# Storm Wave Resonance Controlled by Hollow Block Structures

**by Fritz Büsching[1]**

## 1. TOPIC

The formation of long shore bars in front of sandy beaches often is assumed to act as a shore protecting feature only. At Sylt Island/Germany, however, boundary conditions formed by a structured long shore bar, running roughly parallel to the shoreline, are found to be the reason for intense resonance absorption effects at storm surge conditions as well. Incoming waves interact with the water level deflections in the trough located between the bar and the beach in such a way that frequency components match a limited number of possible harmonics of the enclosed body of water. As there are significant energy densities to be found in the wave energy spectra at harmonic numbers 1 to 5 of the enclosed water body, this phenomenon is believed to be responsible for the tremendous coastal recessions at this island due to storm surge occurrences in the past.

## 2. RESONANCE EFFECTS IN A WAVE TANK

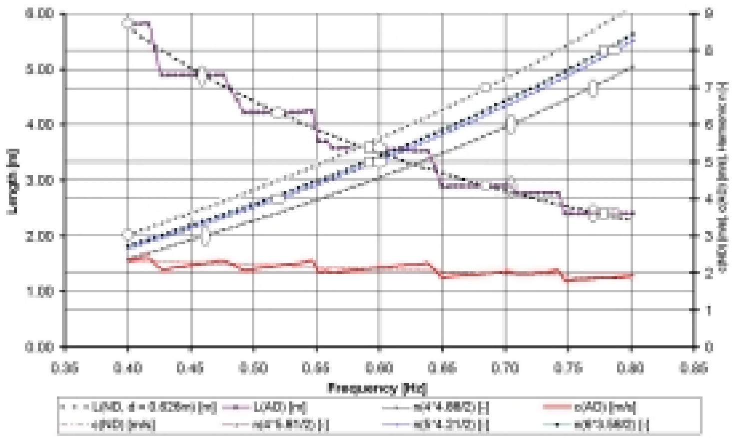

Fig.01: Component Lengths, Phase Velocities and Harmonic Numbers $3 \leq n \leq 8$ with Frequency.

From electromagnetic wave propagation in dielectrics it is well known that *resonance and anomalous dispersion* are combined effects.

Using a special technique of analysing composite spectra (containing information of incoming, reflected and re-reflected waves), it was possible to detect a set of partial standing waves existing in a wave tank coincidentally. As each of such harmonics is composed of a number of frequency components disposing of nearly equal wave length, they are governed by an anomalous dispersion law dc/df > 0, see lower curve of Fig.01.

## 3. RESONANCE ABSORPTION AT A RIDGE COAST

At Sylt Island (North Sea) boundary conditions, formed by a structured long shore bar running roughly parallel to the shore line, are found to be sufficiently comparable to that of the above tank. High energetic spectra (Fig.02), measured at two beach stations synchronously, had been used for the calcula-

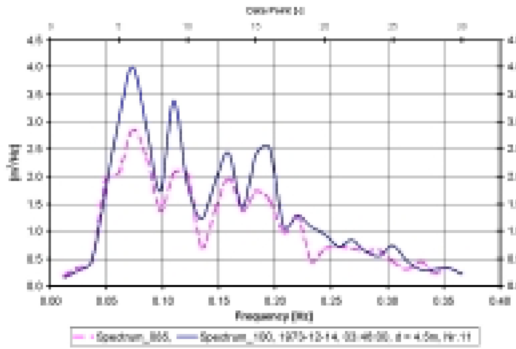

Fig.02: Synchronously Measured Storm Surge Spectra at Stations 100m and 85m.

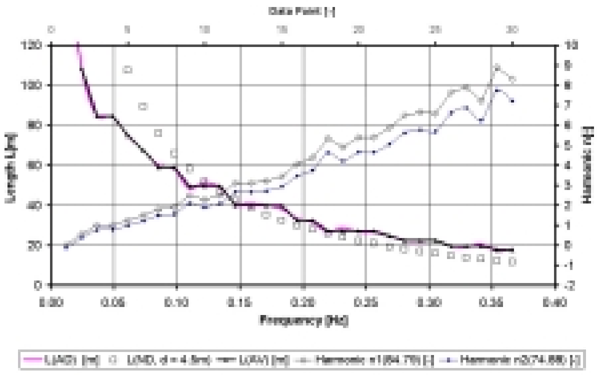

Fig.03: Component Length spectra L(ND)(f), L(AD)(f) and Harmonic Numbers n(f).

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tion of transfer functions. Based on such data the author previously had observed an intense anomalous dispersion effect (ADE), documented by $dc/df > 0$ in the respective phase velocity spectra c(AD)(f). Recently spectra of component length L(AD)(f) (Fig.03), derived from c(AD)(f), did reveal a wavy or stepped structure, significantly differing from lengths spectra L(ND)(f) deduced from the classical dispersion relation c(ND)(f). The result being similar to that of the above wave tank investigations supports the thesis of resonance absorption effects to be relevant with respect to storm surge action at the beach and the formation and/or stability of sand ridges running parallel to the coastline.

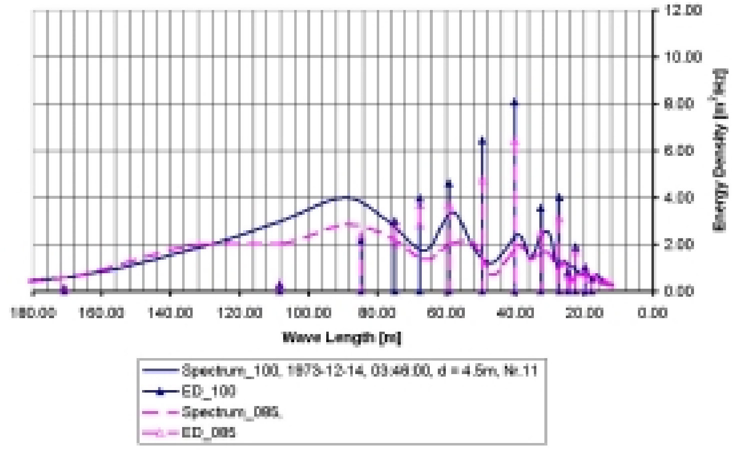


Fig.04: Energy Density Spectra Transferred to the Length Axis and Line Spectra of Energy Density Based on Length Spectrum L(AD)(f).

Essential effects of resonance can be demonstrated impressively by transforming the energy density spectra into line spectra of energy density ED(L) (Fig.04). This is done in applying L(AD)(f) instead of L(ND)(f). In the case of Fig.04 it can be seen that maximum energy density is related to a wave length of $L \approx 40m$ instead of $L \approx 90m$. Actually such smaller wave lengths are found, if zero crossing evaluation method is applied on the respective analogue wave data.

### 4. PROPOSAL: HOLLOW CREST STRUCTURE PLACED ON TOP OF THE RIDGE

As a consequence of the assumed resonance, extreme water level deflections should occur not only at the beach face *but also* at the landward slope of the long shore bar. Since maximum Clapotis energies coincide with the maximum water level deflections at the boundaries of the water body, taking suitable action on damping of the movements at the beach and/or at the landward slope of the long shore bar can be expected to be most effective. Applying protective structures on top of the ridge, such structures could be made more effectively by hollow concrete elements,- for instance from such concrete frames to be seen in Fig.05. The concrete elements would even be nearly invisible, if their crests do not extend much above SWL. At the seaward side of the crest structure the incoming waves are reduced extraordinarily due to the rough turbulence of the uprush and backrush of broken waves entering and leaving the hollow concrete block layer respectively. The still persisting oscillatory movements in the trough between beach and bar will be diminished by similar energy consuming vortex action at the landward slope. As a consequence it can be expected that breakers at the beach also will be reduced extraordinarily and no additional nourishment is required.

The structure disposing of a rather big amount of cavity supports air entrainment and provides protective space for small animals.

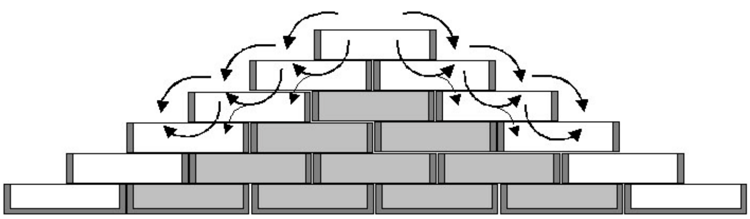

Fig.05: Schematic cross section of permeable crest structure composed from concrete frames. Rough turbulent outflow at wave trough passing the structure.

Further information on “Hollow Cubes” and on published documents on hollow structures can be found at http://www.hollow-cubes.de .

### 5. CONTENTS OF FULL PAPER AND OF ORAL PRESENTATION

Total material of both field measurements and model investigations will be presented in the full paper. For further confirmation of the essential findings spectra of four additional field measurements will be shown transformed to the wave length axis also.