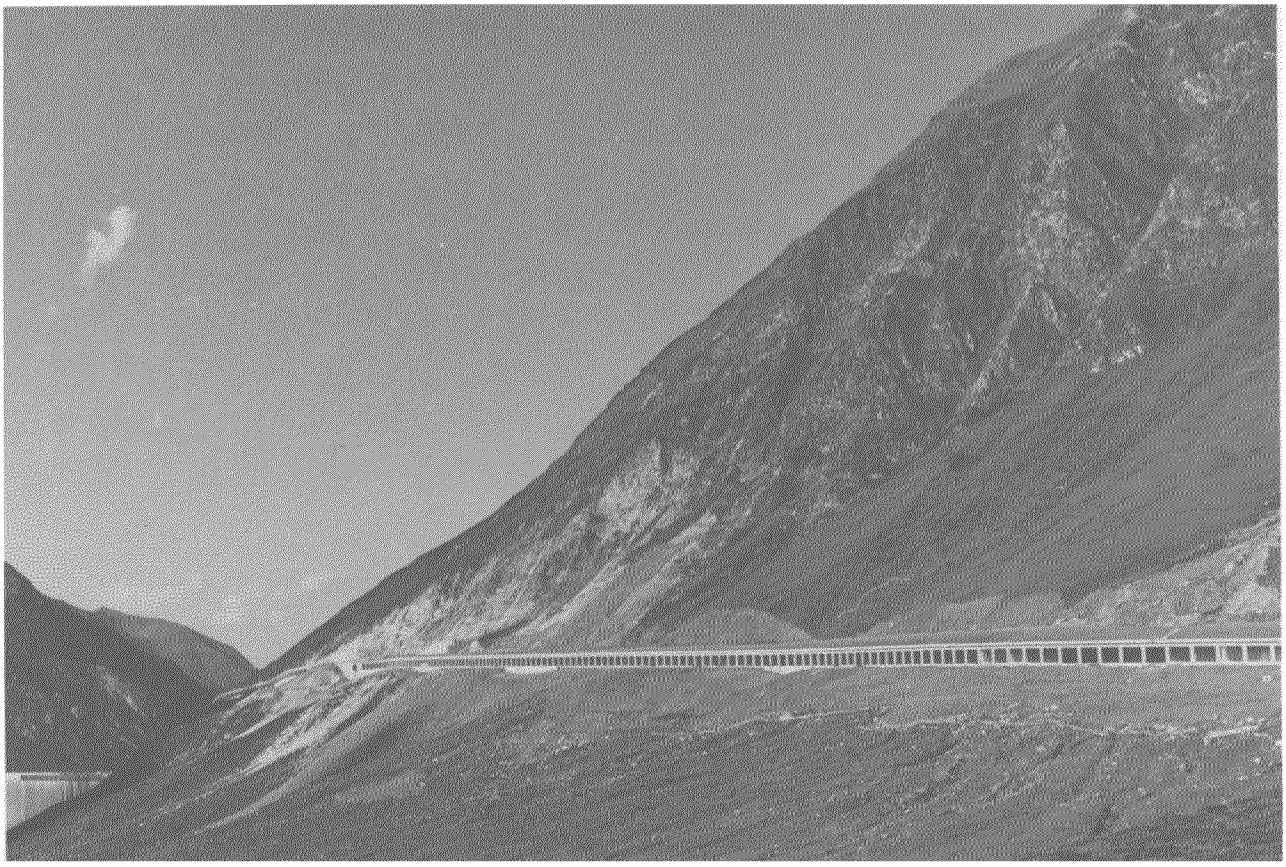
When it is required to provide special protection for some important facility, e.g. railway lines or buildings, some structures are placed in the known path of an avalanche in order to change its course and make it miss the protected objects. This device (see figure 11) is more effective near the foot of the slope where the avalanche has gradually lost its speed and force. In addition, walls or dams may be used to cause diversions or change of course and braking action can be accomplished by means of conical mounds of earth or concrete walls.

Figure 11



The measures referred to are most useful for so-called flow avalanches, the movement of which is mainly along the surface of the ground and in which the individual snow particles remain in contact with one another. By contrast, powder avalanches can only be checked with great difficulty.

4.2.5 Planning measures

Planning requires a detailed knowledge of the past history of avalanches in the area under consideration. A study of the catalogue of past records and of climatological data and terrain conditions should lead to the production of an avalanche risk map for which a scale of 1 in 10,000 or 1 in 25,000 is suitable. As a rule, three zones of risk are shown on the map :

i) Red zone : areas of high risk, frequent avalanches of all sizes or occasional very large avalanches.

ii) Blue zone : areas of slight risk where small avalanches may occur from time to time or areas bordering the Red zone.

iii) Yellow zone : areas where the risk of avalanches is very slight or when large avalanches may occur with a frequency less than 1 in 300 years.

Avalanche risk maps are an indispensable aid for the numerous officials who participate in a variety of ways in local and regional planning and in the planning of transport facilities. With these maps, the short term evacuation of villages threatened by avalanches can be arranged, new buildings can be correctly sited and transport systems can be planned in such a manner as to be free from danger.

4.2.6 Public education

It is of the highest importance that the public and officials of local authorities should be fully informed about the dangers of avalanches and the precautions that are available. Inhabitants of mountainous regions, tourists, people who work in the mountains, controllers of transport, etc., should all have a good background as to the causes of avalanches and how to seek protection.

4.3 STORM SURGES

Storm surges have been the principal cause of death and destruction in some of the worst tropical cyclone disasters. For that reason there is an inclination to regard storm surge as a phenomenon of tropical regions but it occurs much more widely. Any low-lying coastal region which is exposed, however infrequently, to the influence of deep depressions is vulnerable to flooding from the sea. The risk is greatest when strong on-shore winds and tidal conditions reinforce each other.

The vulnerability to storm surges of low-lying coastal regions, whether in the tropics or elsewhere, may be greatly reduced by long-term protective measures and by the operation of an emergency organisation which includes a storm surge warning service or, as it is sometimes called, a storm tide warning service. The Netherlands, where much of the coastal region is below sea level and occupied by more than half the population, has always had to face problems of storm surge. The manner in which these problems have been tackled by the Netherlands may provide useful guidance to other countries which are exposed to storm surges.

4.3.1 Measures to prevent or reduce flooding

The main objective is to contain the storm surge at its natural level and encourage its rapid recession by the creation of additional storage capacity or by diverting the flow in order to distribute the water more widely. The Netherlands has many examples of these different devices.

Construction of dikes

When it would be too expensive or too difficult to prevent the water level reaching a critical value, a system of dikes, used for centuries in the Netherlands, offers a high degree of security. However, constant vigilance and regular maintenance are necessary since serious engineering and structural problems can arise quite suddenly in consequence of the pressures exerted by high water levels and wave attack. It is therefore essential to know when high water levels are to be expected so that the arrangements for flood control can be brought into action. This in turn depends on the functioning of an organisation for reporting and forecasting water levels.

Land-use control

It can be useful and convenient to permit flooding in one area in order to prevent it in another and more vulnerable area. In the Netherlands some coastal areas and the flood plains along the major rivers are examples of areas where flooding is accepted.

In such areas there must clearly be strict regulations covering land use.[13/] Neither large concentrations of people nor extensive industrial development should be allowed. However, these areas would probably not be entirely uninhabited so the safety of people must be ensured by the establishment of an evacuation organisation and by the construction of mounds. Here again the warning service has an important part to play.

4.3.2 Technical factors

The main technical factors in regard to the occurrence of a storm surge are the tides, the winds and the height of the dikes.

Tides

The tide in the North Sea is semi-diurnal, producing high and low water twice a day. The nature of the tide varies along the Netherlands' coast. The greatest average difference in height between high and low tide occurs at Flushing and its magnitude is 3.80m. This difference decreases to the north as far as Den Helder, where its magnitude is 1.40m, and increases again further east to the Eems estuary where the difference is 2.80m.

13/ For further information, see Volume 5 : Land Use Aspects, Disaster Prevention and Mitigation, published by the Office of the United Nations Disaster Relief Co-ordinator, Geneva (Switzerland), 1977.

Strong winds

The height of the tide can be affected by strong winds. Winds of gale force blowing from the northwest, quite often in the rear of a cold front, can cause the water level to rise by a metre or more and thus increase the risk of flooding. The meterological service will therefore be alert to the approach of pressure systems which may give strong on-shore winds along the Netherlands coast.

The height of dikes

A detailed meteorological and hydrological survey was carried out in the Netherlands utilizing the records assembled over many years and statistics were obtained for the frequencies of high water levels of various magnitudes. It was then decided that the height of the dikes should be equivalent to that reached by the storm surge which has a frequency of occurrence of once in 100 years. This is an exacting requirement which ensures a substantial degree of protection against storm surges in general.

4.3.3 The role of the Meteorological Institute

The meteorological service prepares routine forecasts of wind speed and direction for the storm surge warning centre and originates a special message whenever an additional rise of 0.5m or more in the tidal level of high water is forecast. The warning centre then consults the forecaster in order to decide whether to issue a dike watch warning for the whole or any part of the coast.

4.3.4 The storm surge warning service

As shown in figure 12, the western part of the Netherlands, part of the low-lying Rhine-Meuse delta, lies below mean sea level with the exception of their ridges of dunes. The area is densely occupied and protection is provided by hundreds of kilometres of dikes which are still being extended.

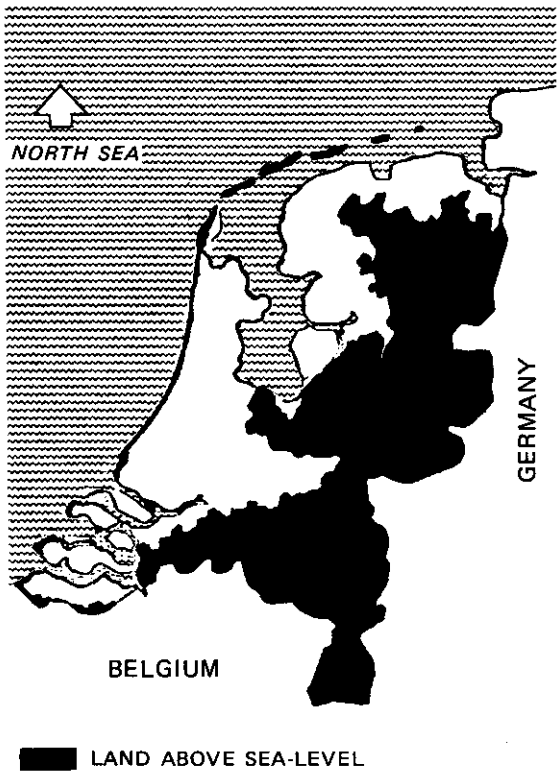


Figure 12
The Netherlands
Areas above Mean Sea Level - shaded
Areas below Mean Sea Level - unshaded

The storm surge warning service is responsible for informing all concerned authorities if the water levels are expected to reach or to exceed dangerous heights. Two types of warning are issued, one for a limited dike watch and the other for an extensive dike watch. The Netherlands coast is divided into five sectors, and for each sector criteria are laid down for the forecast level of the water to require the issue of a warning calling for either a limited or an extensive dike watch.

Warning messages are generally issued about six hours before the time of high water and are given full operational priority in order to ensure prompt delivery to all concerned.

When an extensive dike watch warning is issued there is considerable activity by the authorities responsible for the safety of the population and for other protective measures. Continuous patrols take place, and burgomasters, fire brigades, civil service and military personnel all proceed urgently to their appointed tasks. The Netherlands Red Cross makes arrangements for emergency centres and for additional ambulance drivers. Trains for the evacuation of people are made available.

The public are kept informed through the radio news bulletins and the broadcast weather forecasts. At the end of each weather forecast the expected levels of high water in each of the five coastal sectors are given. Mention is also made of any warnings that are in force. Whenever an extensive dike watch warning is issued, the people are requested to listen continuously to the radio in order to receive all necessary instructions and advice.