

Hanauma Bay, Island of Oahu

PART I

THEORETICAL AND OBSERVED WAVE CHARACTERISTICS

Wailea Point, Island of Maui



CHAPTER 1

REVISIONS IN WAVE DATA PRESENTATION

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In 1966 the author proposed, at the Tenth Conference on Coastal Engineering, methods (Reference 1) of presentation of wave data which were thought likely to be useful to the engineering user. Data obtained from many recording stations have been processed and presented in the formats proposed, and appear to have been able to provide answers to many of the wave questions posed by engineers. However, from time to time additional questions arise, and improvements in technology enable answers to more sophisticated questions to be given. The purpose of this paper is to describe the additions thought necessary to cope with these changes; there are no alterations to the 1966 presentation methods, only additions.

Extreme waves

In the last decade the ability to estimate the likely height of the highest individual wave in some long period of time, say 50 or 100 years, has assumed a new importance. The methods employed all rely on the extrapolation of measured sets of data, but as no one method has an impeccable theoretical parentage several methods have to be resorted to. Considerable effort has been put into such work by this Institute and at present the log-normal, Gumbel and Weibull distributions are used on each set of data.

Persistence

In the original paper the only recommendation made concerning persistence dealt with the persistence of wave conditions with heights at and above given thresholds; this is used mainly in connexion with the estimation of downtime, and is now known as the Persistence of Storms. However, in rougher sea areas it becomes necessary to quantify the number and duration of quiet spells, so that working time on operations such as pipelaying, which can only proceed in prolonged calm conditions, can be estimated. This is known as the Persistence of Calms. It is not possible to derive the Persistence of Calms from the Persistence of Storms, or vice versa.



Figure 1. Presentation of hypothetical wave spectra illustrating the characteristics of swell and locally-generated waves

One-dimensional spectra

The most important improvement stems from the arrival of data-logging equipment and the ability to produce spectra on a routine basis at an acceptable cost. A publication listing spectral data for 3000 wave records, the number commonly obtained in a year, would not be easy to comprehend unless the spectra could be extremely condensed. It now seems likely that spectra for a month can be presented on one page in a form which can be assimilated by visual inspection and yet which can give quantitative results. This is an extension suggested by M.J. Tucker to the method used by Snodgrass et al. (Reference 2) in the Pacific swell attenuation study. Each spectrum is presented as a column of numbers giving the energy density in metres²/Hz each plotted at its appropriate frequency level. Subsequent spectra are displayed in the same way one after another and then contours of wave energy are drawn. A hypothetical result is given in figure 1. Apart from giving the actual data, the method identifies immediately where the waves are under generation and where swell is arriving from a distant storm. The arrival of swell is characterized by the appearance of low-energy long-period waves whose energy gradually increases as the frequency increases (period decreases) so that the contours are aligned upwards to the right; in contrast, with locally generated waves the energy and wave period increase together and the contours align downwards to the right. This presentation is a powerful method for the identification of the wave regime at any given time. Once a potentially dangerous time (for the engineer) is defined, the full details of the spectra can be obtained from the original data. Returning to the figure, which is a hypothetical demonstration of this type of presentation, it shows the appearance of swell between days 1 and 3; the slope of a line drawn along the ridge can enable the distance of the source (storm) to be calculated. About noon on day 4 a local storm is beginning to generate waves of increasing period; this continues to day 6, after which calm conditions return.

Actual examples are given in Figures 2 and 3. These present data from a Waverider Buoy situated 6 miles to the west of the island of South Uist in the Outer Hebrides, north west Scotland. Figure 2 illustrates fairly rough conditions with significant heights up to 5.72 m. The highest energy concentrations lie between about 9 and 16 seconds period. The figure covers the time between 10.59 hours on day 100 (9 April) and 0759 hours on day 105 (14 April). The second illustration, figure 3, covers the time between 10.56 hours on day 115 (24 April) and 0459 on day 120 (29 April). It is a time of lower waves, significant heights up to 1.24 m, with a swell of about 9 seconds dying away and another swell of 15 or 16 seconds arriving, reducing in period and dying away. There is a





Fig 2

Actual spectra for five days with significant wave height and zero-crossing period calculated from each spectrum



WEST OF SOUTH UIST, OUTER HEBRIDES



Fig 3

Actual spectra for five days with significant wave height and zero-crossing period calculated from each spectrum

small amount of local wave generation at about 3 seconds. probably due to winds of around 10 knots. In these cases, to make the presentation more complete, the significant wave height in metres and the zero crossing period in seconds are given below each column. In these two figures the data are not as condensed as in the hypothetical case, figure 1, and because there were several sources of wave energy in the North Atlantic at the time the picture is not as simple as in the idealized figure 1.

Sea-bed waves

With the improvement in techniques there is the possibility of presenting on a routine basis information on the magnitude of the wave motion at the sea bed. This can be done either as spectra in an analogous way to the presentation of surface data, or in a more condensed way as was done for some wave data around the U.K. This is by means of an exceedance diagram for wave-induced particle speeds at the sea bed (Reference 3).

Titles of graphs at present proposed for data presentation:

- (1) Wave Height Exceedance one for each season.
- (2) Zero-crossing Period Histogram one for each season.
- (3) Spectral Width Parameter annual.
- (4) Scatter Diagram annual.

spectra available.

- (5) Persistence of Storms annual.
- (6) Persistence of Calms annual.
- New (7) Extreme Waves - several methods - annual. 1 method at present. New (8) Spectra if available. New (9) Sea Bed Spectra if available and desirable. New (10) Sea Bed particle speed exceedance if surface

New

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REFERENCES

- (1) Draper, L. 1966 The Analysis and Presentation of Wave Data - a Plea for Uniformity. Proc. 10th Conference Coastal Engineering, Tokyo, Vol. 1, pp. 1-11.
- (2) Snodgrass, F.E., Groves, G.W., Hasselmann, K.F., Miller, G.R., Munk, W.H. and Powers, W.H. 1966 Propagation of ocean swell across the Pacific. Phil. Trans. roy. Soc. (Lond.) A (1103) <u>259</u>, 431-497.
- (3) Draper, L. 1967 Wave Activity at the Sea Bed around Northwestern Europe. Marine Geol. <u>5</u>, 133-140.