material around the perimeter of a bay:

(*a*) Refraction will tend to concentrate wave energy on to the promontories and hence to shelter the coastline of the bay.

(*b*) Other conditions being constant, the flatter gradient of bed slope around the bay by comparison with the promontory will tend to cause a greater degree of damping of wave energy.

(*c*) Longshore currents will tend to be stronger at the promontory than in the centre of the bay for the same depth of water.

(*d*) For a beach composed of sand, reduced fluctuation will occur in the more sheltered zones. For a shingle beach, the material will tend to be contained within the bay if the bay is sufficiently deep (in plan). For a sand or shingle beach, the beach line will tend to be parallel to the approach of the dominant waves.

22. An interesting case arises where an artificial bay is designed to be formed in an area of unstable cliffs where material derived from erosion of the cliffs can be relied upon to provide a shingle beach around the margin of the bay. By making simple assumptions it is possible to make a first estimate of the equilibrium depth of the bay as described below although it is appreciated that this is only the beginning of a comprehensive account of such a process.

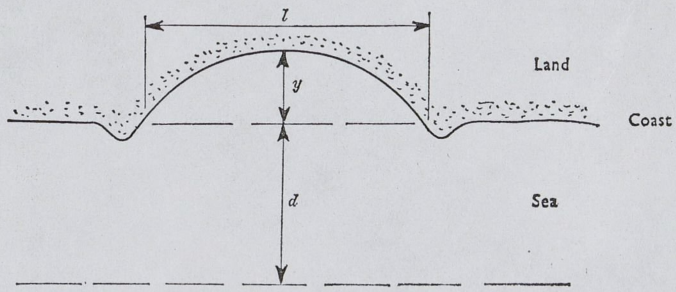

Fig. 6. Reference diagram for the evolution of a bay between artificial headlands

23. Consider a bay in the process of formation between two rigid headlands A and B distance l apart in Fig. 6. Assume the foreshore is protected by shingle derived from erosion of the cliff and that, on the original straight line of coast, a volume Q per unit length is sufficient to give full protection against wave action. From the geological structure we calculate that erosion provides volume p of shingle of adequate size per unit plan area. We further assume that:

(*a*) $Q \propto H^2$ where H is the 'equivalent wave height' corresponding to a year's energy flux arriving at the shore per unit length of shoreline.

(*b*) $H \propto (y+d)^{1/2}$ where d is the distance offshore of the storm breaker point from the initial line of the coast (assumed to remain unchanged).

(*c*) The bay develops in plan in an approximate parabola.

24. These assumptions require some explanation since they cannot be related to direct evidence or applicable theory. Assumption (*a*) assumes direct proportionality between wave energy and volume of effectively protective beach without scale effect. Assumption (*b*) assumes that wave damping is proportional to distance of travel over a bed at a given depth. Assumption (*c*) provides a reasonable relationship between maximum extent of erosion and area eroded in plan.

25. Then, for a maximum extent of erosion y (see Fig. 6), the land area eroded is $\frac{2}{3}lyp$ and the gain in shingle per unit length of foreshore is given by

$$q \simeq \tfrac{2}{3}yp \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

26. We know that the initial rate of erosion is λ/year for a negligible shingle foreshore and, as a first guess, we may assume that this rate reduces exponentially until equilibrium is achieved, i.e.

$$\frac{dy}{dt} = \lambda(1 - e^{(1-\alpha)}) \quad \text{for} \quad \alpha \ngtr 1 \quad . \quad . \quad . \quad . \quad . \quad (3)$$

where $\alpha = QH^2/qH_0^2$ and H_0 is the initial 'equivalent wave height'.

27. Equation (3) is easily solved for selected values of y to arrive at rates of erosion during the bay's development. The asymptotic value of y occurs when $dy/dt = 0$ and hence where

$$qH_0^2/H^2 = Q \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

But since $q = \frac{2}{3}yp$, equation (4) and assumption (*b*) yield

$$y = -d/2 + (d^2 + 6Qd/p)^{1/2}/2$$

and hence a first approximation of the equilibrium bay, taking no account of the many complexities in wave diffraction and refraction and in the variation of cliff face slope with respect to the rate of retreat. In a specific instance an approach of this sort has been combined with judgement by eye to take account of the angle of approach of prevailing waves in order to give a first order prediction of the formation of a bay between bastions to be set about 1200 metres apart on an eroding coastline of clay cliffs surmounted by gravel deposits in Christchurch Bay.

28. While much has been published concerning landslips at Folkestone Warren[5-7] a point of special interest is that regular failures (Terzaghi[8] has drawn attention to a 19 year cycle) only appear to have occurred from a time shortly after completion of Folkestone Harbour breakwater arm in about 1875. Littoral drift in this vicinity is from west to east and a very great accumulation of material has occurred during this time against the breakwater arm. It appears highly probable that the degree of shelter of East Wear Bay, where Folkestone Warren is situated, was earlier sufficient to maintain a good shingle beach until supplies were cut off. In all probability the beach would soon disappear after cut-off, since littoral drift increases as a beach becomes thinner on account of the reduced dissipation of longshore energy flux.

Investigations

29. The initial investigations constitute a most important feature of any scheme of coast stabilization. In view of the relationships between coastal authorities and central Government, considerable practical difficulties are often

experienced in the allocation of adequate funds for investigation and studies prior to the design and this situation is detrimental to overall economy of a scheme of works. The investigations may be considered for convenience in two parts, those concerned with the sea and those concerned with the land.

30. Concerning the sea first, considerable engineering judgement is required in determining what facts should be assembled as relevant to the scheme. Silvester[9] provides an example of an academic approach to this question which would entail the assembly of a vast amount of information over a period longer than that required for the construction of the works and much of it showing little relevance to the scheme. We are dealing with forces in a very delicate balance and, except for schemes on the largest scale and with climatic and other conditions susceptible to valid simplification, we can frequently learn a great deal more by observation of conditions immediately adjacent to the site with which we are concerned, than by any elaborate programme of recording of waves, tidal currents and so forth. The most important points to determine concern the offshore trend, i.e. whether a problem of erosion extending out to the offshore area has to be considered, and the degree and direction of exposure. The height of design waves on many coasts is controlled by the depth of water offshore and any programme of recording of deep water waves in the vicinity will have no great relevance to the design of inshore structures. A feature of considerable significance is the angle of approach of storm waves and this may be considered on the basis of fetch, wind records and an elementary refraction analysis. A most important feature concerns the capability of retaining beach material on a foreshore and this will largely depend upon the degree of exposure and orientation of the foreshore which, in their turn, determine whether littoral drift will tend to increase or decrease in the direction of drift. Local to any point of marked increase in potential littoral drift, special measures may be necessary. A possible solution here may be one that reduces the degree of wave reflexion by the provision of some form of permeable revetment.

31. No scheme of cliff stabilization can be effectively designed without adequate consideration of the geology of the area.[10,11] With a knowledge of the geology and, preferably, with information concerning the stability of similar material elsewhere, the sinking of boreholes may be preceded by the making of certain hypotheses which are then required to be supported or contradicted. Such an approach frequently assists in determining whether adequate site investigation has been carried out. So long as serious anomalies are found which do not comply with the hypotheses, further site investigation may be justified. The boreholes for such a problem are designed to test assumptions of stratigraphy, to determine the most relevant physical properties of the ground, to determine levels of water tables and their fluctuations and, possibly, for the carrying out of tests of permeability and of movement. There is some conflict between the desirability of sinking boreholes through undisturbed ground to discover the soil properties and the sinking of boreholes in tumbled ground of the undercliff to determine the nature of failure. It is often possible to establish simply by observation and by records of surface movement that failure occurs in a complex and locally variable manner and hence that any precise observation at one point will have little relevance elsewhere. Boreholes sunk from the clifftop in undisturbed ground will provide more reliable data on the geology, geohydrology and properties of the virgin

ground. Again, however, this is largely a matter of setting up important hypotheses to be tested rather than drilling holes in a spirit of serendipity.

32. It is important that the site investigation should have in mind the possible countermeasures in order that their effects may be evaluated. Thus it is important to have, for instance, information on water tables which should, if possible, provide data relating to flow prediction in areas of drainage or draw-down. Again, the effect of the use of a sea wall and toe weighting in any form must depend upon the shape of the preferential surface of failure near the toe. It should be possible to determine whether the toe is required principally to provide horizontal support or vertical weighting and to calculate whether increased stability is conferred in relation to the pre-existing surface of failure or along some other surface. A question of this type may only be answered for non-homogeneous materials by a study of alternative failure surfaces.

33. Where rock cliffs are concerned, the orientation and extent of jointing may be the most important feature. It may be far more worthwhile to sink a very few boreholes which will provide orientated cores than to sink a large number which provide information on joint spacing but not on joint direction, where this is not evident at the cliff face. It may be of interest to consider the technique of extracting cores in which a central steel bar has been previously grouted in order to determine the degree of opening of joints. Typically, however, cliffs by the sea have been exposed to attack for many years and will have revealed their stable condition, to which only an allowance for weathering has to be added. It is of interest to record that at Dover, the chalk cliffs (Fig. 7) which have been protected against attack from the sea for approximately 400 years, indicate by the extent of talus that, during this period, they have weathered back less than 1 metre to the present angle of about 80° (Fig. 1).

Stability analysis

34. It is desirable to include a few words on the analysis of problems of cliff stability. Insufficient distinction is made in the analysis of the stability of slopes between those which are man-made, such as embankments and dams, and those of natural ground. Rarely can the stratigraphy and effective ground properties in relation to natural landslips be determined and analysed sufficiently precisely to justify the application of the more refined forms of computation such as that of Morgenstern and Price except as an academic post-mortem after a slip has occurred. Furthermore, coastal landslips are frequently shallow or of compound type. The former can be readily analysed by a simple vertical slice method such as that of Janbu; the latter, if the principal surface of failure may be approximately represented as two planes (it frequently can), may be solved by a wedge analysis. Where possible one should try to explain why a certain type of ground should be stable in one situation and unstable in apparently similar circumstances elsewhere.

35. Elsewhere, the Author has commented upon the present inadequacies of theory in explaining major movements of landslips in over-consolidated clays.[7] A most interesting feature has recently been observed at Folkestone Warren which may have some bearing upon this aspect. During the investigation of slight creeping movement of a landslide along a pre-existing surface of failure, located by palaeontological means,[5] the existence of pore water pressures corresponding to levels appreciably lower than sea level has been

Fig. 7. Prestressing rock bolt fitted with optical load cell for underpinning of chalk cliff at Dover, Kent

established by piezometers placed adjacent to the failure surface. It is suggested that this phenomenon might be an important factor in helping to explain why a landslip along a surface of residual strength may yet, once set into motion, move for an appreciable distance.

36. While low pore water pressures persist, effective normal stresses and hence shear strength of the frictional material will be increased. Incipient movement may cause fissuring and re-adjustment of pore pressures to correspond to perched water tables above the level of the surface of failure. A rough analysis suggests that the over-consolidated Gault clay at Folkestone Warren beneath reduced cover in the undercliff might be far short of completion of equilibrium swelling; the high shear stresses induced in the vicinity of an incipient failure surface would accentuate this effect and could well explain why local low pore water pressures might be unrelieved in such a position. This theory could be tested by regular monitoring of pore pressures in the vicinity of such a potential failure surface elsewhere. This is an example of present

doubt which suggests that, where coastal landslips are known to be in a critical state of stability, a simple analysis may be used to evaluate the likely benefit from remedial works, providing that the type of analysis introduces a reasonable manner of estimating such improvement. For example, where drainage, regrading or toe weighting has to be introduced, a method based on effective stresses will provide a suitable basis providing the strength parameters are well chosen. There is no fully satisfactory explanation yet of the mechanism whereby landslips in over-consolidated clay lead to reduction in strength along the surface of failure. Where an elaborate investigation is not executed, it is unsafe, for a cliff that has been the scene of previous landslips, to rely upon strength in the clay greater than residual strength.

37. Another feature to be considered carefully in the design of remedial works is the extent of the rate of dissipation of pore water pressures since this will determine a safe rate to apply additional loading on the ground. The addition of toe weighting where pore pressures may be critical should be carried out in the summer when other factors are less likely to provoke slipping. Where time does not allow this rule, it is sometimes possible to design a revetment to provide temporary protection from the sea but which will tolerate further movement until pore pressures are dissipated and long term stability ensured.

38. Hutchinson[12] has referred to another important aspect concerning pore pressures in that falls from the face of a cliff on to an unstable undercliff may not only provide a trigger mechanism to set a slide in motion but may also give rise to high local pore pressures equivalent to the load of the fallen ground and hence a high temporary reduction in resisting forces.

39. It is important to be able to make reasonable assessments of the worst combinations of ground water levels and tides for a stability analysis where the toe emerges below high water mark. Generally, the worst case will be found to occur at times of the highest water tables and lowest tide. In certain special circumstances, reduced stability of a non-circular slip may occur at high water due to increased pore pressure ratio to total overburden at the toe of the slip and this possibility should not be overlooked.

40. Ground water may be detrimental to stability for two different reasons. Where the water emerges from the undercliff as springs, internal erosion may result adjacent to the issue, with or without associated piping, leading towards collapse of the cliff above. High ground water levels will reduce stability since they will reduce effective normal stresses across potential surfaces of slipping and hence reduce effective shearing resistance; in addition high ground water surface gradients in the direction of sliding will increase the forces provoking slipping and any valid method of analysis should take account of such force. When considering any form of drainage we must therefore take account of the different requirements of these two aspects of the water problem:

(i) To prevent surface springs it is necessary to provide sub-surface drains with filters designed to suit the ground. Experience shows that Terzaghi's rules of maximum filter particle size given by $R_{50} < 30$ and $R_{15} < 18$ provide an effective filter where R relates to the ratio between the size of sieve passed by the filter material and the material to be protected, the suffix figure indicating the percentage passing the sieve sizes concerned. Particularly where the filter medium has to be graded in intermediate sizes, the possibility of continuing ground movement requires very generous thicknesses of each size of filter medium to reduce the risk of failure. It may alternatively be practical to make use of nylon fabric filters with or without accompanying granular filter. There is no need to set the drain deep since its primary purpose is simply to ensure that springs no longer break surface at times of maximum flow.

(ii) Where questions of stability arise, it is necessary to consider a deeper system of drainage or one which provides a high degree of cut-off landward of the area vulnerable to slipping. Surface water drainage towards the rear of the undercliff may play an important role in reducing percolation into the ground.

41. Apart from deep cut-off drain to the rear of the slip, counterfort drains, to maintain low water tables, may be provided at intervals down the face of the unstable undercliff. The counterfort drains, backfilled with filter material and with stone or hardcore, will also provide a certain degree of buttressing for shallow slips. Trenches for cut-off drains may reduce the resistance to sliding and the siting of deep drains should take account of this factor. Coast protection works have often to be designed to factors of safety far lower than those accepted for engineering structures and the consequences of small movements or local failures should be taken into account in assessing the overall economics of the works to be undertaken, including the costs of maintenance. Extreme storms may cause local damage and part of the concept of design must be to limit the spread of such damage laterally or inland.

Remedial works

42. The traditional and well proven methods of stabilizing an unstable undercliff are by regrading and by drainage. In order to evaluate the benefits of a scheme of regrading it is necessary to know the approximate positions of the surface of actual or potential failure. The object must be to reduce loading immediately above a portion of the surface of failure inclined markedly inland or to increase loading over the surface sloping markedly upwards in the direction of the sea. Lesser benefit, the extent depending upon the properties of the ground, will be achieved by loading above the sensibly horizontal portions of the surface of failure for a frictional type of ground. Care is often necessary in ensuring that the stabilization of slopes nearer to the sea will not lead to an unacceptable reduction of the factor of safety of other deeper or more extensive slips. It is frequently found that slipping of a softer material leads to tilting and periodical subsidence of slices of the upper cliff composed of a stronger material. Hence any removal of ground which may be composing a talus against the foot of the high cliff should only be considered with caution.

43. A particularly attractive method of providing toe weighting is by the accumulation of a natural beach. Where there is a strong assured littoral drift this object may be achieved by the construction of groynes, not however overlooking the expectation that the trapping of beach in this way may well lead to the formation of a scour hole of comparable volume at the downdrift end of the protected beach.[2] In addition, such a solution must take account of the intermediate condition arising from the anticipated rate of accumulation and must entail confidence in the permanent retention of the beach material,

in the face of the most adverse conditions of wind, wave and tide. As an alternative to conventional groynes a parallel offshore breakwater may be considered for the same purpose. Such a breakwater operates in this manner:

(*a*) increased shelter in the 'shadow' of the breakwater will encourage a steeper inshore profile and a beach projected seaward of the line to each side, tending towards the formation of a tombolo[2];

(*b*) partial refraction off the ends of the breakwater will encourage littoral drift into the section concerned;

(*c*) where appreciable longshore littoral drift exists, equivalent to the accumulation behind the offshore breakwater, scour will occur off the downdrift end.

44. Offshore breakwaters, exposed or partially submerged, have been widely used but not in Britain. Ideally they require a tideless sea, a firm bottom, a shoaling inshore sea-bed, together with economic condition for obtaining and placing rock fill.

45. The solution adopted at Folkestone Warren in 1949 was to remove a certain amount of chalk from the slipped area (over the rising back of a minor slip and over the sensibly horizontal surface of the major slips) and transfer this material to the beach where it was contained by a massive surrounding wall of precast concrete blocks with a reinforced concrete apron.[13]

46. Barton-on-Sea has attracted attention as a typical scene of coastal landslips caused by water bearing sands overlying clay.[11] At the time of the design of remedial works there appeared to be an assurance of a reasonable supply of littoral drift of shingle to provide a beach, derived from erosion of the unprotected cliffs westwards. The scheme of groynes and breastwork is shown in Fig. 2. The breastwork was designed also as a filter to allow free movement of water draining from the ground behind and hence to increase the angle of stability of the lower part of the undercliff. It was evidently necessary to intercept the relatively high flows of water draining from the Barton Sands and which maintained a waterlogged condition of the underlying silts. Several alternative schemes were studied including a heading tunnel beneath the cliffs in the sands, a heading in the clay with raised drainage shafts and, in view of the inland component of dip of the strata, a system of drainage wells fitted with pumps some way inland of the cliff. This latter was the only scheme comparable in cost to that ultimately selected, whose principal feature was a deep drainage trench with cut-off piling into the undercliff (Fig. 2). The difficulty of any scheme on the undercliff was seen to be the possibility of damage or further movement before the drain became fully effective. The prospect of maintenance and operation of well pumps in perpetuity was considered undesirable and such a scheme could not be 100% effective in preventing the flow of water towards the sea. Boreholes in the undercliff disclosed considerable pockets of plateau gravels from the top of the cliff and an attempt was made unsuccessfully to use one such existing pocket as a natural filter tapped by a thrust-bored drain. Generally the drainage was considered in two distinct parts. Ground water intercepted by the main drainage trench and by subsidiary features from other perched water tables in water-bearing zones was discharged direct to the sea. Surface water was generally designed to be intercepted by open drains to the landward side of berms formed in the undercliff with slight falls inland. It is important always with such a scheme

of drainage to ensure that surface water does not lead to silting of the ground water system.

47. Brief mention should be made of the more exotic proposals[10] for stabilizing landslips which might have application to the coast, such as the use of electro-osmosis for drying out mud flows, heat treatment of clays and the use of a chemical or cement grouting of fissures (this latter has normally more relevance to man-made poorly compacted embankments than to normal landslips, apart from rock falls). Since coastal erosion has normally been continuing over a long period it is unusual to find property values immediately adjacent to an unstable area to be so high as to justify the more expensive expedients of drainage by tunnel or mechanical anchorage by tendons, although these may be locally practicable expedients.

Conclusions

48. Coastal landslips provide a rich variety of problems of the ground and of the sea. The appropriate economic solutions are simple in principle but often fairly subtle in detailed concept. It is usually far more important to be able to recognize the significant factors affecting stability than it is to attempt to apply any very precise method of analysis. Academic studies of landslips that have occurred may justify sophistications that are totally irrelevant to the engineering of remedial works to the incipient landslip.

49. Perhaps the most important capability of the engineer who works in this field is that of observation. To stand on a cliff top on a fine day may reveal a wealth of information about the problems to be countered. The pattern of the sea and the distribution of the beaches will indicate the shape of the sea-bed and the predominant wave directions. The nature of the exposures will often reveal the geological structure in some detail, while the topography of the ground will reveal circular slips (landward sloping surfaces), compound slips (steps in the ground marking graben[6]), superficial slips (tears and hummocks) and seepages (growths of coltsfoot) and so the list might continue. The forces at work are elemental and the engineering must be undertaken on the same scale.

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What the s
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The Paper argues the need for harbour desig
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ships in harbour waters. The point is made
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Introduction

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Ordinary meeting 17.30 h, 25 January 1972.
Written discussion closes 29 February, 1972.
* Director, Shell International Marine Lim

MASS MOVEMENT

The crust of the earth is raised or depressed with respect to the geoid by endogene phenomena associated with epeirogeny and orogeny. These large-scale crustal movements come within the province of tectonics and are not considered here. The surface layers of the crust are subject in addition to the action of exogene processes, largely controlled by climate, of which weathering, mass movement and mass transport are the chief. These interact with the endogene processes to produce surface form.

Weathering results in most cases in a weakening of a surface zone of the crust, rendering it more susceptible to downward movement under the influence of gravity. Mass movement comprises all such gravity-induced movements except those in which the material is carried directly by transporting media such as ice, snow, water or air, when the process is termed mass transport. In nature, the two processes merge into each other and in intermediate cases the distinction becomes arbitrary.

Mass movements exhibit great variety, being affected by geology, climate and topography, and their rigorous classification is hardly possible. Here the various types are subdivided mainly by mechanism, insofar as this is known, and morphology. Consideration is also given to the rate of the movement and the nature of the material involved. A primary division is made between mass movements occurring on slopes and those involving only a sinking of the ground surface.

Mass Movement on Slopes

In every slope, gravity-produced shearing stresses exist which increase with slope inclination and height, and with unit weight of the slope-forming material. Within the surface zone, the processes of freezing and thawing, shrinkage and swelling and thermal expansion and contraction produce further shearing stresses.

The response of the slope to these imposed stresses is controlled by the resistance to shear deformation currently exhibited by its component materials, itself closely dependent on the pressure exerted by the groundwater which generally occupies the soil pores. Very slow, largely irreversible deformations termed *creep* begin as soon as a "critical" strength is exceeded, which may be considerably lower than the strength at which shear failure occurs (Haefeli, 1953). As the imposed stress approaches the average shear strength, the rate of creep increases until eventually some form of relatively rapid failure takes place, to which the generic term *landslide* is applied (Terzaghi, 1950).

The various forms of mass movement on slopes are listed in Table 1 and described below.

Creep. In this context, the term "creep" has been used rather loosely to describe any very slow, permanent deformation of a slope, regardless of the mechanism causing it. It is useful to distinguish between seasonal, or mantle creep, the more continuous mass creep (Terzaghi, 1950; Haefeli, 1953), and a phenomenon which may be referred to as progressive creep.

(1) *Shallow, Predominantly Seasonal Creep; Mantle Creep.* This type of creep is largely confined to the weathered surface zone of fluctuating ground temperature and moisture content. Viscous move-

Table I. Mass Movement on Slopes

Creep	(1) Shallow, predominantly seasonal creep: (a) Soil creep (b) Talus creep (2) Deep-seated continuous creep: mass creep (3) Progressive creep
Frozen Ground Phenomena	(4) Freeze-thaw movements (a) Solifluction (b) Cambering and valley bulging (c) Stone streams (d) Rock glaciers
Landslides	(5) Translational slides (a) Rock slides: block glides (b) Slab, or flake slides (c) Detritus, or debris slides (d) Mudflows (i) Climatic mudflows (ii) Volcanic mudflows (e) Bog flows; bog bursts (f) Flow failures (i) Loess flows (ii) Flow slides (6) Rotational slips (a) Single rotational slips (b) Multiple rotational slips (i) In stiff, fissured clays (ii) In soft, extra-sensitive clays: clay flows (c) Successive, or stepped rotational slips (7) Falls (a) Stone and boulder falls (b) Rock and soil falls (8) Sub-aqueous slides (a) Flow slides (b) Under-consolidated clay slides

ments contribute little to the net downslope creep.

(a) Soil Creep. This affects the surface zone of the soil mantle and is especially active in regions with a wide seasonal variation in climate. Annual downslope surface movements tend to increase with slope angle and soil colloid content and vary in order of magnitude from less than 1 mm to several centimeters. On the more clayey slopes, the greater part of the creep is likely to result from volume changes caused by wetting and drying. Observations suggest that soil creep movements diminish progressively with depth and are most marked in a surface layer less than a meter thick.

The effects of soil creep are well revealed by the downslope deflection of weathered outcrops of stratified rock in hillsides. The slow and largely seasonal downhill movement of isolated boulders or blocks on slopes, for example, of as little as 5° would seem also to be a manifestation of creep in the underlying soil. The use by Sharpe (1938; see reference in Terzaghi, 1950) of the term "rock-creep" to describe these two phenomena is unfortunate. It is better reserved for the mass creep of rock at depth.

(b) Talus Creep. This involves the very slow downslope movement of the surface layers of the slopes of rock fragments or scree which typically occupy the foot of steep cliffs. Such material, with some exceptions, is predominantly frictional, rather coarse and well drained and in the steeper talus slopes stands at inclinations, often of around 35°, which approach its angle of internal friction. In general, recurrent expansion and contraction from temperature fluctuations probably make an important contribution to talus creep. In periglacial regions, talus creep is probably stimulated by freeze-thaw processes. Rates of talus creep of as much as 10 cm/yr have been observed in such a climate by Rapp (1961).

(2) *Deep-seated Continuous Creep; Mass Creep.* This type of creep can be expected to occur in all soils and rocks which are subjected to shear stresses in excess of the critical. It is probably the result of viscous movements and has a much lower order of magnitude than the other forms of creep mentioned in Table 1. It is therefore of chief significance when acting alone, below the zone of mantle creep. Mass creep in rock slopes is mentioned by Terzaghi (1953; see reference in Haefeli, 1953). There is, as yet, scarcely any direct field evidence for its existence.

(3) *Progressive Creep.* Creep movements of this type occur in slopes which are approaching failure. They are thus characterized by a stress level near to that at which failure takes place and by gradually increasing and relatively high rates of movement. Such movements frequently arise through, and hasten, a progressive deterioration in strength, particularly in slopes of heavily overconsolidated, argillaceous sediments. A well-documented case record of progressive creep in a slope of such material at Kensal Green, London, is given by Skempton (1964). The total movement there during the year preceding failure was approximately 20 cm. In heterogeneous slopes, progressive creep deformation of the less rigid strata can effect a further reduction of the overall stability by bringing about the fracture of more rigid, overlying beds.

Frozen Ground Phenomena. Phenomena resulting predominantly from the natural processes of freezing and thawing of ground moisture are widespread and in both their active and their relict forms are currently much studied. Only those involving significant downslope mass movement are mentioned below:

(4) *Freeze-thaw Movements.* (a) Solifluction. This involves the slow, downslope movement of surface material under the influence of freeze-thaw processes. In periglacial environments, solifluction is one

of the main agents of denudation (Rapp, 1961) and varies between general, creep-like movements and localized, more active forms which grade into the Alpine type of mudflow (Sharpe, 1938). It is most active when shallow thawing of the slope, generally to a depth of less than a meter, produces saturation of the surface layer above the impermeable, still-frozen subsoil. Frost heaving soils are particularly susceptible.

Solifluction deposits are characteristically unsorted and are limited in source to the higher parts of the slope, which may be inclined as little as 2° (Flint, 1957; see reference in Menard, 1964).

(b) Cambering and Valley Bulging. These related features were first clearly recognized in 1944 by Hollingworth, Taylor and Kellaway (see reference in Terzaghi, 1950) in the Northampton Ironstone field of central England, where they are believed to have a Late Pleistocene origin. The ironstone occurs in the near-horizontal and relatively thin Northampton Sands, which are the uppermost solid rocks in the neighborhood. These are underlain, conformably, by a great thickness of the Lias, into which shallow valleys, typically 1200–1500 meters wide and 45 meters deep, have been eroded. Excavations for dam trenches in the valley bottoms have shown the Lias there to be thrust strongly upward and contorted, while opencast workings in the Northampton Sands occupying the interfluves reveal a general valleyward increase of dip of "camber" of this stratum, often passing into dip and fault structure, suggesting corresponding downward movements along the valley margins. In adjusting to these movements, the rigid cap-rock has been dislocated by successive, regularly spaced fissures which parallel the valley and are known as "gulls". Similar features have been recognized in other parts of England and in Bohemia. The mechanisms by which cambering and valley bulging have been formed remain to be established.

(c) Stone Streams. Also called stone rivers, these are linear concentrations of boulders on slopes and valley floors. Related to solifluction deposits, they reach lengths of more than 1 km and thicknesses of several meters. Stone streams are abundant in formerly glaciated areas of Europe and North America. Most are now inactive. Although these features are not fully understood, it seems likely that the majority represent the residue of solifluction deposits from which the fines have been washed out (Flint, 1957).

(d) Rock Glaciers. Also called rock streams, these are glacier-like accumulations of angular rock waste which in their lower parts frequently exhibit successive lobate ridges, suggesting flow. They may exceed 1 km in length and have a thickness of 30 meters or more. Rock glaciers seem to be confined to currently glaciated terrain, generally contain interstitial ice at depth, and are sometimes genetically connected with true glaciers (Haefeli, 1953; Flint, 1957). The origin of these features and the mechanics of their motion is still in dispute. While creep may contribute to the movement of some rock glaciers, it seems that the majority, especially the more active, move predominantly through ice flowage and are better regarded as a form of mass transport.

Landslides. Landslides are relatively rapid movements involving failure. In further contrast to mantle and mass creep movements, where there is generally a continuous gradation between the stationary and the moving material, the movement in landslides takes place characteristically on one or more discrete surfaces which define sharply the moving mass. (The strain distribution in progressive creep movements is likely to be transitional between these two extremes.)

(5) *Translational Slides.* Landslides of this type are usually fairly rapid and involve shear failure on a fairly plane surface running roughly parallel to the general slope of the ground. The movements of the slide masses are therefore predominantly translational and relatively shallow, the depth to the slip surface being as a rule less than one-tenth of the distance from toe to rear scarp of the slide.

Translational slides are characteristic of slopes of largely frictional material, in which the rapid increase of shear strength with depth inhibits the development of a deeper, rotational type of failure. They are also widespread in cohesive soils in which the failure surface is predetermined by a marked heterogeneity, such as a sharp transition from soft to hard material with depth, or the presence of an adversely located weak layer within the slope.

(a) Rock Slides or Block Glides. These are the most clear-cut type of translational failure. The rock mass involved may move as one or break up to produce a multiple failure. In either case, movement is generally fairly rapid. The slip surface is commonly formed by a bedding, cleavage or joint plane, frequently occupied by an argillaceous filling. In the rock slide of 1806 at Goldau, Switzerland, failure occurred on a bedding plane in stratified marly sandstone, dipping approximately parallel to the valley side at about 25°. The volume of rock involved is estimated to have been about 15×10^6 cubic meters (Terzaghi, 1950; Haefeli, 1953).

(b) Slab Slides. These are similar in form to rock slides, but involve uncemented materials. The landslide at Jackfield, Shropshire, described by Henkel and Skempton in 1954 (see reference in Skempton, 1964), exemplifies a failure of this type in the moderately deep weathered zone of hard, Upper Carboniferous clays. That at Furre, Norway, reported by the writer in 1961, was determined, in contrast, by the presence of a thin layer of quick clay, interbedded in silty Post-glacial deposits and dipping at an average inclination of about 6° beneath the slope foot. In both of the slides, the failing mass moved predominantly as a single unit. Multiple slab slides also occur. These are usually retrogressive, but progressive forms are also known.

(c) Detritus or Debris Slides. These slides are characterized by the tendency of the slide material to behave as a more or less cohesionless mass, suffering considerable distortion during movement. They generally occur on fairly steep slopes, typically between about 15 and 40°, and are frequently fairly rapid. The depth of the movement and the degree of distortion involved is influenced largely by the cohesion of the slide debris. At one extreme, heavily weathered clay debris may approach the nature of a *slab slide*: at the other is the *sand run* in slopes of dry, cohesionless material, in which the movement involves only the grains in a thin surface layer.

Extremely rapid debris slides often result from sudden heavy rainfall, particularly in the tropics. In cold mountainous regions, significant mass movements are brought about by dirty snow avalanches, as pointed out by Rapp (1961). Both these types of movement clearly grade into mass transport.

(d) Mudflows. These form an important group of mass movements, and again, in their wetter manifestations, involve a strong element of mass transport. They are typically glacier-like in form, with surface slopes ranging from about 25° to less than 1° and normally consist of poorly sorted, weathered rock debris in a soft, clayey matrix. Their movements are commonly highly seasonal and vary widely in rate between the different types of flow.

(*i*) Climatic mudflows develop characteristically beneath steep, bare slopes of deeply weathered, fissured or jointed rock, which serve as a debris source. If, upon wetting, a sufficient amount of the accumulated debris breaks down to a clayey paste, mudflowing will begin. This cycle is naturally favored by climates which alternate between stimulating the production of rock and soil debris and providing a fairly plentiful supply of water.

That such conditions are not limited to the semi-arid and Alpine environments recognized by Sharpe (1938) is illustrated by the widespread occurrence of mudflows in southern England. These "temperate mudflows" develop on outcrops of over-consolidated clays and are currently most active on the coast, where their tongues are subject to marine erosion. Summer drying and shrinkage in the steep upper cliffs lead to falls of hard clay fragments which, particularly in fissured clays, supply much of the debris. This is supplemented by frost spalling and shallow slides during the winter, when the chief mudflow movements occur. An alternative supply mechanism, which affects both fissured and intact clays, is the undermining of clay beds by seepage erosion in an underlying fine sand. The mudflow margins are generally sharply defined and slickensided. The movements of a mudflow in the London Clay have recently been observed by the writer to approximate *plug flow*.

The term *seepage erosion* is employed when groundwater discharges at a free face and the seepage drag may be large enough to dislodge individual particles of the soil, thus permitting their removal. This phenomenon is largely confined to soils in the coarse silt to fine sand range. It occurs typically at the base of a free face of water-bearing, fine cohesionless material underlain by an impermeable bed. The resultant back-sapping tends to undermine the superincumbent strata and produce their eventual collapse (Terzaghi, 1950).

(*ii*) Volcanic mudflows or lahars occur in association with explosive eruptions and arise from the sudden supersaturation of great accumulations of volcanic dust and ashes. The necessary supply of water may be derived from the ejection of crater lakes, the condensation of steam clouds or the melting of snow banks. Mudflows of this type are frequently terribly destructive and may owe some of their mobility to included gases. In 1929, Scrivenor (see reference in Thornbury, 1964) described a Javanese volcanic mudflow which, in threequarters of an hour, overwhelmed a tract of land extending over 38 km from the crater and having a width of up to 4 km. (See *Lahar*, pr Vol. VI.)

(e) Bog Flows or Bog Bursts. These consist of the predominantly translational, downhill movement of masses of saturated peat. They are confined to ombrogenous mires and are common in the rainy, mountainous areas of Ireland and north-west England. Many examples are described in the *Scientific Proceedings of the Royal Dublin Society*.

The most catastrophic bog bursts are associated with raised bogs, which consist typically of a domed mass of soft peat enclosed within a perimeter of firmer material. On receiving a sudden access of water, it appears that such a bog may swell until some form of failure releases the inner, semifluid peat. In a burst of this type in the Knocknageeha bog, County Kerry, Ireland on December 28, 1896, nearly 5×10^6 cubic meters of peat were discharged.

Bursts in blanket bog, which forms on slopes up to about 15° in wet, mountainous areas of north-west Britain, are more limited in extent. In the deeper blanket bogs, on slopes as flat as 3 or 4°, failures typically involve areas of the order of 4×10^4 square meters and are accompanied by a discharge of semifluid peat. On the steeper slopes, of about 6–15°, the blanket bog is generally thinner and the whole peat profile may be fairly firm. Failures in such situations are more limited in extent and are better described as bog slides.

(f) Flow Failures. These originate through the collapse of metastable structure in certain loose, predominantly non-cohesive silts or fine sands, which are generally also saturated. Such collapse usually results from a sudden disturbance and probably gives rise to transient, high pore pressures in the failing material which give it briefly a semi-fluid character.

(*i*) Loess flows, although not yet closely investigated, appear to involve the failure of virtually dry deposits. Collapse is usually caused by earthquake shock, probably through breaking of the weak intergranular bonds. The mobility of the resultant flows suggests that pore-air pressures may be generated within the flow masses. Loess flows in Missouri and Kansu, China, are referred to by Terzaghi (1950).

(*ii*) Flow slides occur chiefly in subaqueous environments (see Section 8). Flow slides have also been initiated in saturated, or nearly saturated, metastable deposits above free water level by slip movements, pile driving, explosions and earthquakes. Artificial sand fills and industrial waste deposits, particularly where placed hydraulically, have been fairly frequently involved.

(6) *Rotational Slips*. Rotational landslips occur principally in slopes largely formed of, or underlain by, a fairly thick and relatively homogeneous deposit of clay or shale. Failure takes place, usually fairly rapidly, by shearing on a well-defined, somewhat curved, slip surface. This, being concave upward, imparts a degree of backward rotation to the slipping mass which produces sinking at the rear, heaving at the toe and back-tilting of the slipped strata. Elongated pools commonly collect in the depression formed behind the slipped mass. Failures of this type are as a class more deep-seated than translational slides.

The main types of rotational landslip are illustrated in Fig. 1. Further subdivision is made below:

(a) Single Rotational Slips. These are characterized by the presence of a single, concave slip surface upon which the slipping mass moves as a virtually coherent unit (Fig. 1). They have received much

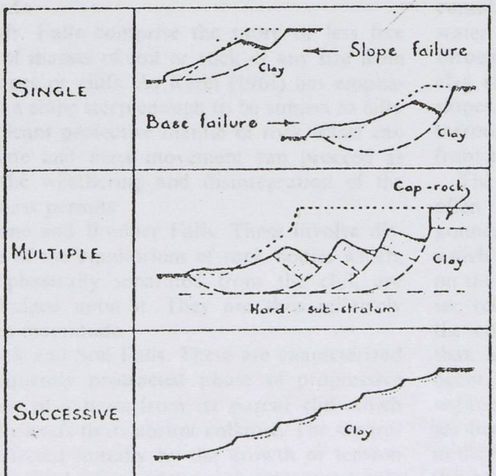

FIG. 1. Main types of rotational landslip.

attention in the geotechnical literature as they are of frequent occurrence in cuttings. A typical landslip of this type is that in Lodalen, Norway, described by Sevaldson (1956; see reference in Skempton, 1964).

(b) Multiple Rotational Slips. Under certain circumstances retrogression of single rotational slips can occur, producing two or more slipped blocks, each with a curved slip surface tangential to a common, generally deep-seated, slip sole (Fig. 1). Clearly, as the number of units increases, the overall character of the slip becomes more translational, though in failing, each block itself rotates backwards. Two widely different types of multiple rotational slip can be recognized.

(*i*) One type occurs in *stiff, fissured clays*. Prerequisites for the occurrence of multiple rotational slips in such clays appear to be fairly high relief, the presence of a considerable capping stratum of well-jointed but otherwise competent rock, a relatively thick layer of underlying clay or shale, and active and continuing erosion at the foot of the slope. In Britain the most well-developed landslips of this type are found on the coast and appear to have a Post-glacial origin. Long intervals seem to have elapsed between the failure of consecutive blocks, and contemporary activity generally comprises chiefly a renewal of movement in the old slipped masses.

A well-investigated multiple rotational landslip is that at the Folkestone Warren on the south coast of England. This involves a 45 meter thick bed of Gault clay capped by over 120 meters of Chalk, and was described by Toms in 1953 (see reference in Bishop and Bjerrum, 1960).

Multiple rotational slips rarely occur in cliffs formed entirely of stiff, fissured clays. In the absence of a competent cap rock, the rear scarp formed by the initial slip is degraded so rapidly by shallow slips, soil falls and mudflows that unless erosion at the toe of the protecting slip masses is exceptionally severe, the general level of imposed stresses does not again rise high enough to bring about a further deep-seated failure.

(*ii*) The other type is found only in *soft, extra-sensitive clays*. Retrogressive failures in deposits of quick clay form a distinctive category of multiple rotational slip, to which the Late- and Post-glacial marine clays of Norway and east Canada are particularly prone. A good example is the landslip at Ullensaker, described by Bjerrum in 1954 (see reference in Bishop and Bjerrum, 1960). Such failures generally begin with a single rotational slip in a bank produced by fluvial incision in a near-horizontal surface of the clay deposit. The slip movements remold the quick clay forming the lower part of the initial slip to the consistency of a heavy liquid. This runs out of the slide cavity, carrying with it flakes of the stiff, weathered crust which normally forms the upper few meters of the deposit. The steep rear scarp is thus left unsupported, and a further rotational slip is induced. This, in turn, is largely remolded and flows out of the cavity, and retrogressive failures continue until a stable scarp is attained. The retrogression is extremely rapid, consecutive slips following each other in a matter of seconds. Lateral spread of the failure is usually more marked in the deposits remote from the river than in the more weathered, somewhat stronger material forming the river bank. This gives these slips their characteristic bottle-necked shape in plan and their Scandinavian name of "bottle-neck slide" in quick clay. Either this name or that of "clay flow" suggested by Terzaghi and Peck (1948; see also Terzaghi, 1950) is preferable to the term "flow slide" sometimes used, as the latter has long been applied to liquefaction failures in loose noncohesive deposits (see Sections 5 and 8).

(c) Successive or Stepped Rotational Slips. Slopes of stiff, fissured clay that are approaching their angle of ultimate stability frequently exhibit repeated, shallow rotational slips. [The angle of ultimate stability is discussed by Skempton and DeLory, 1957 (see reference in Skempton, 1964), who conclude it to be about 10° for the London Clay.] Each rotational slip is of limited extent in a direction down the slope but of considerable extent across it, thus forming a succession of cross-slope steps or terraces (Fig. 1). Typical successive rotational slips, with terrace widths between 9 and 12 meters and rear scarps about 1.5 meters high, occur on 35-meter high slopes of approximately 12° inclination in the London Clay.

Some of the features known as *terracettes* may represent a miniature form of stepped rotational slip. Investigations of terracettes by Odum are referred to by Sharpe (1938). They seem to occur chiefly on relatively steep slopes in somewhat frictional soils.

7. *Falls*. Falls comprise the more or less free descent of masses of soil or rock of any size from steep slopes or cliffs. As Rapp (1961) has emphasized, on a slope steep enough to be subject to falls, no significant protective mantle of rock waste can accumulate and mass movement can proceed as fast as the weathering and disintegration of the parent mass permits.

(a) Stone and Boulder Falls. These involve disturbance of the equilibrium of rock bodies which, already physically separated from the cliff, are merely lodged upon it. They are thus relatively limited in magnitude.

(b) Rock and Soil Falls. These are characterized by a frequently protracted phase of progressive separation of a mass from its parent cliff which eventually leads to its abrupt collapse. The separation is effected initially by the growth of tension cracks: the final release of the rock mass commonly occurs through shear failure of the root of the mass. These failures are confined to the surface zone of rock in which the effects of pressure release and of seasonal variations in temperature and cleft-water pressure are most significant. In Norway, a widespread, well-marked annual peak of rock-fall intensity in the spring suggests thawing following frost-bursting to be a relevant mechanism (Rapp, 1961).

8. *Subaqueous Slides*. The processes of weathering and erosion, which under subaerial conditions are the chief promoters of mass movement, are largely absent from subaqueous milieus, where deposition and consolidation naturally predominate and relief is generally more subdued. Fossil structures resulting from submarine slumping have long been known, however, and recent oceanographic investigation has established firmly that contemporary submarine slides and resultant turbidity currents are widespread and extensive (Menard, 1964).

In shallow, coastal waters, the bottom sediments are subject to disturbance by waves and tides, and submarine slides are frequent, particularly in areas such as large river deltas where the rate of sedimentation is high. The volume of such sublittoral slides ranges from 10^4 to at least 3×10^8 cubic meters (Menard, 1964). Two main types can currently be distinguished:

(a) Flow Slides. Under certain conditions, masses of cohesionless or slightly cohesive silts or fine sands are deposited underwater with a metastable structure (see Section 5). A subsequent slight disturbance may be sufficient to cause a collapse of this structure, which can lead, through the generation of transient high pore-water pressures, to a flow slide (Terzaghi, 1957; see reference in Menard, 1964).

(b) Underconsolidated Clay Slides. Terzaghi (1957) has suggested that under submerged conditions in which predominantly clayey sediments accumulate fairly rapidly upon a slope, excess pore-water pressures will build up within the deposit through a lag in consolidation. Under-consolidated clay slides may then result, even on very gentle slopes, without further external stimulus. The numerous grooves which descend the Mississippi delta front are believed to be the scars of this type of slide.

The abyssal plains of the ocean basin floor are often blanketed by great thicknesses of fine-grained deposits brought in by turbidity currents, which were themselves probably initiated by slides on the continental slope (Gorsline & Emery, 1959; see reference in Menard, 1964). Investigations of the continental slope so far carried out suggest that, as in the sublittoral zone, submarine slides occur chiefly in localities having a high rate of sedimentation. Most of these slides of the deeper sea bed are thus believed to originate, recurrently, in the heads of the submarine canyons which notch the continental slope and form natural sediment traps (Moore, 1961; see reference in Menard, 1964).

The largest submarine slide yet reported is that generated by the 1923 Kwanto earthquake in Sagami Wan, off Japan. This had a volume of 7×10^{10} cubic meters (Menard, 1964). The nature and mechanics of these failures are still obscure though their initiation is often associated with earthquakes.

Mass Movement Involving Sinking of the Ground Surface

In contrast to those on slopes, mass movements involving sinking take place by the predominantly vertical, downward movement of superficial parts of the earth's crust which are confined on all sides. Although less widespread than slope movements, they can be more deep-seated. A distinction is drawn between the relatively rapid *subsidence*, resulting from roof breakdown in subsurface macrocavities such as caves, and the generally more gradual *settlement*, arising from a reduction in volume of soil microcavities or pore spaces. The various categories are listed in Table 2 and described below.

TABLE 2. MASS MOVEMENT INVOLVING SINKING OF THE GROUND SURFACE

MASS MOVEMENT INVOLVING SINKING	(9) Subsidence caused by (a) Mining (b) Marine erosion (c) Subsurface erosion, or piping (d) Subsurface solution (e) Melting of ground ice (f) Chemical changes (g) Outflow of lava (h) Old land movements
	(10) Settlement caused by (a) Consolidation (i) Surface loading (ii) Lowering of ground-water level (iii) Underdrainage (b) Collapsing grain structure

9. *Subsidence*. The many forms exhibited are subdivided according to the process by which the subsurface cavity is produced:

(a) Mining. Extensive subsidence has been brought about artificially by the mining of coal, salts and metalliferous ores. Examples are given by Sharpe (1938).

(b) Marine Erosion. Subsidence may result from roof collapse in caves formed by the sea. Falls of the inner parts of such caves in Cornwall, England, have led to the curious "blow holes" there.

(c) Subsurface Erosion or Piping. Under conditions where susceptibility to seepage erosion is accompanied by a tendency to "roofing," the progressive removal of fine material on a limited front may lead to the formation of a subterranean conduit of considerable length. Several cases in which large sinkholes were produced by the roof collapse of conduits eroded in fine sands are reported by Terzaghi & Peck (1948). Related subsidence into erosion channels located at the base of deep, blanket peat occurs in the English Pennines.

(d) Subsurface Solution. In limestone and dolomite regions, the drainage tends to sink underground and produce a system of subterranean solution channels. Widespread subsidences of very variable form, termed *sinkholes*, result from the solution and fall of cavern roofs and from the collapse of overlying unconsolidated deposits (Thornbury, 1964). These features are among those which characterize karst topography. Related phenomena, referred to generally as *solution subsidence*, occur in chalk, gypsum, anhydrite and halite terrain (Morgan, 1941; see reference in Thornbury, 1964). Artificial solution subsidence has been produced in Cheshire, England, by brine pumping from Triassic halite deposits.

(e) Melting of Ground Ice. A common form of this type of subsidence is the kettle hole, which is generally produced by the melting of a mass of dead ice buried in glacial deposits. Less widespread are the features referred to as *thermokarst*. These consist of depressions, termed thaw lakes and thaw sinks, which have been reported from Alaska and are ascribed to subsidence following the thawing of perennially frozen ground (Flint, 1957; p. 204).

(f) Chemical Changes. Certain subsurface ore bodies suffer volume reductions as a result of oxidation, which lead to surface subsidence similar in appearance to that produced by mining. An example of oxidation subsidence in Arizona is described by Wisser (1927; see reference in Thornbury, 1964), and cases of appreciable and continuing subsidence resulting from the burning of seams of coal or lignite are mentioned by Sharpe (1938). The lowering of the surface of peat mires as a result of drainage is a complex phenomenon, but in many instances a significant part of the total loss in level is due to decomposition of the drained peat.

(g) Outflow of Lava. Some volcanoes exhibit steep-walled depressions known as *volcanic sinks*. These are formed predominantly by collapse following withdrawal of magma from below and may have a width of over 5 km. Mokuaweoweo, on the summit of the Mauna Loa lava dome in Hawaii, is a good example (Thornbury, 1964). Various smaller-scale forms of subsidence in lava fields, including roof collapse in lava tunnels, are described by Cotton (1944; see reference in Thornbury, 1964).

(h) Old Land Movements. Landslides, or cambering movements, can give rise to deep fissures, aligned along the affected slope and usually located in the neighborhood of its crest. Superficial unconsolidated deposits may mantle these, particularly if the fissures were ancient, and the collapse of this loose cover may eventually produce a locally severe, characteristically linear subsidence.

10. *Settlement.* (a) Consolidation. In a saturated soil, the superimposed load is carried partly by the soil structure and partly by the fluid, usually water, which fills the pore spaces. As the pore water is relatively incompressible in comparison with the soil structure, any load increment is carried, initially, by the liquid phase of the soil-water system. The excess pore-water pressures, which are thus set up, initiate a drainage process which effects their gradual dissipation, at a rate controlled largely by the permeability of the loaded soil. This transfers an increasing proportion of the incremental stresses to the soil structure which compresses accordingly, producing a surface settlement. This process, which is termed consolidation, is of chief importance in soils, such as soft clay, with a highly compressible structure (Terzaghi & Peck, 1948). It is most frequently brought about in the following ways:

(*i*) By far the most widespread and extensive consolidation takes place as a result of the surface loading, through continuing deposition, of sea and lake bed deposits. On land, consolidation of this type is brought about by the loading imposed, for instance, by ice sheets and their outwash deposits. It is also frequently caused by man-made structures and fills.

(*ii*) Lowering of groundwater level results in an increase in the effective weight of the mass of soil situated between the initial and final positions of the water table. This causes a corresponding additional consolidation of this mass and the deposits underlying it. Extensive consolidation of this type has taken place in soft, marine clays raised above sea level by the isostatic recovery of regions which were previously heavily glaciated. Consolidation settlements of similar nature but smaller scale are often caused by artificial drainage (Terzaghi & Peck, 1948).

(*iii*) Underdrainage, or the reduction of pore-fluid pressures at depth, is a related form of loading resulting chiefly from either the extraction of oil or water at depth or the fortuitous drainage of a confined aquifer by excavation or tunnelling. Heavy pumping of water from beneath soft, clay deposits has led in about 13 years to consolidation settlements of up to 1.2 meters in the Santa Clara valley, California (Terzaghi & Peck, 1948), and even the stiff clay beneath London has settled several centimeters through abstraction of water from the underlying Chalk.

It appears that considerable reduction of pore-fluid pressures in sands located at great depth can lead to unexpectedly large surface settlements, which seem to derive from the sand layers rather than from the overlying strata. Laboratory studies on the sands suggest that the settlements are produced by *grain crushing* at high effective pressures.

(b) Collapsing Grain Structure. Certain loose, dry deposits of fine sand or coarse silt exhibit considerable settlement on wetting. This is generally only large when the deposit is wetted under a superimposed load, but in some very high-porosity deposits, settlement can occur under the self-weight of the soil alone. The settlement results from a collapse of the metastable soil structure following weakening by the water of clay bonds which may be present at grain contacts, and its destruction of intergranular capillary tensions. The rate of collapse seems to be below that necessary for flow slides to develop (see Sections 5 and 8). The phenomenon is well documented in the loess of Europe and the United States and is reported from residual granite soils in South Africa and slightly clayey, marine sands in Angola (see papers in the *Proceedings of the Fifth International Conference on Soil Mechanics and Foundation Engineering*, Paris, 1961). Relatively flat deposits of such soils which suffer structure collapse under earthquake shock exhibit large regional settlements, apparently unaccompanied by flow failures.

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This information is circulated with the approval of Sandgate Councillors: Messrs: J.Fulford, E.Hamer and P.Ovenden and has been compiled by Mrs L.René-Martin, a long-time resident.

ENCOMBE ESTATE, SANDGATE: (Re SH/88/1072)

Ministry of Technology Building Research Station (EN/35/65) A Survey of the Coastal Landslides of Kent by Professor J.N.Hutchinson, documents the age-old instability along this stretch of coast. In January 1970, a further six landslips were reported between Hythe and Dover. In Sandgate the geological instability has been considerably aggravated by development of the former Encombe Estate which, in 1966, destabilised a wide area. These results were, as residdents warned, entirely predictable.

This Summary of events and Fact Sheet attached (p.3-7), is for the benefit of Local Councillors and Council Officers who may be of too recent origin to appreciate the full background to this highly unstable area. It is also for the benefit of those whose memories may be short, or who are unaware of the devastating and costly impact of development upon neighbouring private and public property, for the past 20 years over a wide area of Sandgate:

SUMMARY:

1. Sandgate lies between the devil and the deep -- earth movement and water percolation from the north, coast erosion on the south
2. Two landslips were recorded in the 19th century. The first in 1827 affected an area 500 yards east of Encombe House. The second in 1893 extended as far as Hospital Hill to the west, damaging 200 houses in and around the village.
3. This notorious landslip area was zoned for residential development in the Kent Development Plan (confirmed 1958). The former Folkestone Borough Council ignored their duty and offered no comment prior to its inclusion. In 1962, however, consent to build flats was refused (Note 1 p.2
4. Extensive development on the Encombe Estate in the early 1960's wrecked the 1893/94 land-drain laid under the supervision of the Sandgate UDC and which had provided stability for 70 years. The developers also destroyed the Encombe Water Gardens (see O/S maps) an effective way of channelling off springs and surface water from the area. The Sandgate Laundry (site of Car Park) utilised 100,000 gallons of this water a week.
5. Consequent upon development, ground movement was reported in 1966 over a wide area, accompanied by cracking up of residential property and frequent breakdown in main services: gas, water, electricity and telephone cables.
6. Despite the threat to public property also, Folkestone Council turned their back on the whole situation.
7. In 1967, under pressure from residents, and following the findings of the Aberfan Tribunal, the Council called on Halcrows who recommended two test borings on the hillside, only. These were carried out in 1968
8. In 1970, the Ministry of Housing and Local Govt. agreed to contribute to a Coast Protection Scheme. For reasons shown on p. 6 nothing was do
9. Shepway Council inherited a rapidly deteriorating situation. Finally, in 1978, Halcrows carried out a well-point scheme to intercept the water. This, on their own admission in 1986, proved ineffectual. The downhill flow of water today (1988) is as bad or worse than twenty years ago. (See p.6)

VERY IMPORTANT - this helped to scupper the 1988 Application

10. The 1986 Halcrow Report recommended trial borings over a six month period in the rainy season, September to March. Three out of five boreholes were not ready for readings until mid-January 1988.'A complete set of wet season's readings are required before detailed design [of dowelling] can be undertaken'. (p.7)

11. Conclusion: There is no guaranteed method of stabilisation. The Proposed 'Dowelling' solution may control future rotational movement along the major slip-curve, but will not necessarily prevent -- and may even enhance -- local ground movements nearer the surface. This pattern of local movement is clearly visible over the area of the 1893 landslip. The continued flow of water down the hillside, both rain and springs, will continue to cause wash-out of large quantities of silt, and provoke subsidence beneath roadways, seawall and property, generally. New development high on the hillside will be equally at risk.

DAMAGE TO PROPERTY SINCE 1966

a. Weakening of sea defences, water forcing its way under seawall, wash-out of silt, subsidence

b. Trunk road subsidence and buckling, also Encombe driveway (adopted) and side roads. Under constant repair and patching up

c. Cracking of house and garden walls in Wilberforce Road, Prospect Rd. Sunnyside, Coastguard terrace, Gloster Terrace, Encombe driveway and former Encombe House itself. Also Sandgate High St.

d. Rodney Court demolished 1969

e. Four houses, 156-162 Sandgate High St (incl Hillside villas rebuilt 1896 after 1893 collapse) demolished 1972. Now site of Wilberforce Green.

f. 37 garages on Wilberforce car park site ruined, later demolished

g. No.19 Encombe (built 1966) in a very bad state

h. Encombe terrace subsidence

i. Leaning houses on Esplanade

j. Earth fall beside Serena Cottage, Esplanade (1987)

k. Wellington Terrace improvement grant refused (1969) because of 'engineering considerations'.

l. Holmvale House, subsidence of balconies on seaward side (1988)

m. Costly repairs to house foundations. Mortgages refused to intending property purchasers

n. Eighty recorded incidents of fractured gas and water mains and interruption of telephone and electricity services between 1966 and 1972. Latest sheared water mains in Wilberforce Road, Jan 1988 and next to Request stop in High St, March 1988

o. Recorded land movement, post-war: Coastguard 3 m. seaward) Encombe 2 m. seaward) O/S

p. In 1987, 5 months to relay gas mains throughout Encombe Estate

No 160 High St (formerly 2 Hillside Villas
Advance [illegible] £2000 in 1964. (Council loan) } closing order
180 for repairs 1967 } 30.12.69

BACKGROUND TO ENCOMBE DEVELOPMENT

DO YOU KNOW THAT:

1. In 1827, a landslip 500 yards long extended from Encombe House eastwards to the Church. There may well have been earlier landslips of which we have no record.

2. In 1884, a newspaper account of a garden fête held in the beautiful grounds of Encombe, describes the leaning and subsiding state of the uninhabited house: 'Great cracks appear in the walls, the windows are assuming a diamong shape, and the pretty pavement in front of the house has opened up considerably in places... There are many pretty little ponds about the estate for unfortunately the soil is full of springs. We say unfortunately for it is, doubtless, because of the action of water that Encombe is not inhabited...'.

3. In 1893, a major slide took place which involved two thirds of the town of Sandgate and damaged 200 houses. It extended about 920 yards along the coast, reached just over 230 yards inland and involved more than 40 acres of land. (Min of Technology Building Research Station EN 35/65).

4. Nature (March 1893) ascribed the disaster to the geological formation 'which cannot be altered by human agency' and to the 'excessive rainfall and the numerous springs that may be seen along the upper limit of the disturbed area... The liability may be reduced to a minimum by a suitable system of land drainage which shall prevent the access of so large a body of water to so dangerous an area'. The Builder (25 March 1893) also notes that 'water in the subsoil has behaved in an erratic manner, springs becoming dry and so forth'. Note: There is also a possibility that there may be an underground tributary or tributaries from the Enbrook stream at the eastern end of Sandgate. This may have given rise to the name of 'En Combe'.

5. In 1893/94, a 4000 ft long land-drain with five collection points and outfalls to the sea, was laid from Encombe westwards, under the supervision of Baldwin Latham, Engineer to the Sandgate Local Board of Health. The Board had exceeded its borrowing powers and, following legal opinion, the works were funded by consensus, out of the Lord Mayor's Disaster Fund.

   This land-drain helped to stabilise the area for many decades. Both the Folkestone Council Planning Consent 1962 and the Halcrow Report 1967 ignored its existence.

6. In 1925, Encombe House which had been rebuilt in 1912, was entirely remodelled and transformed into a Mediterranean style villa, with bea tiful paved courtyard, well and gardens. In particular, the Water Gardens (see O/S maps) were designed with a series of descending ornamental pools and falls, to channel off surface and spring water. In the 1930's on, the Sandgate Laundry (formerly on site of present Wilberforde car park) drew off 100,000 gallons of water a week, by arrangement with the Encombe owner, until the laundry was burnt down.

7. In 1950, a small cliff fall occurred at the eastern end of Encombe -- said to be caused by surface water discharge from Camp drains above (Halcrow to Abbey National, 1959)

8. In 1951, cracks appeared in Encombe House and terrace walls. In April, existing ½" wide cracks at front of house opened to 1½" wide. Loggia underpinned with 37 ft concrete piles and roof repaired including 2" closing pack at ridge.(Halcrows to Abbey National, 1959)

9. In Feb 1958, the Folkestone and District Water Company overhauled the high-level reservoiron the N.W.height above Encombe (see O/S maps) which since its installation after World War 1 had encountered problems. The following November 1958, however, a serious landslip took place in the cliff face above Encombe. The middle of the reservoir collapsed, causing cracks to open in the floor and walls. The reservoir was abandoned. About the same time, new buildings and a swimming pool at Shorncliffe Camp showed signs of cracking.

10. In 1959, the Abbey National bought Encombe for a staff holiday home, without a survey. Muir Wood of Halcrows told the Chairman he would not only need an umbrella but galoshes as well!

NOTWITHSTANDING the liability to earth movement, flooding and subsidence the Folkestone Borough Council, in an unprecedented act of land-greed and folly, failed to draw attention to the unsuitability of the area and assented to the residential zoning of this area in the Kent Development Plan, (1958) without comment or murmur.

This failure in their duty, carried serious consequences for long-established private and public property and utilities, over a very wide area, besides imposing heavy, ongoing costs to the ratepayer and taxpayer, (Summary of damage, p.2) as will be shown:

11. In April 1962, Town Planning Committee (Folkestone Council) visits Encombe. April 16: Resolved that application for 30 houses and 49 flats in three blocks, and 10 detached bungalows be refused as proposals would a) spoil a unique site by changing its character completely and tend to prejudice stability of site and b) type of houses proposed to be created is unsuited to this setting.
2 Applicants be informed that before any permission is given to develop site, the Corporation will require to be furnished with a report by soil mechanics specialists* as to what steps, if any, are necessary to ensure the stability of any development which may be undertaken on this and adjoining sites and that subject to the furnishing of a report, the Corporation would be willing to consider alternative development which could be undertaken without substantiall altering the ground levels and so that the majority of the trees could be retained, the development prefereably being in small units carefully sited.

12. Despite these stipulations, the whole pattern of natural and artificia land drainage was totally disrupted. Hundreds of tons of earth were shifted around the and the contours of the land were entirely altered. Many fine and mature trees which had bonded the earth and absorbed water, were hacked down in disregard of Tree Preservation orders. Most damaging, the old land-drain system which had provided Sandgate with a measure of stability for 70 years, was doubtless ripped up during bulldozing operations; the ornamental Water Gardens specifically designed to channel off surface and spring water, were totally destroyed. Today, 1988 this water flows unabated down the hillside behind Wilberforce Car Park, and another stream issues at the rear of Wilberforce Green, floods the ground and undermines public and privat property.

13. December 1966: Residents report tremors and cracking up of property at main road level. Cracks apparent on Coastguard terrace, side walls of 162 Sandgate High St and elsewhere; broken gas main outside No.156

Borough Engineer for Folkestone BC issues disclaimer, front page Folkestone Herald '... responsibility of the respective owners to take any necessary action, as no danger to the public'.

* This was an old Report (Halcrow 1960) prepared for Dr. Leader for another purpose

14. In April 1967, Mrs René-Martin writes to Albert Costain, MP, to advise him of the situation in Sandgate: 'The local council have permitted considerable development on the Encombe Estate, and the cutting down of trees on land where there is a known history of landslip and inadequate drainage facilities... roads and pavements have been dug up 8 times since Christmas in order to repair fractured mains and cables...'. MP agrees to accompany her on site visit; notes springs issuing from hillside in area of 'the tip'.

15. 28 May 1969, Mrs René-Martin shows Borough Engineer (Mr T.G.Greening) the streams and quagmire behind Wilberforce Garages (later demolished) in particular the remains of the Encombe Water Gardens, an ornamental and highly effective way of channelling off surface and spring water. This was entirely wrecked by the developers, a consortium of six of the major builders in Folkestone.

16. October 1969, Folkestone Council adopts 1400 ft of roads through Encombe. These have had to undergo constant repair -- see roller-coaste effect today, and fissures in tarmac.

17. In July 1970 Encombe House and grounds (2 acres 30 perches) was offered for auction with detailed consent (5 May 1969) for the conversion of Encombe House into 8 self-contained flats and the erectic of 11 car ports subject to stringent conditions. These included the demolition of the servant's quarters to the west which were badly cracked, and on which the car port was to be erected.
Later, the main building cracked so badly and the front paving sank 2 feet that, if a fire in 1978 had not totally destroyed it, it would have had to be demolished anyway.

UPHILL STRUGGLE AGAINST A DOWNHILL FLOW

In 1967, following the findings of the Aberfan Tribunal, Folkestone Council no longer dared to turn their backs on the Encombe situation. Under continued pressure from residents, led by the late Mr Arthur Gadd, Hon. Solicitor to the Sandgate Society (later President, Kent Federation of Lawyers) Mr A.Todd of Encombe and Mrs L.René-Martin/on the Coastguard Terra the Council called on Halcrows to advise.

In October 1967, Halcrows admitted that 'recent movements in Wilberforce Road and Sandgate High St. clearly indicate that parts of the ground are in a delicate state of equilibrium, and that earthworks carried out by the developers could have given rise to ground displacements and to disturbance which occurred at the Coastguard cottages, but this could not be satisfactorily proved or disproved'. Their report concluded that 'ground movements in the Sandgate area are likely to continue into the future. Some improvement could be achieved by the construction of a drainage scheme designed to intercept and collect water flowing from the cliff face. A limited site investigation consisting of two test borings only, on the hillside was recommended.

In August 1968, work began. In the course of drilling operations, Mrs L.René-Martin sent a telegram to the Mayor 'urgently requesting a thir test boring on public property, as close to toe of slip as possible'. This surely, is normal procedure, unless Folkestone Council had imposed a limited brief, in an attempt to confine the matter to the private sector only, despite the far greater amount of public property at risk -- a matter that in 1988 is at last being recognised. No 1. borehole has since been built over, and No 2 and No 3 (beside John Moore statue) became useless.

In April 1970, the Ministry of Housing and Local Govt. following an inspection of the area, were prepared to consider a Coast Protection

Scheme. They wrote 'Additionally they [the F'stone Council] may also wish to consider methods such as <u>beach feeding</u> to maintain the foreshore in the vicinity of Encombe Estate, 4-5ft above the tops of the piles in order to increase the factor of safety against the slip'.

<u>In August 1977</u>, Mr Greening wrote: 'Halcrows have consistently advised that the high cost of beach feeding is out of proportion to the marginal benefit of additional stability it would provide'.
Nonetheless, the Halcrow 1986 Report shows beach feeding to be the cheapest of three stabilisation methods.' See p.5: '... if the beach were increased and maintained at its 1871 levels, the landslip movement would reduce to a fraction of its present rate and this might be an acceptable solution'.

Shepway Council inherited a rapidly deteriorating situation.

<u>In 1978</u> Halcrows were therefore asked to carry out a well-point scheme.

<u>In 1979</u> Shepway DC wrote 'The Encombe Drainage Scheme has recently been completed and <u>this should reduce the flow of water running down the hill</u>'.

On the contrary, the 1986 Halcrow Report admits that the rate of movement of the landslip was reduced only marginally. 'Much larger quantities of rainfall are entering the landslip than those intercepted by the well-points -- a substantial inflow of water [may be] entering from other locations unknown'.

Halcrows, in an attempt to excuse a 7-year delay and then the failure of their scheme of limited drainage, have cast an <u>unwarranted slur</u> on Encombe residents and their refusal to contribute to costs. (Report p.1)

The onus must lie entirely with the former Folkestone Council who firstly, misrepresented the facts of the case to the Ministry and then misquoted its reply. At no time did the Ministry say, (as quoted) that 'it was reasonable for residents to contribute to the cost'. In any case, the Council made no attempt to even formulate a scheme.

<u>Conclusion</u>: There is no guaranteed method of stabilisation. The proposed 'dowelling' operation may control future rotational movement along the major slip-curve, but will not necessarily prevent -- indeed may even enhance -- local ground movements nearer the surface. This ...tern of local movement is clearly visible over the area of the ...93 landslip. The continued flow of water down the hillside, both ...in and springs, will continue to cause wash-out of large quantities of ...lt, and provoke subsidence beneath roadways, seawall and property ...nerally. New development on the hillside will be equally at risk.

<u>WARNING</u>

It is to be hoped that Shepway Council will heed the lessons of the past, and that very careful limitations be placed on future development of the Encombe House site and grounds.

There is, without a doubt, a much older slip-line to the north of the demolished house, which has never been fully investigated. (A.G.Weekes, Geo-technical engineers, confirm this). The 1883 Encombe sale brochure also points to the existence of many springs, ponds and a lake about the grounds. The present well-point system has generally failed to intercept these.

A WARNING (cont)

Trees: As a result of the recent hurricane, there has been a terrible massacre of trees, especially onthe steep cliff-face. It is surely the responsibility of the landowner to conserve the hillside, maintain healthy trees and shrubs, and replant new ones. This must be included in the planning stipulations.

Stabilisation: Halcrow 1986 proposals for stabilising the area carry no guarantee, and will need at least a decade to prove their worth. Halcrow's efforts to date, to intercept the flow of water (one major cause of movement) have on their own admission been ineffectual. The unceasing flow of water from the hillside will continue to cause wash-out of considerable quantities of fine silt with inevitable subsidence and cracking-up, and this should be tackled first.

Tidal infiltration may have a far greater effect than rainwater infiltration. The gault at the toe of the slip acts like a sponge. It not only exudes water under pressure, but absorbs great quantities of water at high tide. With the enormous drop in beach levels since the 1930's, depth of water at high tide is greater than ever, and can only increase the water table for a considerable distance inland.

Land Drainage on Cheriton (Chunnel) Site: may also have a profound effect. Giving evidence before the Select Committee, Mrs René-Martin warned: 'Earth movement is thought to be associated with changes in beach levels, with surface water flows and, chiefly, with subsoil water whose courses are unknown but which may have their origin in the hills to the north. Indded, this area of Kent is well-known for its streams and wells which suddenly dry up, then reappear ..... Those works could disrupt the natural, seaward flow of spring water (eleven major springs on Cheriton site due north of Encombe) and within a few years, considerable drying-out and subsidence could occur'. In planning future building on the Encombe site, this new factor cannot be ignored.

In view of the deteriorating conditions since the 1969 Encombe House planning consent, the Council should act even more warily. It should also be understood that Halcrows are retained by the Council and therefore their opinions will be suitably hedged in favour of the prevailing policy. Likewise, the developer's geotechnical consultant will seek to show 'as far as practicable' that there will be no adverse consequences directly attributable to building operations. But even if new buildings were to remain stable, there can be no guarantee that the surrounding areas would not be affected. Local residents personally, and the ratepayer and taxpayer generally, have paid dearly for the errors of the past.

LATCHGATE CONDITIONS ARE, OF COURSE, A PRECAUTION BUT THE EFFECTS OF 'NON-NATURAL CAUSES' CAN NEVER BE PROVED BEYOND DOUBT. THOSE WHO SUFFER, AS THEY HAVE SINCE 1966, WILL HAVE NO RECOURSE UNLESS CONSULTANTS BACK THEIR ADVICE WITH INDEMNITIES. OPINIONS ALONE CARRY NO GUARANTEES. LOCAL RESIDENTS, THEREFORE, HAVE NO ALTERNATIVE BUT TO HOLD SHEPWAY DISTRICT COUNCIL LIABLE FOR ANY FURTHER DAMAGE TO PROPERTY CONSEQUENT UPON BUILDING OPERATIONS OR OVERLOADING OF THE SITE.

1988 Application for 22 flats

Own extracts from Act.

88/6.

TOWN & COUNTRY PLANNING ACT 1962

Part III

Section 15.

(3) Provision may be made by a development order for designating the classes of development to which this section applies, and this section shall apply accordingly to any class of development which is for the time being so designated.

Section 18.

(1) Without prejudice to the generality of subsection (1)* of the last preceding section, conditions may be imposed on the grant of planning permission thereunder-

(a) for regulating the development or use of any land under the control of the applicant(.......) or requiring the carrying out of works on any such land, so far as appears to the local planning authority to be expedient for the purposes of or in connection with the development authorised by the permission.

(* which states that the Local Authority are to have regard to provisions of development plan and to any other material considerations)

Section 19.

(4) Every local planning authority shall keep, in such manner as may be prescribed by a development order, a register containing such information as may be so prescribed with respect to applications for planning permission made to that authority, including information as to the manner in which such applications have been dealt with.

(5) Every register kept under the last preceding sub-section shall be available for inspection by the public at all reasonable hours.

Part VI Compensation for Planning Decisions Restricting New Devt. Unexpended balance of established development value.

Section 101

(4) Compensation under this part of the Act shall not be payable in respect of the refusal of permission to develop land, if the reason or one of the reasons stated for the refusal is that the land is unsuitable for the proposed devt. on account of its liability to flooding or to subsidence.

P.T.O

From Leslie Bennett.

88/5

TOWN & COUNTRY PLANNING ACT 1962

Part III Planning Control.

Section 15.

(1) On application for Planning Permission for development of any class to which this section applies -

(a) Shall not be entertained by the Local Planning Authority unless it is accompanied by a copy of a notice of the application, in such form as may be prescribed by a Development Order, and by such evidence as may be so prescribed that the notice has been published in a local newspaper circulating in the locality in which the land to which the Application relates is situated; and

(b) shall not be determined by the L.P.A. before the end of the period of twenty one days beginning with the date appearing from the evidence accompanying the Application to be the date on which the Notice was published as mentioned in the preceding paragraph.

(2) Any such Notice as is mentioned in paragraph (a) of the preceding Sub-section shall (in addition to any other matters required to be contained therein) name a place within the locality where a copy of the Application, and of all plans and other documents submitted therewith, will be open to inspection by the public at all reasonable hours during such period (not to be less than 21 days beginning with the date of publication of the Notice) as may be specified in the Notice.

~~T & C.P.ACT 1962 Section 108 (4)~~ ~~PART VI Claim for compensation to L.P.A. who must pass to Minister of Housing & Local Government See also Section 106.~~

(3) See ~~over~~ attached

MINS. FILE.

Ex 28/5

Highways Committee - 9th November, 1967.

RESOLVED -

(1) That a contribution of an amount equal to the cost specified in the final apportionment of costs in respect of the land belonging to British Railways be made by the Corporation towards the cost of the private street works.

(2) That this Council do, in pursuance of the Highways Act 1959, (Code of 1892), approve the specification, plan, section and estimate of the probable expenses and provisional apportionment of the estimated expenditure among the premises liable to be charged therewith under the Act prepared by the Borough Engineer and now submitted for the private street works to be done with respect to that part of the street known as Risborough Way lying between its junction with Risborough Lane and a point 220 feet on the easterly side thereof.

(3) That the Town Clerk be and is hereby instructed to publish the foregoing resolution and to serve copies thereof in the manner and upon the persons directed by the said Act.

(56) TRUNK ROAD A20 - KILLICK'S CORNER/HILL ROAD - LINK ROAD

Further to minute 122 of the proceedings of this Committee of 15th April, 1965 and minute 23 of the proceedings of this Committee of the 15th June, 1967, the Borough Engineer stated that he had invited tenders for the construction of a link road from Killick's Corner to Hill Road, and submitted 5 tenders for the consideration of the Committee.

RESOLVED - That subject to the approval of the Ministry of Transport (who will bear the whole cost of the work), the tender of Messrs. Walker Bros. (C.E.) Limited, the lowest received, amounting to £106,439.11s.4d. be accepted.

(57) EARTH MOVEMENT AT SANDGATE

X

Further to minute 2 of the proceedings of the Highways Executive Sub-Committee of the 5th July, 1967, the Town Clerk submitted a report by Sir William Halcrow and Partners, previously circulated to members of this Committee, of the result of their investigations concerning the recent earth movement at Sandgate in the vicinity of the western end of Sandgate High Street and Sandgate Esplanade.

The conclusion reached by the consulting engineers was that some improvement could be achieved by the construction of a drainage scheme. They recommended that two test borings be made at an estimated cost of £1,000 to determine the main sources of water and water pressure; if, as a result of this investigation, it was decided that a remedial drainage scheme would provide a measurable improvement of the existing conditions these works would cost approximately £10,000.

The Borough Engineer stated that in reply to his letter to the consultants asking for clarification of certain matters in the report they had stated, inter alia, that in their opinion plots 20, 21 and 22 Encombe would not be unsuitable for building provided the precautions enumerated in their report were observed.

Highways Committee - 9th November, 1967

CONT'D FROM 28/5.

After a full discussion on the implications of the report it was

RESOLVED -

(1) That arrangements be made to inform the developers of the Encombe Estate and owners of property likely to be affected by the earth movements, of the conclusions reached by the Consultant as a result of their investigation.

(2) That the matter be discussed with the Ministry of Housing and Local Government.

(3) That the information contained in the consultants' report be made available to persons interested in the area.

(58) FORELAND AVENUE - YARD AND PREMISES - LETTING

The Borough Engineer submitted a request from the Folkestone Timber and Haulage Company for permission to use part of the yard and premises at Foreland Avenue for the storage of bricks, timber etc.

RESOLVED - That the request be not granted.

(59) SEWER LINING - TRAM ROAD

The Borough Engineer reported on work being carried out to the Canterbury Road sewer and showed photographs of the sewer lining before, during and after completion of the works. He stated that a similar repair was required to 2,000 feet of sewer in Morrison Road and Tram Road. The estimated cost was £10,000.

RESOLVED -

(1) That selected firms be invited to tender for the above work and that, in this connection, the Council be recommended to except the contract for this work from the provisions of Standing Order No. 2 with regard to contracts in so far as it relates to the invitation to tender by public advertisement.

(2) That this matter be referred to the Finance Committee in accordance with Standing Order No. 45.

(60) SHORNCLIFFE ROAD/BEACHBOROUGH ROAD JUNCTION

The Borough Engineer submitted a proposal for improving the junction of Shorncliffe Road and Beachborough Road by removing the centre island and forming a T junction. The section of Shorncliffe Road east of the junction and Beachborough Road would then be the primary road and the section of Shorncliffe Road west of the junction the subsidiary road. He stated that, as this was a Class III County road, approval was required from the Kent County Council, who if they approved the scheme, would bear the majority of the cost, estimated to be £800.

RESOLVED - That the scheme be passed to the Kent County Council for their consideration.

(61) COAST PROTECTION AT SANDGATE

The Borough Engineer reported that on the 4th November, 1967, damage necessitating immediate repair had been caused by rough seas to a 30 feet section of sea wall at Sandgate near Martello Terrace. Together with the Chairman he had inspected the damage and given instructions to a contractor to carry out repairs on a day work basis. Work would be

(1)

MOVEMENT OF LAND AT SANDGATE, FOLKESTONE.

17 3/67. TODD /57/1 (OLD 14)

S/S INTERESTED ITSELF IN FEB. 1967 - See Ex. 57/6/3.

GEOLOGICAL.

Geology of the Country around Canterbury & Folkestone. By Smart, Bisson and Worssam. H.M.Stationery Office 1966. Copy in Folkestone Library.

The Landslip at Sandgate. By J.F.Blake. Nature. London 47, 467-9. 1893. (16th March)

The Landslip at Sandgate. W.Topley. Proceedings of the Geological Association. 13, 40-7. 1893.

Report by G.C.Chapman, sub-district surveyor at Shorncliffe Camp-newspaper cutting dated March 1893 in Folkestone Library-photo copy attached. See Ex 1.E.

Fynmore Album, Folkestone Reference Library. (Note-this album is not available for inspection by the general public as it is in a very frail condition) page 175-Column 1-near top. Quotes Rev. J.D.Glenny remembering a slip on the Encombe carriage drive in 1829 (?). This is of interest in view of the report in the first mentioned publication above that "According to Topley (1893, p44) a slip occurred during 1827 from the church with spire to about the large house (Encombe House) 500 yds to the West" See Ex 12.

CHRONOLOGICAL.

1827 Slip in Sandgate-Church to Encombe.
1829 (?) Slip on Encombe carriage drive.
1884. Cutting dated 21st June. (Fynmore p 254).
"..many little ponds about the estate for... the soil is full of springs...the southern side of the house is evidently subsiding seriously. Great cracks appear in the walls, the windows are assuming a diamond shape and the pretty pavement in front of the house has opened considerably in places. (See Encombe History notes under 1884)
Cutting dated December 6th. (Fynmore 249)
House at Encombe sold as building materials. House to be pulled down and removed. (do.)
1893 March. Landslipfrom Rose Inn to point below the Hospital. Map given in newspaper cutting dated "March 1893" in Folkestone Library. Photo attached. (Ex 1 C)

After 1893- Drainage scheme carried out in Sandgate. (See p3-*)
1958. (6TH NOV.) Landslip behind garage and to West of it, at ~~(or 59)~~ Encombe. Photo Kent Messenger 30.1.59. (EX. 1D) (See Appendix I to Halcrow 1959)

It is believed that it was at this time that a series of "soundings" pipes were sunk in the bank along the North side of the house at Encombe.

1961-63 (?) Raised edge of Encombe estate running East-West along the Esplanade removed and tipped into western end of Encombe's "Water Garden". (See Ord. Survey plan of 1933-North of West end of Wilberforce Road).

1964 (?) "New Road" built, eastwards from Encombe's Carriage way to point near west end of lake.

1966. Evening of 29th October. Part of new road slipped, at junction with Encombe carriage way.
0807 hrs 30th*October-roar of falling bricks heard. Thought to have come from north-west corner of Encombe estate. (* a Sunday morning)
11th December-Dovecot found lying in ruins on the ~~gx~~ ground.(Roughly south-east of W.D.Boundary Stone No.40).

~~xxxx~~.After the new road slip a number of hair cracks appeared in one of the new houses on Encombe estate, indicating that normal "working" of its raft was ~~xx~~ taking place. These cracks have not enlarged themselves Paths etc of concrete ETC around this house and others tilted and moved. At about this time the garages on the site of the old laundry in Wilberforce Road began to break up, some cracking of walls was noticed in the Rose Inn-Coastguard Cottages-Hillside areas, garden walls of Encombe Lodge were showing signs of land movement under them and it was suspected that slight signs of movement could be detected in the Prospect Road area.

SPRINGS OF WATER.

1884 Fynmore-p.254-Cutting dated 21.6.1884, quoted under 1884 above."...the soil is full of springs..."

1893 Folkestone Library-cutting dated 7th March-"...water is trickling down in various directions where the land has moved..."

1963-Summer. Heap of fallen land at foot of 1959 slide behind Encombe garage squelching with water. Ground round childrens' playing place south of heap by the garage very wet. Also the land south of the playing place down across the footpath behind the plot where de Grange's bungalow now stands.

1967 Trickle of water from below Dovecot to clump of bamboos on carriageway, just west of Sir Dudley Bowater's bungalow.(Enters manhole)
Trickle of water in southerly direction from point south of W.D.Boundary Stone No. 39 approx. into back gardens of semi-detached houses north-west of Miss Obee's "West Lawn Cottage".
Two trickles of water running between gate pillars of Encombe, north of junction of New Road.
Trickle of water running onto new road off one of

the building plots, on the north side of the New Road.

George Punnett, caretaker and barman at the Sandgate Mens Club, was for forty years a gardener at Encombe, from about 1924. His duties used to include clearing the drains on the estate, some of the water being piped to the laundry where the garages now stand, in Wilberforce Road. This clearing, it is understood, has not been done for some time. He states that the Water Gardens, a descending series of pools and walks built by Mrs. Phillipson about 1924, were fed with water from five springs in the bank on the north side of the Water Gardens. It is to be presumed that some of these springs were buried when tipping in the Water Garden took place. Trickles of water may now be seen coming out of tipped and slipped earth at the scene of the New Road slip. These trickles run down to the east end of the water garden and were lost until recently a small amount of work was done and some water led into a pipe which passes through the north wall of one of the northerly row of laundry garages, under its floor and out to a drain. There is evidence that a system of land drainage was laid down in Encombe after 1893. *
But ignorance of what has been laid down in Encombe in the past seems to be borne out by the fact that during the building of No.11 Encombe an electric cable was found, and accidentally cut and after the house was finished a drain was found to exist under the house and had to be cut and re-routed. At the start of construction it was understood that the ground was virgin and contained no cables or pipes.

SEWER

The greenish-grey subsoil of Encombe (a mixture of sand and clay?) has theproperty of becoming fluid if "worked" when saturated. In places it exhibits the properties of a quicksand, flowing upwards around an area of pressure, but unlike quicksand, remaining quite dry in appearance.

* For an account of methods used see Fynmore p 178. (Ex 12)

CONCLUSIONS.

7 12/68

The 1893 slide may have been helped by the action of the sea. But it seems inescapable that rain water is the main cause of trouble. So long as the land is not very fully drained anything built solid and rigid will move, sink or crack. Cutting into banks without first inserting sheet piling seems to lead to an inward flow of surrounding earth towards the cutting, leading to disturbance of ground over the surrounding area.

Immediate and inexpensive action of benefit to houses in the Coastguard Cottage area and that to the north of it might be to employ Mr.Punnett to locate, mark and clear the old drains on the Encombe estate. He could then take a surveyor round and have them mapped. Any trickles of water over open ground should be led into pipes to prevent soakage into the ground.

Long term action to protect the whole of Sandgate would doubtless involve numerous borings to ascertain and map the nature of the subsoil and thelevel of water tables, followed by the laying of new drains as necessary. Particular attention might be paid to the land above the Encombe New Road and to the faces of the Water Garden and the tip.

In the absence of any published survey of land conditions at Sandgate and in spite of the construction of the new sea wall the people of Sandgate are entitled in view of the recent movements outlined above to assume that another 1893 may be on the way.

17th March, 1967.

Note. In addition to the Fynmore Album, Folkestone Library have for reference a file on the 1893 landslide.

TODD/76.

EARTH MOVEMENT
SANDGATE

December, 1968

Engineers and Geologists have in the past mentioned various possible mechanisms which alone or in combination might be responsible for earth movements at Sandgate.

(1) The "Paste in the Sandwich" theory in which one particular strata becomes fluid under certain conditions and subject to the laws of Hydraulics. This stratum under pressure from the ground above is squeezed out and escapes through a fault in the sea bed to be carried away by the sea. In this connection it would be interesting to know the source of a pronounced sharp-edged brown streak in the sea close to the shore which may sometimes be seen. It could be due to disturbance of sand on the sea bed by the tide, to muddy effluent from the Military Canal at Hythe or to the extrusion referred to above. Again, in places the ground of Encombe when patted with the foot exhibits the characteristics of a quicksand. This mechanism might be expected to show a relationship between earth movement and tides.

Yes. This is the course. [illegible] 23/3/1986.

The attached graphs with tables of data extracted therefrom and Summary Analysis suggest that such a connection does in fact exist. 20 out of 25 incidents occurred on or near Spring Tides, which are of course accompanied by the lowest tides of the fortnight. In the case of the two main moves of the 1893 slip and probably also in the case of the October 1966 movement, the actual slips took place near low water. The graphs also show that 11 out of 25 incidents took place during dry weather which might suggest that tides are a more important factor in movements than rainfall. The difficulty in compiling accurate records must however be very much kept in mind. Much of the movement needed to break a water main may occur on one occasion and the break itself not occur until some later minor movement proves t-he last straw. But where the figures obtained from the graph are adequate in number and heavily loaded in one direction it may perhaps be permissible to attach some weight to the apparent inference. In other cases curious behaviour of the graph may at least point to useful ideas.

Other points stand out from the Summary Analysis. Of 20 incidents which occurred on or near Spring Tides, 13 were accompanied by rain. Of 5 incidents which occurred away from Spring Tides, 4 occurred on dry days. Of the 14 which occurred on wet days, 13 were on or near Springs. The figures for "Rainfall since same date last month" seem to follow closely the figures for Daily Rainfall, in their relationship to the occurrence of incidents. But there is a suggestion that in the case of the Encombe Crack figures the two sets of figures move in opposite directions. Incidents seem to occur mostly in the Autumn, after the dryer Summer months. But the incidents of June and July in both 1967 and 1968 are curious. And the Autumn spate of movements does seem to be triggered off by heavy rain.

(2) Underground Erosion. Whilst the drain shown on Halcrow's Drawing No.2 to their Report of 16th April, 1959 as "connected through drains of New Garages"was blocked and the water flowed over the floor of the garage and out into the yard where it entered a crack in the ground instead of flowing under the garage floor into a public drain, a large amount of silt was deposited on the floor of the garage.(No.32). The flow of water which deposited such a large amount was surprisingly small and did not appear to vary. All the springs on Encombe and indeed in the whole area of the '93 slip are remarkable in this way-their flow never seems to vary, either after drought or heavy rain.

On 10th December, 1968, after ten days without rain, the flow of water out of the spring on the face of the tip south of Plot 20, Encombe, was measured and found to amount to 2 gallons 3.6333333 in 3mins.38 seconds, or 793 gallons per day. A sample two gallons taken in a clean container from a point about 4 ft below the spring (which has cut no channel in the face of the tip) was

33 gals/hr.
289,445 gals p.a.

allowed to settle for 24 hrs, syphoned off and the sediment collected, dried and weighed. The weight was found to be 0.468 ozs., which amounts to 1.89 tons per annum. ON 14 12/68 TEMP. OF WATER AT POINT OF EXIT WAS 55°F. AMBIENT AIR TEMP. WAS 29.5°F. (AT 16.55 HRS.)

On the same day the rate of flow into the pipe leading from the foot of the Encombe Water Garden into the New Garages was measured and found to be 2 gallons in 1min 47 seconds, or 1615 gallons per day. It is understood that water used to come out of the wall along the foot of the slope bounding the northern edge of the Water Garden in ~~four~~ FIVE places. Some of these now doubtless lie under tipped material and will though not visible contribute towards the difference between the two flow rates quoted. The area at the foot of the Water Garden is wet, with pools of water, and it may perhaps be assumed that owing to soakage not all of the water coming down enters the pipe. Ex. 57/3

The Latham Drain of 1893-94 discharged into the sea through five outfalls. The total discharge from all five amounted to 36000 gallons per day. The average per outfall would therefore be 7200 gallons per day. The present flow through the New Garages drain equals between a quarter and a fifth of this figure and some 4½% of the total discharge from all five outfalls of the 1893 drain. The area of the slip in 1893 amounted according to Latham to "not more than 28 acres" and extended from Wilberforce Road to roughly Helena House, a distance of some 2600 ft or about half a mile. Bearing in mind that substantial flows of ground water are entering the Encombe modern storm water drain outside the Encombe entrance above No.19 and via the drains laid under the new house on Plot 21 it begins to seem likely that the known flow of water in this area roughly equals that which must have flowed through Latham's "Manhole E". With such a large catchment area the balance of the 36000 gallons does not seem an unduly large figure for the rest of the area which lies to the west. The results of the bore holes may show whether there is also deep seated errosion, not now visible and not known to Latham.

Results show depth of water in 2 and to some extent in 3 but NOT in 1. i.e. No water deep under undisturbed ground. in 2 & 3 is all surface or near surface water entering slipped material at top.

COAST PROTECTION, SANDGATE

CASE AGAINST PRIVATE CONTRIBUTIONS

In the following, figures in brackets are page and paragraph references to the relevant portion of the report, or to Ministry of Housing & Local Government Circular 41/62.

1. There have been two slips in Sandgate before, one very serious slip in 1893 being accepted by the Sandgate Board of Health as public responsibility. (1/1. 1/2.)

2. The Sandgate Board of Health took the necessary remedial measures in their official capacity and paid for them out of public money. (2/8.2/9.3/7.)(2/6.2/13.)

3. Sandgate Local Board, Sandgate U.D.C. and Folkestone Corporation neglected the drain. (4/2.4/6.6/4.)(6/6.)

4. Before development commenced in 1963 Folkestone Corporation accepted an unsuitable engineers report. (7/12.8/1.8/4.)

5. This unsuitable report was then ignored, disobeyed and suppressed. (9/2.9/3.)

6. Folkestone Corporation allowed unwise removal of 8000 tons of earth from toe of slip and its dumping in the worst place at the rear of the slip over an important pair of Latham's drains. (9/6.)

7. Folkestone Corporation say in 1968 that repair of the drain is vital. (12/1.)

8. Knowing of the importance of Latham's drain and being responsible for it as public property as successors to Sandgate U.D.C. Folkestone Corporation fail to enter it on the Land Charges Register as a maintenance charge on purchasers of land thus rendering any such proposed charge invalid and admitting that its maintenence was their own responsibility. (12/1.)

9. Folkestone Corporation's contention that a NEW drain is required is incorrect. Halcrows have stated that only a renewal of a perfectly satisfactory drain is required.(11/4.)

10. A Coast Protection Scheme is appropriate as

    (i) Movement has been conclusively proved to be directly linked to tides. (13/10.14/1.14/3.)

    (ii) Movement has been proved to be occurring near the sea wall. (14/4.14/5.14/6.) 134/1

11. Turning to Ministry of Housing & Local Government Circular No.41/62 of 20th August, 1962, neither owners of houses on Encombe nor, of course, owners of older houses in the Village are in any sense a large entity such as is envisaged in para. five. They are all in fact precisely those single individual householders specifically labelled "private interests" in paragraph two and as such NOT to be made the subject of Works Schemes for the purpose of recovering compulsory contributions.

Note. The tidal link suggests that the present sea defences are inadequate and that insufficient account of local landslip geology may have been taken in their design.

P.T.O.

12. Conditions attached to grants of Planning Permissions in respect of Latchgate, Sunnyside Road (Ex.129/1, 2 & 3)(Mins) ⊗ and two areas in the Undercliff (Ex.130)(Mins) show beyond doubt that the Corporation consider the land between Latchgate in the west and Gough Road in the east as bad. This includes two thirds of Sandgate and roughly coincides with the 1827 and 1893 slip areas taken together. The length of coast line involved is 3250 feet, over 6/10ths of a mile. Clearly therefore the Corporation do not consider Encombe to be the only area affected nor do they blame the Encombe development for the state of the ground outside Encombe. They cannot therefore maintain that the state of the ground within Encombe is the result of the development. Although the unwise conduct of the development which they permitted may have made conditions worse than they otherwise would have been, there is no escaping the fact that Latham's drain is all that stands between Sandgate and another 1893 whenever the tidal and rainfall conditions are right, and that the root cause is the bad nature of the ground. The cure for this is a Coast Protection Scheme for the whole of the 1827 and 1893 slip areas. Such a scheme would be a perfectly normal Coast Protection Scheme and paragraph 2 of Ministry of Housing & Local Government Circular No.41/62 of 20th August, 1962 would apply.

Para 12 read by Costain 18/9/70
"You have a point here"

⊗ & West Lawn (Mins. 2/10/68 - T.P App 6/61/119B)

HIGHWAYS AND WATCH COMMITTEE

Borough of Folkestone) in the) County of Kent)	At a meeting of the Highways and Watch Committee held at the Civic Centre on Monday, 15th July, 1968, at 4 o'clock in the afternoon.

PRESENT:- Councillor Lamb in the Chair, the Mayor, Aldermen Hamer, Harris and Moody, Councillors Barnes and Ellender.

(31) EARTH MOVEMENT AT SANDGATE

The Town Clerk submitted his report following the meeting with representatives of the Sandgate Society and owners of property in the Encombe area held on 8th July, 1968, in accordance with minute 8 of the proceedings of this Committee of the 18th June, 1968.

The report referred to the history of earth movement in the Sandgate area, including the laying of a land drain in land north of Sandgate High Street and the Esplanade, following the 1893 landslip. There were no means of knowing whether this drain, which was linked by five lateral drains running to the beach, had been maintained, but it was probable that, due to land movement, the drain was not continuous in its entire length.

Although the Council had no powers to maintain and repair land drains on private property, they had regularly inspected the manholes in the lateral drains to see that surface water was running.

Since 1893, there had been a number of minor slips in the area and for several years, Sir William Halcrow & Partners, Consulting Engineers and soil experts, had advised the owners on remedial measures.

In recent years, houses and bungalows had been erected on the Encombe site, following advice which the developers had received from the Engineering Consultants and which had been submitted to the Council. Having regard to the report, the Town Planning Committee had no reason to refuse planning permission for the development.

About a year ago, there had been a slip on the Encombe site. Although the Borough Council had no legal liability for any damage, they had considered that, as a responsible authority, they ought to seek the advice of Messrs. Halcrows in the matter. (This decision had been taken by the Highways Executive Sub-Committee in July, 1967). Messrs. Halcrows' report was received in October, 1967, and suggested that it would probably be necessary to carry out a drainage scheme for the purpose of removing the pressure of water in the disturbed area at Encombe. The consultants suggested that, in order to design a suitable drainage scheme, it would be desirable first to carry out a limited soil investigation in the area by putting down two borings in the Encombe area. The estimated cost of the borings would amount to approximately £1,000. If, as a result of the investigation, it was concluded that the drainage scheme was necessary, then these remedial works would cost approximately £10,000.

The Borough Council had very limited land drainage powers and had no power to carry out the suggested land drainage scheme. It appeared, however, to the Town Clerk that, under section 30 of the Land Drainage Act, 1961, the Kent County Council or the Kent River Authority might have power to carry out such a scheme. Following lengthy correspondence with the Kent County Council, the Kent River Authority, the Ministry of Housing and Local Government and the Ministry of Agriculture, Fisheries and Food, it appeared that such a scheme might be made by the River Authority and considered by the latter Ministry. Consultations had accordingly taken place with the Clerk and Engineer to the Kent River Authority. If such a scheme were made, it would have to be confirmed by the Ministry of Agriculture, Fisheries and Food and it would (inter alia) require the owners of the lands benefitted by such scheme to contribute to the cost of the works and their subsequent maintenance. There were rights to object to the scheme and the Minister had power to hold a Public Inquiry.

An important point made by the Ministry of Agriculture was that they were very doubtful whether the cost of the exploratory borings could be included as part of the expenses of any drainage works.

Members of the Kent River Authority had considered the matter and were of opinion that further consideration could not be given until the investigations proposed by Messrs. Halcrows had been undertaken.

The Committee, at their meeting on the 18th June last, had been anxious that the whole of the facts should be put before the representatives of the Sandgate Society and the owners in the area. The meeting held on the 8th July had been well attended and there had been a full and frank discussion of all points of view. The point was forcefully made by representatives of the Sandgate Society and the owners that, until the exploratory borings had been carried out, it would not be possible to say whether or not a drainage scheme would be necessary and if so, what the cost would be. They therefore felt that the borings should be carried out as early as possible and they asked that the Council should bear the cost of these borings estimated by Messrs. Halcrows at £1,000.

The Mayor, who had presided over the meeting, with Alderman Hamer, Councillors Lamb, Bushell, Cook and Barnes, agreed to recommend to the Council that the Council should bear the cost of these exploratory borings, so that Messrs. Halcrows could then report on the necessity for any drainage improvement works and their extent. It had also been agreed that, should the Council approve the proposal, a further meeting of the Sandgate Society and owners would be called to consider the Consultants' report on the result of the site investigations.

Members of the Finance Committee were present at the discussions which took place on the report. There was a strong feeling that, if the proposal were approved, and the report of Messrs. Halcrows recommended a drainage scheme, it was vital for the Council to encourage the appropriate body to make such a scheme in the interests of improving the stability of the land in the area.

RESOLVED -

(1) That a limited soil investigation in the Encombe area by putting down two borings as recommended by Sir William Halcrow & Partners be carried out under their supervision at the expense of the Council and that they be requested to report to the Council on any drainage improvement works which they consider are necessary to improve the stability of the land in the Encombe area.

(2) That the Town Clerk be authorised to take all steps necessary in the matter.

(3) That the matter be referred to the Finance and Establishment Committee under Standing Order 45.

(32) INSHORE RESCUE BOAT

The Borough Engineer reported that the engine of the inshore rescue boat had been immersed recently during a rescue operation and required replacement. The service was being maintained in part with a hired vessel at £2 per day which was too small to be entirely satisfactory for the purpose. A new engine for the rescue boat would cost about £450.

RESOLVED - That, in the absence of an alternative, the service be maintained as effectively as possible with the hired boat for the remainder of the season and that the provision of a new engine be considered at a later meeting of this Committee.

FINANCE AND ESTABLISHMENT COMMITTEE

Borough of Folkestone in the County of Kent) At a meeting of the Finance and Establishment Committee held on Monday, 15th July, 1968, at the Civic Centre at 4.30 o'clock in the afternoon.

PRESENT:- Councillor Cook in the Chair, the Mayor, Aldermen Brown, Franks and Hamer, Councillors Bushell, Furneaux, Johnson, Lamb and Setterfield.

(33) EARTH MOVEMENT AT SANDGATE

The Town Clerk submitted minute No.31 of the proceedings of today's meeting of the Highways and Watch Committee for consideration. The minute recommended that Sir William Halcrow and Partners be requested to carry out a limited soil investigation by means of two borings in the Encombe area and to report their findings and recommendations. The borings would involve the Council in the expenditure of approximately £1,000.

RESOLVED - That the recommendations of the Highways and Watch Committee be approved, that the necessary expenditure be incurred in accordance with Section 6 of the Local Government (Financial Provisions) Act 1963, and that a supplementary estimate in the sum of £1,000 be approved.

(34) LOAN

RESOLVED - That application be made to the Minister of Housing and Local Government for consent to borrow the sum of £3,000, being on account of the Council's proposed contribution towards the cost of the Folkestone and District Sports Centre and required to meet professional fees to be incurred in connection with the preparation of working drawings, specification and bills of quantities etc.

HIGHWAYS AND WATCH COMMITTEE

Borough of Folkestone) At a meeting of the Highways and Watch Committee
in the) held at the Civic Centre on Tuesday, 30th December,
County of Kent) 1969 at 7 o'clock in the afternoon.

PRESENT:- Alderman Hamer in the Chair, the Mayor, Alderman Moody, Councillors Barnes, Hollis, Morgan, (Mrs.), Moore, Reader-Moore and Revell.

(78) MINUTES

The minutes of the proceedings of the meeting of this Committee of the 18th November, 1969 were now submitted and signed.

(79) DECISIONS OF MAYOR, CHAIRMAN AND VICE-CHAIRMAN

The Town Clerk submitted decisions made by the Mayor, Chairman and Vice-Chairman of 18th November, 21st November and 15th December, 1969, details of which are printed in the appendix to these proceedings. (These decisions are printed for information only as the Mayor, Chairman and Vice-Chairman have been authorised by the Council to deal with the matters reported).

(80) 158 SANDGATE HIGH STREET

The Town Clerk referred to minute 1(a) of the proceedings of the Health and Housing Executive Committee of the 5th July, 1968 and reminded the Committee that because of danger to the family, the Council had provided alternative accommodation for the owner occupier, his wife and four children.

The Borough Engineer and the Chief Public Health Inspector reported that dry rot was now rampant in the timbers of the property and was affecting the timbers of No. 160 Sandgate High Street and the Borough Engineer confirmed that the property was now in such a condition as to be dangerous.

RESOLVED -

(1) That it appears to the Folkestone Borough Council as the local authority that the building No. 158 Sandgate High Street is in such a condition as to be dangerous.

(2) That application be made to the Justices for an Order under Section 58(1) of the Public Health Act, 1936 as amended by the Public Health Act, 1961 requiring the owner to execute such work as may be necessary to obviate the danger within a period of twenty-eight days or if he so elects, to demolish the building within a like period and remove any rubbish resulting from the demolition.

(3) That in the event of the said Order being made by the Justices, a notice be served upon the owner as the person undertaking the demolition of the building under Section 29(5) of the Public Health Act, 1961 requiring him to take the following action:-

(a) to shore up adjacent buildings
(b) to weatherproof any surfaces of any adjacent buildings which are exposed by the demolition
(c) to remove material or rubbish resulting from the demolition and clearance of the site
(d) to disconnect and seal, any such points as the Surveyor to the Council may reasonably require, any sewer, drain or water pipe in or under the building to be demolished
(e) to make good, to the satisfaction of the local authority, the surface of the ground disturbed by anything done under paragraph (d) above.

E.

(4) That if the owner fails to comply with an Order of the Justices made as a consequence of the application under the preceding resolution (2) requiring him to demolish the building within the time therein specified and with the notice served on him in accordance with the preceding resolution (3), the Council shall execute the Order by the demolition of the building and shall execute the works of shoring up, weatherproofing, removal of materials, rubbish, disconnecting and sealing of drains and making good, as required by the notice served under Section 29 of the Public Health Act, 1961 in accordance with the provisions of Section 290 of the Public Health Act, 1936 and shall recover the expenses necessarily incurred by them in so doing from the said owner.

(81) WEIGHTS AND MEASURES ACT, SHOPS ACT ETC. - CHIEF INSPECTOR'S PERIODICAL REPORT

The Chief Inspector of Weights and Measures submitted his report, previously circulated to members of this Committee, of duties undertaken during the period 1st-30th November, 1969.

RESOLVED - That the report of the Chief Inspector of Weights and Measures be received.

(82) ROAD AGREEMENTS - SECTION 40, HIGHWAYS ACT, 1959

(a) Cul-de-Sac East of Park Farm Road

The Town Clerk submitted letter dated 9th December, 1969 from Messrs. Smith-Woolley & Perry, Agents for the Earl of Radnor, requesting an extension of twelve months to the time limit embodied in the Section 40, Highways Act, 1959 Agreement in respect of the cul-de-sac on the eastern side of Park Farm Road.

RESOLVED - That the request be granted.

(b) Castle Bay, Alder Road, Enbrook Valley Stage V

The Town Clerk reported that the Developers of estates at Castle Bay, Alder Road and Stage V Enbrook Valley had requested that agreements in accordance with Section 40, Highways Act, 1959 be entered into in respect of the roads serving these estates. Because of the time factor involved, the Chairman had given authority to enter into these agreements.

RESOLVED - That the Chairman's action be approved.

(c) Delegation of Authority

The Town Clerk requested that consideration be given to the delegation of authority to the Mayor, Chairman and Vice-Chairman in respect of road agreements.

RESOLVED - That the Mayor, Chairman and Vice-Chairman be empowered to authorise agreements to be entered into under Section 40 of the Highways Act, 1959 in respect of roads within the Borough.

(83) MOBILITY FOR THE DISABLED

The Town Clerk submitted letter dated December, 1969 addressed to the Mayor from the Chairman of the Joint Committee of Service and Ex-Service Organisations stating that they were becoming increasingly concerned about the growing problem of the disabled in using the amenities commonly to be found in town centres. He also stated that a number of expedients

COPY.

Sir William Halcrow & Partners
Consulting Engineers.

Stanhope House,
47, Park Lane,
Westminster,
London. W.1.

9th October, 1967.

Our Ref. AMMW/BB

H.W. Castle Esq., O.B.E., M.I.Mun.E.,
Borough Engineer & Surveyor,
Borough of Folkestone,
The Civic Centre,
Folkestone,
Kent.

Dear Sir,

Encombe Estate Development, Sandgate.

We refer to your letter dated 10th July, 1967 requesting our opinion of the ground movements in the Sandgate area with particular reference to the Encombe Estate Development, and to your letter dated 15th August requesting our views on the Developer's surface water drainage proposals for the Estate Plots nos. 20 to 22.

As reported to you during the discussions held in your office on 26th September we inspected the site on 10th July and 26th September and we now wish to submit our preliminary report on the matters you have asked us to investigate.

GEOLOGY OF THE AREA.

As you know, we were retained by the Abbey National Building Society some years ago to advise on the ground movements affecting Encombe House and our Conclusions and recommendations are given in our report dated 16th April, 1959, to the Society.

As explained in that report the geological succession at the site comprises the following series:

(1) Folkestone Beds. - Sand and blocky sandstone forming the cliff face at the rear of Encombe House. This stratum rests on;

(2) Sandgate Beds. - Alternating discontinuous bands of clayey sand and clay. The Encombe House terrace is beleived to represent the upper horizon of these beds, which overly;

(3) Hythe Beds. - Alternate bands of limestone and clayey sand. There is no exposure of this series at the site except on the foreshore where these beds outcrop as a result of displacements caused by old landslides; the upper horizon of the stratum is believed to lie at a level of approximately 20-ft. O.D.

Continued/........

(4) Atherfield Clay, underlying the Hythebeds, comprise bands of clay and silty sand with an upper horizon at approximately - 25ft. O.D.

These beds are subdivisions of the Lower Greensand series; the strata dip at a slope of 1 in/ 135 in/ a north easterly direction. However, it is thought that faults along this section of the coast have caused discontinuities in the alignment of the strata

The beds are covered to a large extent by overburden and in the absence of borehole information, the exact positions and depths of the strata are not known.

The Water Table.

It is evident that the Folkestone beds lying above Encombe House are waterbearing; the phreatic level is believed to be affected significantly by the intensity of rainfall.

It is likely that the underlying Sandgate Beds and also the Hythe Beds (to a greater extent) are also waterbearing, but in the absence of borings it is not known if the water is under artesian head. We have consulted the Institute of Geological Sciences on this point and they are, at present, examining their records of the area for evidence of deep lying aquifers under artesian pressure.

It is believed that the Atherfield clay is relatively impermeable.

HISTORY OF GROUND MOVEMNETS IN THE SANDGATE AREA.

The Sandgate area has been subject to erosion and landslides for many centuries; the area has been relatively stable in recent times probably as a consequence of the protection provided, to the toe of the zone of sliding, by the sea defence works.

The last major movement occurred in 1893 when an extensive landslide caused a half-mile length of the undercliff to move 7 to 10ft. vertically downwards and the ground at the toe of the slide was forced 4-ft. upwards through the seabed slightly below the Low Spring Tide Mark.

The approximate boundary line of this major shearing movement is shown on the drawing accompanying this report. A more detailed account of this collapse and the subsequent ground movements is given in our report dated 16th April, 1959, a copy of which we believe you have.

In 1948, slip plane cracks appeared in Prospect Road and were, at that time, thought to be associated with a washout of the seawall. A minor slip of the undercliff occurred in 1950 and a year later Encombe House developed an extensive series of cracks and the pergola and secret staircase on the west side of the house collapsed. Following minor ground movements in 1954 which caused the fracture of a sewer, a substantial cliff fall behind the annexe to the house occurred in 1958. The remedial measures which were taken at that time on our advice appear to have proved satisfactory.

In our Report dated 16th April 1959 we expressed the view that minor ground movements would continue to occur in this disturbed area and our recent inspections of the site has provided further evidence of continuing ground displacements.

The greatest differential movements occur at the boundary of the 1893 slip as evidenced by the discontinuities in the level of the Encombe House drive adjacent to plot No. 19 and the substantial cracks in the brick walls adjoining Wilberforce Road. At the junction of The Esplanade and the drive to Encombe House there are

Continued/........

signs of minor displacements to the sea wall and evidence of ground disturbance in the Coastguard Cottages at the foot of Wilberforce Road.

Several of the relatively new garages in Wilberforce Road are in a very poor condition caused by the undermining of the foundations, which has caused their failure; in some cases the walls are in danger of collapse and appear to owe their present stability to the support provided by the roof purlins. Uncontrolled ground water drainage in this area appears to have caused or contributed to this serious deterioration. Sand-laden ground water has caused the deposition of a notable quantity of saturated sand in the upper row of garages. (The extent of the damage caused to these garages would probably have been considerably reduced if reinforced concrete foundations had been provided).

We have written to the Director of the Ordnance Survey and requested that he makes available to us data recording the recent movement of the several bench Marks in the Sandgate area.

Causes of present ground movements.

The present ground movements appear to be mainly due to a continuation of the naturally slow settling down of the ground disturbed by the major slip in 1893. In addition to the main plane of sliding, whose position at the ground surface is shown on the attached plan, numerous secondary planes of shearing movements are likely to have occurred within the soil mass which moved. Open cracks may be present in cohesive soild and sandy materials would have tended to bulk, that is, the soil mass would have increased in volume and would therefore be susceptible to gradual self compaction under its own weight aided or aggravated by the percolation of ground water.

The ground disturbance would also have resulted in a reduction of the support given to the undisturbed soil behind the landslide and this undisturbed ground would therefore tend to relax gradually causing relatively minor settlement of the ground above.

The above hypothesis might explain why the major relative movements occur in the disturbed area adjoining the plane of sliding at the back of the slipped zone, as here the depth of disturbed ground is greatest.

In an area susceptible to natural ground movements earthworks require careful planning to avoid disrupting the equilibrium of the ground and its drainage. At this stage it is not possible to state definitely whether the damage caused to the surface water drainage system and the recent ground movements north of the new garages were a consequence of the Developer Operations or the result of natural agencies.

The effect of ground water is important as it is believed to accelerate or aggravate the process described above. As far as it is possible to assess the mechanism from a walk over inspection of the site it appears likely that the main source of water lies in the Folkestone Beds which/ the cliff/ form face inland from Encombe House. Water flowing from these beds and percolating into the disturbed ground at the back of the slip, giving rise to the development of high pressure, could cause unstable conditions of the undercliff area.

Water under pressure within the underlying Sandgate and Hythe Beds could also contribute in a similar manner to these unstable conditions. As noted above, in the absence of borehole evidence, we have asked the Institute of Geological Sciences for information about the aquifers in these strata.

Continued/........

Some information concerning the strength of the subsoil and the levels of the strata is available as a result of the borings put down by Soil Mechanics Ltd., in connection with the Castle Bay Estate development (see attached plan). It would not, however, be meaningful to make use of this data in order to assess the overall stability of the ground in the Encombe Estate, but these boreholes generally confirm the assumed shape of the deep slip planes.

The factor of safety against sliding at the time of the 1893 landslide would have been unity and because of the kinetic componet of the movement the overall factor of safety after the slide came to rest would have been greater than unity. Subsequent deterioration could have caused a reduction of this factor. If we assume, solely for the purpose of a comparative estimate, that the undercliff area is now in a state of incipient failure when the water table is at ground level, then the shear strength mobilised along the old plane of sliding in the Atherfield clay would be approximately 600 lb/ft^2. We have calculated that if the ground water table was drawn down 10-ft. below ground level then the shear strength along the old sliding plan would be reduced from 800 lb./ft. to 700 lb./ft. That is, the factor of safety would be increased from unity to 1.14. This, in our opinion, would represent a very satisfactory improvement.

DRAINAGE IMPROVEMENT WORKS.

From the above remarks it will be clear that we consider ground water to have an important effect on the movements which are taking place at the present time. If this is proved to be the case, then by controlling the ground water an improvement would logically result.

If the main source of water lies in the Sandgate and Hythe beds it would probably be necessary to sink wells into this aquifer in order to reduce this pressure. It should be pointed out however, that although a reduction in the water table in the ground below Encombe House would retard the ground movements in the disturbed undercliff area, some settlement of Encombe House would result.

If the main source of water lies in the Folkestone Beds then the water seeping from these cliffs could be intercepted by a garland rubble filled drain positioned along the terrace at the foot of the cliff and connected into the existing road drainage system. The connections between the interceptor drain and the road drains would pass through the boundary between disturbed and undisturbed ground and would therefore have to be designed to accommodate the continuing vertical and horizontal ground movements to be expected at this boundary.

As the level of the water table in the Folkestone Beds is sensitive to variations in the intensity of rainfall it would probably be necessary to supplement the interceptor drain by thrust boring into the base of the Folkestone Beds. The purpose of these borings would be to draw down the level of the water table some distance behind the cliff face to reduce the development of springs at the foot of the cliff during periods of high rainfall and consequently reduce the risk of piping which leads to sand runs and cliff instability. Headings driven into the cliff face would provide a similar improvement but would be more costly to construct.

To be effective, such a system would have to be installed from Plot 23 to the west side of Encombe House. In the eastern zone of the unstable area the main drainage scheme may not reduce the water levels sufficiently. It may therefore prove to be necessary to construct a supplementary drainage system to intercept and collect storm water at present percolating into the garages in Wilberforce Road.

Continued/........

Estimate of Cost of Drainage Improvement Works.

In order to design a suitable drainage scheme it would be desirable, firstly, to carry out a limited soil investigation in the area. The purpose of the soil investigation would be to determine the main sources of water and the water pressure acting on the back of the old landslide. The borings would also provide positive information concerning the levels of the boundaries between the strata and the strength of the soil.

The above information could be obtained by putting down two borings, one from the terrace at the foot of the cliff face which lies behind Encombe House and the second from the terrace below Encombe House. The first boring would be carried into the Hythe beds and the second shallower boring would be put down to a level below the base of the 1893 landslide. Piezometers would be installed in both borings so that a record of the variation of the ground water levels could be made.

We estimate that the cost of these two borings would amount to approximately £1,000.

If, as a result of this invetigation, it was concluded that an interceptor drain constructed along the foot of the cliff behind Encombe House, supplemented by thrust boring at selected points, would provide a measurable improvement of the existing conditions, then these remedial works would cost approximately £10,000.

Drainage of Plots 20, 21 and 22.

We have, as requested, examined the Developer's proposals for the drainage of plots 20, 21 and 22. Although, in principle, a herring bone system of drainage should prove satisfactory, we hold the view that an interceptor drain constructed along the foot of the cliff behind these plots would be more practible and cost less. This drain could be integrated with the main system of drainage described in the paragraph above. The herring-bone drains would require special care in design under the house foundations.

Although we have not been asked to comment on the type of house foundations which should be adopted in this disturbed area it will be evident, from the remarks made above about the Wilberforce Road Garages, that it would be judicious to make use of properly designed reinforced concrete rafts taking due account of the relative stiffness of the brick superstructure,

Conclusions and Recommendations.

In our opinion the ground movements in the Sandgate area are likely to continue in the future. Some improvement could be achieved by the construction of a drainage scheme designed to intercept and collect the water flowing from the cliff face which passes behind Encombe House. However, before deciding on a particular scheme, we would recommend that a limited site investigation of the type described in this report should first be carried out.

We hope that the above remarks have covered adequately the various matters you have asked us to investigate and report upon. If there are any aspects on which you would wish to have our further views we would be very pleased to deal with these on hearing from you.

We shall look forward with interest to learning from you the Borough Council's decision.

Yours faithfully,

(signed) SIR WILLIAM HALCROW & PARTNERS.

COPY.

SIR WILLIAM HALCROW & PARTNERS
Consulting Engineers.

Stanhope House,
47, Park Lane,
Westminster,
London. W.1,

23rd October, 1967.

N.W. Castle Esq., O.B.E., M.I.Mun.E.,
Borough Engineer & Surveyor,
The Civil Centre,
FOLKESTONE,
Kent.

Dear Sir,

ENCOMBE ESTATE DEVELOPMENT, SANDGATE

Thank you for your letter dated 13th October, asking us to clarify certain matters arising from our report dated 9th October, on the recent ground disturbances at Encombe, Sandgate.

We should like to comment as follows.

In our opinion, when considering the stability of slopes in natural cohesive soils, particularly in those cases where there is evidence of ground movements and in the absence of data concerning the soil strength parameters, the only reliable assumption that can safely be made, is that the ground is in a state of incipient failure, that is, the factor of safety against failure is unity.

The recent movements in Wilberforce Road and Sandgate High Street clearly indicate that parts of the ground are in a delicate state of equilibrium. It is possible therefore that the movement of earth from one point to another caused local changes in this state of equilibrium, ~~(It is possible therefore that the movement of earth from one point to another caused local changes in this state)~~ and gave rise to local ground disturbances. However, it would not now be possible, in our opinion, to state definitely whether the earthworks carried out by the developers did, or did not, give rise to ground displacements, It is possible that these works did contribute to the ground disturbance which occurred at the Coastguard Cottages, but this could not be satisfactorily proved or disproved. It could be coincidental that the ground movements happened at the same time as the developers' activities, but the evidence points towards a relationship even if it cannot be proved.

The supplementary drainage system if it were found necessary would probably be provided at the foot of the steep slope in the old kitchen garden of the Encombe Estate.

In our opinion, Plots 20, 21 and 22 would not be unsuitable for building, provided the precautions enumerated in our report are observed.

We hope that the above observations serve to clarify the points which you have asked us to comment, but should there be any aspect which requires further clarification we should be pleased to deal with it on hearing from you.

Yours faithfully,
(signed) SIR WILLIAM HALCROW & PARTNERS

COPY.

SIR WILLIAM HALCROW & PARTNERS
Consulting Engineers.

Stanhope House,
47, Park Lane,
Westminster,
London. W.1,

30th November, 1967.

N.W. Castle Esq., O.B.E., M.I.Mun.E.,
Borough Engineer & Surveyor,
Borough of Folkestone,
The Civic Centre,
Folkestone,
Kent.

Dear Sir,

ENCOMBE ESTATE DEVELOPMENT, SANDGATE.

You will recall from our Report dated 9th October, on the ground movements occurring at Encombe, Sandgate, that we requested the Institute of Geological Sciences to make available to us information they have concerning water levels in the various strata underlying Sandgate.

We visited the Institute, at their request, on 21st November, to examine the data they had kindly extracted from their records. The data is naturally to a large scale but generally confirms the assumptions we have made regarding the sources of water.

These records show that the strata generally dips in a north easterly direction, but is complicated in the Sandgate area by a local synclinal fold. Although the Sandgate Beds are relatively impermeable they are known to be water bearing in some localities. The Hythe Beds are pinched out to the North East and are believed to be under sub-artesian pressure in the Sandgate area.

This information confirms our view that any site investigation at Sandgate to explore the mechanism causing the ground movements should include a deep borehole to measure the water levels in the Hythe Beds.

Yours faithfully,

(signed) SIR WILLIAM HALCROW & PARTNERS