GOLD COAST CITY COUNCIL

BEACH REPLENISHMENT PROGRAM

REPORT NO. 8

HEADLAND WAVE DIRECTION INDICATOR

SUMMARY
This report covers the investigation, design and development of the headland wave direction indicator.

INTRODUCTION
One crucial part of Council's Beach Replenishment Programme involves investigation and determination of the littoral drift rate along the coast. At present the major indeterminate in the programme lies in estimating the annual maintenance sand pumping needed to maintain the nourished beaches. Many littoral drift calculations have been done over the years. More recently a considerable number were contained in the Delft Report (Ref. 1), however Professor Bijker stated that although these are the best estimates available to date they remain estimates and any experimental data that could help his mathematical model would be most valuable.

As a result of the littoral drift calculation it is accepted that littoral drift must be dependent on five important parameters.

(a) Wave Energy.
(b) Wave Angle of Incidence.
(c) Slope of Beach.
(d) Ripple Height.
(e) Mean Particle Size.

Parameter (a) is obtained from records taken at the Wave Recorder Station at South Nobby; Parameters (c) and (d) can be determined by surveying and Parameter (e) by analysis of sand samples.

However Parameter (b) is most difficult to obtain. The Delft Report (Ref. 1) includes basis wave refraction diagrams for the Gold Coast, however due to its natural complexity, the diagrams do not indicate the wave angles close to shore in the breaker zone where littoral drift is at its maximum. From observations of the coast over a period of time Council's Engineers reached the conclusion that a simple instrument, which would detect comparatively small variations in wave incidence along with the distance offshore that waves broke, could be constructed. This device would thus provide large amounts of field data – at small cost – for littoral drift calculations.

OBJECT
Essentially the Gold Coast is divided into three crescent shaped beaches with a couple of hills either coming close or actually crossing the beach into the sea. Observations of beaches from all these headlands allowed the selection of areas of surf having suitable obliquity to the headland. It was then thought possible to construct a transparent screen on which wave directions for that area could be marked. Using plain trigonometry the viewing area could then be fixed and a "Wave Map" that would convert the optical view into acceptably accurate wave plans and vice versa could be produced. The object then was to construct and calibrate such a device which would be simple and accurate in its construction and method of operation. To attain simplicity the instrument should be designed with as few components and moving parts as possible. Secondly the system used in marking the position and angle of the observed wave front should require little work on the part of the observer. Accuracy had to be controlled in the design itself; as a result there was no use for any system which was involved and tedious. Another criteria instituted through fear of damage, was that the device should be easily set up and dismantled each day, still keeping a high degree of accuracy.

DEVELOPMENT
A method of measuring wave direction was developed in South Africa, (Ref. 2) but this method was thought to be too involved to use in this situation. It was also found that trying to measure the wave direction from the shore involved a great deal of equipment and required a considerable amount of work on the part of the operator. Since the Gold Coast has these headlands it was an obvious step to try and

use them. By observing waves from a suitable position on a headland, the observer can look almost straight down a line of a wave. This allows him to view the wave as it crests without obtaining a distorted view and thus a simple instrument using a simple method of determination could be used.

It was also realised, during investigation of the feasibility of such a device, that the instrument would have to be set up on an approximate line with the breaking waves since a set up too close to the beach causes a distorted view and too far out on the headland causes the observer to look down on the back face of the wave resulting in wave crests very difficult to view.

From analysis of observations South Nobby was chosen as the first set up because from there an observer could look along the waves of Miami Beach. A position on South Nobby was chosen and tied into real property. After further observations from this point an arbitrary point at sea was chosen as approximately the distance any observer would be able to see. It was estimated as approximately 1,000 m. A position now had to be plotted onto a map and a line along Santa Monica Rd. out to sea was within the range. A suitable distance from shore was chosen as the centre of the viewing area. I.e. a distance to where waves would most commonly break, when having moderate wave energy. This point was plotted on the map and bearings and dip etc. were calculated using simple trig. ratios.

Initially the suggestion was made that if wave curves for different angles of incidence were drawn on a transparent screen then real waves could be matched with these drawn curves to obtain their angle of incidence. This proved to be a valid assumption and saved a great deal of time in overall design. However there still was the problem of how the position of the waves was to be marked simply, but accurately. It was agreed that to make the process simple much of the work had be carried out in the Design Office. Council's design Engineer proposed that a grid system by used whereby the observer could match the wave and plot its position simultaneously. As a result a grid plate was drawn up as shown in the inset in (Fig.1) and thus adopted.

A rough screen showing wave curves was also drawn up and using these two screens together a rough test was carried out to judge their feasibility.

With the success of this test it was decided to construct a prototype. The prototype used a length of wood and two plastic screens obtained from short box tops. The prototype proved to have high promise of success. From its use it was found that the screen containing the wave curves would need to be movable and also that the curves should all radiate from a particular origin. From observations leading up to final construction of the prototype it was found that a particular distance between the foresight and grid screen would be needed (Fig. 1) to give an angle of sweep which would cover nearly all possible conditions of the sea. A sweep of 14° included angle was finally selected. The distance between grid screen and wave screen was also experimented with to give maximum clarity (Fig. 1).

The grid on the screen had not been plotted, hence this had to be done before proceeding any further. Knowing the width of each position and distance between grid and foresight and also knowing the distance from instrument to a point on the sea enabled the actual grid positions to be plotted on the map (Fig. 2). There was some difficulty encountered in drawing the wave curves on the screen, (i.e.) plotting the optical view from "Wave Map". The initial curves were very rough, hence it was decided to plot the optical view correctly. The initial plans were much too small so it was enlarged to 1:500 scale. There was no way of knowing accurately just how much curve was on a wave, hence it was decided to plot straight lines with a view to plotting the curves from site observation. However it was found that there was no need to plot the curves. In plotting these straight waves (Fig. 3) it was found that the device would be extremely sensitive for small angles of variation from the centre line.

The instrument (Fig. 1) is constructed from readily available aluminium offcuts and Perspex. The aluminium glazing extrusion was slightly larger than the Perspex, however by using two strips of foam rubber packing the screen was able to be firmly held in this extrusion. The movable screen posed a greater problem; the screen had to be firm, but still had to be moved with one hand. Using one piece of packing held the screen firmly and the application of silicone grease to the perspex and foam rubber allowed easy movement.

The instrument was tested initially by placing it over the telescope of a theodolite but a structural steel frame was later constructed and set in concrete as a permanent set up.

The total cost of the instrument was $2.50 and took approximately five days to design and construct.

USE

The instrument is extremely simple to use. Firstly it slips into the frame and does not require bolting or fixing. Secondly it has one moving part which need only be moved once. Thirdly, time taken in taking a reading is less than a minute although more time may be spent observing uneven wave trains to check initial readings.

OPERATING

The instrument involves fixing the position where a wave is cresting by moving one's eyes across the face of the grid until the cresting wave, foresight and grid position line up. With this grid position the movable screen is slid across until a line is made with the grid position, the origin of the wave lines, the foresight, and the real wave. This having been done, the real wave is observed and matched with one of the angular lines marked to determine angle of wave.

The angle and grid position are recorded by the observer and subsequently plotted on a map in the office or used for computer input in absolute directional terms from calibration diagrams. It is anticipated that with this type of information available for various points along the coast, correlation with aerial photographs might well allow the directions of waves for other beaches to be plotted.

In this way progressive wave refraction diagrams for the surf zone of the whole coast might well be produced.

CONCLUSIONS

The headland wave direction indicator is a simple easily operated instrument and a s a result of the centre sighting line being almost parallel to the beach, the device is extremely sensitive to smaller angles of incidence about this mean centre line. Since the angles of incidence of real sea wave fronts are not expected to vary by plus or minus 10 degrees the device should be comparatively successful.

Based on the utilisation of the prototype it is recommended that two more instruments be developed and set up on Kirra point and on one of the buildings on Surfers Paradise Foreshore. This being done by simply changing the angles of waves on the movable screen.

REFERENCES

1) DELFT HYDRAULICS LABORATORY, - Gold Coast, Queensland, Australia, Coastal Erosion and Related Problems, - Report R257 1970.
2) ZWABORN, RUSSEL AND NICHOLSON, - Coastal Engineering Measurements – Coastal Engineering Proceedings A.S.C.E.

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