3. STATISTICAL ANALYSIS

3.1. Introduction

The statistical analysis in the present study basically comprises of the calculation of representative parameters of the surface elevation and wave height (crest and trough) directly obtained from the surface buoy registration. The main objective is the comparison with the ones obtained from the spectral analysis in the framework of different theories. Moreover, the analysis of some parameters itself is useful to determine the applicability of the well-known linear theory, explained in Chapter 5.

3.2. Definitions of height, crest, trough and period

First of all, the concept of wave has to be defined. In the case of the linear theory or a sinusoidal wave, it is easy but when one looks at real ocean surface elevation it becomes more complicated. For a time record, two main methods are used to describe a wave: the downward zero-crossing (see Figure 3.1) and the upward zero-crossing. If the surface elevation is considered as a Gaussian process, the definition used does not matter for the statistics. Nevertheless, many prefer the downward zero-crossing because in visual estimates the height is taken between the crest height and the preceding trough. In addition, the steep front, which is relevant for the breaking process, is included in the downward zero-crossing definition. In fact, this criterion is recommended by the International Association for Hydraulic Research Working Group (IAHR, 1989). Attending to these recommendations, in the present study the downward zero-crossing method is used.

![Figure 3.1 Sketch of the definition of a wave in a time record of the surface elevation with downward zero crossing](image)

For each wave the following parameters are calculated: wave height, crest level, trough level and period (see Figure 3.2). For the calculation of the period a linear interpolation is made between the two points around the zero level. Note that the definition of crest/trough is not a local maximum/minimum surface elevation but the maximum/minimum per wave. As a consequence, the wave height is the difference between such a maximum and minimum. When reading studies in the literature, one must be careful because sometimes one is referring to the local maxima which, for
instance, would mean the possibility of having negative wave crests. For civil engineering purposes, the definition used in the present study is more useful, which does not allow negative values for wave crests.

![Diagram of wave parameters](image)

Figure 3.2 Definition of the main parameters of each wave

### 3.3. Parameters

Once the above mentioned calculations are made for all the waves, the following parameters are calculated per record:

- **Mean wave height** ($H_{\text{mean}}$)
  \[
  H_{\text{mean}} = \bar{H} = \frac{1}{N} \sum_{j=1}^{N} H_j
  \]  
  (3.1)

- **Significant wave height** ($H_{1/3}$): mean of the highest one third wave heights
  \[
  H_{1/3} = \overline{H_{i}} = \frac{1}{N/3} \sum_{i=1}^{N/3} H_i, \quad H_i \text{ being highest one third wave heights}
  \]  
  (3.2)

- **Root-mean-square wave height** ($H_{\text{rms}}$)
  \[
  H_{\text{rms}} = \sqrt{\overline{H^2}} = \sqrt{\frac{1}{N} \sum_{j=1}^{N} H_j^2}
  \]  
  (3.3)

- **Maximum wave height** ($H_{\text{max}}$)
  \[
  H_{\text{max}} = \max(H)
  \]  
  (3.4)

- **Mean wave period** ($T_{\text{mean}}$)
  \[
  T_{\text{mean}} = \bar{T} = \frac{1}{N} \sum_{j=1}^{N} T_j
  \]  
  (3.5)
• Significant wave period ($T_{1/3}$): mean of the period of the highest one third waves.

$$T_{1/3} = \bar{T}_i = \frac{1}{N} \sum_{i=1}^{N/3} T_i, \quad T_i \text{ being the periods of the highest one third wave heights}$$

The crest and the trough statistics are also calculated in an analogous procedure as in the wave height.

For quantification interval and noise considerations, waves with wave height smaller than 5 cm or crest heights smaller than 2.5 cm or wave periods smaller than twice the sampling interval, are not considered in the statistical analysis.

In addition, the standard deviation, skewness and kurtosis parameters are calculated. These are defined in Eq. (3.7), (3.8) and (3.9)

Standard deviation: \[ \sigma = \sqrt{E\{(\eta - \mu_\eta)^2\}} \] \hspace{1cm} (3.7)

Skewness: \[ s = \frac{E\{(\eta - \mu_\eta)^3\}}{\sigma^3} \] \hspace{1cm} (3.8)

Kurtosis: \[ k = \frac{E\{(\eta - \mu_\eta)^4\}}{\sigma^4} \] \hspace{1cm} (3.9)