

## Chapter 32

### SOME SEA DEFENCE WORKS IN ENGLAND

C. H. DOBBIE

Consulting Engineer  
Westminster, London, S.W.1.

The tidal flood of Jan.-Feb. 1953, which caused much damage to the east and south-east coasts of England, was investigated by numerous Authorities, including the Government Waverley Committee.(1) The report of this last body has resulted in further alterations of methods of financing sea defence works. A fundamental alteration in the basic conception for design of sea walls has also taken place. Instead of attempting to build to extreme heights to exclude tidal flooding, it is now usual to allow for a certain degree of overtopping during top flood conditions. The systems of legislation, administration and finance, now brought up to modern standards, are set out with some reference to their histories. Factors affecting design heights of sea walls are enumerated. A type of revetment developed in England, and much used in the works constructed following the floods is described.

#### ADMINISTRATION OF SEA DEFENCES

Sea defence work, inevitably a community enterprise, can only be carried out before a background of proper legislation and administration. The background has interest and importance in itself, naturally, but to engineers employed in coastal work it is more likely to be regarded as a means to an end. In England and Wales sea defence administration is now divided between two groups of Local Authorities under the general supervision of two Government Departments. The first group consists of Drainage Authorities for low lying, reclaimed lands who have always protected their shores. Some of these Drainage Authorities are of great antiquity. The second group consists of Municipal, Urban and Rural Authorities whose activities on the coast are much more recent.

Originally the Drainage Authorities were rooted in a semi-feudal community whose life was almost entirely local in character. As conditions slowly changed, so did the Drainage Authorities evolve. So sure and strong were their traditions that they persisted right through the Industrial Revolution almost unchanged. Although outmoded by a century or so they survived intact until 1930 and some until 1950. The earliest Authority recorded is that of Romney Marsh in Kent, where, in 1245, procedure could already be defined as by ancient law and custom. In general, jurisdiction of these Authorities derived from a Commission issued by Henry III (1216-1272). Further Commissions followed and are traced by Dugdale.(2) A Statute of 1427 advanced their status, and in 1531 a Bill of Sewers gave permanence to their being and remained the basis of all legislation until 1930.

Although the powers conferred by statute were vague and ill defined, the importance of the tasks fulfilled by the Commissioners led them to assume very real authority with or without genuine legal basis. The larger estates, as the greatest payers of scots or rates, obviously had much influence in determining policy and usually a constructive outlook was accepted as part of their heritage. These estates were represented by agents or baillifs who joined the tenant farmers to form the Drainage Boards or Commissions. Much good work was done, especially with clay walls. As early as Henry VII (1485-1509) Romney Marsh was installing groynes. Works were inspected on foot by the Commission at regular intervals, and the inspection was followed by a dinner where grievances were settled. Sidney Webb (3) in his monumental studies of Local Government has traced the origin of the London County Council to a Commission administering the marshes adjoining the Thames. The Commissions adapted themselves to the slow changes of rural life, but when new ways of life rapidly followed the opening up of communications and the vast expansion of industry, their basic, archaic, and very local structure became a handicap in attempting to cope with new finances and with technical developments. In 1930, by the Land Drainage Act, Catchment Boards were set up principally for arterial land drainage. These new Boards carried out many sea defence works. By the River Board Act of 1948 the whole of England was covered by a number of River Boards, new omnibus Authorities responsible for sea defences of low lying lands, for land drainage and for pollution of rivers. This is again a step forward, although there is an early tendency to exaggerate in importance the somewhat negative subject of river pollution as against the highly technical and administratively untidy subject of sea defence, calling as it does for unceasing positive action and unpredictable expenditure.

The second group of Authorities comprises mainly the seaside towns. These towns have grown up rapidly in the last 200 years. Their origin was the coincidence of popularity of sea bathing with the great extension of transport facilities; but they are now often complete towns with industries. Over the years they carried out many sea defence works, especially for sea front promenades, and usually derived their specific jurisdiction by local Acts of Parliament. By the Coast Protection Act of 1949 their powers were codified and extended. Those difficult lengths where the town overlapped the promenade were also brought in. The frontages of many Urban Districts and Rural Districts, usually cliff frontages presenting many economic problems, were also included.

It was fortunate that the legislation had been straightened out before the disastrous tidal surge of January 31st - February 1st, 1953, brought havoc to the coast. It was, of course, unfortunate that the affected Authorities had not acquired greater experience, but at least they existed, and were able to expand and not entirely improvise to meet the catastrophe. Following this disaster, the Waverley Committee was set up by the Government to enquire into the event. One result of their report has been the final equating of the financial arrangements between

the Government and each group of Authorities.

The position is now that Local Authorities of either kind can borrow money to carry out capital works and can receive grants in aid from the Government up to 85%. For maintenance works they may receive up to 50% grant from the Government. This last concession is of the greatest importance. It was provided for the second Authority group in the Coast Protection Act, but had in practice not been applied before the 1953 flood. It now applies to all Authorities and is likely to be much used and to ensure great benefits to sea defence works where, more than anywhere else, "a stitch in time saves nine" or even ninety.

It is often argued that the State should take over the whole and administer directly, but it is indicative of temperament that the only known countries to do this are Russia and Germany. A complex changing coastline is best handled in daily works and emergencies by those who live with it, although they may from time to time derive much benefit from outside technical skill. The old adage that "He who pays the piper calls the tune" is still the basis of Local Government finance, so to have local control and responsibility the basis must be by local paying. Authorities of the first group were purposely made large enough to have considerable finances. For the second group the principle of local payment is taken through a logical sequence, with provision for dividing the costs amongst frontager interests, the Town or District and the County Council. If the burden is too great the Government grants are available. Theoretically these could make the Government Departments dominant in calling the tune, but in practice they have refrained noticeably from doing so.

#### THE HEIGHT OF SEA WALLS

The protection of low lying land is almost invariably a wall of clay dug from adjacent land. Until the flood of 1953, the basic principle of construction was to make these clay walls so high that they could never be overtopped. They had to be to a height not less than the top level of the highest tide, with a further allowance for wave action. Sea level is affected by the astronomical or predictable tide, by storm surges, by variations in barometric pressure, and by the effects of local winds. It is also affected by long term relative movements of land and sea, eustatic and isostatic. Above the mean sea level are the waves and their projection or swash on meeting sea walls. Above this again is a zone of splash and spray.

The very great height of sea level caused by the surge of 1953 has caused engineers to alter the basic conception that the walls should never be overtopped.(4) The idea now accepted in England, as in Holland, is that under exceptional circumstances walls may suffer a degree of overtopping, and must be designed to pass over this top water without breaching and collapse. This new idea has brought with it many new problems. As an instance, there is a strong controversy as to whether

clay cut off from rainfall by a completely impervious wall covering, front, top and back, would or would not dry out to an extent dangerous to the strength of the wall.

The long term picture is not helpful, as it appears that in the south and south-east, where much of the sea defence works are concentrated, there is a sinking of land relative to the sea at a rate of one foot per 100 years, whilst in the north-west and Scotland, where there are few defence works, the land is rising from the sea. In the Waverley report it is stated: "Since the evidence is entirely consistent in pointing to a sinking of the south-east and rise of North Britain it is clear that some of the movement is differential and so confined to the land. This differential behaviour can be explained by the movement resulting from two different factors. On the one hand a tilt of the land is most reasonably to be explained by the slow recovery from the great weight of ice which covered so much of Britain and north-western Europe in the Quaternary Period; on the other hand the general rise of sea level is due to the progressive melting of the Polar (land) ice, and the shrinkage of glaciers, which has increased the water in the oceans as a whole." This factor is of the greatest importance as the main feature of the immediate past sculpturing the coastline of England has not been so much contemporary erosion and accretion but rather the changes of sea level. Godwin at Cambridge by pollen analysis of peat deposits has traced many such changes in glacial and post glacial times.(5) The present tendencies have been plotted by Valentine.(6)

The next and immediate factor is the question of storm surges which are known to occur, not only in the North Sea, affecting the coast, but also in the English Channel, the Bristol Channel and the Irish Sea affecting the south and west coasts. These are now being studied in some detail.

#### A SEA WALL REVETMENT

##### CONCRETE BLOCKS WITH ASPHALTIC JOINTS

A short paper of this nature is of necessity eclectic in subject, and for construction a revetment has been chosen of a type originated and developed in England during the last 16 years. It has been described in various papers by the author. (7,8,9,10) In this present paper, American practice of describing the product from the oil refinery as asphalt is followed. In England it is called bitumen and asphalt is reserved for the mixture of bitumen filler and graded sand and/or stone commonly used in road work.

The sea walls, already described as being of local clay or silt, rest on foundations of the same materials, sometimes with sub-layers of almost semi-liquid mud, and often with layers or pockets of peat. On such foundations the wall mass must sink gradually and in uneven degree.

This factor must be considered in designing the revetments which protect the walls from wave action. The revetment itself must have sufficient flexibility to settle with the wall resting properly on it, and yet maintaining protection against waves. The classical method of hand-pitched stones on a broken stone bed has become inordinately expensive, and there is a shortage of skilled men. A method originated by Essex Rivers Catchment Board some 16 years ago is to lay pre-cast concrete blocks directly on the clay surface, and to grout the joints with a hot mixture of asphalt, sand and asbestos fibre. The blocks are made and cured under factory conditions to give a strong dense concrete resistant to salt water action and to abrasion. The jointing is selected, proportioned, mixed and heated to give a material inert in salt water which is elastic to shock pressures but plastic to the slow settlement of the wall and the blocks. Even at the highest summer temperatures it does not flow down the wall. The properties of the jointing are not dependent upon adhesion to the blocks, but in the provision of a plastic elastic filler that keeps the revetment surface sealed, and prevents the blocks being moved by direct impact or by pressure effects.

After trying various shapes, including hexagons, blocks are invariably made square in plan. The size of square and the thickness vary with exposure and with designers' ideas. Blocks in current use range from 70 lbs. in weight to 1700 lbs. No failures, no displacements of blocks by waves have been reported. The only maintenance has been some hot ironing and making up of joints. One bay 30 ft. by 30 ft. has sunk unevenly to form a basin of maximum depth 2 ft., without breaking the surface. On the 1st check the area of this type of revetment laid was 500,000 square yards, but it is likely now to be about 1,000,000 square yards.

## REFERENCES

- (1) Report of the Departmental Committee on Coastal Flooding.  
Her Majesty's Stationery Office 1954.
- (2) W. Dugdale (1605-1685) History of Imbanking and Drainage.  
2nd Ed. Owen & Urial, London 1772.
- (3) S. Webb. English Local Government Statutory Authorities for  
Special Purposes. Longman. Vol.IV.
- (4) Conference on the North Sea Floods.  
The Instn. of Civil Engineers. 1954.
- (5) J.A. Steers. The Coastline of England and Wales.  
Cambridge University Press. 1946.
- (6) H. Valentine. Present Vertical Movements of British Isles.  
Geog. Journr. 119(3) Sept. 1953.
- (7) C.H. Dobbie. Some Sea Defence Works for Reclaimed Lands.  
J.Instn.Civil Engineers Vol.25 (1945-46)  
and correspondence.

- (8) C.H. Dobbie. & E.J.R. Kennerell. Use of Bitumen in Hydraulic Works. J.Instn.Civil Engineers. Vol.33 (1949-50)
- (9) C.H. Dobbie. Protective works adopted to limit erosion along the open coast, etc. CI SII Inst. Nav.Cong. Lisbon 1949.
- (10) C.H. Dobbie. New designs of breakwaters, etc. QI SII XVIII Int. Nav. Cong. Rome 1953.

## RESUME

## QUELQUES TRAVAUX DE DEFENSE DES COTES EN ANGLETERRE

C. H. Dobbie

Le raz de marée de la Mer du Nord du 31 Janvier au 1er Février 1953, déjà décrit dans une communication d'un auteur hollandais, a causé de grands dommages en Angleterre. Plus de 300 personnes ont été noyées et l'inondation a atteint 24.000 maisons, plus de 200 propriétés industrielles importantes et 160.000 ares de terrains agricoles. La catastrophe donna une grande impulsion à l'étude des problèmes de défense contre la mer. Un Comité d'enquête, présidé par Lord Waverley, fut constitué par le gouvernement et l'Institution des Ingénieurs civils se réunit en un congrès spécial où 12 rapports furent présentés et discutés. Dans le cadre de la présente communication il est possible d'indiquer seulement une interprétation électrique des nombreux aspects des problèmes qui furent soulevés ; trois d'entre eux sont retenus parce qu'ils caractérisent l'évolution récente de la technique et des idées générales. Nos exemples concernent les dispositions administratives générales, les relations entre le niveau de la mer et les projets des digues et les progrès dans un type particulier de revêtement.

En Angleterre, une longue tradition a conduit à confier entièrement la défense contre la mer aux autorités locales, divisées en deux groupes. Un groupe assure la défense des terrains bas, analogues aux polders de Hollande. Quelques-uns de ces groupes remontent à une haute antiquité. L'un d'eux, ayant des références remontant à l'an 1245, était déjà bien organisé au XIII<sup>e</sup> siècle. Ces autorités, habituellement à faibles effectifs, gardèrent en grande partie leur organisation légale et financière inchangée jusqu'à 1930, quand les commissions de captage des eaux furent instituées. En 1949 un nouveau changement survint lorsque la fusion et l'extension des commissions de captage des eaux se traduisirent par la création des commissions des rivières couvrant le territoire tout entier.

L'autre groupe est d'origine plus moderne et comprend les Conseils municipaux et régionaux dont les activités englobent souvent la défense contre la mer et les soins d'aménagement des plages de bains de mer et les promenades de bord de mer.

Excepté par le moyen d'actes locaux, les autorités n'avaient aucun pouvoir légal spécifique dans les défenses contre la mer jusqu'à ce que l'ensemble de la question fût régularisé par le décret de protection des côtes en 1947.

On doit reconnaître que les deux groupes étaient à peine installés dans leurs nouvelles fonctions lorsque la catastrophe s'abattit sur eux. Cet événement eut au moins une conséquence heureuse : pour la première fois, leurs responsabilités furent clairement définies. Ces changements eurent pour résultat de valoir le concours financier de l'Etat aux deux groupes, sous la forme de subventions. A la suite du rapport du Comité Waverley, de nouveaux remaniements ont été faits et les deux groupes purent obtenir des subventions couvrant jusqu'à 85 % des dépenses pour les travaux d'équipement et jusqu'à 50 % pour les travaux d'entretien. Dans les régions basses, les dépenses correspondantes sont couvertes sur les crédits alimentés par des taxes locales de drainage, des taxes prélevées sur l'ensemble des régions de captage des eaux et par le Trésor public. Pour d'autres dépenses, les crédits proviennent des contributions des propriétaires qui tirent un bénéfice spécial des taxes générales locales, des taxes du comité et des subventions du Trésor public. Par ces moyens, le principe de la responsabilité locale est conservé, mais il se combine avec une répartition des lourdes charges entre des communautés d'un territoire plus étendu.

La protection des terres basses se fait habituellement au moyen des digues d'argile extraito sur place. Jusqu'aux dernières inondations, le principe général était de les construire assez hautes pour qu'elles ne soient pas submergées. C'est pourquoi leur hauteur devait être au moins égale au plus haut niveau de la marée, compte tenu de l'action des vagues. Le niveau de la marée haute est affecté par la marée astronomique, par les raz de marée, par les variations de la pression atmosphérique et les variations dues au vent local et par les mouvements à longue période élastiques et iso-statiques. A ces niveaux stables se superposent l'élévation des vagues et les projections contre les digues. Plus haut encore est une zone d'éclaboussements et d'embruns.

L'énorme élévation du ras de marée de 1953 a obligé de remettre en question ces principes et les projets s'orientent maintenant sur la base d'une tolérance à degré limité de submersion. Cette nouvelle conception a posé de nouveaux problèmes, dont quelques-uns n'ont pas reçu de solution.

Les digues reposent habituellement sur des fondations très précoces, souvent sur de l'humus, en sorte que le besoin se fait sentir d'un revêtement ayant un haut degré de flexibilité, capable de s'ajuster étroitement à la masse de la digue et cependant de continuer à fournir une protection contre l'action des vagues.

Dans le Sud de l'Angleterre, un revêtement de blocs de béton avec des joints bitumineux a été réalisé avec un grand succès. Il est d'un prix de premier établissement raisonnable, et très économique d'entretien. Une surface jusqu'à 500.000 sq.yards a été dès à présent mise en place.