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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BEACH EROSION BOARD RESEARCH

Extracts from a speech by Lt. Col. Wm. B. Stelzenmuller, Assistant Resident Member, Beach Erosion Board, at the Great Lakes Conference on Lake Shore Erosion Control Problems held May 13-14 at Toledo, Ohio, under auspices of the Council of State Governments.

The Beach Erosion Board was established by Act of Congress in 1930 to investigate, study, and report on effective means of controlling or preventing erosion of the ocean, gulf, and major lake shores of the United States. The Board has seven members -- The President and three members are engineer officers of the Army, and three members are civilians selected from engineers of State agencies cooperating with the Federal Government in the study of shore problems. The Board reports directly to the Chief of Engineers, Department of the Army.

Our mission is fourfold:

1st, we assist the Division and District Engineers of the Corps of Engineers in setting up cooperative study programs that result in a report to the local interests and to the Congress on the most practical means of correcting specific erosion problems;

2nd, we review these reports, just as the Board of Engineers for Rivers and Harbors reviews navigation and flood control reports, and transmit our findings to the Chief of Engineers;

3rd, we review navigation reports on proposed improvements that may affect the shore line and inform the Chief of Engineers of any effects to be expected on the shore line for ten miles on either side of the improvement; and

4th, we conduct research or general investigations of the various factors involved in coastal erosion with a view to increasing our knowledge of the complex relationships between the factors, and to improving the design of protective works.

Cooperative beach erosion studies have been frequently discussed, and I will merely recall to you that the Beach Erosion Board provides consultative services and exercises the function of review of these reports. The reports are prepared by the field officers, the District and Division Engineers of the Corps of Engineers.

In order to carry out our research responsibility, the Board maintains a small laboratory in Washington, D. C., and two field research groups equipped for accurate hydrographic surveys, sampling of beach and offshore materials, current and wave measurement, and numerous other field research operations. In the laboratory we have one large wave tank, 4 feet deep, 14 feet wide, and 85 feet long, and two small wave flumes. Scheduled for early construction are a large outdoor tank about

600 feet long, 15 feet wide, and 20 feet deep, and a coast model test basin 3 feet deep, 300 feet long and 150 feet wide. In the large tank, we hope to study at full scale the action of waves up to six-feet in height. It is expected that these two new facilities will provide the means to answer many troublesome problems.

Our work in the laboratory at the present time is principally concerned with studying beach slopes of maximum stability under particular wave conditions, with special attention being given to the effects of sand grain size, initial beach shape, and wave character. Several other related studies are being carried on at the same time, and our objective is to develop criteria for modifying natural beaches so as to obtain slopes that will be more stable within the range of wave conditions which exist in each section of the shore line.

Another important activity in the laboratory is the development of new or improved instruments for taking essential measurements in the field. Some of the instruments which have been developed are wave height and wave direction recording gauges, devices for sampling the suspended sand load in the sea, and for sampling the bed load (or sand in movement on the sea bottom), and an apparatus for measuring the settling velocity of beach sands. It might be mentioned that our current feeling is that the settling velocity of sand in water is a more reliable indication of its probable behavior on a beach than is the grain size alone.

It will be obvious that we must know a great deal about the height, frequency, and direction of waves reaching the shore if we are to establish dependable quantitative information about rates of littoral drift. For this reason, one of the key objectives in our entire general investigative program is to obtain accurate statistics on waves for long periods of time at selected points along each of the principal shore lines of the United States, and particularly at locations where we are gathering data on sand movement. Wave stations are now located at Huntington Beach and El Segundo, California; at Long Branch, New Jersey; and on an oil drilling platform seven miles or so offshore from the coast of Louisiana. These stations have been in operation for approximately one year, and already a tremendous mass of wave data is on hand and is being analyzed by our Engineering and Research Branch.

A project that is closely tied in to the program of recording wave conditions is that of developing and testing methods of forecasting waves from weather reports and synoptic charts. If a satisfactory method can be devised and perfected, it would be of untold benefit to everyone whose occupation or avocation is connected with the sea and its changeable moods. We are carrying on this study partly by means of a contract with the New York University.

An account of the current activities of our field research groups might be of interest. One party is now on the West Coast and one on the East. The West Coast group has three projects, two of which will be described briefly to illustrate the type of work being done.

In 1947 and 1948, approximately 14 million cubic yards of sand was deposited on central beaches of Santa Monica Bay. (See figure) The beach was widened some 600 feet from Hyperion northward a distance of seven miles to the Ocean Park Pier. This wide section of beach is to be developed with access roads, parking areas, and playgrounds, and it will be of immeasurable value to the people of Los Angeles County, as well as to the beach cities of Ocean Park, Venice, Playa del Rey, and Manhattan Beach.

The field research group is conducting a sand movement study in this area. As mentioned before, a wave recording station was established on the end of the El Segundo pier, near the center of the Santa Monica Bay shore line, and seasonal volumetric surveys are being made. Daily littoral current readings are taken in cooperation with Los Angeles County authorities, and beach and offshore sand samples are taken.

Littoral drift is quite variable in this large bay, and the study of sand movement is further complicated by a deep submarine canyon off Redondo Beach that approaches within a few hundred feet of the shore.

The fill was not completed until October 1948 and its slopes have not yet reached equilibrium. Preliminary studies indicate a net downcoast movement of sand over the fill area at a rate of about 1,300 cubic yards per day. This rate will lessen considerably as the fill stabilizes. This study will naturally be of value in determining the rate at which this filled beach will need replenishment, but it will also provide us with basic knowledge which will be very helpful in studying similar situations elsewhere.

The second project is in the vicinity of Anaheim Bay, California. From October 1947 to January 1948, approximately 1,100,000 cubic yards of sand was deposited on the beach fronting the Surfside Beach Colony and the Anaheim Bay Naval Ammunition Depot. The beach had been denuded due largely to interruption of the downcoast littoral movement of sand by the jetties protecting the Anaheim Bay entrance.

The field research group has been studying the movement of this fill since March 1948. A wave station has been established at the seaward end of the Huntington Beach Pier, and volumetric surveys and littoral drift studies are being made from Anaheim Bay south to the mouth of the Santa Ana River, a distance of eleven miles.

The littoral drift in this area is predominantly upcoast in the summer, due to waves from storms generated in the Southern Hemisphere, and downcoast during the rest of the year. As a result, the rate of littoral sand movement has varied during the seasons from about 200 cubic yards a day upcoast to about 2,500 cubic yards a day downcoast. The net movement in the vicinity of the fill from April 1948 to February 1949 was about 600 cubic yards a day to the south.

The other field research group, on the East Coast, is studying a somewhat different kind of problem -- the movement of a spoil bank of dredged sand containing 600,000 cubic yards in 38 feet of water. This project was an experimental one to determine whether dredged material from harbor channels dumped by hopper dredges, as close to the shore as they could safely navigate, would eventually move in to the beach.

The dump area is about 3,700 feet long by 750 feet wide and is located about one-half mile from shore, just north of the pier at Long Branch, New Jersey. The material was dumped during the spring and summer of 1948, and surveys were made by the field research group before, during, and after the dumping operations. The surveys extended for four miles along the beach and for a distance of a little more than a mile out to sea. Surveys of the entire area were made in April, July, and October, with weekly surveys of the immediate dumping area, weather permitting.

On this section of the New Jersey Coast, the predominant littoral drift is northward toward Sandy Hook. Onshore winds prevail about 60 per cent of the time. It was found that bottom velocities existed in the dump area high enough to move the sand in the pile, but on completion of the fall surveys no appreciable movement of the pile shoreward could be detected. About 21 per cent of the dredge bin measure appeared to have moved outside the dump area, but the beach showed little evidence of receiving enough sand to measure. The change was in the nature of a flattening of the pile and some scattering of sand in a thin layer away from its boundaries.

The spring surveys completed in April are being studied now. Detailed computations have just begun, and the general indication is that a rather appreciable portion of the pile has been moved. The beaches nearby appear wider in places to the casual observer, but we cannot attribute any apparent improvement to the offshore sand bank until we have made an exhaustive analysis of the data from the spring surveys.

In conclusion, it can be stated that the Board feels strongly that the general investigative program will be of great benefit in providing more economical, yet sound, solutions to individual coastal erosion problems. The results of the research are made available in publications of the Board and are applied to specific beach erosion studies by means of consultation between personnel of the field offices and the staff of the Board.

* * * * * *

NEW JERSEY CREATES BEACH EROSION COMMITTEE

The State of New Jersey has by action of its legislature on April 9, provided for the creation of a commission to consider and provide ways and means to protect and preserve the beaches and shore front of the state by the erection and construction of protective works, dredging, and other suitable methods.

The enabling act follows:

Senate Bill 120
State Beach Erosion Commission

TITLE

AN ACT creating a commission to investigate and study the subject of the protection and preservation of the beaches and shore front of the state from erosion and other damage from the elements, to effectuate such protection and preservation of the said beaches and shore front and other purposes incidental thereto and making an appropriation to the said commission. (Herbert and Farley)

Commission created. There is hereby created a permanent commission to investigate and study the subject of the protection and preservation of beaches and shore front of the state from erosion and other damage from the elements, to effectuate such protection and preservation of the said beaches and shore front, and other purposes incidental thereto.

Name; members; terms. The name of the said commission shall be the state beach erosion commission, and the said commission shall be composed of four members of the senate, to be appointed by the president of the senate, four members of the general assembly to be appointed by the speaker thereof, and four members, at large, to be appointed by the governor.

The terms of the members appointed by the president of the senate and the speaker of the general assembly shall continue from the date of their respective appointments until the second Tuesday in January following. The term of each commissioner appointed by the governor shall be four years. Vacancies occuring otherwise than by expiration of term shall be filled in the same manner as though occurring by expiration of term but for the unexpired terms only. The members of the commission shall serve without renumeration but shall be reimbursed for all expenses incurred in connection with the work of the commission.

Duties. In connection with the effectuation of its purposes, the commission shall consider and provide ways and means to protect and preserve the beaches and shore front of the state by the erection and construction of seawalls, bulkheads, jetties, basins, and other devices, and shall take into consideration dredging and other methods suitable for said purposes. The said commission shall also take into consideration the advisability of repairing existing seawalls, bulkheads, jetties, basins, and other similar devices.

Chairman: by-laws. The members of the commission shall choose one of their number to be chairman and may adopt by-laws for the regulation of its meetings and to carry out its purposes. The several state departments and agencies shall render assistance to the commission in making its studies when called upon to do so by the commission.

Meetings: annual report. The commission may hold meetings in any part of the state and shall annually report to the legislature and to the governor and any such report may embody the findings and recommendations, including planning and other proposals of the commission.

Appropriation. There is hereby appropriated to the commission from the general funds of the state the sum of thirty-five thousand dollars ($35,000.00), when included in any annual appropriation act; for payment of expenses incurred and services required in preparing a state program for coast protection based upon the regional planning concept.

Material to commission. The commission created by joint resolution number nine of the laws of one thousand nine hundred and forty-eight, shall turn over to the commission, created by this act (chapter), any and all material which it may have relating to its studies, hearings, and report to the governor and the legislature.

The members of the commission had not been named at the time of preparation of this note.

* * * * * *

THE CAUSES OF PLUNGING AND SPILLING BREAKERS

> The following notes first appeared in limited issue as Technical Report HE-116-192, Fluid Mechanics Laboratory, University of California. They are reproduced here to bring the concepts therein to the attention of research workers and other persons having an interest in ocean waves. The notes were prepared by Dean M. P. O'Brien, University of California in January 1946.

Plunging breakers are more hazardous for landing craft than spilling breakers. As yet there has been no method developed to forecast the type of breaker. The following notes discuss this problem qualitatively. It is hoped that quantitative data will follow.

Plunging breakers are characterized by uniformity of breaker height and by long-crestedness but there are other factors involved in this phenomenon. Field observations and examinations of photographs have led to the following general conception of the conditions causing plunging or spilling breakers:

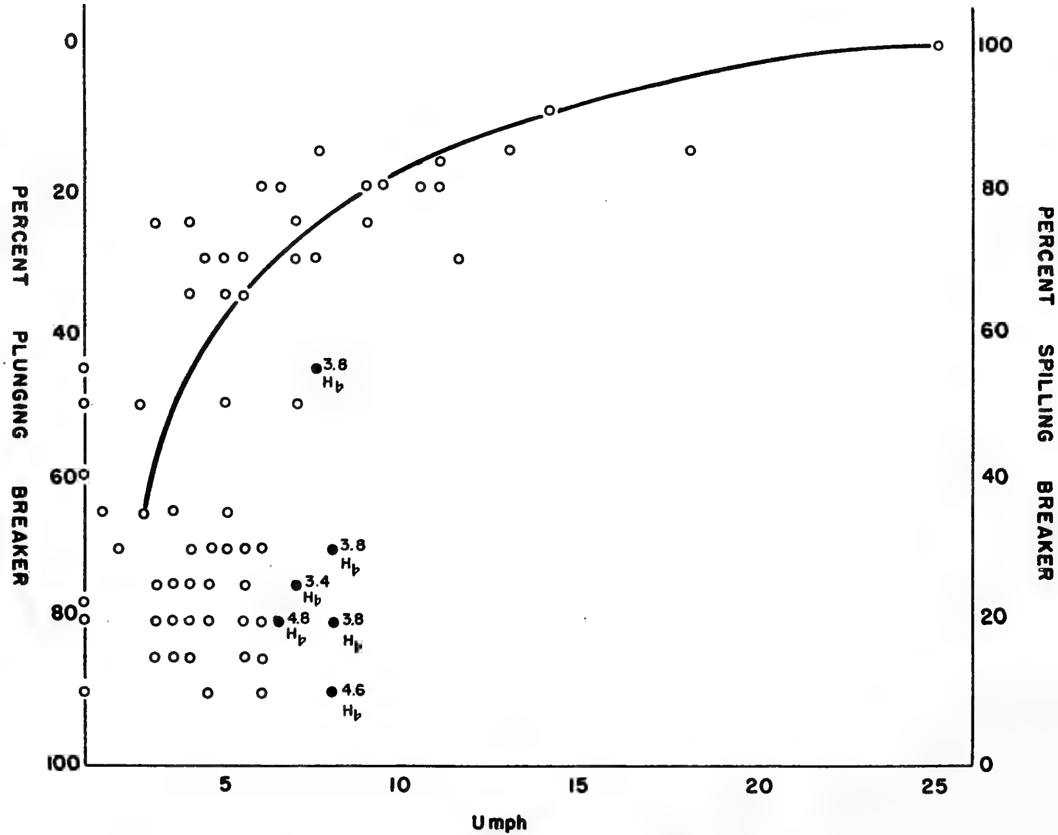
Plunging

a. Long crests and uniform wave height.
b. Small curvature of crests. (small angle of breaker with shore line.)
c. Steep bottom slope.
d. Regularity of bottom.
e. Absence of other swells or wind waves and absence of irregular current.
f. Size; large waves tending to plunge.

Spilling

a. Short crest length or variations in height.

b. Large curvature of crests at the break. (Abrupt change of crest angle by refraction.)
c. Flat bottom slope.
d. Irregularity of bottom.
e. Superimposed waves, such as wind waves making an angle with the main swell in the breaker zone.
f. Irregular current, particularly "tide rip" and tidal current.
g. Obstacles such as boats, piers, etc.
h. Variation in strength of proceeding backrush current due to variations in height and period.



EFFECT OF ON-SHORE WINDS ON TYPE OF BREAKER

FIGURE 1

The principle underlying these statements is that the plunging breaker is the "ideal" breaker in the sense that it will occur only under conditions approximating the idealized conditions assumed in theoretical investigations and approximated in the laboratory, namely, infinite crest length and uniform period and height. Any disturbance which causes the wave to peak up more at one point than at adjacent points tends to produce a spilling breaker.

The role of slope seems clear. On a steep bottom the wave must complete its break quickly, leading to plunging and there is the added factor that the distance over which the wave is peaked up approaching the point of breaking is short and the wave is thus exposed during only a short interval to the disturbing influence of superimposed waves, currents, and irregular bottom. On flat slopes, a wave is exposed longer to the possibility of disturbance by the factors causing spilling.

The role of wave steepness, or H'_o/L_o, is complex. It appears that smaller values of this ratio lead to more pronounced plunging if the general conditions for plunging are met. For example, if the bottom is smooth, the wave length uniform and the crest long, swells of small H'_o/L_o will plunge even on a flat slope. However, waves of small H'_o/L_o which exhibit a greater increase in height before breaking are more easily affected by the factors causing spilling.

If this conception of the causes of spilling and plunging is correct, it has a bearing on the relationship between depth and wave height at the point of break. The more nearly ideal the conditions, the more the wave peaks up before it breaks and the smaller the ratio, d_b/H_b. (Water depth at point of break/wave height at point of break). Spilling is the result of an incomplete transformation before breaking starts and the ratio d_b/H_b is larger. The two dimensional laboratory experiment probably approaches the limiting ratio of depth to height at breaking as closely as ocean waves ever do. It is believed that the ratio d_b/H_b does not have a single value but may have any value greater than that for the "ideal" breaker of the same H'_o/L_o moving over the same bottom slope. As the distrubing influences previously enumerated increase in importance, the wave crest breaks earlier in its transformation and the ratio d_b/H_b increases.

Determination of breaker heights from aerial photographs may be obtained from either wave velocity or depth but wave velocity itself depends upon depth in shallow water. The value of d_b/H_b to be used must therefore be a matter of judgment based on an appraisal of the effect of all types of irregularities, most of which will be evident in the photographs. Neither d_b/H_b or d_b/H_o (H_o is wave height in deep water) has a definite value for all waves and the breaker index values or the relationships between d/L_o and H_o/L_o at the point of breaking is a zone and not a line.

The point at which the quantity d_b is measured must be accurately defined for breakers on steep beaches because an appreciable change in depth occurs in the zone in which the wave breaks. In certain laboratory experiments, the depth d_b was taken at the point at which the crest reached its maximum elevation, and this condition occurred before the wave plunged. Consequently, this depth is probably greater than would be observed with less precise methods of measurement in a dynamically similar prototype.

It is likely that not all of the factors which lead to spilling change the relationship between d_b/H_b. For example, short crestedness leads to spilling but each point of the crest may break at the same depth as would a long crested wave of the same height.

Observations of breakers made in conjunction with studies of landing craft included an estimate of the percentage of breakers which were spilling or plunging. These observations were made for another purpose before the causes of spilling and plunging had become clear. The local wind velocity was measured and it was noticed that the percentage of spilling breakers increased with wind velocity. This effect was the result of superposition of wind waves, usually at an angle, on the main swell. It was also noted that the larger the breaker, the less the tendency towards spilling at any wind velocity. Figure 1 shows the observed percentages of spilling and plunging breakers. The breaker heights are shown near points in the range 5 to 10 m.p.h. wind velocity to indicate the effect of breaker height.

In the lee of headlands such as at San Simeon and Halfmoon Bay, California, the filtering effects of refraction results in long crested breakers of small effective steepness. The breakers at these points are almost always of the plunging type, even though small. A relatively slight disturbance, such as the superposition of waves from small boats, changes those waves to the spilling type. At the earliest opportunity, a controlled experiment of this type will be performed using Dukw's to generate waves.

Observers of landing craft performance agree that plunging breakers are more hazardous for landing craft than are the spilling type. J. D. Isaacs estimates that a plunging breaker presents about the same hazard as a spilling breaker 50 per cent higher. The differential may be even greater for LCVT's. Two important consequences follow, namely:

1. In the critical range of breaker heights, where casualties increase rapidly with height, weather forecasters should forecast breaker type.

2. Artificial means of changing plunging to spilling breakers may be feasible.

* * * * *

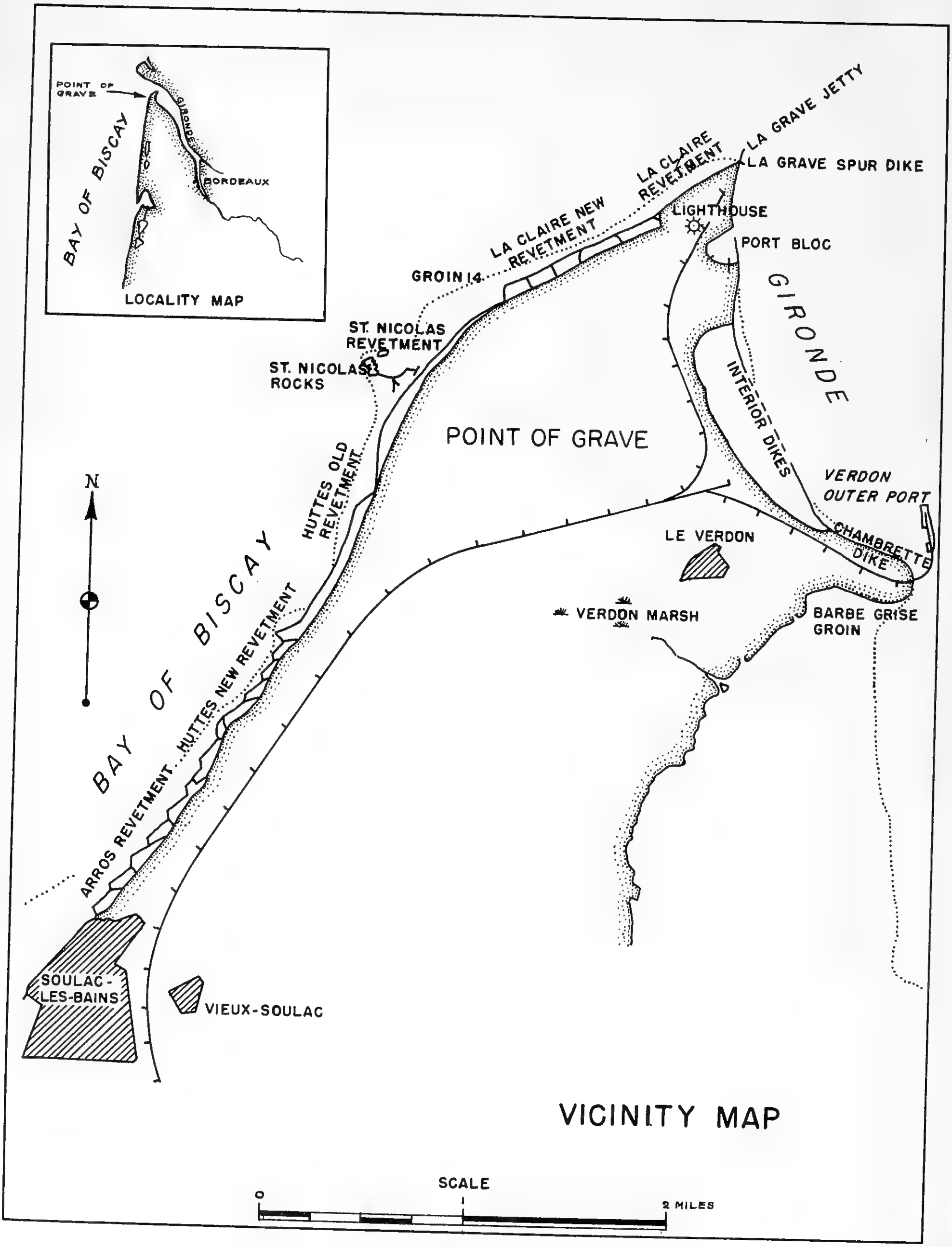
DISCUSSION - A FORMULA FOR THE CALCULATION OF ROCK FILL DIKES

Discussion by Mr. R. M. McCrone, Lower Mississippi Valley Division, Corps of Engineers

Formulae set forth by Mr. Iribarren, or appropriate modification thereof, will be quite useful to shore and harbor engineers concerned with sizes of stone and slopes of riprap structures for resisting wave action. Presumably, the Beach Erosion Board will correlate these data with those presented in the report on "Slope Protection" presented in Proceedings ASCE, June 1948, with discussions in later months. It seems pertinent to suggest that serious consideration be given to developments in the use of sand asphalt mixtures for structures which are to provide protection against wave action or erosion due to river currents since it has been demonstrated to practicable and economical to place suitably proportioned masses of hot mix by gravity under water as well as in air to congeal as dense, insoluble, homogeneous, concreted masses with adequate stability and toughness, highly resistant to water and hence to attack by wave action or stream flow. (Reference discussion pages 1653 and 1654, Proceedings, ASCE, December 1948).

It seems pertinent to emphasize that structures for protection against wave action or scour due to stream flow preferably should be homogeneous non-erosible monoliths rather than heterogeneous masses of riprap consisting of discrete aggregates even if rock sizes are adequate. Where such structures are sited on sand, it is obviously desirable that the sand, the nearest and cheapest material, be used for construction. Developments in the use of hot sand asphalt mixtures in large mass demonstrate the feasibility of combining sand and asphalt suitably proportioned at appropriate temperatures for gravity placement under water or in air to congeal substantially as a homogeneous monolith. One such monolith, about 1,800 tons, is pictured on page 1654 of the December proceedings. Another, upward of 6,000 tons, placed (Fall 1948) as a wing dam in the Mississippi River (Mile 468 AHP), provides protection at the lower end of the Filter Bend revetment.

* * * * *



POINT OF GRAVE
GIRONDE
BORDEAUX
BAY OF BISCAY
LOCALITY MAP
LA GRAVE JETTY
LA CLAIRE REVETMENT
LA GRAVE SPUR DIKE
LA CLAIRE NEW REVETMENT
LIGHTHOUSE
PORT BLOC
GROIN 14
GIRONDE
ST. NICOLAS REVETMENT
ST. NICOLAS ROCKS
INTERIOR DIKES
POINT OF GRAVE
HUTTES OLD REVETMENT
N
VERDON OUTER PORT
CHAMBRETTE DIKE
LE VERDON
BAY OF BISCAY
HUTTES NEW REVETMENT
VERDON MARSH
BARBE GRISE GROIN
ARROS REVETMENT
SOULAC-LES-BAINS
VIEUX-SOULAC
VICINITY MAP
SCALE
0
1
2 MILES

FIGURE 1

COMITE CENTRAL D'OCEANOGRAPHIE ET D'ETUDE DES COTES

The Central Committee for Oceanography and Coastal Studies is a French Governmental agency associated with the Naval Hydrographic Service of the French Ministry of National Defense. The president of the committee is Vice Admiral Missoffe and the permanent secretariat is under the direction of Chief Engineer A. Gougenheim.

The Naval Hydrographic Service have conducted studies of the regime of various coasts over a long period. The results of these studies are published in "Recherches hydrographiques sur le regime des cotes".

In January 1949 the Central Committee for Oceanography and Coastal Studies initiated the periodic issuance of an information bulletin. This bulletin contains articles of general information on committee activities and interests, technical communications in condensed form, and bibliographic notes. Distribution of the bulletin is limited to members of the Central Committee and associated local committies, and a few French and foreign persons or agencies whose principal interest is research in oceanography and coastal phenomena.

Four issues of the Bulletin have appeared (January-April) and have been received at the Beach Erosion Board. This opportunity is taken to brief some of the information thus received in order to acquaint American students with the extent and character of the coastal problems in France.

* * * * *

NOTES ON POINTE de GRAVE, FRANCE

The coast between Soulac and Pointe de Grave, (see Figure 1) at the mouth of the Gironde River, is retreating rapidly to an extent endangering the port installations at Verdon and the existence of the point itself. The eroded material, which is chiefly fine dune sand, is shoaling the Gironde River channel.

The shore is constituted by dunes formed since the 17th century of fine sand derived from the larger size beach sand, the dunes being covered by pine forests. At Pointe de Grave the shore is advancing by accretion, whereas to the south, toward Soulac, erosion has been very rapid, destroying the dunes and the forest.

The eroding areas have been protected by concrete revetments and groins but have nevertheless receded as much as 200 feet since 1914. Several German pill boxes, built during the last war, have contributed to dune erosion. The revetments are of massive construction, it having been found that light construction is easily destroyed by wave action.

* * * * *

THE CENTER FOR RESEARCH AND OCEANOGRAPHIC STUDIES

The objectives of the Center are to unite research personnel and means for solution of problems in geology of the oceans and its applications to economic and technical problems (exploration and prospecting of the continental shelf, shore protection, improvement and maintenance of navigable channels and estuaries, land reclamation, utilization of marine sediments, etc). The center provides facilities for practical training, specialized marine laboratory studies, planning and execution of oceanic research, etc. as well as collaboration with various marine services.

Required financing is furnished from public funds and private subscription.

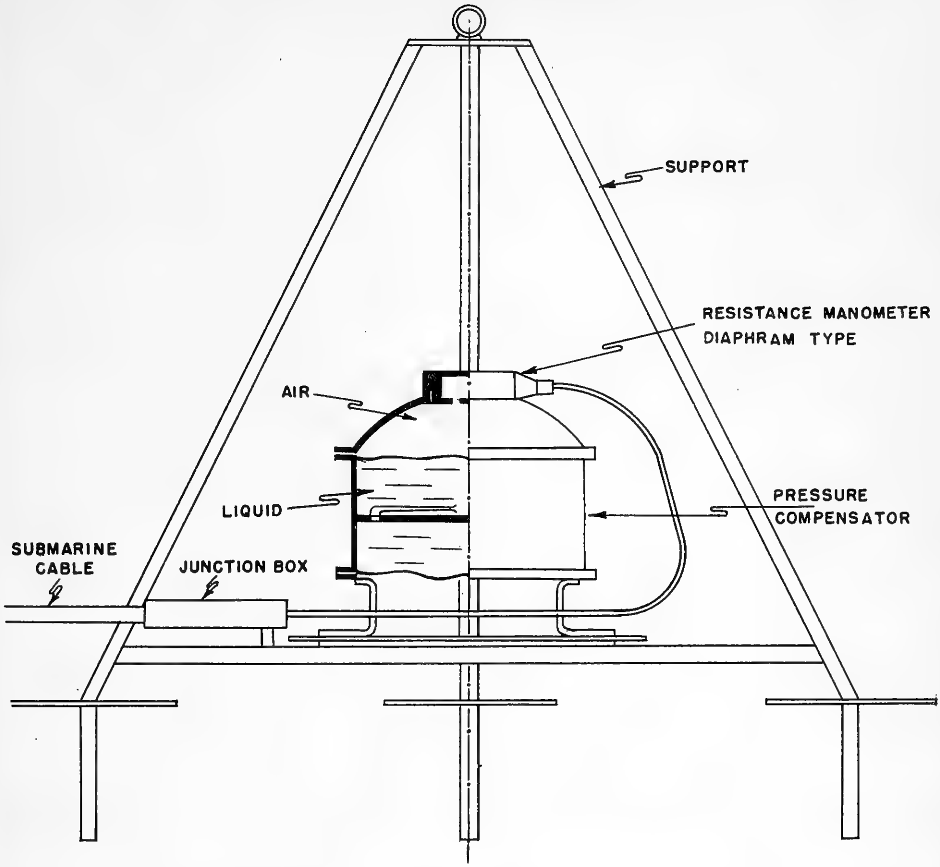
Recruitment of young research workers is one of the most important problems facing the Center and will be the immediate major field of activity of the administration.

* * * * *

RECORDING MANOMETER FOR SUBMARINE PRESSURE

Note: This manometer was developed at the National Hydraulic Laboratory at Chatou, and is the first such instrument developed in France. It will be installed at Mont St. Michel in connection with a project for the development of electric power from the tides, and at Tamatave.

The device (see Figure 2) consists of dual chambers connected by a capillary, and an electric differential manometer composed of a metal diaphragm to which strain gauges are attached. Variations in resistance of the strain gauges are measured by a Wheatstone bridge circuit. The system is sensitive to pressure differences of the order of 1/1000 of the maximum pressure differential of the manometer. An armored cable of the submarine telegraph type connects the pressure element to a shore-based recorder; maximum cable length is of the order of 7,000 feet.



NATIONAL HYDRAULIC LABORATORY
WAVE GAUGE

SCALE
0 5 10 20 INCHES

FIGURE 2

MEASUREMENT OF HEIGHTS BY RESISTANCE ELEMENTS

The following article was first published in limited issue as Technical Report HE-116-270, Fluid Mechanics Laboratory, University of California. It is reproduced here to acquaint research workers and others who would not otherwise know of the work with the valuable results of the study. The paper was prepared by Mr. J. R. Morison, University of California.

Introduction

In measuring wave heights for model studies, it has been found that wire elements or electrodes placed in the water act as a variable resistance for a recording system. Through many experiments, a definite method has been established for this type of wave height recording. It is the purpose of this paper to summarize the method of measuring wave heights with wire elements recorded by an oscillograph. Further, some of the difficulties and limitations of the method will be presented for the experimenter. The essential difficulty of the method is in obtaining a stable, correct, and characteristic calibration of the system used.

General Measurement of Wave Height

The measurement of one wave height at just one point by electrodes may be accomplished in several ways. A two wire element fed by a transformer and powerstat and connected in series to the galvanometer of an oscillograph is a very satisfactory method. The calibration curve in this case is practically linear depending, of course, on the actual experimental conditions and instruments used. It is also possible to use the side of a metal tank as one of the wires of the electrode. The calibration curve in this instance is not linear.

The immediate questions arising from the above statement are: (1) What is the effect of the distance between the electrodes?; and (2) What type and size of electrodes are being discussed? The distance between the electrodes when small (less than one-half inch) is a factor in determining the resistance that is in the circuit. When the electrodes are farther apart, the resistance is determined by the water to wire relationship. A small diameter (0.033 inches) wire in water gives a higher resistance than does a larger diameter wire (1/16 inches). It has been found that a distance of approximately one-half inch (range $\frac{1}{4}$ to 1) is very satisfactory for two wire elements and distances up to 6 inches have been used for the case where the metal tank is one electrode. Further consideration of the resistance of the water between the wires and how the circuit actually operates indicates that the wire and water act together in taking resistance out of the circuit. This resistance starts near infinite (electrodes in air) and is immediately reduced to several thousand ohms when the wires touch water (the magnitude of this resistance depends on the distance between the electrodes, the solution, and the wire size). The resistance is further reduced by lowering the elements into the water until they are completely submerged, at which point only the resistance of the recording circuit remains. Hence, it is seen that the galvanometer (a current measuring instrument in this case) will record from a zero current to some constant current of the circuit with respect to the variance of the resistance as described.

The type of electrodes used have been (1) silver plated constantine wire, (2) silver plated music wire, and (3) iron welding rod. Sample construction of elements are shown in Figures 3-A, B, C. For convenience of measurement the wire elements are attached to point gages which have a least count of 0.001 foot. Types (1) and (2) were 0.033-inch diameter wire and 6 inches in length. Type (3) was 1/16-inch diameter wire and 15 inches in length. The 0.033-inch diameter wires and 6 inches long were used to measure waves of 0.45 feet maximum height and a magnification of the actual wave was obtained when desired. This type of element requires a smaller power supply (1 to $1\frac{1}{2}$ volts) than does the larger elements. It is more sensitive to amplitude changes and less sensitive to power changes than the larger elements.

The 1/16-inch diameter wires and 15 inches long were used to measure waves of 1.3 foot maximum height and a reduction of the actual wave was obtained. This type of element requires a larger power supply ($1\frac{1}{4}$ - 2 volts) and is more sensitive to power changes than is the smaller element. The 1/16 inch diameter elements with a high power input (2.5 volts) were used satisfactorily for measurement of small model waves.

The power supply to the elements, of course, depends on the resistance and the magnification desired. Thus, it will be different for each experimental set up.

The effect of the meniscus or surface tension on the wire element compared to another type of wave measurement was found to be about 5 per cent when compared with a point gage. The experiments showed that there was 3 per cent variation in the wave heights as measured by the point gage due to its meniscus effect and the variation of waves generated. The corresponding measurements made with the wire elements were found to differ from the point gage measurements by a maximum of 7 per cent in all cases. Thus, it is seen that the actual meniscus effect is about 4 or 5 per cent. Furthermore, the difference was on the high side part of the time and on the low side at other times. The meniscus effect will be neglected in the future.

Two or More Circuit Method

The measurement of wave height at several stations simultaneously is often desired so that not only the wave height can be determined from the record but also the wave period, wave velocity and wave length. The method proposed is best described by Figure 1-A. It is seen that for any one power supply or transformer that one and only one circuit can be traced out and, hence, the water path connecting pairs of elements has no effect and can be ignored.

The calibration of the individual elements is independent of the position of any of the other elements. Hence, each calibration curve measures only what takes place at the corresponding element. Furthermore, the calibration of each element is essentially linear. A typical calibration curve is shown in Figure 2-A. The calibration and operation of the elements are independent of the solution's electrolytic properties other than its influence on the resistance of each element. The non-linearity of the calibration is slight and contributed to the water to wire resistance relationship. The calibration may be effected also by progressive corrosion. Best results will be obtained in water of constant temperature.

It may be possible to eliminate the first set of transformers and supply power to the set of powerstats with one transformer. It is also possible to supply the power to the set of transformers with one or more powerstat by connecting the 155-V line to the powerstat and thence to the transformers. In both cases different powerstats or transformers would be needed. The disadvantage to any such saving of equipment is that the resulting maximum current available to the galvanometer and elements is limited and the reading of any one element cannot be made prominent. It is considered that the flexibility of this system outweighs any saving of equipment. From an electrical standpoint, it is better to feed the transformers through the powerstats but no difference in the two methods has been noticed.

Sources of Errors in Using Single Power Supplies for Multi-Elements and Common Leads

The possibilities of connecting a series of elements to galvanometers and installing switching circuits for ease in handling in many cases leads to erroneous results between calibration curves and actual measurements. The three common and elementary circuits found to be subject to errors are presented in Figures 1-B, C, D. The same equipment is used in these figures as was used in Figure 1 unless otherwise noted. In each of the cases presented it is seen that there is more than one method of completing the electrical circuit when using the water as a path. This immediately induces the electrolytic characteristics of the water into the problem. When the electrolytic properties of the water solution are such that the resistance of the solution is low and of the order of magnitude of the recording circuit, then errors are observed and the relative submergence of the elements effects their mutual recording circuits. Figure 2-C is an example of a calibration showing this effect. The error is due partly to the polarization effects when the solution is a concentrated one. However, when the electrolytic properties of the water solution are such that the resistance of the solution is high, (reference is made to tap water as compared to laboratory storage water which contains a solution to prevent fungus growth) and, hence, is very large compared to the recording circuit; then the errors disappear and the elements are independent of each others position when recording. Figure 2-B is an example of a calibration showing this effect. The full explanation of the phenomena discussed requires a knowledge of the theory of interionic attraction, the disassociation theory of solutions, and the tank effect on the interionic force fields. It is plainly seen that the change of the electrolytic properties of the water during an experiment or even from day to day would give undesirable results.

Conclusion

The above method of measuring wave heights at simultaneous positions will give accurate measurements of wave height, wave length, wave velocity, wave period, and in special cases, wave profiles. The expected error can be less than 5 per cent if the proper type of elements and magnitude of power supplies are used when recording. This, of course, requires a beforehand knowledge of the maximum wave height to be expected so that the range of calibration necessary can be made. Calibrations should be made before and after each experiment or at least twice a day if elements are used continuously.

Acknowledgments

The author wishes to take this opportunity to thank Dr. H. A. Einstein for his helpful advice and Professor J. W. Johnson for his suggestions and cooperation. The confirmation of the information assembled and helpful reference suggested by Mr. F. F. Davis was deeply appreciated. Since this report is an extension of previous work, the author feels that Mr. R. L. Wiegel was instrumental in laying the ground work.

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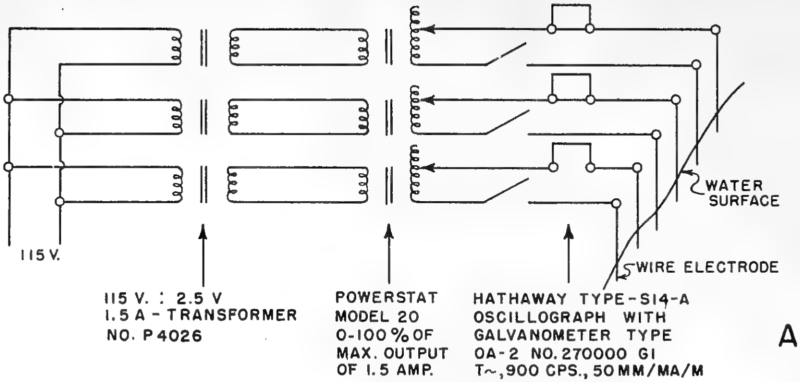
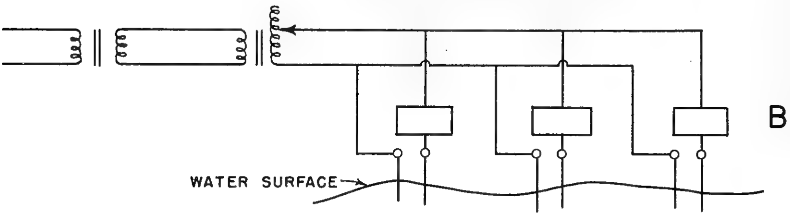
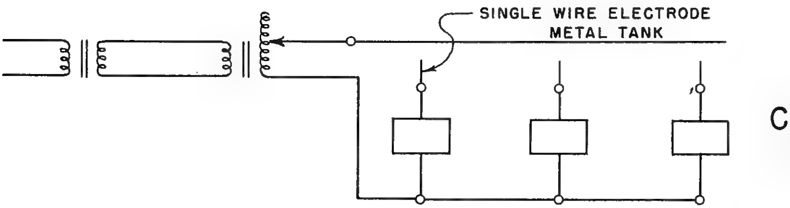


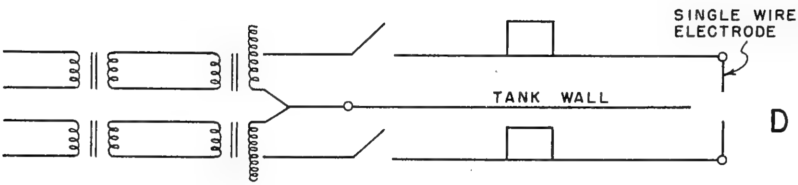
MULTI- ELEMENTS ON MULTI-POWER SUPPLY CIRCUITS



SINGLE POWER SUPPLY AND MULTI-ELEMENT CIRCUIT

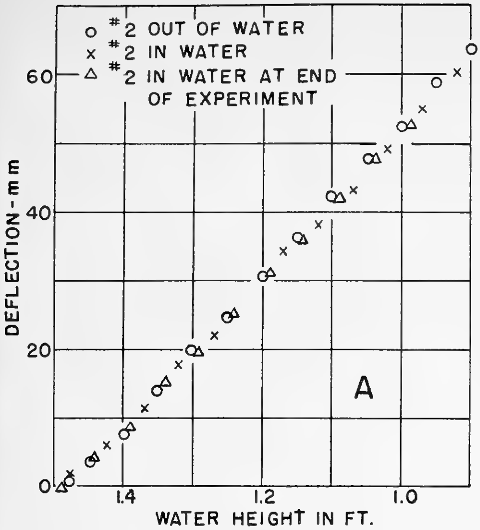


SINGLE POWER SUPPLY AND MULTI-SINGLE WIRE ELEMENTS
WITH METAL TANK AS SECOND ELECTRODE.

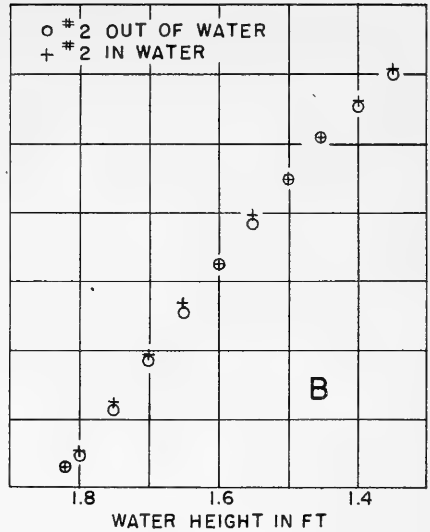


TWO POWER CIRCUITS AND TWO SINGLE WIRE ELEMENTS
WITH TANK WALL AS SECOND ELECTRODE.

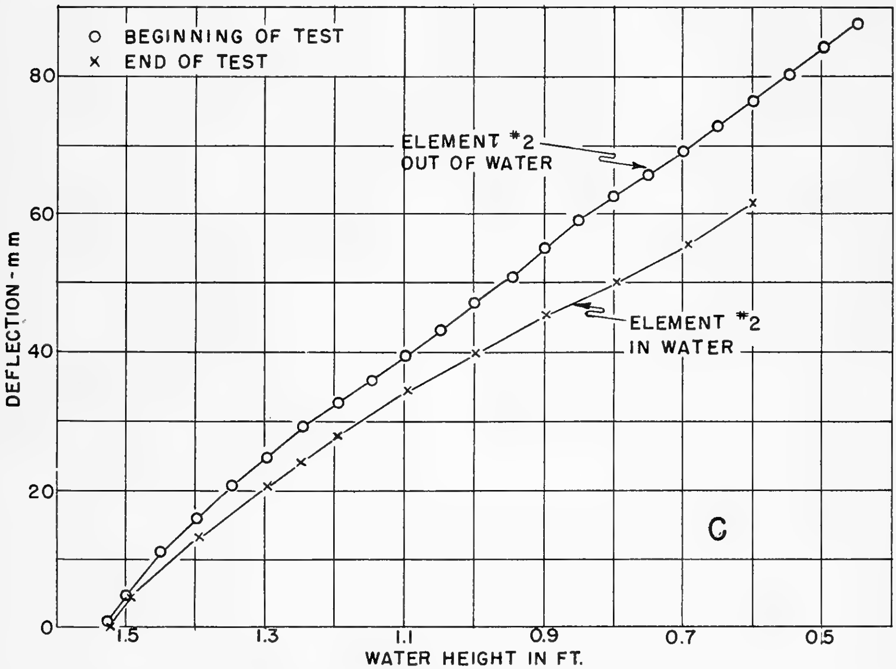
FIGURE I



CALIBRATION–DOUBLE WIRE ELEMENT #1 (1/16 DIA.) ON SEPERATE POWER SUPPLY

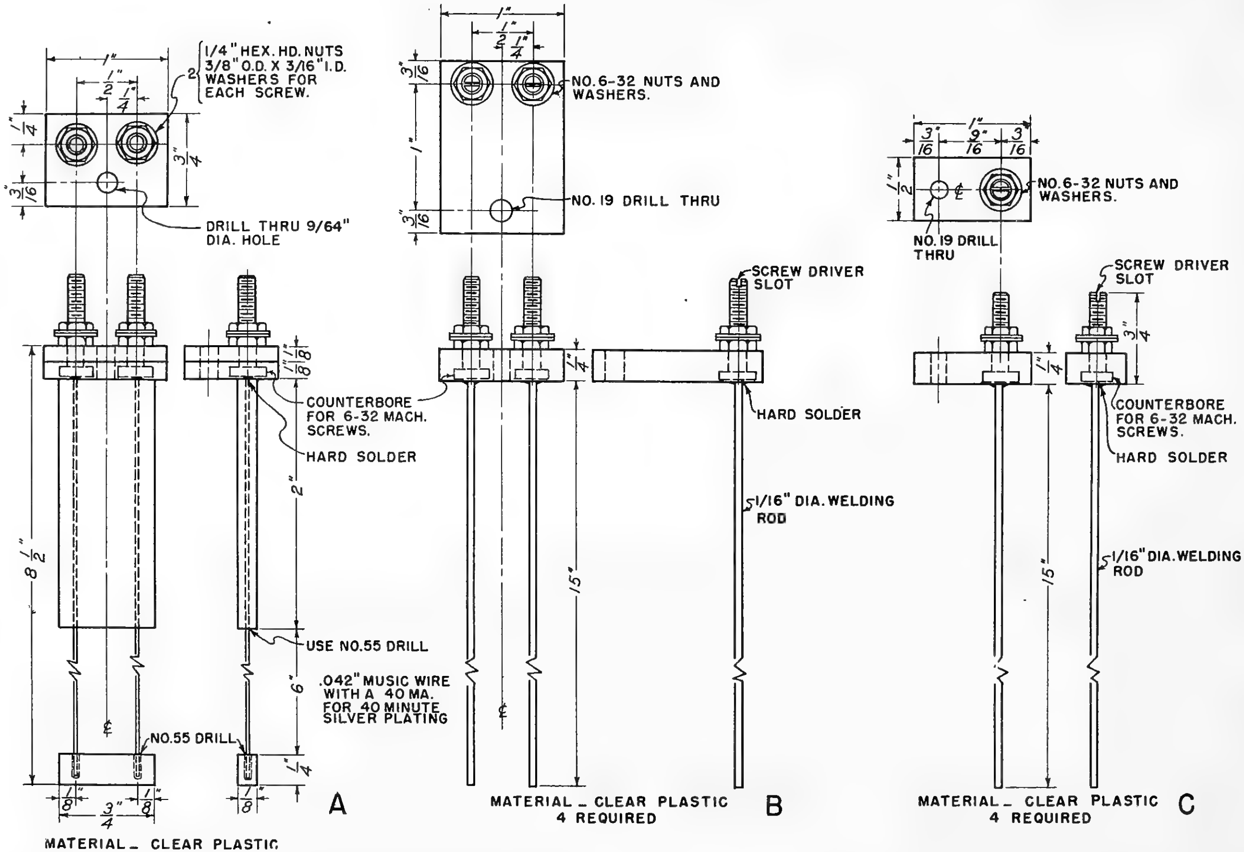


CALIBRATION OF TWO WIRE ELEMENTS (0.033 DIA) WITH SINGLE POWER SUPPLY IN TAP WATER



CALIBRATION-SINGLE WIRE ELEMENT #1 (1/16 DIA.) WITH SINGLE POWER SUPPLY IN SALT WATER

FIGURE 2



OSCILLOGRAPH ELEMENTS
SCALE FULL SIZE

WAVE HEIGHT GAGE
SCALE FULL SIZE

49 11739

FIGURE 3

BEACH EROSION STUDIES

The principal types of beach erosion reports of studies at specific localities are the following:

a. Cooperative studies (authorization by the Chief of Engineers in accordance with Section 2, River and Harbor Act approved on 3 July 1930).

b. Preliminary examinations and surveys (Congressional authorization by reference to locality by name).

c. Reports on shore line changes which may result from improvements of the entrances at the mouths of rivers and inlets (Section 5, Public Law No. 409, 74th Congress).

d. Reports on shore protection of Federal property (authorization by the Chief of Engineers).

Of these types of studies, cooperative beach erosion studies are the type most frequently made when a community desires investigation of its particular problem. As these studies have, consequently greater general interest, information concerning studies of specific localities contained in these quarterly bulletins will be confined to cooperative studies. Information about other types of studies can be obtained upon inquiry to this office.

Cooperative studies of beach erosion are studies made by the Corps of Engineers in cooperation with appropriate agencies of the various States by authority of Section 2, of the River and Harbor Act approved on 3 July 1930. By executive ruling the cost of these studies is divided equally between the United States and the cooperative agency. Information concerning the initiation of a cooperative study may be obtained from any District Engineer of the Corps of Engineers. After a report on a cooperative study has been transmitted to Congress, a summary thereof is included in the next issue of this bulletin. A list of completed cooperative studies and of those now in progress follows.

COMPLETED COOPERATIVE BEACH EROSION STUDIES

Location	Completed	Published in House Doc.	Congress
	MAINE		
Old Orchard Beach	20 Sep 35	---	---
	NEW HAMPSHIRE		
Hampton Beach	15 Jul 32	---	---

Location	Completed	Published in House Doc.	Congress
MASSACHUSETTS			
South Shore of Cape Cod (Pt. Gammon to Chatham)	26 Aug 41		
Winthrop Beach	12 Sep 47	764	80
RHODE ISLAND			
South Shore (Towns of Narragansett, South Kingstown, Charlestown & Westerly)	4 Dec 48		
CONNECTICUT			
Compo Beach, Westport	18 Apr 35	239	74
Hawk's Nest Beach, Old Lyme	21 Jun 39		
Ash Creek to Saugatuck River	29 Apr 49		
Hammonasset River to East River	29 Apr 49		
NEW YORK			
Jacob Riis Park, Long Island	16 Dec 35	397	74
Orchard Beach, Pelham Bay, Bronx	30 Aug 37	450	75
Niagara County	27 Jun 42	271	78
South Shore of Long Island	6 Aug 46		
NEW JERSEY			
Manasquan Inlet & Adjacent Beaches	15 May 36	71	75
VIRGINIA			
Willoughby Spit, Norfolk	20 Nov 37	482	75
Colonial Beach, Potomac River	24 Jan 49		

Location	Completed	Published in House Doc.	Congress
	NORTH CAROLINA		
Fort Fisher	10 Nov 31	204	72
Wrightsville Beach	2 Jan 34	218	73
Kitty Hawk, Nags Head, & Oregon Inlet	1 Mar 35	155	74
State of North Carolina	22 May 47	763	80
	SOUTH CAROLINA		
Folly Beach	31 Jan 35	156	74
	GEORGIA		
St. Simon Island	18 Mar 40	820	76
	FLORIDA		
Blind Pass (Boca Ciega)	1 Feb 37	187	75
Miami Beach	1 Feb 37	169	75
Hollywood Beach	28 Apr 37	253	75
Daytona Beach	15 Mar 38	571	75
Bakers Haulover Inlet	21 May 45	527	79
Anna Maria & Longboat Keys	12 Feb 47	760	80
Jupiter Island	13 Feb 47	765	80
Palm Beach (1)	13 Feb 47	772	80
	MISSISSIPPI		
Hancock County	3 Apr 42		
Harrison County - Initial	15 Mar 44		
Supplement	16 Feb 48	682	80

(1) A cooperative study of experimental steel pile groins was also made, under which methods of improvement were recommended in an interim report dated 19 Sep 1940. Final report on experimental groins was published in 1948 as Technical Memo. No. 10 of the Beach Erosion Board.

Location	Completed	Published in House Doc.	Published in Congress
	LOUISIANA		
Grand Isle	28 Jul 36	92	75
	TEXAS		
Galveston	10 May 34	400	73
Galveston Bay, Harris County	31 Jul 34	74	74
	CALIFORNIA		
Santa Barbara - Initial	15 Jan 38	552	75
Supplement	18 Feb 42		
Final	22 May 47	761	80
Ballona & San Gabriel River (Partial)	11 May 38		
Orange County	10 Jan 40	637	76
Coronado Beach	4 Apr 41	636	77
Long Beach	3 Apr 42		
Mission Beach	4 Nov 42		
	PENNSYLVANIA		
Presque Isle Peninsula, Erie (Interim)	3 Apr 42		
	OHIO		
Erie County - Vicinity of Huron	26 Aug 41	220	79
Lake Erie Shore - Michigan Line to Marblehead	30 Oct 44	177	79
Cities of Cleveland & Lakewood	22 Mar 48		
	WISCONSIN		
Milwaukee County	21 May 45	526	79
	PUERTO RICO		
Punta Las Marias, San Juan	5 Aug 47	769	80

COOPERATIVE BEACH EROSION STUDIES IN PROGRESS

NEW HAMPSHIRE

HAMPTON BEACH. Cooperating Agency: New Hampshire Shore and Beach Preservation and Development Commission.

Problem: To determine the best method of preventing further erosion and of stabilizing and restoring the beaches; also to determine the extent of silting and erosion in the harbor.

MASSACHUSETTS

METROPOLITAN DISTRICT BEACHES, BOSTON. Cooperating Agency; Metropolitan District Commission (for the Commonwealth of Massachusetts).

Problem: To determine the best methods of preventing further erosion, of stabilizing and improving the beaches, and of protecting the sea walls of Lynn Shore Reservation, Nahant Beach Parkway, Revere Beach, Quincy Shore, Nantasket Beach.

SALISBURY BEACH. Cooperating Agency: Department of Public Works (for the Commonwealth of Massachusetts).

Problem: To determine the best methods of preventing further beach erosion. This will be a final report to report dated 26 August 1941.

CONNECTICUT

STATE OF CONNECTICUT. Cooperating Agency: State of Connecticut (Acting through the Flood Control and Water Policy Commission).

Problem: To determine the most suitable methods of stabilizing and improving the shore line. Sections of the coast will be studied in order of priority as requested by the cooperating agency until the entire coast is included.

NEW JERSEY

ATLANTIC CITY. Cooperating Agency: City of Atlantic City.

Problem: To determine the best methods of preventing further beach erosion.

OCEAN CITY. Cooperating Agency: City of Ocean City.

Problem: To determine the causes of erosion or accretion and the effect of previously constructed groins and structures, and to recommend remedial measures to prevent further erosion and to restore the beaches.

VIRGINIA

VIRGINIA BEACH. Cooperating Agency: Town of Virginia Beach.

Problem: To determine methods for the improvement and protection of the beach and existing concrete sea wall.

SOUTH CAROLINA

STATE OF SOUTH CAROLINA. Cooperating Agency: State Highway Department.

Problem: To determine the best method of preventing erosion, stabilizing and improving the beaches.

LOUISIANA

LAKE PONTCHARTRAIN. Cooperating Agency: Board of Levee Commissioners, Orleans Levee District.

Problem: To determine the best method of effecting necessary repairs to the existing sea wall and the desirability of building an artificial beach to provide protection to the wall and also to provide additional recreational beach area.

TEXAS

GALVESTON COUNTY. Cooperating Agency: County Commissioners Court of Galveston County.

Problem: To determine the best method of providing a permanent beach and the necessity for further protection or extending the sea wall within the area bounded by the Galveston South Jetty and Eight Mile Road.

CALIFORNIA

STATE OF CALIFORNIA. Cooperating Agency: Division of Beaches and Parks, State of California.

Problem: To conduct a study of the problems of beach erosion and shore protection along the entire coast of California. The initial studies are to be made in the Ventura-Port Hueneme area and the Santa Monica area.

WISCONSIN

RACINE COUNTY. Cooperating Agency: Racine County

Problem: To prevent erosion by waves and currents, and to determine the most suitable methods for protection, restoration and development of beaches.

ILLINOIS

STATE OF ILLINOIS. Cooperating Agency: Department of Public Works and Buildings, Division of Waterways, State of Illinois.

Problem: To determine the best method of preventing further erosion and of protecting the Lake Michigan shore line within the Illinois boundaries.

OHIO

STATE OF OHIO. Cooperating Agency: State of Ohio (Acting through the Superintendent of Public Works).

Problem: To determine the best method of preventing further erosion of and stabilizing existing beaches, of restoring and creating new beaches, and appropriate locations for the development of recreational facilities by the State along the Lake Erie shore line.

PENNSYLVANIA

PRESQUE ISLE. Cooperating Agency: State Parks and Harbor Commission of Erie (for the Commonwealth of Pennsylvania).

Problem: To determine the best method of preventing further erosion and stabilizing the beaches of Presque Isle Peninsula at Erie, Pennsylvania. This will be a supplemental report to the report dated 3 April 1942.

TERRITORY OF HAWAII

WAIKIKI BEACH. Cooperating Agency: Board of Harbor Commissioners, Territory of Hawaii.

Problem: To determine the most suitable method of preventing erosion, and of increasing the usable recreational beach area, and to determine the extent of Federal aid in effecting the desired improvement.