Concrete Bridges in Germany

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Abstract

This article gives an overview over the state of the art of concrete bridges in Germany. In addition to the presentation of actual bridges projects (e.g. winners of German bridge award) new trends in bridge construction and post-tensioning technology will be presented. One is prestressing by combining unbonded internal and external tendons which already had been realized at the pilot-projects Mühlenbergbridge and Rohriether Graben-Bridge. Furthermore, the development and actual state of standards for the design concrete bridges are shown. At the moment the design is done according to the German code DIN-Fachbericht 102 “Betonbrücken”.

Keywords: concrete bridges in Germany, construction, post-tensioning, standards

1. INTRODUCTION

The first post-tensioned concrete bridge has been built in Germany. Post-tensioning of concrete bridges had been adopted first in 1936 in Aue, Saxony. In the following a lot of construction methods for mid-span concrete bridges have been developed by German engineers. Those construction concepts are still up to date and are used all over the world. Although the first bridge was using external tendons, the use of internal bonded tendons rose to the standard way of post tensioning. After World War II the need of a high-capacity infrastructure could be matched by building motorways. Especially in the following of the economic boom in Germany in the 1960s and 1970s a lot of post-tensioned concrete bridges have been built. Those bridges are forming the main stock of the German concrete bridges. Since then, a lot of things changed in design and construction and of course also in traffic loading. Reasons for the changes in design were on the one hand experiences with bonded tendons, e.g. bad grouting or material problems (e.g. stress-induced corrosion) or compaction problems in the webs of box bridges. Also some bad experiences during construction and accessibility of those tendons have been made. With an information letter of the ministry of infrastructure in 1998 (ARS Nr. 28/1998) and the new standard DIN-Fachbericht 102 (2003) significant changes in concrete bridge construction method have been made. So building with externally arranged tendons has become the standard construction method for prestressed superstructures with box sections. The formerly wide-spread method of post-tensioning with bonded tendons is increasingly being replaced by combined prestressing forms (unbonded external and bonded internal post tensioning). Nowadays the maximum length for tendons is limited to 200m, new load models have to be used for ULS and fatigue and a minimum part of all tendons have to be external tendons. The ideas of changeability, restressability and the possibility of easy control of tendons in a bridge are well discussed this time.

2. RECENT CONCRETE BRIDGES

In 2006 a national award for bridges has been introduced in Germany: “Deutscher Brückenbau Preis 2006” (German Award for Bridge Construction 2006). This award will be given every two years to technical and aesthetical outstanding bridges in Germany. In 2006 two categories have bee created: road-/railway bridges and pedestrian bridges. Talbrücke Wilde Gera and the La-Ferté-Steg have been awarded. Actual projects are shown afterwards. A bridge built by incremental launching is the Itztalbrücke. Another construction method is the cantilever method. Bridges built this way are the Weidatalbridge or the Rhinebridge at Worms. At last two projects for high-speed railway Ilmtalbridge and Froschgrundseebridge are shown.

2.1. Deutscher Brückenbau Preis 2006 (German Award for Bridge Construction 2006)

Winner Category “Road and Railway Bridges” - Talbrücke Wilde Gera (Design Engineer: Dr. R. von Wölfel), [2], [3]:

The jury awarded the Talbrücke Wilde Gera the “Deutscher Brückenbau Preis”. Due to the special design of Dr. R. von Wölfel the bridge was built as an arch bridge. The arch spans 252m. It is the largest arch span in Germany (5th in Europe and 12th in world). The special aesthetic design also convinced the jury to award this bridge the prize. Near Thüringer Wald the new Autobahn BAB A 71 is being built to improve traffic between Erfurt and Schweinfurt. The Talbrücke Wilde Gera was necessary to cross a valley with a depth of 110m. The bridge is located between two tunnels. The reasons for choosing an arch bridge were economy and aesthetics. The arch cross section is a twin-box, 10.3m in width with a wall
thickness between 30 and 40 cm. The height at the abutment is 5.5 m and in the crown 3.3 m. To reduce bending moments in the arch the geometry had to be statically optimized. With this optimization the geometry changes from a circular arch to a geometry similar to a parabola. Fig. 1 shows the bridge during construction. It is shown a cantilever construction with temporary cable-stays, used to build the arch in 24 steps. After each step the angle was changed slightly to achieve the parabolic arch geometry. Hence, the arch geometry is similar to a polygon. The arch has been anchored back by the temporary cable stays. The static calculations were very extensive. The stressing of the stays had to be calculated exactly. The calculated values were controlled by the first four cable stays and the remaining calculations were calibrated and verified by these values. The bridge was based with a flat foundation because the rock had enough resistance capacity directly under the ground level. The one-piece composite steel-reinforced concrete superstructure was inserted and subsequently the deck slab was concreted with a formwork carriage. Normally bridges are built with two parallel superstructures to be able to reroute the whole traffic onto one superstructure for maintenance reasons. In this project only one superstructure has been built. But the deck slab has been developed the way to have four traffic lines on one half of the bridge during maintenance work on the other half of the superstructure (it is possible to remove parts of the deck slab without structural problems). More detailed information about the composite box girder with wide concrete decks is given by Hanswille, [4].

Winner Category “Pedestrian Bridges” - La-Ferté-Steg (Design Engineer: Dr. M. Schüller), [3]:

The second bridge awarded with the “Deutscher Brückenbaupreis 2006” was the La-Ferté-Steg in Stuttgart-Zuffenhausen. This pedestrian bridge had been designed by the engineer Dr. M. Schüller (structural engineers Peter und Lochner GmbH, Stuttgart) and designed by the architects Arat Siegel & Partner, Stuttgart. It is a curved, elegant shaped reinforced concrete bridge with a total length of 119 m and a radius of 53.7 m. The superstructure of this jointless bridge was concreted in three parts with an intermediate creeping gap between the abutments. The design contained an extra slender superstructure and six small steel pendulum columns. This engineering work fits into its environment.
2.2. Itztalbridge,[5]

Incremental launching was the construction method for the Itztalbridge of the Autobahn BAB A 73 near the city of Coburg in Oberfranken/Germany. This 852m long bridge consists of two superstructures and 15 spans with a maximum length of 58m. The bridge just has been finished. Costs are about 20 Mill. €. For the superstructure of the girder bridge (height: 4.2m) combined post tensioning with unbounded external and bonded internal tendons is used. Because of the large length of this bridge additional jacks have to be used at the middle pier to get the horizontal loads, that are necessary for launching the superstructure, into the bridge. At this pier temporary stay-cables had to be arranged to bear the horizontal forces of the launching jacks that are located there. (see Fig. 3) At the eastern end the bridge is wider because of an acceleration lane. This was done after the bridge launched completely by concreting a third web next to the regular section on falsework.

![Itztalbridge, Coburg: Launching of the superstructure of the 15-span bridge, additional launching jack at mid-pier and temporary cables for stabilizing the pier during launching (from left; source: [5])](image)

2.3 Weidatalbridge, [22]

The Weidatalbridge is a bridge for the Autobahn BAB A 38 (between Kassel and Halle) and is under construction since 2004. It will be finished 2007 at estimated total costs of 16.8 Mill. €. The engineers Schmitt, Stumpf, Frühauf and Partner designed this 453m long launched girder bridge with box section and a maximum span of 169m. The post tensioning concept was combining unbounded external and bonded internal tendons. In order to reduce the cross section and stiffness of the main reinforced concrete piers and to avoid the erection of a temporary pier during cantilevering, each has been divided into two piers with rectangular cross sections at a distance of 11m. The piers and the box are monolithically connected. The height of the superstructure is varying from 3.50m in the span to 9.0m at the support. The construction method for this bridge was by the balanced cantilever method from the two centre piers (main span and adjacent spans). Parts of the approach spans have been erected on Falsework. During construction the bridge was post tensioned (primary tendons). Finally, the external post tensioning was applied (secondary tendons). The webs of the box are inclined by 7:1 to the outside. So the bottom slab is getting wider from 6.00m at the piers to 7.07m in the span. The width of the webs is 0.40m in midspan and at the main pier 0.60m. Between the webs the deck slab has a thickness of 0.50m. This is necessary to be able to arrange all bonded internal bundle tendons within the concrete section. The thickness of the bottom slab is varying of 0.30m at the support to 1.00m at the pier. Due to the monolithically connection of piers and superstructure the arrangement of bearings can be avoided.
2.4. Rhinebridge at Worms, [6]

In 2004 the construction of a road bridge crossing the river Rhine has been started at the city of Worms. This bridge, called the “Nibelungenbrücke”, has 12 spans with a total length of 745m and a maximum span of 115m. The cross section of the bridge is a box, which has been built by cantilevering with temporary stay cables. In the approach the spans are 23m and 42m and the height of the box varies between 1.0m and 1.7m. The approach has been built using falsework and the three middle spans crossing the Rhine were manufactured by cantilevering. Due to the large span a temporary pylon was built to install stay cables during cantilevering. This way deformation of the superstructure could be reduced. The superstructure is haunched with heights of 2.8m to 6.8m. The box is post tensioned in longitudinal direction by combined post tensioning with unbonded external and bonded internal tendons. All foundations are built on bored piles.

2.5. Strelasund Crossing, [7], [13]

The Strelasund Crossing is a project built between 2004 and 2007. The new Strelasund Crossing with a total length of
4100m consists of six parts, the dam in Stralsund, two approaching bridges Stralsund, the Ziegelgrabenbridge, the approaching bridges Dänholm and Strelasund, the Strelasundbridge and the dam on the island Rügen. This bridge connects the island Rügen and the mainland. The Strelasundbridge (BW5) is a 539m long part of the whole bridge with 10 spans and has been built as a post tensioned box girder. Overhead formwork carriage was used to build the superstructure. The foundation of the piers is realized by cast-in-place bore piles.

2.6. Ilmtalbridge (Railway bridge: 1.7 km, arch spans 175, 155 and 125 m), [12]

One interesting railway project in Germany is the Ilmtalbridge. It is currently under design and construction will start soon. This post tensioned railway bridge will have a length of 1681m and consists of three arches with spans of 175m, 155m and 125m. June 2011 is the estimated completion date. The width of the superstructure is 14.1m and the height is about 5.0m. A box section is planned for the superstructure which is separated in four parts of continuous girders with a length of 471m, 459m, 415m and 336m. The deck slab is post tensioned in transversal direction. Because all three horizontally fixed supports are arranged at the crowns of the arches, the arches have to take all horizontal forces in longitudinal direction. Hence expansion joints will be put at the piers between the arches and the abutments. For constructing incremental launching, starting from the sides is used. The intermediate part will be erected with falsework founded on the ground. The total costs are estimated to be about 30.0 Mill. €.

2.7. Froschgrundseebridge, [22]

In 2006 construction of the Froschgrundseebridge began (Fig. 8). It is located between the cities of Coburg and Erfurt. This arch bridge with a total length of 798m and an arch span of 270m will be used as a high-speed rail bridge. This will be Germany’s longest arch and Europe’s longest arch of a railway bridge and is topping the Talbrücke Wilde Gera. To cross
a nearby nature reserve an arch bridge with this long span has been chosen. The piers consist of a rectangular reinforced concrete construction (3.5m/2.7m x 5.8m; piers built on arch 2.0m x 4.8m) and the arch itself is constructed as a box (abutment: 7.4m x 6.5m crown: 5.9m x 4.5m). Because of the horizontally fixed support at the arch crown, all horizontal loads in longitudinal direction e.g. due to accelerating/stopping of the train have to be taken by the arch itself. The superstructure is separated in three continuous girders with a length of 220m, 358m and 220m. The cross section is a box with a height of 3.60m. It is post tensioned in longitudinal direction. Additionally the deck slab is post tensioned in transverse direction. There will be two construction methods used during the building of this bridge. The arch will be built by cantilever method with temporary stay cables (Fig. 8) and afterwards the deck is incrementally launched. For the cantilevering the piers next to the abutments of the arch are built higher as their final height to deviate the temporary stay cables during construction (Fig. 8, left).

Fig. 8 Froschgrundseebrücke, left – cantilevering during construction, right - arch bridge with max. span of 270 m (source: Kinkel&Partner)

3. DEVELOPMENTS AND FUTURE TRENDS

3.1. Unbonded post-tensioning: Combination of unbonded internal tendons with external tendons
Currently most box girder concrete bridges are post-tensioned both with external cables and with bonded internal cables that are arranged in the slabs of the superstructure. A future trend in Germany might be full unbonded post-tensioning: that means using unbonded rather than bonded internal tendons. The following features represent the characteristics of unbonded post-tensioning:

- Robustness: A higher amount of reinforcement has to be arranged. An increase in local stressing of the structure leads to a small increase in stress in the unbonded tendon. Furthermore, the unbonded steel cannot be taken into account for the limitation of crack width. Nevertheless, the amount of reinforcement is responsible for the high level of robustness of the structure.

- Fatigue: For unbonded tendons neither fatigue nor fretting corrosion is a limiting design consideration.

- Friction: The friction coefficient for unbonded tendons (mostly steel with wax or grease in PE-pipe) is smaller than for bonded tendons. That is why there are smaller losses in force and, thus, savings because of a smaller amount of steel required for post-tensioning.

Fig. 9 Early indication of failure for unbonded prestressing
- Design as a reinforced concrete structure: Corrosion protection of the tendons is ensured by the sheathings. Therefore, the requirements for crack distribution are less strict. Savings in reinforcement and prestressing steel can be achieved.
- Unbonded tendons can be exchanged, their force can be proven easily and they can be restressed, later.
- High quality products: Unbonded tendons can be manufactured off-site and delivered just in sequence. Their production is disconnected from the production of the structure on site. E.g., the concrete temperature on site does not have to be taken into account any more as it had to be for grouting of bonded tendons.
- Indication of tendon failures: Simple indication of tendon failures can be achieved by using unbonded tendons. Fig. 9 (left) shows a two span girder with a bonded tendon (top) and a girder with an unbonded tendon (bottom), both with failed tendons close to the left support, e.g., due to stress corrosion. For the girder with the unbonded tendon, a local tendon failure is equivalent to a total failure along the total tendon length since there is no reintroduction of the force due to bonding. Therefore, the prestressing is also reduced in the areas of maximum bending moments (mid-support, mid-span) so that the girder will crack in these areas. Concrete cracking can be observed by many monitoring systems and can be verified numerically as an indication of tendon failure. The cracks are indicating the failure of the tendon; see Fig. 9 (left). Zilch et al. have shown in their research, that cracking occurs far from the ultimate limit state of the structure, [10]. In Fig. 9 (right) they illustrate their results in which a rather long part of a span will show cracks at rates of prestressing losses that do not harm the load capacity (e.g., 25% loss). Hence, a sudden collapse of the structure (e.g., a bridge) can be avoided by using unbonded tendons.
- When using PE-HD sheathings/ducts the wear of the plastic has to be taken into account, mainly since the pressure between deviated steel on the sheathing their thickness might be reduced significantly, [9].

3.2 First projects

Two bridge projects using both unbonded internal and external tendons have been realized quite recently:

- Mühlenbergbridge, North Rhine-Westphalia
- Roßriether Graben-Bridge, Bavaria

The six-span Mühlenbergbridge is 255 m in total length, [11]. The single box girder has a height of 2.45 m. The bridge has been constructed span by span on formwork. In case only external tendons are used for post tensioning very many tendons would have to be arranged within the box of a concrete bridge. That not only leads to difficulties in checking the webs during regular inspections but also results in complicated and large concrete deviators and cross girders. That is why it had been decided to use internal unbonded tendons (monostrands) in addition to external tendons. Fig. 10 (left) shows the post-tensioning concept of a part of the bridge. The external tendons (band tendons with 16 strands each) are deviated in the spans and at the supports. The internal tendons are arranged straight-line since they should not be arranged within the webs. Although costs are higher for unbonded tendons and more reinforcement was necessary the project was competitive. The reason was that the savings in prestressing steel compensated the additional costs. When designing the structure less strict requirements to crack distribution have to be matched when using unbonded post tensioning. The polyethylene ducts are protecting the steel tendons inside.

The Roßriether Graben-Bridge is 130 m long with three spans (cross section – Fig. 10, right, top image). Tendons wires arranged in a PE-HD pipe had been chosen both for internal and external use (e.g., Fig. 10, right, bottom image). The exchangeability of one internal tendon had been proved shortly after finishing the bridge construction. The wires had been removed while the pipe remained. Costs have not been higher as for use of bonded internal tendons. Both projects have been finished successfully. For bundle tendons exchangeability might be more difficult as for monostrands since the single wires/strands are pressing each other when deviated so that the friction increases.

3.3. New developments of internal unbonded tendons

There are some different requirements that unbonded tendons for internal use have to fulfil in contrast to external use. The PE-HD sheathings are covered with concrete for the whole length. Due to the bond between polyethylene and concrete friction occurs between polyethylene and prestressing steel during stressing. This kind of friction might wear the pipes. Since the tendons are arranged within the concrete section in the slabs they are reducing the shear capacity of those members. Therefore, a future trend is to reduce the size of the tendon cross section. Several monostrands can be arranged in a very compact way (Fig. 11). For a tendon using 16 monostrands with a single sheathing 45% of the tendon cross section is filled by prestressing steel. When using ordinary unbonded external tendons this rate is about 25-30%.
3.4. Stay cables using strands

The Ziegelgrabenbridge of Strelasund Crossing is Germany’s first bridge with stay cables using prestressing strands (Fig. 12, left). Galvanized, waxed and PE-coated strands are used as tensile elements. Since no supplier has a general approval for these stay cables using strands many tests according to the new fib-recommendation are required. Within only six months all tests required for the specific project approval were performed successfully at MPA BAU of Technische Universität München. An expert team evaluated the fatigue tests, the exchangeability test and the water-tightness test. Special requirements were specified for the installation. Requirements on manufacturing, production and conformity control were defined based on the results of the approval tests. The stay-cables were installed successfully, [7], [13]. Fig. 12, right, shows in the top image an illustration of the second project: a stay cable bridge crossing the Rhine near Wesel which shall replace the old steel truss bridge. In contrast to Strelasund there are two rows of cables that are anchored in the middle of the superstructure. The bottom image of Fig. 12, right, shows a section of the cable and its anchorage. Fatigue testing with subsequent static testing has been done at MPA BAU of Technische Universität München according to fib-recommendation „Acceptance of Stay Cable Systems using Prestressing Steels“ (fib Bulletin 30, 2005), see Fig. 13. Some technical details of testing were:

- Cable: 55 strands 150mm²
- GUTS: approx. 15 MN
- Stress range: 200 MPa
- Upper load: 45% GUTS
- Testing frequency: approx. 0.7 Hz
3.5. General use of 60t-trucks for Germany’s roads

In Germany it is currently being discussed whether the maximum total weight of trucks shall be increased from 40t to 60t. The maximum load on the axes shall remain constant at 11.5t. While the design of bridges for ultimate limit state has been taking this traffic into account for decades (e.g. bridge class 60/30) special emphasis has to be put on the fatigue of older concrete bridges that are subject to danger of fatigue fracture at their coupling joints. Those bridges have been built before the 1980s. At joints most of their tendons are coupled. In the nearer future it has to be investigated whether this change in traffic loading leads to structural problems for the concrete bridges.
4. DESIGN CODES

The first German standard for post-tensioned concrete bridges (DIN 4227) had been prepared in 1953 and introduced in 1955. This first draft neither took the special features and needs of the “new” construction methods into account (e.g. stepwise construction) nor had it been based on testing experience of statically indeterminate systems (e.g. continuous beam) and box-girders. Therefore, several tasks like the possibility of fatigue fracture of post-tensioning steel at coupling joints arose. In the following German standard has been modified and improved as more technical know-how and experience had been gained. In 1966 the minimum amount of reinforcement steel had been increased and a minimum transverse reinforcement had been obligatory since then. In 1980 the design of coupling joints had been changed, e.g. a minimum number of tendons have to pass through the joint (at least 30 %); the concrete cover as well as again the amount of reinforcement steel had been increased. All these changes significantly improved the robustness of the structures. After introducing an updated DIN 4227 in 1998 the next big step was the development of the DIN Fachbericht 102 “Betonbrücken” in 2003 which is the newest national standard in accordance with the European standardization. The DIN Fachbericht 102 for instance does not allow the arrangement of tendons in the webs of box girders to avoid concrete compaction problems. At the moment the standard design of post-tensioned box girder concrete bridges makes the usage of externally arranged tendons obligatory. By the European Union the aim of a uniform technical standard for the design of structures in the structural engineering was developed. Responsibility for the development of European standards was given to the Comité Européen de Normalisation (CEN) in 1989. In 1992 one of the first parts of the structural Eurocodes program, the prestandard prEN 1992-1-1 “Design of Concrete Structures – General Rules and Rules for Buildings” was published. Part 1-1 of EC2 was approved by CEN (European Committee for Standardization) as a prospecitive standard for provisional application. It gives a general basis for the design of concrete structures as well as detailed rules which are mainly applicable to ordinary buildings. The DIN standard 1045-1 [17], obligatory for the design of structures in general building constructions, was introduced in 2001. For the first time, the regulations of the steel and prestressed steel construction are combined in one standard. On the one hand, the content is strongly based on the standard DIN ENV 1992-1-1, published in 1992, but otherwise it has been adapted to the foreseeable developments of DIN EN 1992-1-1 (EC 2-1-1) [18], published in 2004, in order to facilitate the following adjustment [16].

In Germany the DIN-Fachbericht 101 “Einwirkungen auf Brücken” (technical document about actions on bridges) and the DIN-Fachbericht 102 “Betonbrücken” (technical document about concrete bridges) were developed in the construction standard committee (NABau) in 2003. The intention was to implement the state achieved by the union of the European regulations for the bridge construction in Germany. This happened on the basis of adopted European preliminary standards and respective national application documents (NAD). The different regulations were integrated in...
one document, the DIN-Fachbericht and the conformity of the technical contents with DIN 1045-1:2001-07 as German comment to EN 1992 – the definite standard for concrete construction - was reached. In Fig. 13 the European Regulations for Concrete Structures (EC 2) are shown. The orange marked boxes, the national guidelines for concrete bridges with external tendons and the adjustment to DIN 1045-1 were the relevant parts for the design of DIN-Fachbericht 102. In DIN-Fachbericht 102 all relevant chapters according to Concrete Bridges are summarized including Basis of Design, Serviceability Limit States and Ultimate Limit States. This procedure reflects at the same time the fundamental difficulties of the standard works in the last years. There is a tendency of creating standardized regulations at European level, but it has to consider the interests of the meanwhile 29 national member organizations, which were assigned by the European Commission for the development of the Eurocodes. On the other side it is necessary to have standards at national level, which satisfy the continual development and experience recollection and guarantees the profitability of the construction in competition. The originated coexistence, with European and national standards, which are partially identical in content and otherwise subjected to a strict mixture prohibition, will be terminated with the obligatory introduction of the Eurocodes and the respective national annexes (NA). All contradictory national regulations are to be withdrawn - so the idea of the European Commission- until the deadline of 31 March 2010 (Date of Withdrawal, DoW). The whole EC 2-package, composed of (basic) part DIN EN 1992-1-1 [18] and the subordinated parts, is currently going through a transition phase in Germany. This means, that the European basic documents (European Standard, EN) are as far as possible available, and the national annexes are being developed. The security level and many aspects of the durability and the profitability are understood in the youngest Eurocode-generation as a sovereign task of the state members. Therefore are almost all regulations, which concern these interests, provided with nationally determined parameters (NDP) in the main text. The state members can make here (and only here) individual adjustments – in the context of the allowed possibilities. The main text may not be changed or adapted. Different “European” annexes are added to the main text, which have a normative or an informative status, and also the national annex of the respective member state. Only through the national annex the member states have the possibility of formulating additional specifications to the main text. In addition to the definition of the NDPs, supplementary regulations (application rules) and informative annotations can be included, if they do not contradict the main text. Even if until the final conversion to the Eurocodes many efforts need to be executed, the true merits of a unitary European standard, which reaches about 490 million people, will not be totally manifested until its obligatory introduction in 2010.

With in DIN-Fachbericht 102 “Betonbrücken” there are also given rules for structural design. On the one hand side tendons are not allowed to be arranged within the webs ob box girders. On the other hand there is a minimum amount of tendons that have to be arranged within the boxes of concrete bridges as external tendons. Another example is that a certain amount of tendons must cross joints, so that all of the tendons are not coupled at the same section. The post-tensioning systems delivered by manufacturer are not included within the DIN-Fachbericht 102. The information a designer needs that depends on the system (e.g. dimensions, friction coefficient et cetera) has to be taken from the approval text. Post-tensioning systems have to have an European Technical Approval (ETA) before used in Europe. The Guideline ETAG 013 (edition June 2002, [21]) contains a number of tests and criteria that have to be done/matched before getting an ETA (e.g. static and fatigue loading, load transfer to the structure). ETA's can be given to systems by several approval bodies around Europe. However, in Germany all ETA's for systems that shall be installed there are additionally proved by the German approval body Deutsches Institut für Bautechnik, Berlin (DIBt), which gives a national permission for the accepted systems. For products that do not have a technical approval a “Zustimmung im Einzelfall” is necessary. This means that for a specific project the use of the product has to be permitted. Mostly, a reduced testing program compared to that of ETAG or expert opinion based on experiences and know-how is sufficient to show the quality of the product.

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6. REFERENCES


