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Observed Short- and Long-Term Distributions of Wave Steepness

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ABSTRACT

Steepness, and its conditional distribution with respect to significant wave height, is an important characteristic of the severity of a sea state, for shipping applications as well as for offshore platforms.

We analyse in this paper the observed distributions of the "sea state steepness", defined from significant wave height and zero-crossing periods. Special emphasis is given to the tails/limits of the distributions, estimated here from a large number of measurements.

We also study the distribution of individual waves steepnesses within a given sea state. Using radar measurements of the sea-surface elevation at a North Sea location, we compare the observed steepnesses with the distributions deduced from the Cavanié *et al.* and Longuet-Higgins models of heights and periods.

Special attention is given to the extreme waves among which one might expect "*Freak waves*".

The possibility to predict the probability of waves of extreme steepness, or combined extreme height and steepness, by convolution of the long- and short-term distributions is investigated.

Further analysis is carried out for the wave front steepness, which is the most relevant for damage to ships and offshore structures.

KEYWORDS: Ocean waves, steepness, asymmetry, design conditions.

NOMENCLATURE

$\eta(t)$	sea surface elevation as a function of time t
m_n	n^{th} moment of spectral density
H	Zero downcrossing wave height
T	Wave period (by zero downcrossing analysis)
L	Wave length
T_{02}	Mean period computed from spectral moments of order 0 and 2

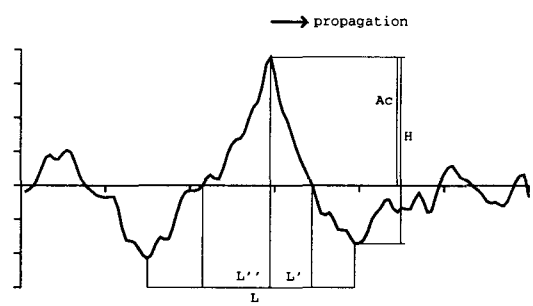

Figure 1. Wave parameters

H_S	Significant wave height defined as average of the highest one-third of the wave heights and estimated by $H_{1/3}$
$H_{\frac{1}{3}}$	Average of the highest one-third heights in a wave sequence
H_{m_0}	H_S estimated by $4\sqrt{m_0}$
H_{max}	Maximum zero downcrossing wave height
$S_{\frac{1}{N}}$	Average steepness of the waves belonging to the highest one-Nth in a sequence
S_b	Crest back steepness (S''_C in [3])
S_d	Individual wave down-steepness, from crest to trough
S_f	Crest front steepness (S'_C in [3])
S_l	Individual wave steepness (by space-domain analysis), H/L
S_m	Average of wave steepnesses in a sea state
S_S	Sea state steepness by time-domain analysis, $2\pi H_s/gT_{02}^2$
S_t	Individual wave steepness by time-domain analysis, $2\pi H/gT^2$
S_u	Individual wave up-steepness, from trough to crest