CHAPTER 46

SAFETY OF SEA-WALLS

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The disastrous stormflood of 1953 has caused in the Netherlands an intensive research on the mechanism of damages of sea-walls and on the problem of safety. It was rather quickly understood that the damages of the sea-walls must have been caused by overflowing water only. The overtopping water, flowing down along the inner slope, penetrated into this slope. The resulting groundwaterflow in the section of the bank-body just beneath this slope must have reduced the friction resistance of the soil, in consequence of which slides occured in the inner slopes, in many cases resulting in a total destruction of the bank-body.

Obviously there was something wrong with our sea-walls, but at first it was not very clear in which way they had to be improved. We could distinguish two different ways, two different principles. Either we should design our sea-walls so high, that overtopping would never occur, or we should construct a bank-body, that would be wholly proof against the action of overflowing water.

The first way is in accordance with the traditional way of designing, originating from the principle that "the safety of the wall lies in the height of the wall". However, a stormsurge-level that will never be surpassed, cannot be indicated. Studies on this subject have shown, that probably some semi-logarithmic relation exists between the height of the stormsurge-level and the frequency of surpassing, calculated as an average probability over a very long period. The chance of surpassing a certain level decreases with increasing height of the level, but as a rule, the frequency curve has no upper limit. In his paper in this conference: "On the use of frequency curves to determine the disign stormflood", Ir. P.J. Wemelsfelder deals in detail with these frequency problems.

From this considerations it is quite obvious, that it will be impossible to make a sea-wall so high, that overtopping will never occur. A bank-body, built in the traditional way (a sand body, covered by a clay layer with a grass-cover on top), however, will collapse if a certain quantity of overtopping water flows down over the inner slope. To each level of the crest, therefore, corresponds a certain risk of destruction of the bank-body and inundation of the hinterland.

Apparently, constructing in the traditional way, it is impossible to make a sea-wall, which has a safety of 100% in itself and which guarantees a safety of 100% in the area behind. Always there will remain a certain risk of disaster for both the wall and the hinterland. It is the task of the engineer to keep this risk within acceptable bounds. He may do so by weighing the cost of heightening the wall against the harm to be expected (frequency curves!) in the hinterland.

From an engineering point of view, designing sea-walls in this way seems not to be quite satisfactory. Usually, an engineer wants to design his constructions in such a way, that they are wholly proof against the forces acting upon them. In the case of a sea-bank of the traditional type, however, he knows it for certain, that his structure, constructed in order to withstand the sea, under unfavourable conditions will be destructed by that same sea. Is it possible to design a wall, the body of which is wholly proof against the forces acting upon it?

If overflowing water could be prevented from penetrating into the bank-body, no dangerous groundwaterflow could come into existence, no reduction of the friction resistance would occur and no sliding of the inner slopes could event. Apparently, a bank covered with an impermeable layer would be safe against damages by overflowing water. Nowadays a watertight coating will be realised by a bituminous layer.

An asphalt covered sea-bank, in opposition with a bank of the traditional type, will not collapse from overtopping water, even if very large quantities of water would flow over the wall. The area behind the wall, therefore, will never be exposed to a total inundation by sea water flowing through a dike breach. This may be a very great advantage.

Neither the asphalt covered bank, nor the bank of traditional type is able to produce a safety of 100% in the hinterland. However, if a same degree of safety in the protected area has to be realised either by a grass covered bank or by an asphalt covered bank, it is quite obvious, that the former has to be much higher than the latter.

Therefore, the asphalt covered wall seems to be the best solution of the problem. Not only the asphalt covered bank possesses a safety of 100% in itself and will never collapse, but also a bank of this type can be much lower than a bank of the traditional type.

However, this best solution may not be identical with the cheapest and most economic solution. Attention may be drawn to the fact, that bitumen is a very expensive building material. The advantage of the lower crest, resulting in lower costs of the earth body, may be outdone entirely by the high costs of the expensive asphalt layer.

Having calculated many cases, it is my opinion, that in this country the wall of the traditional type (a sand body, covered with a clay layer grown over with grass) under normal building conditions always give the most economic solution. The asphalt covered sea-bank in this country is justified only under exceptional conditions, for instance if the clay required under the grass-cover is very expensive, or if the protected area may tolerate a huge amount of overflowing sea water so that a very low bank can be accepted, or if it is impossible to obtain a reliable grass-cover.

Though from a technical point of view every engineer will prefer the asphalt covered sea-bank, economic considerations may force him very often into the direction of the high, grass covered wall of the traditional type. Matters might turn to the contrary if modern research would lead us to a much cheaper solution of the problem of the reliable watertight coating of a bank-body. In my opinion, this is one of the most important problems to solve in sea-wall research.