

THE MONITORING OF RUBBLE MOUND BREAKWATER STABILITY USING A  
PHOTOGRAPHIC SURVEY METHOD

by

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ABSTRACT

A method of surveying the above-water slope of breakwaters by means of photography has been developed at the National Research Institute for Oceanology. The method is simple and inexpensive and yet capable of detecting movement or displacement of a single armour unit on a breakwater.

This poster paper describes the method and presents some examples of its application in the field.

1. INTRODUCTION

The long-term stability of, and the intermittent storm damage to, rubble mound breakwaters are of considerable interest to the designers, builders and authorities responsible for maintenance. A major disaster will obviously be noted immediately, whereas a gradual deterioration, settlement or breakage and movement of individual armour units can often pass unnoticed until major damage occurs. Early detection of cases of potential damage is therefore essential. Full breakwater surveys can become costly and time-consuming and often do not detect the finer details of damage.

A simple yet effective photographic method of surveying the above-water part of a rubble mound breakwater has been developed at NRIO to monitor effectively the movement, displacement and breakage of armour units on the slope. Since this method only records the above-water part of a breakwater it cannot reveal its overall condition, however, it will nevertheless give a reasonable indication of the condition of a breakwater since it is able to record damage in the above-water part of the zone where damage normally commences, that is, the zone with boundaries just above and below still water level (Zwamborn, 1980).

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To determine the overall stability of a breakwater this method of survey should obviously be supplemented with an under-water survey method.

## 2. THE METHOD OF SURVEYING

The technique involves photographing the breakwater in sections from a distance such that individual armour units on the breakwater can be identified easily. A picture of the whole length of the breakwater is obtained by joining the photographs. The sections of the breakwater and the positions from which the photographs are taken are recorded so that subsequent photographs, taken of these sections from the set positions, when compared with the earlier photographs, permit damage to the breakwater to be detected and estimated.

The horizontal photographs taken at sea level can be complemented by photographs taken vertically from the air e.g. aerial survey photographs enlarged to the same scale as the horizontal photographs. These provide means for even closer examination of the condition of the breakwater.

The success of the method depends largely on the accuracy with which it is possible to identify and fix the positions from which the photographs are taken of the breakwater sections. However, no sophisticated position-fixing equipment is used in the surveys and the method is as follows:

Two large beacons are erected on shore to provide a fixed reference line parallel to the breakwater. By sighting and keeping the two beacons in line, the survey boat from which the photographs are taken can maintain a course parallel to, and at the required distance from, the breakwater.

Each breakwater section is identified by two marks painted on the breakwater, one on the top of the splash wall and the other on the land side of the breakwater deck. The line connecting these two marks is perpendicular to face of breakwater. During a survey a large board with the number of the breakwater section and with a flag at its top is placed over the mark on the splash wall. A long staff, also with a flag at its top, is placed over the corresponding mark on the land side of the breakwater. These two markers, clearly visible from the survey boat, thus provided a reference line of sight to the breakwater section. The positioning of the survey lines and of breakwater sections is shown diagrammatically in Figure 1.



As mentioned earlier, the photographs can be viewed in pairs under a stereoscope to provide a three-dimensional image of the breakwater section.

For initial comparison of any two surveys, photographs of corresponding breakwater sections are enlarged to the same scale, usually 1:250, and the two photographs examined to detect any changes in the breakwater.

If any changes are noted, and if a closer inspection is needed, the photographs can be enlarged to a much higher degree. The photograph of the first survey (A) is printed in the normal way on photographic paper while the corresponding photograph from the second survey (B) is printed on a positive transparency sheet film. Changes in the positions of dolosse on the breakwater can be detected accurately when the transparency B is placed over the photograph A. If even more detailed analysis is warranted the photographs of only the damaged section can be enlarged further. Since lighting conditions, shadows, etc., are not likely to be the same in any two surveys, the outline of each dolos in the damaged section can be traced onto a film sheet to make the comparison easier. The two tracings overlaid can then be examined dolos by dolos.

When only one or two dolosse have been noted to have moved, the change in dolos position can be shown sufficiently well on an enlargement of the photograph of the relevant breakwater section.

Since damage to an armour slope normally occurs in a zone with boundaries just below and above still water level it is important to do the photographic survey during low water spring tide so that as much as possible of this zone is recorded.

### 3. SOME RESULTS OF SURVEYS

To date, the method has been used to monitor the stability of breakwaters at three sites, the western breakwater of the Table Bay harbour, the cooling water intake basin at the Koeberg power station and the harbour entrance breakwater at Richards Bay.

Table Bay harbour western breakwater is an old structure which in the course of time has been extended and modified. Because of this there are different types of construction and armour units along its length of about 1 km. These range from caissons to concrete blocks to dolosse. The breakwater is subjected to severe breaking wave action during the winter storms and some parts of the breakwater occasionally require repairs. Photographic surveys are



Figure 2 Loss of dolosse at section P10

used there to monitor the effectiveness of the repairs as well as the general stability of the breakwater. Examples of photographs of damage on the breakwater are shown in Figure 2.

The two breakwaters of the cooling water intake at Koeberg were completed recently (1980). Both breakwaters are rubble mound constructions overlaid with dolos armour units. Regular breakwater surveys have been undertaken as part of the post-construction monitoring programme. Very limited settlement of a few individual dolosse has been recorded on the two breakwaters. An example of settlement (two dolosse) on the head of the breakwater is shown in Figure 3.



Figure 3 Dolos settlement at section S2

Richards Bay harbour breakwaters, both of rubble mound construction with dolosse as the armour unit, were surveyed prior to the proposed improvements. Further surveys are planned to monitor the long-term stability of the breakwaters.

#### 4. CONCLUSIONS

The method of photographic surveying of the above-water part of breakwaters has been found capable of detecting the movement and displacement of individual armour units on a breakwater slope. In spite of the fact that it can only record the above-water part of the zone about the still water level where damage normally commences it can be most valuable as far as giving an early warning of damage in that zone. The method is simple and inexpensive, involving a few people and a boat. A survey takes an average of

about one hour for a 1 km length breakwater. The time required for the analysis of results depends on the extent of change or damage on the breakwater recorded during the survey.

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#### 6. REFERENCE

ZWAMBORN, J A (1980). Measuring techniques, dolos packing density and effect of relative block density. CSIR Research Report 378, Stellenbosch.