70 kg, a new post generation of pure aluminium was designed specially for Cologne's flood defence systems. Thus these components can be installed by two people, independent of additional technical equipment, and an optimal speed of construction is achieved. Seven men are thus able for example to construct a fully functional 100 m long demountable barrier 1.50 m high in one hour.

Two men carry a centre support post for flood height 2.10 m

Safety of the construction

In the section generally describing the principle of the demountable flood defence barriers from dam beam systems, the almost selfexplanatory and repetitive construction sequence allows all the available operating personnel to quickly familiarise themselves with the process and easily coordinate themselves. To bolt the posts and exert the pressing tool only two different allen keys are required. Posts of the same height fit into each place as envisioned and are interchangeable with each other. In the event of a post being misplaced, the post readjusts itself into position automatically with the help of an integrated centring device. Because of special guided help the bolt can only be misfitted if handled very carelessly. An accidental mix-up of the post positions is impossible due to various appropriate bolt diagrams.

Bolts from the centre support foot and pressing tool

Conclusion

It is no coincidence that in 1994 the first free-standing demountable flood defence barrier greater than one hundred metres in length was built in the Porz/Zündorf district of Cologne. This construction was the starting signal for the development and constrution of many medium-sized and larger flood defence barriers along all the stretches of water in the whole region. Thus in over 15 years the necessary experience of building many thousands of square metres of flood defence barriers has been gathered, in order to responsibly meet this daunting challenge in Cologne with tried and tested and at the same time state-of-the-art technology.

Autor

Xaver Storr, Dipl. Ing.,
Leiter Vertrieb,
IBS GmbH Thierhaupten

IBS

Demountable flood defence system in Cologne

Worldwide unique demountable flood defence system

Inauguration of the new flood defence system barrier in Cologne's old town

Sukzessive Aufbaudarstellung anhand von vier Bildern

Stone socket

Assembly of center posts

Center posts with dam beams

Complete flood protection wall

Introduction

Since the end of 2004, work has been ongoing to implement the new flood defence plans agreed at the beginning of 1996 by the town council of Cologne. With the official opening ceremony on 13 May 2006 another important stage of Cologne's new flood defence system was completed between Deutzer bridge and Hohenzollern bridge.
By the end of 2008, as a general rule a target defence level in Cologne of 11.30 m (for areas in critical danger up to 11.90 m, in the Porz/Zündorf area 10.70 m) will be constructed along further sections of the in total 64 km long banks both sides of the Rhine. In order to make the new flood defence systems as far as possible compatible with the characteristics, beauty and quality of life of the residential areas adjacent to the river, demountable flood defence barriers of approx. 9.3 km long in total and approx. 13,200 m^2 will be implemented.

The principle of the demountable flood defence barriersas dam beam systems

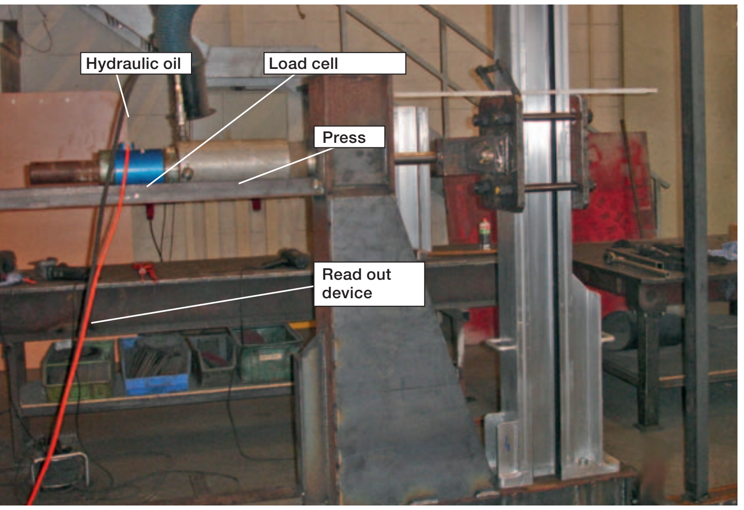
Basically, the system's mobile building parts consist of two components: centre support posts, which in a flood are assembled at regular intervals; and dam beams, which are stacked between the centre support posts.
Two further system components, bolts and pressing technology, are required to add the finishing touches to the defence. On assembly, the centre support posts are bolted to the fixed reinforced concrete substructure using screw thread tubes. In order to ensure that the system is highly

IBS Head Office Germany I Gemeindewald 4-6 I DE-86672 Thierhaupten I Tel. +49 (0) 8271 8176-0
Fax +49 (0) 8271 8176-76 I info@ibs-technik.de I info@ibsengineeredproducts.com I www.ibsengineeredproducts.co.uk
www.ibsengineeredproducts.com

impermeable, the dam beams must be press-fitted vertically using the pressing tool. The dam beams are thus sealed on top of each other and the bottom dam beam is securely pressed onto the contact surface. Using the centre support posts, dam beams, bolts and pressing tools, demountable barriers over 4.0 m high can be constructed from only four system components.

Design concept of the mobile components

The complex situation which Cologne's flood defence plan must satisfy has resulted in a worldwide unique demountable flood defence system in the region. Bearing in mind this particular situation, an area load of 2 tonnes per m² (= 20 kN/m²) was allowed for on the top metre of the mobile barrier, equating to a Cologne level of flooding of 11.30 m, as a load scenario over and above the maximum flood irrigation. In order to increase the resulting safety even more, these loads will additionally be increased by around 35% (basic combination case 1 DIN 19704-1 table 5). As an alternative standard dummy load, the impact of flotsam with a concentrated load of 3 tonnes (= 30 kN) was factored in on the worst respective point of the component. This load size was provided with a safety margin of 21.5% (basic combination case 2 DIN 19704-1 table 5). As a further safety feature, on failure of a tension screw, the remaining anchoring screws must safely deflect the above mentioned loads to the post fixtures in the case of reduced safety. This design plan ensures that only robust component structures are used.



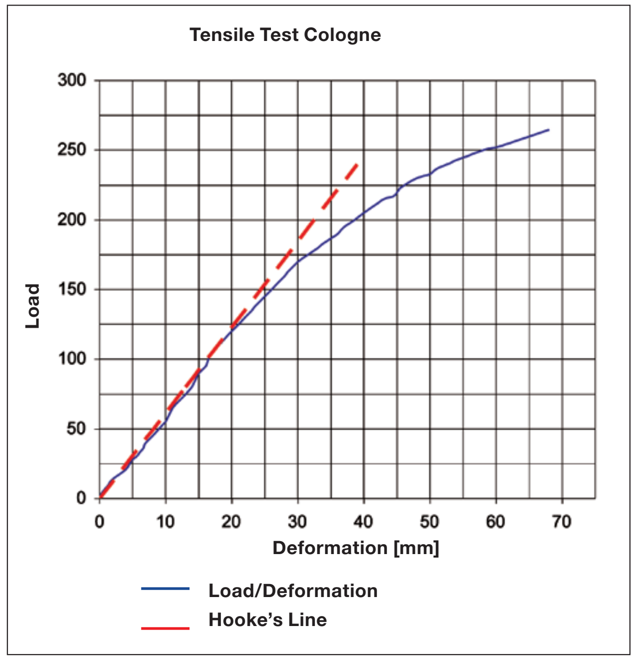
Experimental rig with test post

Deformation/plastification/ breaking of the posts

In order to know the deformational behaviour as well as the actual breakage trend of the posts, in an experimental rig an original post (flood height 2.10 m) was loaded to the point of collapse. The test results were plotted onto a loaddeformation graph. The post structures remained linearly elastic up to a load of 140kN. This is shown on the graph by Hooke's line. The equivalent standard sized load (on a characteristic load level) equates to 75kN. With this approx. 85% is under the theoretical initial plastification of the post structures. This means that for the structure, under the impact based on the load estimates, no lasting deformations are incurred and so it can be put to use an unlimited number of times.

Data for the breakage load

The anticipated break on the tension side of the centre support foot occurred at an experimental load of 270kN. The breakage moment correspondingly amounts to 270 kN x 1.2 m = 324 kNm. Shortly before reaching the breakage stress the horizontal post deformation amounted to 68 mm measured at a height of 1.41 m. Thus the component collapse evidently precedes deformation.

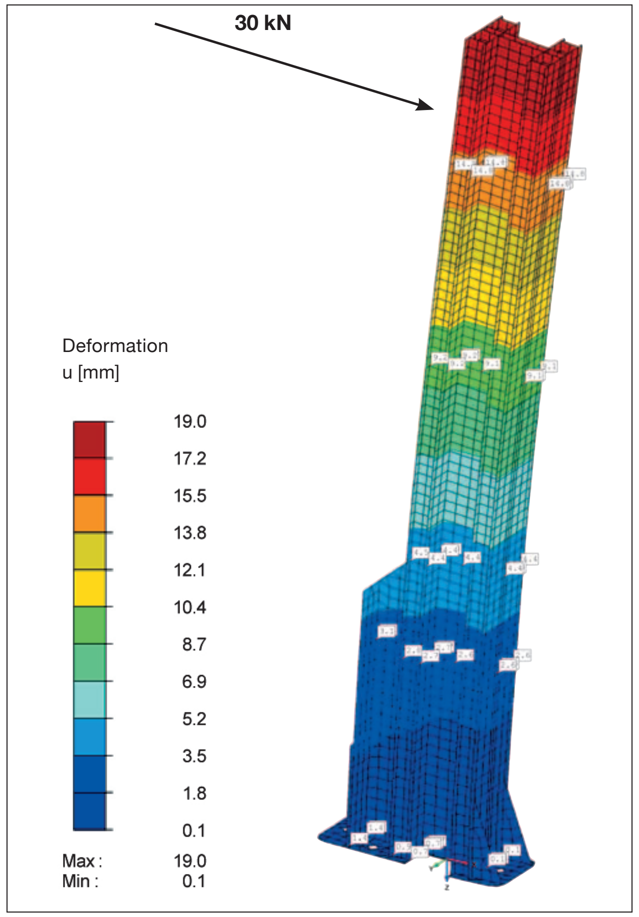


Load-deformation graph

This provides important practical knowledge for estimating the possibly critical deformation of a post structure while in use. On reaching the breakage stress the component Isometry of the deformed evaluation model abruptly collapses. The tension flange of the centre support foot breaks in the heat-affected zone. Through heat entry in the component areas adjacent to the welded seam (= heat-affected zone), there is a structural change (= brittleness) in the aluminium alloys, which eventually causes the brittle fracture behaviour.

Actual component stiffness

Based on the data obtained from the experiment the finite-elementmodel made for the evaluation was able to be verified. Thus it can be guaranteed that the theoretical computer models amply and accurately reflect the reality and that the calculated results offer an appropriately reliable representation. Moreover the actual equivalent stiffness constant for the post has



Isometry of the deformed evaluation model

been obtained. This is particularly interesting with regard to dynamic problems. The simulation represented in the isometry of a concentrated load of 30kN on the centre support head produces a deformation of 19 mm. This results in an equivalent stiffness constant of approx. 1580 kN/m.

Comparison of the collapse loads from the breakage experiment with the measured loads

The so-called one hundred-year sized flood equates in Cologne to a level of 11.20 m; the height of the flood defence systems amounts to the 11.30 m Cologne level with an extra 10 cm margin. Impacts from the pressure of ice, surges, flotsam or impact loads are adequately incorporated into the above-detailed design plan. The significant breakage moment for the collapse from the experiment amounts to 324kNm. This with the following factors lies above the aforementioned typical impact scenarios. As regards human conveyance systems (e. g. lifts, rollercoasters), safety against breakage must be proven with factor 10. In comparison to this the safety of the test post against collapse from hydrostatic water pressure in the event of a one hundred-year flood still clearly lies (factor 12.1 see above) over the figure for human conveyance systems.

Impact scenario	M_{CR}/M_{CL}	›	resulting safety against breakage according to DIN 4113
Flood irrigation as in the one-hundred year flood	12,1	›	2,5
Maximum flood irrigation	10,5	›	2,5
Maximum flood irrigation with 20 kN/m² equivalent surface load	4,0	›	2,5
Maximum flood irrigation with 30 kN concentrated load	3,6	›	2,5

Speed of construction

The just-now described structural safety of the component structures would be achievable without problems by using many or heavyweight appropriate materials. The demountable flood defence barrier can however only function if it is assembled in good time, i. e. within the available assembly time before the flood wave arrives, which in turn entails light and compact components. In order to also press the posts for flood heights up to 2.10 m alongside dam beams under a weight of