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Application of ETAG 032 as a new level of expansion joint assessment
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ABSTRACT

Even though the European Technical Approval Guideline ETAG 032 "Expansion Joints for Road Bridges" has been introduced already in 2013 only rather simple flexible plug and nosing joints have been granted an European Technical Assessment (ETA). Nevertheless many national standards and regulations like Czech TP 86, Austrian ÖNorm B4031 and Dutch RTD 1007 refer to ETAG 032 or copied basic parts of it.

Latest efforts by the European Organization for Technical Assessment (EOTA) resulted in the transition of ETAG 032 to the actual format of European Assessment Documents (EAD). These EADs provide a more comprehensive specification for expansion joints, which is expected to push much more for ETAs granted for various types of expansion joints.

The paper will introduce these EADs and show first applications of the assessments not limited, but in particular for complex expansion joint systems like modular and large cantilever finger expansion joints. This way a new level for assessment of expansion joints is reached, which exceeds significantly any other common national specifications for expansion joints in Europe or on an international level. Overrolling tests on special prepared test tracks with statistical evaluation of measured data serves as viable basis for the assessment of the dynamic behavior of expansion joints respectively their fatigue design. Fatigue tests analyze the fatigue resistance and durability supported by wear tests. Full size kinematic test for modular joints are presented that prove the movement performance for up to 1800 mm total movement capacity. Important findings from these applications are shared in regard of general consideration of ETAG 032.

Keywords: ETAG 032, expansion joint, testing

1 INTRODUCTION

1. Introduction

mageba has been the very first company holding an European Technical Assessment (ETA) according to ETAG 032 [1 to 8] for expansion joints made of steel and therefore has been the first supplier worldwide being able to provide such expansion joints in full accordance with ETAG 032. Basis for the related CE marking is ETA-17/0612 [9] granted 13.07.2017 by OIB (Austrian Institute of Construction Engineering) in combination with the "Certificate of Constancy of Performance" issued by the notified certification body according to the Construction Product Regulation (CPR) [10].

This way mageba has proven to fulfill general requirements regarding ETAG 032 applicable for various types of expansion joints including nosing RS type joints as well as modular joints with and without noise reduction sinus plates and cantilever finger joints. The particular assessment procedure for obtaining an ETA related to these types of expansion joints for road bridges has been initiated by mageba already in 2015 and finalized for ETA-17/0612 covering single seal nosing joints.

Mageba has continued efforts for assessment in particular of modular type LR expansion joints in constant adaptation to the latest drafts of the EADs [11 to 16]. This way mageba claims to be the only supplier for modular expansion joints that succeeded in all tests according to the final draft of EAD 120113-00-0107 [16] and currently being fully prepared for submittal of an ETA. These tests cover in particular – but are not limited to – the following:

- Static testing – mechanical resistance of the product represented by test methods for components
- Dynamic testing – resistance of fatigue and wear of the product represented by test method for components
- Dynamic assessment and field testing
- Fixing of sealing elements represented by test method for components
- Assessment of resistance to fatigue by testing
- Assessment of movement capacity

Such efforts and results of successful tests have been considered for other major projects referring in particular to design according to ETAG 032. Official approval of such compliance has been granted e.g. for the largest ever build modular joints with noise reduction sinus plates (LR23-LS100 with 23 seals) supplied by mageba to the Forth Replacement Crossing Bridge project in Scotland. Involved have been expert assigned by OIB for the structural expert statement regarding compliance to ETAG 032 respectively superseding EADs.

2. Current status of ETAG 032

While mageba prepared assessments including various tests according to ETAG 032 the transition of ETAG 032 (all parts) to European Assessment Documents (EADs) has been initiated as referenced in the listing “ETAGs and their numbering as EADs” published by EOTA [17]. Mageba as well as other suppliers for modular expansion joints contribute actively to the Working Group (WG) dealing with this transition. Even though the mandate of the WG relates to a transition solely ~~with~~ without technical changes to the document it became clear that the EAD will provide significant improvements in terms of distinctiveness. Consequently it is a clear benefit for customers and suppliers of modular expansion joints to wait for the citation of the transferred EAD instead continue on the soon superseded ETAG 032. Progress on EAD 120113-00-0107 [16] (superseding ETAG 032 Part 8 for modular expansion joints [8]) has been fast and citation by the European Commission is expected for spring 2020. Likewise all suppliers for modular expansion joints have shifted their focus to an ETA based on the new EAD and none has continued or even received an ETA referring to ETAG 032 Part 8.

3. Application of ETAG 032 in EU member states

The CPR defines EADs and ETAGs used as EADs as "harmonized European specification", which is coordinated among all EOTA member states and shall not be conflicted by national standards. This way expansion joints with granted ETA according to ETAG 032 can be placed on the market in the European Economic Area (EEA) in general and national standards shall specify only the use and application and/or additional aspects not covered by ETAG 032. Assessment methods including Assessment and Verification of Constancy of Performance (AVCP) cannot be changed by national regulations.

Various national standards and regulations in EU member states refer to ETAG 032 or copied basic parts of it. Namely the following have been introduced:

- Czech TP 86 introduced 2009
- Austrian Önorm B4031 introduced 2018
- Dutch RTD 1007 introduced 2013
- Romanian AND 590 introduced 2016

Furthermore other national specification are currently under preparation. Such includes one of the oldest and most established specifications for expansion joints TL/TP FÜ [18] introduced already in 1992 and currently applicable in its 2005 revision [19]. A new revision of TL/TP FÜ based on ETAG 032 respectively the transferred EADs is expected to be published in 2020. Beyond the European Union respectively EOTA members (including e.g. Switzerland) many authorities recognize the value of ETAG 032 and have referenced it in various general and project related specifications. This way ETAG 032 gains international importance and has the potential to substitute other specifications like AASHTO LRFD Bridge Design [21] and Construction [22] specification more and more.

4. Role of the Technical Assessment Body and Notified Body

EOTA lists currently [23] 33 Technical Assessment Bodies (TAB) in the field of "Road equipment: Circulation fixtures", which relates to ETAG 032 according to EOTA listing [24]. Few of them have expertise in the field of expansion joints for road bridges or can refer to reasonable history of involvement. OIB with executive members being involved in the development of ETAG 032 from the very beginning and providing the chair of the WG in charge for the transition of ETAG 032 to EADs is among one with the highest expertise in the field of expansion joints for road bridges. Apart of this particular expertise OIB is cooperating with other experts in this field supporting the assessment. Checking of design calculations is supported by independent specialists from Fritsch Chiari an Partner (FCP) e.g. providing sophisticated engineering services and survey with particular focus on expansion joints for decades. Testing is conducted by independent and renown experts like the Materials Testing and Research Institute (MPA Karlsruhe). E.g. MPA Karlsruhe has conducted for various manufacturers tests based on different standards and national accreditations of expansion joints for road bridges within their 100 years of history in construction product testing.

Without such involvement of experts responsibilities respectively interfaces including a minimum "four eyes principle" between basic tasks like, testing, checking and assessment cannot be ensured or guided by otherwise mandatory quality assurance systems like EN ISO/IEC 17025 [25] for testing.

The same applies for the notified certification body (NB), which ensures third party survey based on control plans defined by the TAB granting the ETA. Currently 7 NBs have an accreditation and notification as NB for expansion joints for road bridges according ETAG 032. Few of them have experience in the field of road expansion joints or have been accepted as third party survey based on other national standards and regulations in the past like e.g. TL/TP FÜ. Various NBs survey manufacturers related to ETAs that have been issued by the same NB acting as TAB including the definition of control plans, which disregards the independence of the NB and stops revealing of mistakes in the interpretation of standards, assessment and even the ETA itself.

The coordination between the different experts within their particular focus (testing, engineering, assessment and survey) is considered as vital aspect to ensure full use of expertise and mutual control. Such has been an important principle in the past in the application of TL/TP FÜ in Germany e.g. including definition of dedicated test labs and checkers with sufficient level of expertise. CPR is shifting that responsibility now to the manufacturer and client as far as national standards and regulations do not provide additional aspects in this regard.

5. Static testing

Static tests regarding mechanical resistance of the product represented by a test method for components relate in particular to creep and relaxation of components used for modular joints. Prestress of the sliding system connecting centerbeams with support bars is a vital aspect in the overall performance of a modular expansion joint. All expansion joints face certain vertical upswing at the point the wheel loses contact with the load carrying elements like centerbeams or fingers. EAD 120113-00-0107 for modular joints requires to identify this upswing and dynamic factors from dynamic assessment based on field tests (compare 7.), while most other types allow for an upper threshold values of 30%. The special kinematic of modular joints does not allow to define such upper threshold values. The load impact on the sliding bearings result from the design load multiplied by identified dynamic factors acting to the prestressed sliding system of the connection of the centerbeam to the support bar and connection of the support bar to the structure at the support box. The uplift acting on the sliding springs is that load impact multiplied by the identified upswing value. Creep effecting the sliding bearing and relaxation effecting the sliding spring reduce the effective prestress for these connections and may result in decompression (gaping) if not considered. In particular fatigue resistance will not be given in case of hammering connections due to decompression. Testing covering service, fatigue and ultimate load conditions is described in detail in EAD 120113-00-0107, Annex C and requires the use of special chambers (compare Fig 1)) to consider temperature effects.

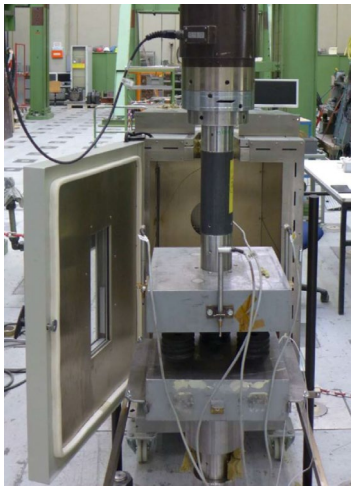

Fig. 1) Static test setup including climate chamber

6. Dynamic testing

Dynamic tests regarding resistance to fatigue and wear of the product represented by a test method for components relate in particular to sliding components used for modular joints. Wear and load impact challenge both the durability of modular expansion joints respectively maintenance of such joints as the related sliding bearings and sliding springs are considered as replaceable parts according Table 2 of EAD 120113-00-0107. Category "B" applies for these components, which shall provide an intended working life not less than 0,5 times the intended working life of the kit relating to minimum 25 years for these components based on recommended 50 years for the kit (overall expansion joint). Apart of the large accumulated movements related to such long working life it is clearly related to very high number of load cycles. Accordingly the second phase is recommended to cover unlimited fatigue life by testing for 5 x 10^6 cycles. Mageba has tested sliding springs and sliding bearings according to phase 1 described in EAD 120113-00-0107, Annex D for up to 9 km of accumulated sliding path with double amplitude of up to 1 m (compare Fig. 2a)) proving stable and low friction as well as succeeding without any sign of wear. Subsequent the sliding bearings have been tested (compare Fig. 2b)) according phase 2 for fatigue loads adjusted with results from dynamic assessment based on field tests (compare 6.). Such testing for 5 x 10^6 cycles resulted in less than 2,4 % change of height. Both phases require active temperature control of the entire test setup.

Fig. 2) a) Wear test setup and b) fatigue test setup both with active temperature control

7. Dynamic assessment and field testing

Dynamic assessment and field test relate in particular to the dynamic behavior of expansion joints, which are identified by overrolling tests per each type and system applicable to a range of similar behavior. Especially vertical dynamic impact, upswing, transfer of horizontal to vertical load and horizontal response ratio factors have significant impact on the loads that need to be considered for fatigue calculations as well as for loads applied in tests. Apart of EAD 120113-00-0107 [16] for modular joints all other EADs [11 to 15] related to expansion joints for road bridges provide default values, which can be applied instead of values identified by overrolling tests. Nevertheless results from dynamic assessment and field tests can be applied for most types almost identical to modular joints. For all such tests it is vital to fulfil requirements given by the applicable EAD in detail like in EAD 120113-00-0107, Annex E for modular joints. In particular all dynamic influences need special attention like evenness of medium quality ensured for the pavement minimum 30 m before and behind the installed expansion joint specimen. Proving that criteria requires defined prepared pavement as well as very special expertise and equipment in the field of roads surface survey and data processing. Similar applies to the dynamic measurements from different truck impacts on various speed, full

acceleration and full braking. Field measurements by the use of strain gauges, accelerometers and laser signals as well as statistical data evaluation requires particular expertise, which can be offered by few experts especially if such should cover experience related to dynamic assessment of expansion joints. It took mageba with various partners several weeks of test campaign to conduct these tests for various types of expansion joints such as nosing (single seal), cantilever finger and modular joints with and without noise reducing elements (compare Fig. 3)).

Fig. 3) Dynamic assessment and field test setup

8. Fixing of sealing elements represented by test method for components

Fixing of sealing elements represented by test method for components relates in particular to seal elements applied for nosing (single seal) and modular joints. Test are specified in EAD 120709-00-0107, Annex D and F respectively EAD 120113-00-0107, Annex F and address proper fixing and mechanical resistance as well as watertightness and cleanability. Specific cycles of partially combining longitudinal, transversal and vertical movement have to be conducted under permanent control regarding proper fixing and for some cycles filled with sand to simulate debris or water to check for watertightness. Such covers new and artificially aged components and as tested by mageba as well special connection details for waterproofing membranes (compare Fig. 4)).

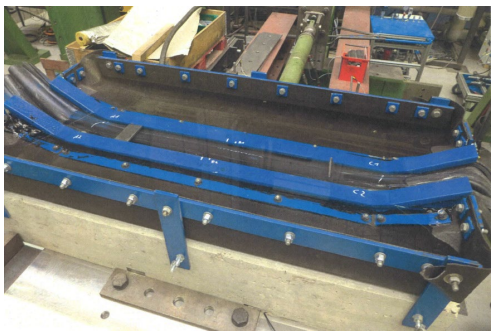

Fig. 4) Watertightness test for strip seals

9. Assessment of resistance to fatigue by testing

Assessment of resistance to fatigue by testing relates in particular to details, which are difficult to be assessed by calculation only like the anchorage of expansion joints to concrete structures. Taking into account that these elements cannot be replaced and an intended working life of 50 years is anticipated, the number of load cycles should cover unlimited fatigue resistance by testing for 5 x 10^6 cycles. Again test loads shall be based on fatigue loads adjusted according results from dynamic assessment based on field tests (compare 7.) in order to cover the effective behavior of the tested type

and system of expansion joint. Particular care is required regarding simulation of the wheel print for the load application (compare Fig. 5).

Fig. 5) Fatigue testing of anchorage

10. Assessment of movement capacity

Assessment of movement capacity is required for all types of expansion joints for road bridges and is specified in EAD 120109-00-0107, Annex D.3 (referenced by the other EADs). The test shall cover full movement capacity of the expansion joint in several cycles partially combining longitudinal, transversal and vertical displacement as well as rotations if relevant. In particular for very large movement capacity such testing is very demanding and requires very special test equipment. Mageba has used such equipment to test 18 gaps modular expansion joints with and without noise reduction elements and movement capacity of up to 1800 mm in longitudinal, 900 mm in transversal and 90 mm vertical direction (compare Fig 6)).

Fig. 6) Assessment of movement capacity

11. Conclusion

First applications of ETAG 032 respectively superseding EADs have shown its high level in regard of considered design requirements in comparison to other currently applied specifications for expansion joints for road bridges. This high design level in combination with demanding and extensive test procedures provide a new level of safety, robustness and durability of expansion joints serving the bridge owner and public in general. Still national specifications have in important role in defining the use and application of expansion joints according to ETAG 032 and additional aspects not covered by ETAG 032. These national specifications as well as ETAs shall refer to the EADs superseding ETAG 032 for the benefit of a more comprehensive specification and consequent fulfilment of the Construction Products Regulation (CPR). The Technical Assessment Body (TAB) has a special role as a key element in ensuring the declared performance according granted ETA. Considering the complexity of the assessment task it seems not only vital, but inevitable to involve

other experts as no TAB has the broad expertise covering formalities, engineering, testing, measuring and data processing (among many other challenges). Expansion joints and in particular their detailed testing is a very specific field with very few experts available, which the TAB needs to involve in coordination with the manufacturer of the expansion joint. Similar applies to the later Assessment and Verification of Constancy of Performance (ACVP) by the Notified certification Body (NB). The particular expertise and independence of the TAB and NB will give the basis for surveillance of the values declared by the supplier.

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