

CHAPTER 13

COMPILE OF OCEAN AND LAKE WAVE STATISTICS

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RESUME AND COMMENTS

The wave program described in this paper is one intended to provide wave statistics by having our Los Angeles County life guards observe the wave heights, directions and periods.

Mark-sense cards and high speed data processing equipment and computers are used to handle the volumes of statistics.

While some scientists are planning very accurate, costly solutions to the problems of wave statistics, agencies are reluctant to venture into an expensive, elaborate wave surveillance program requiring a large quantity of personnel.

I feel that neither the accuracy of present day design or construction methods warrant "split hair" accuracy in wave surveillance.

The method described in this paper will provide a practical solution if the statistics are handled as follow

1. Wave statistics are gathered continuously over many years of time.
2. A standard is set to check the observed values.
3. Large rare damaging storm conditions will be developed by any reasonable means available until enough years of observation have passed to provide adequate statistics.

TEXT

With good wave statistics, we can provide a design that will prevent the insipient failure that occurs, occasionally, with various coastal structures such as coastal homes, hotels, jetties, groin systems with sand fills, breakwaters, bulkhead walls, etc.

This wave compilation program coupled with surveys showing shoreline movement is all that is needed to design coastal structures for todays coast line profiles as well as for predicted coast line profiles that might exist 20 years from now.

This paper will be confined to the problems of wave statistics.

Wave statistics, used in my work, must include wave heights, periods and directions and be compiled in a way that gives the results of daily observation, individual storm energies, resulting azimuths, resulting energies, root mean square wave heights and average periods.

Our wave observation program is planned to be a continuous program for years to come and will include observations in areas of special interest along miles of Los Angeles County Coast Line.

Hindcast wave statistics have been compiled on the deep water side of the island maze that surrounds our County, but the effects of island sheltering and wave refraction have to be calculated to make these wave statistics usable as design waves along the shores of the continent. This is a laborious method of compiling design wave values even with the use of present day computers. The method doesn't have the accuracy or the usefulness that the wave compilation system discussed in this abstract will illustrate.

After investigating deep water buoy type wave gauges, shallow water pressure gauges, and many other systems, we decided to tabulate wave statistics by visual observations from chosen points along our shoreline.

The chosen points were shoreline areas of future design, areas where man-power is available and areas involving unusual shoreline culture and contours. There were

points where much of the tabulated data could be converted, by applying wave refraction calculations, to deep water waves. The deep water waves could then be used to tabulate wave statistics in coast line areas, where wave observations were not recorded. This was to enable us to provide wave statistics for larger coast line areas.

A great volume of work is eliminated in data retrieval and tabulation by the use of mark sense cards and the I. B. M. 1620 and 360 systems. Our process will supply the wave statistics needed by the County of Los Angeles at little additional cost and may be the type of program that many coastal engineering groups can implement.

The procedure enables us to use County lifeguard personnel without interruption of their daily duties. The lifeguards will mark the wave observations on mark-sense cards which are easily edited and processed with our I. B. M. 1620 computer. Neither personnel time to edit, nor the cost of machine time is a large quantity. The direction of the waves is observed with a vane compass, the periods are timed with the second hand on a wrist watch or stop watch and the average wave heights will be obtained by comparing wave heights to swimmers, rocks, surfboard riders, etc. Observations are made twice a day with each observation being over a period of five minutes or more. The wave conditions are averaged during each observation and the resulting values marked on the specially prepared mark-sense cards.

This statistical sample is quite small but is often enlarged considerably by the fact that the lifeguards observe the waves for a number of minutes prior to the above five minute period.

While the most accurate immediate use of these statistics will be for beach improvement projects, observations over many years will provide enough statistics to allow us to make accurate calculations for rock construction and other types of coastal structures.

The mid range wave conditions, in our County, are those most important in shaping the beaches because of the large energy provided as the results of their frequency of occurrence.

Just one year's observation will result in average statistical waves close to the correct values for the entire family of wind formed waves.

Years of tabulating the above statistics would enable us to do the following

1. In the design of a barrier groin system, we can determine from the tabulated resultant wave direction

the plan view alignment of the shoreline and the realignment with changing storm waves.

2. By defraction calculations, we can determine the wave heights inside a Harbor.
3. We can determine the height of groins from wave statistics. Uprush resulting from the compiled statistics can be added to the tidal averages to determine how high a groin has to be to provide for sand over topping.
5. Knowing the beach profile movement, we can use the wave statistics to determine the height of buildings on the shoreline, the type of foundations to be used, the height of the bulkhead walls and revetment structures.
6. From the wave statistics we can determine the size rock for revetments, breakwaters and jetties and the dynamic and static forces that coastal structures must resist. The designs of these and many other types of coastal structures are dependent on the Coastal Engineer's having these basic wave statistics.

After recording the name of the beach, the position on the beach and the date, the lifeguards record the average breaking wave heights, directions and periods. These tabulations are made twice everyday during the year.

The following list shows symbols and a resume of the basic formulas used by our I. B. M. computers to compile these wave statistics.

List of Symbols

H _b	= Breaking height of wave observed by lifeguards
d	= Breaking depth of wave observed by lifeguards
n	= Value used in computation of shoaling co-efficient
R	= $\pi = 3.1416$
L	= Shallow water length of wave
L _o	= Deep water length of wave
H _o	= Height of deep water wave
T	= Period of wave observed by lifeguards
C	= Inshore velocity of wave
C _o	= Deep water wave velocity
g	= Gravity
E _n	= Energy in millions of foot lbs/foot of beach
N	= Number of observations
W	= Weight of water

Computations

$$d = H_b \times 1.28 \text{ (Approximate)}$$

$$C = \sqrt{gd} \text{ (Approximate)}$$

$$L = C \times T$$

$$C_0 = 512 \times T$$

$$L_0 = 512 \times T^2$$

$$n = \frac{1}{2} \times [1 \times (4 \pi d/L) / \sin h(4 \pi d/L)]$$

$$H_b/H_o = \sqrt{\frac{1}{2} \times \frac{1}{n} \times \frac{L_0}{L}}$$

$$H_o = H_b/H_b/H_o$$

$$* E_n = W \times H^2 \times C/B \times 10^6 = W \times H_o^2 \times C_0/16 \times 10^6$$

$$\text{Root Mean Square Wave Height} = \sqrt{\frac{1}{N} \sum H_b^2}$$

$$\text{Arithmatic Average For } T = \frac{1}{N} \sum E_n \times 16 / (W \times \frac{1}{N} \sum H_o^2 \times 512)$$

* Greater accuracy was obtained by converting H_b to H_o and calculating E_n by the use of the following

$$E_n = W \times H_o^2 \times C_0/16 \times 10^6$$

All energy values are in millions of foot pounds.

Most of these listed formulas are commonly used in the Coastal Engineering field, but the solutions used for resulting azimuths, energies and average periods are special innovations. Resulting energy is calculated by making vectors from each observation. The vectors are formed by wave direction and calculated energy. The machine mathematically joins the vector ends and calculates the resultant direction and energy. The formula for the average period calculation is shown in the preceeding tabulations.

The program tabulates each daily observation and will calculate the resulting azimuths, energy, root mean square wave height, and average period for any time duration the computer operator desires.

Once the data has been edited and sorted for the I B M 1620, it takes only 7 minutes to tabulate an entire years observations for one point on the County Coast line.

This type of tabulation will very quickly give the design engineer wave statistics that he can convert to any type of design use. Accuracy is well within the limits needed. The data processing program for the I B M 1620 and 360 systems is available in the Office of the Los Angeles County Engineer, where it is filed as "Library Program No TG016".

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