DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS

THE

BULLETIN

OF THE

BEACH EROSION BOARD

OFFICE, CHIEF OF ENGINEERS
WASHINGTON, D.C.

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FEDERAL RESPONSIBILITIES IN SHORE PROTECTION

The responsibility of the Federal government with respect to shore protection is fixed, first, by the plain terms of Federal laws and second, by the attitudes both of Congress and the White House to budgetary matters. Within these limits, the Corps of Engineers has some leeway.

THE FEDERAL BEACH EROSION LAWS

Public Law 520, 71st Congress. The first of these is Public Law 520, passed by the 71st Congress in 1930. It authorized the formation of the Beach Erosion Board and the conduct of cooperative studies of beach erosion. The law provides that the Chief of Engineers shall appoint to the Beach Erosion Board four officers of the Corps of Engineers and three civilians who shall be selected from state agencies charged with beach erosion and shore protection. The act outlines the functions of the Beach Erosion Board as being the conduct of beach erosion studies and further requires that no money shall be expended under authority of the act in any state which does not provide for cooperation with the United States and contribute such funds or services as the Secretary of the Army shall deem advisable. Subsequently this cooperation was fixed at fifty per cent of the cost of any cooperative study.

Public Law 409, 74th Congress. Public Law 409, 74th Congress, approved in 1935, requires that whenever any study is made of proposed inlet or river mouth improvements, the report should include information as to the configuration of the shore line for a distance of not less than ten miles on either side of the improvement and determination of the probable effects on the shore of the proposed improvement. This law is the basic requirement under which reports on river and harbor improvements (and in some cases, flood control improvements) at the mouths of rivers or inlets are required to include information on the probable effect of improvements on the adjacent shore line.

Public Law 166, 79th Congress. The principal feature of this act is the authorization of general investigations at Federal expense. Remember that Public Law 520, the first law relating to beach erosion, provided for cooperative studies and required that the state contribute funds or services to studies of beach erosion. Public Law 166 authorizes the Federal government, through the Corps of Engineers and the Beach Erosion Board, to make general investigations with a view to preventing erosion of the shores of the United States by waves and currents and determining the most suitable methods for the protection, restoration, and development of beaches. The purpose of this act was to provide authority for the Corps of Engineers to conduct basic research and general investigations with a view to increasing the basic knowledge of the science of shore protection, as contrasted with the study of remedial action to be taken at specific localities. As there has been some confusion on this point, it should be stressed that this act does not authorize the study of problems at specific localities at Federal expense and thus supersede cooperative studies. It does not do that. The cooperative study still is in effect as provided by the first beach erosion law, Public Law 520, 71st Congress.

It is worthwhile to point out the enormous importance of the general studies under the Act of 1945, for which the Beach Erosion Board is entirely dependent on allotments from Federal appropriations. Beach protection is a branch of engineering in which the forces involved, wind, waves, and earth movement, are difficult to determine in quality, and still more difficult to measure. The materials upon which they act, notably sand, are elusive. In the present state of the art, it is hard to give exact answers as to the effect at a certain point of a certain improvement. We will increase our knowledge by observance of existing works and by general studies. If existing works fail, the answers may be as valuable as a good autopsy, but, after all, the patient will be dead. Good general studies give us a better chance of effecting a real cure.

In addition to the principal provision authorizing general investigations, Public Law 166 also states that all provisions of existing law relating to examinations and surveys of river and harbor improvements shall apply, insofar as practicable, to examinations and surveys and works of improvement relating to shore protection, except that the reports are referred to the Beach Erosion Board instead of to the River and Harbor Board. This provision has been interpreted to provide authority for preliminary examinations and surveys of beach erosion problems at Federal expense. Another feature of Public Law 166 is the requirement that the Beach Erosion Board include in its report statements of its opinion on three points: (a) the advisability of adopting the project, (b) what public interest, if any, is involved in the proposed improvement, and (c) what share of expense, if any, should be borne by the United States. River and Harbor acts authorizing preliminary examinations and surveys with a view to shore protection have, so far, also included this requirement for surveys of that type.

Public Law 727, 79th Congress. The latest act which has been passed on this subject is Public Law 727, 79th Congress, approved 13 August 1946, which authorizes Federal participation in the cost of protecting the shores of publicly-owned property. The act states "it is hereby declared to be the policy of the United States to assist in the construction, but not the maintenance, of works for the improvement and protection against erosion by waves and currents of the shore of the United States that are owned by States, municipalities, or other political subdivisions: Provided, That the Federal contribution toward the construction of protective works shall not in any case exceed one-third of the total cost:" "Provided further, That the plan of protection shall have been specifically adopted and authorized by Congress after investigation and study by the Beach Erosion Board under the provisions of Section 2 of the River and Harbor Act approved July 3, 1930, (Public Law 520, 71st Congress) as amended and supplemented." A so-called sea wall proviso, which represents a departure from the basic general policy for Federal participation of not more than one-third contribution toward the first cost of works for the improvement and protection of shores owned by States, municipalities, or other political subdivisions, reads as follows: "Where a political subdivision has heretofore erected a sea wall to prevent erosion, by waves and currents, to a public highway considered by the Chief of Engineers sufficiently important to justify protection, Federal contribution toward the repair of such wall and the protection thereof by the building of an artificial beach is authorized at not to exceed one-third of the original cost of such wall."

The Office of the Chief of Engineers has indicated informally that any case which appears to come under the terms of this proviso should be very carefully examined in the light of the exact language of the law and all aspects of the situation in order to determine that the case does actually fall under this proviso. The language is such that it permits considerable leeway in the determination of whether an existing sea wall can be considered to come under the provisions of this section or not.

The act also provides that the work may be done by the State, municipality or political subdivision which owns the shore or, if it requests, by the Chief of Engineers. The Chief of Engineers is authorized to make payment to the State, municipality, or political subdivision, of the amount authorized by Congress when he finds that the project has been completed in accordance with the authorized plans and specifications. The Chief of Engineers is also authorized in his discretion to make partial payments as the work progresses with the restriction that the payments made, including previous payments, shall not be more than the United States pro rata part of the value of the labor and materials which have actually been put into the construction in conformity with the plans and specifications.

LOCAL GOVERNMENT RESPONSIBILITIES

The responsibility of the various States with respect to shore protection is fixed by State laws and the attitudes of state legislatures and governors to budgetary matters. Certain States and local governments have provided means by which shore protection works can be and have been built independently of the Federal Government.

The State or local government usually is the responsible agency cooperating with the Federal Government in the conduct of cooperative studies of beach erosion at specific localities. In the case of construction of protective works it is usually their responsibility to provide, by methods of their own determination, two-thirds of the first cost and the entire maintenance for protection of shores owned as non-Federal public property.

SUMMARY OF FEDERAL AND CORPS OF ENGINEERS' RESPONSIBILITIES

Summarizing, now, the responsibilities placed on the Federal Government and on the Corps of Engineers by Federal statutes, let us reconsider the Federal responsibilities for shore protection. The study responsibilities of the Federal Government with respect to shore protection comprise; first, cooperative studies, preliminary examinations and surveys of shore protection to determine remedial measures at specific localities; second, determination of the effect on adjacent shore lines of proposed inland improvements; third, study of methods of protection of the shores of Federal property; and fourth, general investigations seeking to increase the general "know-how" of the science of shore protection.

The construction responsibilities of the Federal Government with respect to shore protection comprise, first, the construction and maintenance of works for the protection of Federal property and second, the contribution of up to one-third of the first cost (but not the maintenance) of protection for shores owned by States, municipalities, and other political subdivisions.

The responsibilities of the Corps of Engineers with respect to shore protection can be summarized similarly under the heading "study" and "construction." First, the study responsibilities. The Corps of Engineers, has been designated by Congress as the agency to make beach erosion studies and specifically that those studies should be reviewed by the Beach Erosion Board. In addition, the Corps of Engineers can study the erosion of Federal property at the request of the owning agency. Second, the construction responsibilities. The responsibility of the Corps of Engineers relates to the fact that it has been designated by the Congress as the agency to certify payment of the Federal contribution toward shore protection or to construct the works at local request with local cooperation. The Corps of Engineers construction responsibilities with respect to protection of Federal property is ordinarily restricted to property owned by the Corps of Engineers. The protection of Federal property owned by other agencies is ordinarily effected by that agency after study by the Corps of Engineers (if the owning agency requests such study).

In accordance with the procedure customary in the preparation of civil works reports in the Corps of Engineers, the District Engineer is charged with the preparation of reports on beach erosion and shore protection. Such reports are referred by the Chief of Engineers to the Beach Erosion Board for review.

The District Engineer is required to report on the advisability of adopting the project, the public interest involved, and the Federal Government's share of the cost, which is not necessarily the full 1/3 stated in the law to be the maximum contribution.

The District Engineer's decisions are not simple. First, he must decide whether it will pay to protect a given beach or shore line. This involves more than pure economics. No one wants to limit the improvement of beaches only to places where bathhouse profits and increased sale of refreshments would return the cost of protecting the beach. On the other hand, a beach cannot be said to pay merely because people who already swim there will have a better beach.

He has to rule on the public interest involved. This involves such factors as the number of persons who will probably make use of the beach, the length of the season, the probable increase in public revenues due to the improvement, and the benefits accruing to public agencies concerned as landlords.

Finally, the District Engineer must state specifically that certain local interests will supply all the funds not contributed by the Federal Government, and that some responsible local agency is prepared to assume responsibility for maintenance, for providing all lands, easements, and rights-of-way required, and for claims for damages arising from the improvement.

EXTENT OF FEDERAL ASSISTANCE

The extent of Federal assistance in shore protection needs some discussion. There is a certain parallel between shore protection and flood control. Some officials have expressed themselves as anticipating that the Federal interest in shore protection will increase in the future and will parallel the growth of Federal interest in flood control. At a meeting last summer a prominent legislator stated that he thought that the extent of Federal assistance authorized by legislation now in effect did not go far enough. He said that he believed, in view of the extent of Federal assistance in flood control and the fact that the Federal Government pays large sums of money for the development of national parks that the extent of Federal assistance to shore protection for publicly-owned beaches should be 100 per cent instead of 33 1/3 per cent.

By far the major portion of our shore line, and certainly, with few exceptions, the presently most desirable beach areas are held in private ownership. Entirely aside from questions of restricted public usage and development associated with private ownership, there is the problem of conserving privately owned beaches. One owner may protect his beach to the detriment of his adjoining neighbors. The best intentions in the world cannot prevent this condition at present. Beaches occur as physical units, not as subdivided lots, and protection should be provided on the physical unit base. This is difficult to arrange for privately owned beaches.

Under present Federal policy, Federal contribution toward construction of works for the protection of privately owned shores is not authorized. Should this be changed? Of course, adoption by Congress of a policy providing for increased Federal participation may be a future development, but its consideration at this time is of purely academic interest because the present policy concerning the maximum degree of Federal participation is clearly specified.

We do have a few cases which may be considered to justify a departure from policy stated in Public Law 727. These cases are ones that are now being studied and concerning which no decision has been reached. They are cases where the Federal Government has either constructed, or taken over after construction, structures which may have caused an adverse effect on the adjacent shore line. One such case is that of Port Hueneme, California, where the construction of two jetties by local interests has caused erosion downcoast from the jetties. The jetties and the entire harbor were taken over by the Department of the Navy early in the war. The erosion has continued. Near Cape May, New Jersey, the Federal Government built twin jetties at Cold Spring Inlet which have apparently increased the extent of erosion downcoast.

It is well established that the Federal Government does not have any legal responsibility for consequential damages in such cases. The frequently quoted legal opinion on this point is interesting (extract from the opinion of the Court of Claims in the case of Southern Pacific Co. V. United States, 58 Ct. Cls. 428):

> "It is true that the loss of property did not occur until the jetty had been built by the Government; that the building of the jetty caused the loss is matter of opinion; but assuming that there was some connection between the work of the Government and the flow of the ocean currents and the consequent loss or damage of the plaintiff's property, it does not follow that the Government is under obligation to pay therefor as for the taking of the property. Horstmann Co. v. United States, 257 U.S. 138, 145. If the plaintiff can recover in this court for a taking under the fifth amendment to the Constitution it must be upon an implied contract. 'When in the exercise of its governmental rights the Government take property, the ownership of which it concedes to be in an individual, it impliedly promises to pay therefor.' But in this case the facts found preclude the implication of a promise to pay. The property was admittedly not taken for public use; there was no intention to take it, the damage done, if any, was consequential; what was done was done in the exercise of a right, and the consequences are incidental, and no liability is incurred."

The people who are suffering damage have no legal recourse against the Federal Government. However, if the facts in these cases seem to warrant a Federal contribution in excess of one-third, the Congress has the power to authorize such a contribution regardless of the fact that the sufferers have no legal recourse otherwise against the Federal Government.

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Extracts from a lecture by Donald F. Horton at the Engineer School

AN ELEMENTARY DISCUSSION OF TIDES, CURRENTS, AND WAVE ACTION IN BEACH EROSION

Tides and Currents

The subject of the tides has engaged the attention of mathematicians and engineers for several centuries. From the viewpoint of beach erosion our principal interest in tides is due to the fact that they shift the zone of wave attack on the beach and may set up currents that affect the movement of the sand particles which compose the beach.

A connection between the moon and the tide was first recognized about 350 B. C. However, the explanation of the cause of this relation was not forthcoming until Sir Isaac Newton published his "Principia" in 1687, wherein was set forth a statement of the law of gravitational pull.

It is now generally recognized that the tide around the globe results from the gravitational pulls of the moon and the sun, with the moon being the dominant factor due to its closer proximity to the earth. In fact, its tide producing force is some 2-1/4 times that of the sun.

On first consideration it might seem that we could expect only one high and one low water each lunar day of 24 hours and 50 minutes. The mechanics of the gravitational system, however, is such that in most areas two highs and two lows are obtained each day. This is due to the fact that the effect of the gravitational pulls of the moon and sun are felt on both sides of the earth. It is readily seen that the water mass on the side of the earth facing the moon will tend to rise toward the moon. On the other side, the moon tends to draw the earth mass from the water mass due to the fact that the center of gravity of the earth mass is in this case closer to the moon than the center of the water mass. The effect of tending to produce a high tide is the same however. Thus we find that, generally speaking, the tides around our coast for the most part show two highs and two lows each lunar day.

Other factors at times enter the picture and serve to bring variations in the tidal picture from place to place and from day to day. Thus we find that the movement of the moon from the northern hemisphere to the southern hemisphere and back again each $27\frac{1}{2}$ days gives rise to a diurnal inequality in the tide, that is, the range of the two tides each day is appreciably different. This diurnal inequality is particularly noticeable on our Pacific Coast. It is of little significance on the Atlantic Coast.

Another variable feature is the phase of the moon. At times of full moon and new moon the moon and sun work together and give us high tides known as spring tides. At times of the 1st and 3d quarter of the moon, the moon and sun are working against each other and we find that we have low or neap tides.

Most of the work with tides in this country is done by the U. S. Coast and Geodetic Survey. They publish yearly a set of predicted tide tables that cover the coast of the world that are of commercial significance. The Survey also has the job of defining the various datum planes which serve as the working datums throughout the country as well as along our seacoasts. Mean sea level at Sandy Hook is the standard datum for this country whether in Boston, on the top of Pikes Peak, or in Death Valley. A full hour's lecture and more could be devoted to the subject of the importance of datum planes and the proper respect of them when making beach studies. Over one square mile of beach, an unrectified error of 0.1 of a foot in datum will produce a cubage error of 100,000 cubic yards. Yardages of this magnitude are of primary importance in beach studies and errors of this magnitude can produce seriously misleading interpretations of basic data.

The other feature of tidal action, which we will touch on briefly, is tidal currents. These currents are generally noticeable along the coasts only in the vicinity of bays, estuaries, or inlets. The rise and fall of the tide produces a flood and ebb of the current filling and emptying the estuary. This current can reach sufficient magnitude in the vicinity of the estuary to cause erosion by its own action. However, the effect of the current is felt over a much larger beach area where the currents are too small to affect the movement of the beach sand by themselves but can contribute to a significant action by working in conjunction with the waves breaking on the beach.

The mouth of an inlet or estuary is usually a meeting point of beach interest and navigation interest. Attempts to improve one feature frequently work to the detriment of the other. Since the Corps of Engineers has a major responsibility in both cases, it is easy to see that we are frequently found in the somewhat uneviable position of serving two masters.

Of course some streams and rivers have sufficient fresh-water discharge so that this fresh-water discharge dominates the picture rather than the tidal flow. However, the hydraulics of the two can be studied on somewhat the same basis.

Wave Action

Beach material in the shore environment is subjected to the action of various forces, a dominant one being the wind-generated ocean waves. The heights of waves generated over the open ocean by the wind is controlled by three factors: the wind velocity, the duration of the wind, and the fetch. The "fetch" is the length of the stretch of open water actually in contact with a specific wind development.

Once these waves have been generated by a wind disturbance, they may leave the area of the disturbance and travel for hundreds or even thousands of miles before being interrupted by a land mass. In fact, most of the waves noted along our ocean beaches are generated at a distance.

There are several descriptive terms for water waves, among them are progressive waves, stationary waves, and solitary waves. So far as beach action is concerned we will confine ourselves to a discussion of progressive oscillatory waves. These waves are characterized by a progressive movement of successive wave crests in a single direction whereas the water particles themselves oscillate in an essentially circular path when in deep water. In effect this means that the wave form moves forward but there is little or no progressive forward movement of the water particles. The waves themselves are described by the "length" from crest to crest, the "height" from trough to crest, and the "period," which is the time interval between the arrival of successive crests at a stationary point.

As the wave moves into shallow water, the bottom begins to affect the form and mechanics of the wave. Initially, the circular paths of the water particles are gradually changed into elliptical paths and the height and length of the wave are altered. Finally, the wave reaches a depth so shallow that the mechanics of the fluid motion make it impossible to transmit the wave form any further; at this point the wave combs over and breaks.

In order to obtain a picture of these ocean waves, let us mentally follow a wave from the time of its inception in the open sea until it destroys itself by breaking on some distant shore. Suppose a meteorological disturbance over the North Atlantic generates a wind of 26 knots blowing for some 24 hours over a fetch of 300 nautical miles. Empirical relations which have been established show that these conditions would generate waves which would leave the storm area with a height of about 15 feet, a length of about 300 feet, and a period of about 7.5 seconds.

One way of describing this wave is by length-height (L/H) ratio or steepness ratio. For the present case, the ratio would be 20. The mechanics of the fluid make it impossible to have an L/H ratio less than about 7. The shorter ratios, 7 through about 35, are characteristic of waves in or near their generating area and such waves are called storm waves.

As the waves leave the generating area they begin to lose energy due to atmospheric resistance. This results in a change in the shape of the wave, specifically a decrease in height and an increase in length. Let us suppose that our 15-foot wave in the above example leaves the generating area and travels over some 2,000 miles of open water before reaching a shore. This 2,000 miles is called the decay distance, and studies show that at the end of this decay distance the selected wave would have decreased in height to 2.5 feet, would have increased in length to 1300 feet and would have lengthened its period to 16 seconds. The wave has now become a low swell, which is the type of wave usually noticed on our beaches during fair weather periods.

It is to be noted that the L/H ratio of this wave has now become 520. A large L/H ratio is characteristic of swells. In fact, this L/H ratio is one method by which waves are classified. At the Beach Erosion Board we usually consider that L/H ratios between about 10 and 35 characterize storm waves, between about 35 and 70 characterize intermediate waves, and L/H ratios greater than 70 characterize well-developed swells.

Now let us study this 2.5-foot swell as it comes into shallow water. So far as the wave is concerned, the water becomes shallow when the depth is equal to or less than about 1/2 the wave length. At this depth we say that the wave "feels" the bottom, and the motion and form of the wave starts to adjust itself to this new condition. Generally speaking the effect is to increase the height and decrease the length. Also, the internal motion of the water particles changes from circular to elliptical with a noticeable increase in the velocities at the bottom. In fact, these bottom velocities finally become of sufficient magnitude to roll the sand particles back and forth on the bottom and sand ripple formations result. Some of the sand may be temporarily thrown into suspension where any existing currents will cause a corresponding movement of the sand particles.

As the wave moves into even shallower water, we find that it finally reaches a depth where the wave crest can no longer be supported. At this point the wave combs over and breaks. This breaking is accompanied by great internal turbulence and causes large quantities of sand to be thrown into suspension. This breaker zone is generally the most active zone from the standpoint of action of the sand particles forming the beach. Hydrodynamic relations show that our 2.5-foot swell will increase in height to about 5 feet by the time it reaches a water depth of 9 feet, at which depth it will break.

After breaking, the wave, on gently sloping beaches, may reform only to break again in even shallower water. On the steeper beaches, the broken mass of water will rush up on the beach and return to the sea as backwash, without reforming.

It would be well to note that waves in nature do not travel as simple uniform wave trains. The picture is usually rather confused, with what might be described as a spectrum of waves present, some high, some low, and of varying length. In the deeper water the longer waves travel the faster and overtake and move through the shorter waves. Thus the picture is generally confused and descriptions of the state of the sea usually describe only the dominant waves present whereas a complete description would involve a breakdown into all the types of waves present.

Another feature of wave action on beaches is angularity of approach. The waves in deep water may approach a beach at almost any angle from the perpendicular. However, as they move into shallow water they are refracted in such a way that they tend to adjust their crests parallel to the bottom contours. Thus, a wave approaching in deep water at say 45° may have an angularity of some 5 degrees or so by the time it finally breaks on the beach. However, even this slight residual angularity has the effect generally of setting up a littoral current along shore in the direction of the angularity. This littoral current in turn, frequently becomes a dominant feature in beach erosion and accretion.

Before leaving the subject of waves, mention should be made of the contrasting action of storm waves and swells on the beaches. Generally speaking, the swells, those waves with high L/H ratios, tend to move sand from offshore and deposit it on the beach above mean tide level. On the other hand, waves resulting from local storms tend to tear the beach down by removing sand from above the mean tide line and placing it in the form of submerged bars offshore. These two statements are somewhat generalized; other factors such as beach slope and sand size enter the picture at times in such a way as to upset this generalized relation.

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Extract from a lecture by Joseph M. Caldwell at the Engineer School

NOTICE OF PUBLICATION

The Beach Erosion Board announces the publication of its Technical Memorandum No. 10, "Experimental Steel Pile Groins, Palm Beach, Florida."

The report is the result of cooperative effort between the Beach Erosion Board; the Jacksonville District, Corps of Engineers; the Inland Steel Company; the Carnegie-Illinois Steel Corporation; the Bethlehem Steel Company; the Jones and Laughlin Steel Corporation; the Larssen Company; and donors of protective coatings.

A field test was made of five steel sheet pile groins constructed at Palm Beach, Florida, in April 1937. Between that date and 1946 the groins were inspected at about bi-monthly intervals; the web thickness of typical individual piles was measured in 1940, 1942, and 1946.

The report discusses the factors influencing the life of the piling in four zones; the air corrosion zone; the wetting and drying zone; the abrasion zone; and the sand protected zone. Loss of steel was most rapid in the abrasion zone.

Copies of the report can be obtained in limited number upon request to the Beach Erosion Board, 5201 Little Falls Road, N.W., Washington 16, D. C.

BEACH EROSION LITERATURE

There are listed below some recent acquisitions of the Board's library which are considered to be of general interest. Copies of these publications can be obtained on 30-day loan by field offices of the Corps of Engineers and other government agencies.

"Contribution a L'Etude de la Houle au Voisinage des Cotes," L. Carlotti, La Houille Blanche, Norwelle Serie, 2nd year, No. 6, November-December 1947, and 3rd year, No. 2, April-March 1948.

The article discusses the conditions for model studies of wave action in ports or harbors required to insure accurate results. Geometric, or form, similitude and dynamic similitude only in respect to wave damping and resonance are discussed. Rules governing the allowable distortion of models are presented. A discussion of the required accuracy of measurement of model quantities is valuable.

"Stabilization of Sand Dunes in the Pacific Northwest," Orlie W. Smith, H. D. Jacquot, Robert L. Brown, Agricultural Experiment Stations, The State College of Washington, Bulletin No. 492, August 1947, 16 pp., bibliography.

This paper reviews the important literature, and reports on an experiment on control of inland sand dunes near Delight, Adams County, Washington. Seven of the 43 grasses tested showed promise for initial sand-stilling. Vegetative propagation was found to be the only practical method of establishing the grasses. Permanent stabilization was found to be more adequately assured by using adapted woody plants in combination with secondary herbaceous species. Three of the six woody plants that survived trial demonstrated value for permanent stabilization.

"Gradual Damping of Solitary Waves," G. H. Keulegan, Journal of Research, National Bureau of Standards, Volume 40, June 1948, Research Paper RP 1895.

This paper treats the problem of damping by viscous action of translation waves. Boussinesq's boundary layer theory for wave motion is discussed, and expressions for the damping of rectangular and solitary waves are derived. Scott Russell's experimental results for solitary waves are compared with the theory, and satisfactory agreement is found to exist. Therefore, the formulae developed may be applied to correct for the dissipative effects that occur in shallow water waves in model tests of harbors or in like tests.

"Empirical Verification of Transference Equations in Laboratory Study of Breakwater Stability," U. S. Waterways Experiment Station, Bulletin No. 31, April 1948, 22 pp.

The paper presents the results of tests that demonstrated the validity of the equations used to transfer data from model to prototype breakwaters. It was found that the Froudian relationships are valid for all motion occurrences having palpable effect upon the quantity and disposition of the material eroded from model and prototype breakwaters; and that model breakwaters should be founded upon materials which have friction coefficients and interlocking characteristics similar to those of their prototypes.

"Oceanography in the Offshore Drilling Campaign," Charles C. Bates, Alfred H. Glenn, World Oil, April 1948, 7 pp.

The authors briefly discuss some of the new problems confronting petroleum engineers in offshore oil exploitation. The problems are those associated with wave and tidal action, currents, marine biology, fouling, corrosion, and water supply. The desirability of establishing oceanographic research facilities in the Gulf of Mexico is mentioned.

"Storm Surges," A. T. Doodson, The International Hydrographic Review, Volume XXIV, 1947, pp. 108-126.

This article reports the results of several studies on the effects of meteorological disturbances on sea level and tides. Several case histories are presented. The internal mechanism by which the surges are propagated are not discussed.

"First Report on the Mark V (Thermopile) Wave Meter," R. L. Wiegel, J. D. Isaacs, University of California, Department of Engineering, Berkeley, HE-116-287, June 1948, 6pp.

The theory of the thermopile wave meter is developed. The instrument construction, calibration and installation at Point Cabrillo, California, are described. Construction drawings and calibration curves are furnished. It is claimed that the instrument is as accurate as the Mark III. It has no moving parts other than the bellows, is light, and is relatively inexpensive.

"Graphical Construction of Wave Refraction Diagrams," J. W. Johnson, M. P. O'Brien, J. D. Isaacs, U. S. Navy, Hydrographic Office, H. O. Publication No. 605, January 1948, 45 pp.

The technique of construction of wave refraction diagrams by the methods of wave fronts, orthogonals, and aerial photographs are described in detail. Several illustrative examples are included. Some of the mechanical aids useful in the constructions are explained and illustrated.

"Oceanographic Observations of the 'E. W. Scripps' Cruises of 1941," H. U. Sverdrup, Scripps Institution of Oceanography, Records of Observations, Volume 1, No. 4, 1947, 159 pp.

The data presented are of observations of temperature, salinity, and oxygen content at depths from surface to 600 meters. Computed values of σ_t anomalies of specific volume, and dynamic depth are included. The observations of plankton diatoms are for seven depths to a maximum of 60 meters.

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