PART 4
DESIGN AND CONSTRUCTION OF COASTAL WORKS

Chapter 29

ABOUT THE ESTIMATION OF THE NUMBER OF DAYS WITH FAVORABLE METEOROLOGICAL AND OCEANOGRAPHICAL CONDITIONS FOR ENGINEERING OPERATIONS ON THE SEA COAST AND IN ESTUARIES

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INTRODUCTION

When an engineering work has to be carried out on the sea coast, in estuaries, etc -for instance dredging operations, reclamation and harbour works, works for coast protection, etc- it is important to know the circumstances under which the work will have to be done. More in particular it is important to know the probable number of days with favourable meteorological and oceanographical circumstances to do the work. In many cases these data are available from experience. They are lacking, however, in remote areas, where no or only a few small works have been carried out so far. In this paper the factors dominating the possibility to work are discussed. A method for the calculation of the probable number of days with favourable conditions for engineering operations on the sea coast, in estuaries, etc., in remote areas, is indicated.

The days with favourable conditions for engineering operations will be indicated in this article, for the sake of brevity, by "A days".

FACTORS DOMINATING THE POSSIBILITY TO WORK ON THE SEA COAST, IN ESTUARIES, ETC.

The possibility to work at a certain moment on a certain place in any water depends on many factors. Some of these are:

1. character of the work.
2. kind of equipment.
3. strength and direction of the currents.
4. velocity and direction of wind (see also 5 and 6).
5. height, length and direction of waves (see also 6).
6. direction in which a vessel is moored or anchored with regard to the direction of the wind and the waves.
7. fog and mist, ice and temperature.
8. distance to objects which may be a danger for a vessel -for instance shoals, a ridge under water, piers, etc.- and intensity of shipping traffic.
9. distance to a port of refuge or a safe roads.

10. duration of the period with adverse conditions for work.
11. human factors.

The character of the work to be done determines the kind of equipment to be used. This equipment will generally be of the existing types. A more detailed study of the circumstances under which the work has to be carried out, however, will sometimes lead to the conclusion that specially designed equipment will have to be used.

The strength of the current sometimes dominates the possibility to work, This is especially true in the oase of fascine construotions. Fascine mattresses are used on a large scale in Dutch practice for protection of lightly erodable soils under water. The transport and sinking of these mattresses is only possible when the velocity of the water is small.
Otherwise these constructions are damaged or reach the bottom in the wrong position. In tidal regions especially the period round the turn of the tide is used for these operations. The limitary velocity for transport is 2,0 m/sec, for sinking 0,6 m/sec.

Also for the transport and placing of large elements, such as caissons, the strength of the ourrents is a dominating factor. Large caissons have been used in the Netherlands for the reconstruction of the dykes after the stormflood of February 1, 1953 (62 x 19 x 18 m3, 7000 tons displacement). Tugs with a total installed power of 5000 hp could tow such a caisson with a maximum velocity of 10 km/hour. This determines some limitary velocity of the water. The placing of these oaissons asks for a nearly zero velocity.

In many cases data about the strength and direction of the currents are scarce. Measurements in the field are neoessary, but usually the time available for this preparatory work is too short to learn enough about the statistical distribution of velocities in certain periods. Comparative studies about similar, better known areas and tidal calculations may also fill up the gap in our knowledge. Sometimes laboratory tests are valuable. Tidal calculations and laboratory tests are espeoially necessary if the work in progress influences the direction and strength of the currents. In the Netherlands a detailed knowledge of the ourrents on the coast and in the estuaries exists. A staff of mathematicians is specialized in tidal calculations and provides for data with respect to

*) See also: Proceedings of the first conference on coastal engineering October 1950; chapters 18 and 19.

any new, not yet existing, situation. Hydraulic and electrical models are used.

Wind itself is not the dominating factor in most cases. For the transport and placing of the above-mentioned caissons, which project high above water, a limitary wind velocity is 10 m/sec, however; for transport in a complicated system of gullies even from 5 to 7 m/sec.

Meteorological data, such as records of wind velocity, wind direction and temperature, may be available directly for the area under consideration or may be derived from data in surrounding areas, for instance by interpolation. Severe frost causes difficulties for all kinds of fascine constructions. For other engineering operations severe frost is at least an inconvenience. The hindrance which may be expected from ice, fog and mist can be determined best in the area itself. In Dutch practice floating ice causes difficultties in estuaries and on the tidal rivers only in extremely severe winters. The hindrance it causes is greater in estuaries with a rather complicated system of gullies, than in more open waters. A few comparative measurements, in the area itself and in similar, better known, areas, may teach a great deal.

The possibility of carrying out dredging operations is dominated mainly by the waves. Some date about the limitary wave height follow below:

Character of the work and kind of equipment	Limitary wave height, metres
Dredging with:	
seaworthy suction hopper dredger, with rigid suction tube (also cutters)	0.7-1.0
with flexible suction tube	1.5-2.0
suction dredgers of the non-propelled low pontoon type, rigid suction tube	0.5-1.0
bucket dredger of the non-propelled low pontoon type, hard bottom	0.5
seaworthy tin dredgers	1.5-2.0
Mooring barges alongside a dredger with barge discharge or alongside a barge-unloading dredger	0.5-0.75
Dumping stones, sand, clay with dump barges with bottom doors (up to 400 tons)	0.5-1.0
Dumping stones and clay with self-tipping barges (up to 600 tons)	0.5-0.75
Transport and sinking of fascine mattresses	0.3-0.5
Dumping stones in layers on fascine mattresses from barges	0.4-0.8

These data are based on visual observations. A wave pattern is usually dominated by a certain characteristic range of apparent waves on which the visual observations are based. Although it is difficult to indicate exactly the position of these apparent waves in the wave spectrum, the impression exists that they are comparable with the so called significant wave (H1/3). The use of a suitable type of recording instrument is necessary to learn something more about this. Such an instrument has now been developed by the Rijkswaterstaat (P.J. Wemelsfelder).

The above-mentioned figures are somewhat higher if the waves travel in the direction of the vessel, otherwise they are somewhat lower. Very short wind-generated waves, with a length much smaller than the length of the vessel, are not troublesome. Swell with a very low steepness causes a slow quiet movement of the vessel and thus also little trouble. For dredging in soft soil the limitary wave height is somewhat higher than in the case of a rocky bottom. The figures given for all operations with barges -except the self-tipping type- may be a little higher if the barges are not loaded to the upper limit.

Data about waves are very scarce. To learn more about these phenomena recording instruments may be installed. Reliable recording instruments have been developed only very recently and at present a small number of these instruments exists. Moreover, the time available for measurements is usually too short to get a statistically reliable picture of the wave motion. The modern fore- and hindcasting methods provide means of obtaining an idea of the conditions one may expect at a certain place. The bases for these calculations are the meteorological data discussed above. The hindcasting method uses data from preceding periods statistically and gives an idea of the probable number of A-days at a certain place. It is suitable especially to compare different places with regard to the roughness of the sea. (Example from Dutch practice: The dams for closing the estuaries in the southwestern part of the country may be built a short distance from the sea or somewhat more landinward. What is the influence of this distance from the sea on the number of A-days and thus on the cost of these dams)? The forecasting method can be used in a warning system for work in places with extremely severe conditions. Both methods consist of two parts: in the first place the calculation of the deep water wave before it enters the shallow water region, if necessary corrected for diffraction, and in the second place the evaluation of the influence of shoaling water, including refraction and diffraction, and of currents, if any.

Human factors can have a great influence on the actual number of A-days recorded from a certain work. Examples are known that the number of A-days for dredging operations rose suddenly from the moment a dredger of a competing firm started work in the vicinity, but on a completely different job. The prestige of the crew came into play. During the reconstruction period after the stormflood of February 1, 1953 in southwestern Holland workmen sometimes did a job under extremely difficult circumstances and at another time, with the same circumstances, they said it was too hazardous. This could be explained by the momentary physical and psychological condition of the men. These factors seem to be of great importance always when a work has to be done under difficult circumstances.

CALCULATION OF THE PROBABLE NUMBER OF A-DAYS. EXAMPLES.

From the foregoing chapter it may be seen that the limitary wave height for all operations mentioned is rather low, mostly lower than 1,0 m and only in a few cases lower than 2.0 m. For wind-generated waves these small heights also mean small lengths, so that the influence of shoaling water and of refraction is only seldom of importance. This simplifies the calculations considerably. If the possibility exists that an ocean-swell of very low steepness penetrates into the region where the work has to be done, the situation is much more complicated. The influence of the currents on wave height and wave length is rather great. When the waves travel in the same direction of the current they are somewhat lower and longer than without the presence of a current, but when the directions are opposite the steepness of the waves grows rapidly. At places where the current turns periodically under influence of the tide, the duration of an A-day varies, for a certain direction of the waves and wind, as a function of the strength of the current. In the most unfavourable case this duration is reduced to a few hours round the turn of the tide. At some places the presence of shoals is a factor of importance. If the work can be done at high water as well as at low water and the number of A-days is different for these two waterlevels, one may suppose that the average number is valid for the whole work.

The above-mentioned method was applied for a few places on the Dutch coast where the average number of A-days is known from experience. The kind of the work was such that the probable number of A-days was determined mainly by the waves. With the help of records of: height, length and direction of waves at the place of the Dutch lightships, some 25-30 kilometres away,
direction and velocity of the wind at the place itself, and the limitary wave height for that special kind of

work, the number of A-days could be calculated with the well-known methods for the calculation of wave height. The strength of the currents influences only the duration of an A-day. A correction for fog was applied. Data about fog were available for the places under consideration. Meteorological conditions are such that there is fog only on days when the waves are very small.

The result of the calculations was as follows:

Place and kind of work	1 Average number of A-days from experience*)	2 Calculated number of A-days from limitary wave-height+)	3 Correction for fog and mist and ice*)	4 Calculated number of A-days*)	5 Ratio 1:4
1. Hook of Holland, entrance channel to the Rotterdam Waterway, dredging with a suction hopper dredger	29-32%	42%	4%	38%	0.76-0.84
2. West coast province Zuid-Holland, construction of groynes for coast protection	33%	41%	4%	37%	0.89
3. Island of Vlieland, construction of groynes for coast protection	26%	36%	5%	31%	0.84
				Average	0.85

Generally the number of A-days is lower -in the above-mentioned cases 0.85x- than the calculated number. This can be explained by the fact that a decision to start or to stop the work is not only determined by the momentary meteorological and oceanographical situation, but also by the forecasts. If the forecast is unfavourable and work has to be done at more favourably situated, quieter, places also, the material may be brought to these places before the limitary conditions are reached.

The method presented here must be seen only as a first trial to learn something more about the problem in question.

*) Expressed as a percentage, also independent on Sundays, etc.