C.R. Coll. Int. Renforcement des Sols. Paris 1979.

MALUCHE E.

Reinforced Earth Company, RFA

Reinforced earth used as supporting structures in hydraulic engineering

La terre armée en élément de soutènement dans les travaux hydrauliques

RESUME

Près de Sarrebruck, à proximité de la frontière franco-allemande, diverses constructions de soutènement en terre armèe ont été realisées en rive gauche de la Saare. Il s'est avéré qu'une construction en terre armée offrait ici une solutation techniquement efficace en période hautes eaux. Ces ouvrages sont ainsi des ouvrages hydrauliques et sont construits selon les normes des travaux hydrauliques.

1. INTRODUCTION

"Reinforced Earth" as a method of support construction has been used in West Germany since 1976.

The experience gained in this building process is now available to German contractors. By the end of 1978, 16 constructions with a surface area of approx. 14.000 m^2 had been completed using an alternative design to the conventional retaining walls. As a result of experience gained by the French, the Minister of Transport in West Germany investigated the reinforced earth building method and standard specifications were worked out for the application of this process.

The standard specifications for reinforced earth structures have been employed in highway construction since the beginning of 1977. The German Railway Administration introduced these standard specifications, supplemented specifically for the railways, into their standards at the end of 1977.

The standard specifications for constructions in reinforced earth take into consideration existing German building standards and specific German requirements. This paper gives details of 3 construction projects which were built near the German-French border. As these support structures are washed over when the river Saar is at high water, they had to be designed in accordance with hydraulic requirements and the standards of hydraulic engineering. In this case, the reinforced earth walls are hydraulic structures.

2. STRUCTURE at FREMERSDORF

In 1977 a 1.000 long retaining wall was specified for the Bundesautobahn A 8, between Saarbrücken and Luxembourg near Fremersdorf. The design consisted of a quay wall between the Bundesautobahn and the river bank of the river Saar. The retaining wall is 6,0 - 7,5 m high.

The building administration designed an anchored sheet pile wall for the quay (see Fig. 1). An alternative solution in reinforced earth was proposed by several contractors (see Figs. 2 and 3). This construction satisfied all technical requirements of hydraulic engineering and was about 30 % cheaper than the anchored sheet pile wall. The reinforced earth retaining wall could be constructed in the dry because at the same time the canalisation of the Saar was under construction.

During the high water period, up to 2/3 of the reinforced earth wall is submerged. The fill material between the reinforcing strips will then be in hydrostatic uplift.

Apart from the loadings resulting from water pressure, the reinforcing strips had to be designed in such a way that the frictional forces of the strips allow for the fact that the fill material is in hydrostatic uplift.

In order to prevent fine particles being washed out of the filling when flooding occurs, woven filter material was glued behind the panel joints. As the filling material used contains an average of 12 % silt, a special filter material was placed behind the slabs up to the level of the high water. This filter material consists of gravel and guarantees that in the case of a sudden drop of the water level of the Saar, there will be no greater water pressure behind the panels than that calculated in the statical calculation.

A k-value of 10^{-3} m/sec for the gravel filter guarantees that the difference in water level in front of and behind the panels is not greater than 0,5 m.

In order to satisfy the standards concerning corrosion, electro-chemical and physical tests were carried out on the filling material together with the water of the Saar.

Since the top of the reinforced earth construction will serve as a road, the 2 m wide cast in place coping had to be constructed in such a way that it would be capable of taking the impact of a heavy lorry. The crashing barriers are mounted on the cast in place coping.

Furthermore, a protective foil was arranged between the upper reinforcements and the road surface which diverts surface salt water so that there is no danger of corrosion of the reinforcing roads. This is a specific German requirement. The panels have to be reinforced with steel in accordance with the German standards.

In order to prevent a base failure, and to guarantee that the water can drain out of the reinforced earth structure, a stone filling was placed under the foundation.

The chosen method of construction for this project satisfied all hydraulic requirements which was demonstrated at high water in the spring of 1978 and 1979.

For control purposes each structure of reinforced earth is equipped with so called "dead strips". These strips have no other function than to detect corrosion. During erection these dead strips are placed in such a way that they can be pulled out later. Recesses are built into the concrete slabs through which the "dead strips" can be pulled with hydraulic jacks. To prevent breaking off of the "dead strips" during pulling, the "dead strips" are placed in plastic pipes in the beginning section. The end section rests on 1 - 2 m of the filling. The recesses are closed with circular covers.

3. RETAINING WALL MERZIG

A ramp with connecting bridge was constructed near Merzig. As an alternative to the anchored sheet pile wall, a supporting structure in reinforced earth was commissioned. This ramp is built on the bank of the Saar. The ramp structure is 114 m long and up to 12,5 m high.

The reinforced structure was designed for traffic loads.

As in the case of the structure in Fremersdorf, the statical calculation had to take into account that the fill material would be in hydrostatic uplift i. e. there would be reduced frictional forces when the Saar is at high water.

As the ramp is a service road in the upper area, the ramp had to be designed to take traffic loads corresponding to DIN 1072.

It should be noted that on an intermediate platform of the reinforced earth structure, at a height of 9,0 m, a prefabrication plant was installed, including the foundations, for the manufacture of bridge slabs in the incremental sliding method. Foundations standing close to the panels carry part of the load on to the reinforced earth structure (see Fig. 6). The loads are:

15o to in the vertical direction
and 12 to in the horizontal direction.

After the building of the bridge, the ramp will be constructed to its final height.

Between the conventional abutment and the reinforced earth wall, a vertical settling joint is arranged. It would have been more economical to construct the abutment likewise in reinforced earth. Unfortunately the German standard specifications exclude the use of the reinforced earth for abutments.

4. RAMP WALLS SAARBRÜCKEN

In order to meet the growing traffic requirements the existing Saarbrücken motorway, which passes under a Saar bridge, must now be connected to the bridge itself.

In order to realize these additional entries and exits to the motorway, 4 ramp walls had to be erected.

The ramps are in the flooding area of the Saar so that in order to build a conventional type of structure, special measures had to be taken during the construction of the foundations.

The ramp walls were constructed using the reinforced earth method. Special foundation work was not required here. Since the traffic on the motorway and on the bridge had to be maintained, the reinforced earth method was chosen because of its short construction time.

5. CONCLUSION

Reinforced earth structures have demonstrated clear technical superiority to traditional earth embankment alternates such as earth alone, treated soils, concrete, reinforced concrete, steel and those systems which employ these materials. For these reasons the reinforced method of construction provided the ideal solution both technically and economically in the case of the structures on the Saar, and it is envisaged that this method will be much exploited in the future.

6. REFERENCES

1. Steinfeld, K., "Über Stützwände in der Bauweise Bewehrte Erde, Straße und Autobahn 4/76.

2. Steinfeld, K., Gutachten Stützwand Fremersdorf, 23. 6. 77.

3. Floß, R., Thamm, B.R., "Bewehrte Erde - ein neues Bauverfahren im Erd- und Grundbau", Die Bautechnik 7/76.

4. Deinhard, "Bewehrte Erde" - Erfahrungsbericht über deutsche Bauwerke, Straße und Autobahn 2/78.

5. Der Bundesminister für Verkehr, "Vorläufige Richtlinien für die Anwendung des Bauverfahrens Bewehrte Erde, Ausgabe Januar 1977.

6. Maluche, E., Vorträge der Baugrundtagung 1976 in Nürnberg.

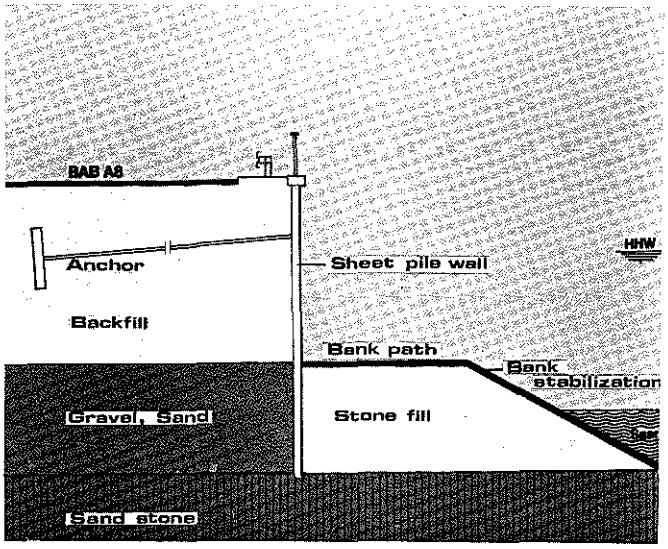

Fig. 1 Retaining wall Fremersdorf, cross section, sheet pile wall

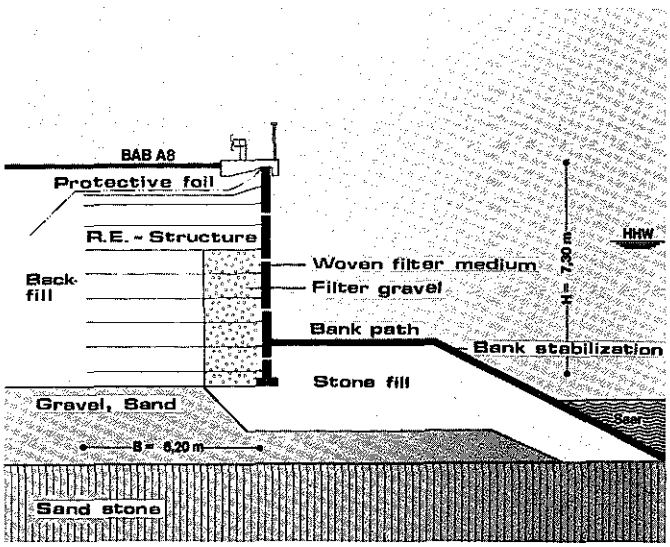

Fig. 2 Retaining wall Fremersdorf, typical cross section of Reinforced Earth wall

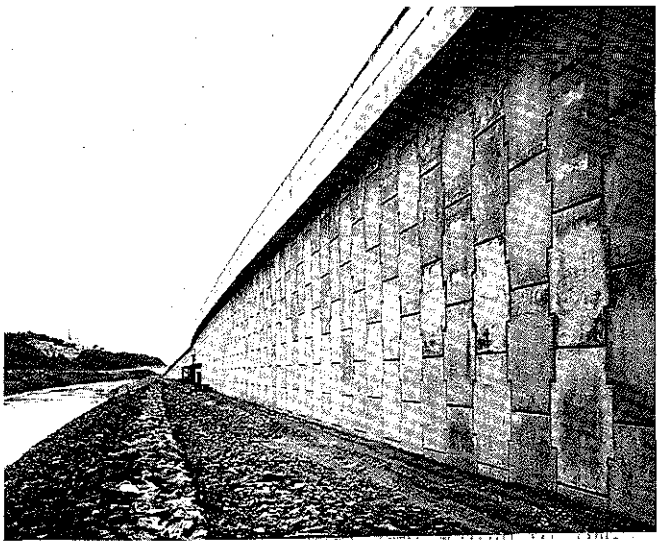

Fig. 3 Reinforced Earth wall in Fremersdorf, view of completed wall

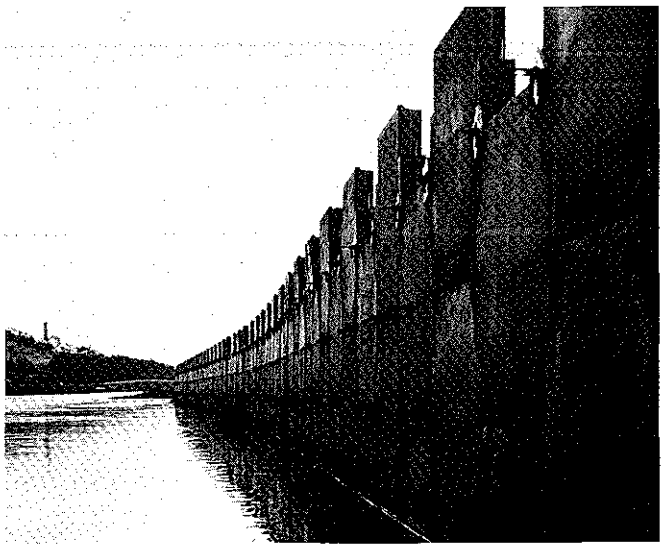

Fig. 4 Reinforced Earth wall in Fremersdorf, high water during stage of construction

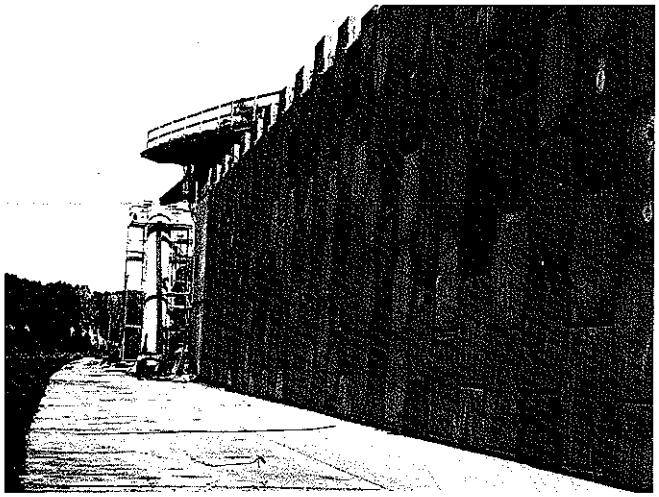

Fig. 5 Reinforced Earth wall in Merzig, view of the wall nearing completion

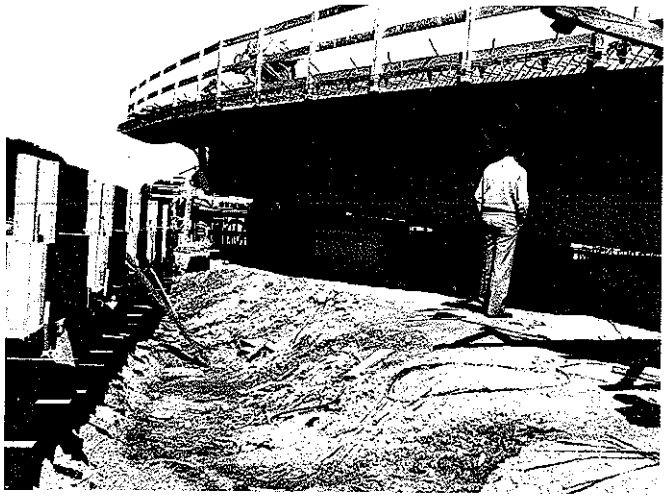

Fig. 6 Reinforced Earth wall in Merzig, platform of the Reinforced Earth structure during manufacture of bridge slab in incremental sliding method