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Steel in Disaster Management: Flood Protection

Flood protection structures designed to protect European countries from natural disasters have been a hallmark of European river landscapes for decades.

Giant steel dampers reliably shut off the fast-flowing Thames and Rhine, protecting the Old World from the usual extreme weather events and new disasters caused by global warming.

Using the example of the last winter, the inhabitants of countries in the Northern Hemisphere have already seen that climate change is making it more difficult to predict dramatic natural phenomena. The authorities have been working to calculate the damage to infrastructure from heavy precipitation such as rains and snowfalls, storms, rising sea levels and floods. According to the European Environment Agency, both the number and intensity of floods on the continent will increase. In particular, the agency predicts that during the 21st century, the rains in the winter period will be more abundant than before, by at least one third.

This could be a catalyst for major changes in Europe, where historically cities emerged precisely at river estuaries. Climatologists and hydrologists expect that settlements located on riverbanks will experience floods 10 times more often than in previous decades.

European cities will be the most prepared for the coming cataclysms, since major floods have occurred more than once in their history. Local communities are keenly aware of their dangers and have time-proven flood protection methods in their arsenal. Enormous steel infrastructure facilities are growing on the rivers, helping to reduce the water level and avoid serious damage at critical moments.

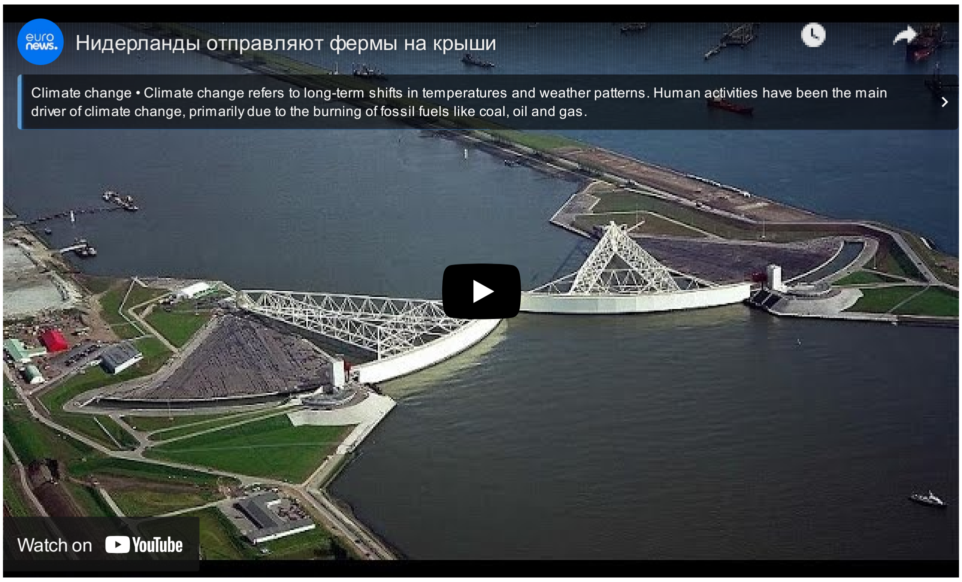
Thames and its steel barrier

One example of such a steel structure is the Thames Barrier that protects London, the capital of Great Britain. The city has experienced devastating floods twice in its history. In the winter of 1928, the Thames overflowed its banks in the City. This was caused by abundant Christmas snowfalls, which quickly turned into thaws and heavy rains. In one of the city’s historic districts, water destroyed the embankment and flooded the houses of London’s poor. The water level was 5.5 metres above the zero elevation. The water reached approximately the same level in 1953. That flood was a disaster not only for the British. In total, six countries of the North Sea were affected and thousands of people died. Great Britain’s damages amounted to about GBP5 billion. British experts estimated the possible loss from a new natural disaster by an order of magnitude more, at GBP30-50 billion, because over time, about a million Londoners have settled in the risk zone.

In the 1970s, the Thames Barrier project was launched in London. Its construction cost British taxpayers GBP1.6 billion. The engineering methods that the barrier uses to protect from floods include a series of gates made of steel sheets with a thickness of about 4 centimetres. When there is no high tide, the steel gates lie at the bottom, in no way obstructing the flow of the Thames or the passage of ships. When the risk of flood increases, the gates rise to completely block the river within a few hours (its width at the point where the barrier is located is about half a kilometre). Full closure of the gates provides protection against surges up to 7 metres high. After a while, the steel gates are slightly opened, allowing a volume of water similar to an ordinary tide to pass. The massive gates weigh more than 3,000 tonnes and span several dozen feet.

The engineers sought to streamline the shape of both the reinforced concrete supports and steel gates to mitigate the water pressure and wind force. The London authorities initially expected the Thames Barrier to serve 50 years, that is, until about 2030. Due to the outstanding strength of the steel structures, their design life was extended for another 40 years.

Netherlands steel delta



Another major project to provide flood protection, the Delta Works in the Dutch Rhine Delta, took almost fifty years to complete. The American Society of Civil Engineers (ASCE) included it in its list of Seven Wonders of Our Time. The reason for its inclusion is the total size and number of structures: with almost 16,500 kilometres of dams and three hundred buildings, the Delta Works is one of the largest engineering structures on the planet.

The flood of 1953 that engulfed the North Sea countries led to the start of the Delta Works' construction. During the project's implementation, many changes were made to the original plans to take into account the opinions of environmental organisations, fishermen, shipping companies and others whose livelihoods are closely linked to the Rhine River. Now the project includes 15 separate facilities, the latest of which was commissioned in 1997. Due to the rise in sea level caused by climate change, construction is expected to continue, expanding the length and width of the flood protection dams.

The original design of the largest, most expensive and most complex of the Delta Works projects, Oosterscheldekering, would have completely separated the Eastern Scheldt river from the sea. Fishermen from nearby villages intervened. They have been cultivating seafood on local aquafarms since the late 19th century. Desalination of the Eastern Scheldt would cause irreparable damage to both the ecosystem and the fishing business. As a result, the authorities decided to build a four-kilometre barrier, which had a total budget of EUR2.5 billion. The construction lasted 10 years.

The Oosterscheldekering flood control structures consist of 65 concrete columns up to 40 metres high. Massive lockages are attached to them with 62 heavy steel gates, each of which is 42 metres wide. Since 1986, the steel gates have been closed to protect against waves over 3 metres high 27 times, most recently in February of last year. Due to the brilliant performance of the steel, Oosterscheldekering is expected to serve at least another 200 years.

Another part of the Delta Works, the Maeslant barrier, is a colossal gate. It is considered one of the largest moving engineering structures in the world. The main components of this mechanism – the gates and the truss – are made of steel. The gates are 210 metres long and the trusses are 237 metres long. These parts are not only very long, they are also very heavy. For comparison, the Eiffel Tower is 300 metres high. While each door of the Maeslant gate is about 100 metres shorter, it is twice as heavy. The gate moves with steel hinges made of huge balls 10 metres in diameter that weigh almost 700 tonnes.

Interestingly, the decision on when to use the Maeslant barrier in the Netherlands has been completely delegated to artificial intelligence. A computer analyses the weather conditions, predicts the wave height and gives the command for the giant steel gate to close. Since its commissioning, the barrier has been used only once, in 2007, due to severe weather conditions. It was initially predicted that the Maeslant gate would need to be closed no more than once every 10 years. Now, due to rapid global climate change, it is believed that the barrier will be used once every five years.

MOSE project steel mechanisms

The history of Venice's flood protection goes back five centuries. In 1966, when the water rose 1.94 metres above normal levels, 80% of the cultural and historical centre was under water and thousands of Venetians were made homeless.

Italy's MOSE project (Modulo Sperimentale Elettromeccanico, or Electromechanical Experimental Module) was built in 2014 to protect the Venetian Lagoon from flooding. With 78 bright yellow mobile gates, this "Moses" (the acronym MOSE is spelled the same as the Italian name for the biblical character) protects Venice and nearby cities from floods caused by excessive Adriatic tides.

When designing the module, the Italian authorities emphasised that the future gateway system should be relatively cheap and very durable. Therefore, the construction of MOSE used 150,000 tonnes of steel sheet piles and pipes up to 50.3 metres in length. Steel was also used to manufacture the gate doors, which are up to 30 metres wide and 5 metres thick. Another integral part of the structure comprises 254 steel rings, which help to set the "gate of Moses" in motion.

The MOSE project is expected to protect the Venetian lagoon over the next century. Last fall, the steel mechanisms of the module withstood a high tide of 130 centimetres honourably. For the first time during such a weather event, water could not reach Venice's Piazza San Marco, a popular tourist destination.

The use of steel in various flood protection structures has become widespread. Steel gates, frameworks, hinged mechanisms, piles, rings and other elements were used in the construction of such structures in the 20th century, are being applied in this century, and will continue to be relied on in the future. The unique properties of steel provide the structures' water resistance and reliability while safeguarding infrastructure, homes and lives.