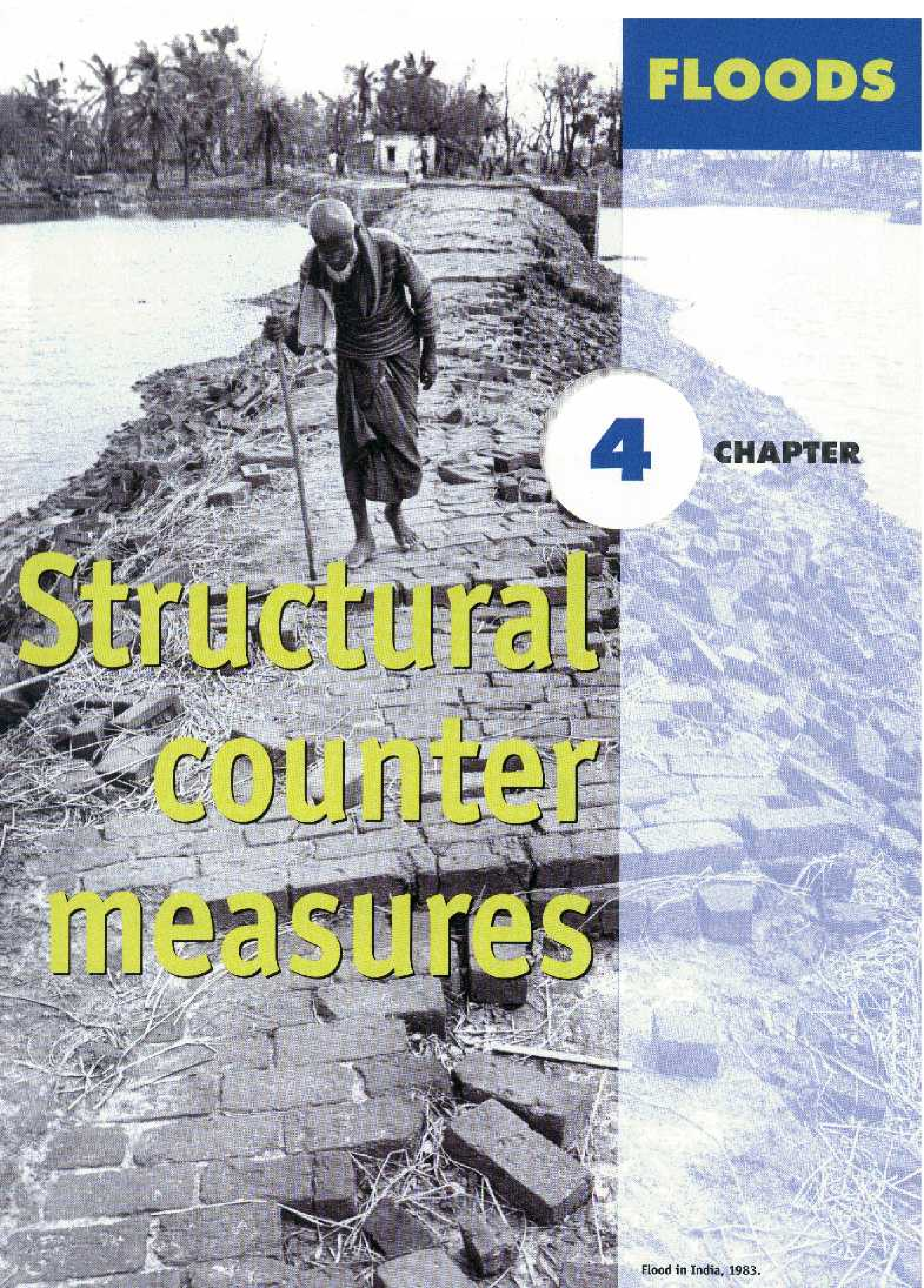
4 CHAPTER

Structural counter measures



Flood in India, 1983.

CHAPTER 4

Structural counter measures

Flood in Frankfurt, am Main.
WWF, H. Jungius

These measures rely on building structures to change the regime of the river in some way to reduce inundation of the flood plain. They include dykes, levees, bunds or stopbanks (the terms are synonymous) to keep the river off the flood plain; upstream storage reservoirs to contain flood waters and to release them slowly; and river training (channel improvements) to evacuate the flood as quickly as possible.

Structures, particularly dykes, are the traditional way of dealing with floods and historically were the first used. They remain very popular with the inhabitants of flood-prone areas and with local politicians that represent them. The structures provide physical evidence that something is being done about the flood problem and they allow increased use of the flood plain which is also popular for reasons that have been described in chapter 3. However, structural measures can give a false sense of security. They are designed to protect against a flood of a certain size, called the design flood, and, inevitably, this will be exceeded at some time. When this occurs the population may not have had any recent experience in coping with floods, leading to more deaths and property damage. Recent floods on the Rhine in Germany gave an illustration of this effect or rather of its converse. Cologne and other regions in the lower Rhine suffered two nearly identical high floods in December 1993 and in January 1995. Estimated damages in the second flood were only half those of the first and this was put down to the better state of preparedness of the authorities and the population after the "rehearsal" 13 months earlier.

Structural measures can also be expensive, largely because they have to be built on a large scale if they are to be at all effective. Many may only be used at long intervals, perhaps decades long, when high floods occur and without regular maintenance it is easy for the installations to fall into disrepair and fail when required. These structures are most effective when they form part of a well-thought out flood control strategy and are combined with the non-structural measures, such as land-use regulation and flood forecasting, described in the next chapter.

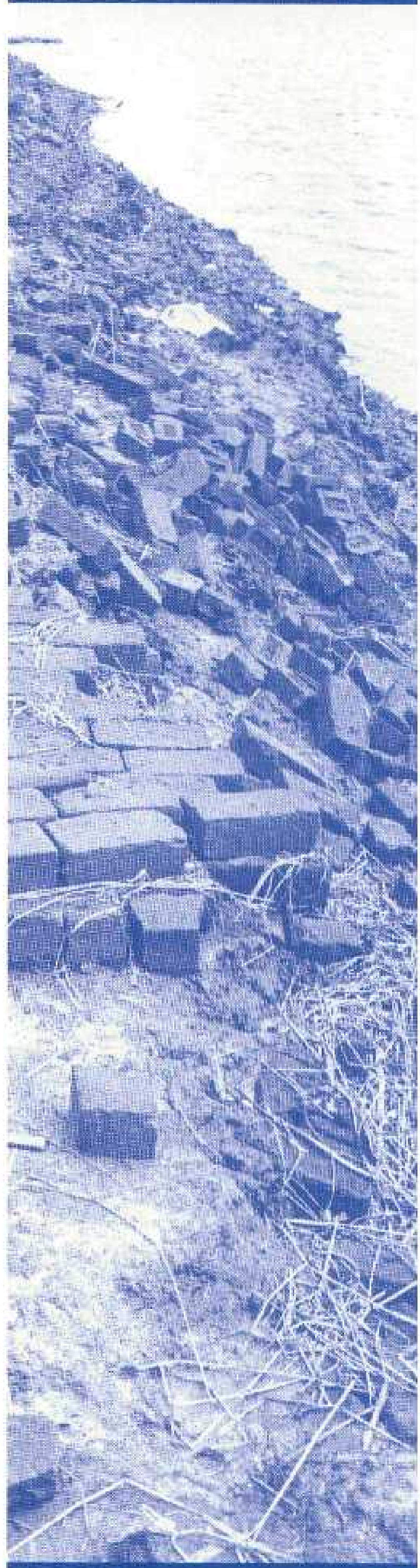
Dykes

These are earth banks built along both sides of the river to contain the flood flow. Other terms for dykes include levees, bunds, stopbanks, flood banks. Confining the spread of flood flows by dykes means and that the river level will flow deeper and faster with increased risk of scouring of the main river channel. Also if the dykes are too near the river bank, the foot of the dyke can be eroded, leading to its collapse. These effects can be avoided by spreading the dykes further apart, but then less of the flood plain would be protected and any pre-existing structures in this area would not be protected unless special ring dykes were built around them.

Dykes are designed to contain some design flood, usually set as the flood with a given return period, say, the 100-year flood. Any higher floods would overtop the dykes and nominally protected properties would again suffer flood damage. For this reason, it is sometimes required that even properties protected by dykes should be floodproofed. The Province of British Columbia in Canada has required this in a number of instances. To contain the flood fully, the dykes need to run the full length of the flood plain, perhaps several hundred kilometres, and can thus be extremely expensive structures. Much of the detailed engineering design concentrates on reducing the costs. An alternative is to dyke the more important areas, such as towns and cities, with the dykes being carried back to the higher land off the flood plain so as to keep the flood from these areas. This compromise is hydraulically sensible. The flood spreading over the unprotected land means lower floods around the protected areas. In the Great Flood of 1993 in the United States many low dykes protecting agricultural land collapsed and this eased the pressure on the dykes protecting cities.

The dyke is constructed by using earth from the site. In many respects a dyke is a very long earth dam, but in the case of an earth dam it is possible to seek the best materials, even from some distance away. However, the great length of the dyke precludes this and the materials available near at hand have to be used. To compensate for the poorer materials the dyke must be made wider, with flatter side slopes to ensure stability even though this requires more material. Once built the dyke needs to be maintained. Regular inspection is required to ensure that parts have not collapsed or been eroded by the passage of humans and animals. After each flood some remedial work is almost certain to be required.

Dykes can fail by overtopping, by seepage eroding the front face of the dyke, and by a form of localized erosion called piping. As the flood approaches the top of the dyke, certain low spots will be the first to be at risk of overtopping and they can be temporarily reinforced by using sandbags. Any overtopping of the dyke must be avoided as it will rapidly lead to erosion of the dyke and an ever widening breach allowing flood waters free access to the protected area. Con-



Floods in Poland, 1993, July 1997.
DHA. S. Piazzi

tinuous patrolling of the dyke is needed during floods to provide early warning of these potential danger spots.

During the flood, water seeps through the dyke and runs down the front face. The quantity of this flow may be enough in places to cause erosion of the face of the dyke. The erosion reduces the width of the dyke which means more seepage leading in turn to faster erosion and eventually to catastrophic collapse. Dyke patrols during the flood have to be on the watch for erosion of this sort so that the area affected can be sandbagged.

Piping is a localized failure where seepage through a weak part of the dyke washes out bank material leading to a circular hole (the "pipe") being eroded back through the dyke. As the pipe erodes back, the seepage flow increases as it does for face erosion, causing an accelerating failure. Animal burrows, tree roots and man-made conduits through the dyke can lead to piping failures. A similar form of failure may also occur in the ground underneath the dyke and manifest itself as a fountain forming at the exit in the ground in front of the dyke. The treatment is to build a ring of sandbags around the exit sufficiently high to reduce the hydraulic gradient and thus the seepage flow.

It will be particularly noted that once any of these types of dyke failure starts it proceeds at an ever-increasing rate. Total failure can thus be very sudden and during floods the dyke must be continuously patrolled to detect incipient failures. The design of the dyke must include provision for easy access for inspection and for remedial measures. Sometimes, a roadway is built along the top of the dyke to provide this easy access. However, many engineers are not in favour of this solution because during a flood when the dyke is saturated with water its strength may be reduced to the extent that it can no longer support vehicles. In addition, outside flood periods, the dyke may settle under the weight of traffic, reducing its level.

A major disadvantage of using dykes for flood control is that they interrupt the natural drainage towards the river and impede access to the river. Major tributaries will have their own dykes, but smaller streams will have to be pumped