Standardisation of dowels - where are we now?

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Introduction

- Dowels and tie-bars
  - Materials
    - Which materials?
    - Which characteristics for these materials?
      - Test methods
      - Classes, thresholds
  - Functioning
    - Which functions? For one dowel or tie-bar – for a combined action of a group of dowels and tie-bars.
      - Test methods
      - Classes, thresholds

Introduction

- Standardisation work in Europe, related to concrete pavements
  - CEN = European Committee for Standardisation
  - CEN/TC 227= Technical Committee “Road Materials”
  - CEN/TC 227 WG3 = “Materials for concrete roads including joint fillers and sealants”
  - CEN/TC 227 WG3 TG1+2 = “Materials and Functional characteristics”

European Standards related to concrete pavements (dowels & tie-bars)

- EN 13877-1 Concrete pavements - Part 1: Materials (2023)
- EN 13877-2 Concrete pavements - Part 2: Functional requirements for concrete pavements (2023)

- EN 13877-3 Concrete pavements - Part 3: Specifications for dowels to be used in concrete pavements (2004)

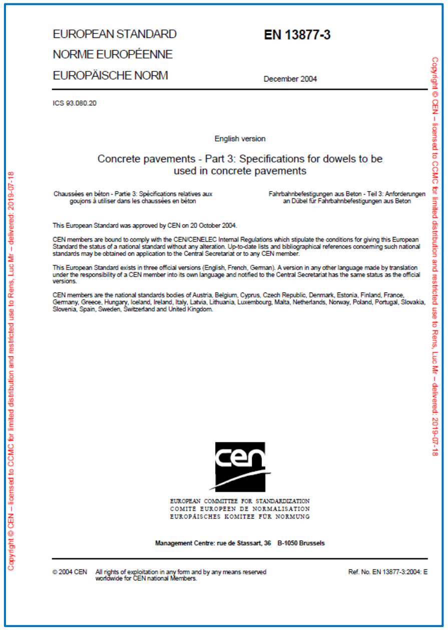
- EN 13863-1, Concrete pavements — Part 1: Test methods for the determination of the thickness of a concrete pavement by survey method (2003)
- EN 13863-2, Concrete pavements - Part 2: Test method for the determination of the bond between two layers. (2003)
- EN 13863-3, Concrete pavements - Part 3: Test methods for the determination of the thickness of a concrete slab. (2004)
- EN 13863-4, Concrete pavements - Test methods – Part 4:Determination of wear resistance to studded tyres (2014)
- EN 13863-5 Concrete pavements – Part 5: Determination of the bond stress of dowels to be used in concrete pavements (2024)
- EN 13863-6 Concrete pavements – Part 6: Testmethod for the determination of the tensile strength of concrete at cylindrical discs (2024)
- **+ 30 standards on joint fillers and sealants**

European Standard EN 13877-1 (new: 2023)

- **Concrete pavements – Part 1: Materials**
- **6.5 Tie bars**
  - Deformed or ribbed bars (EN 10060)
  - Minimum diameter of 10 mm; minimum length of 500 mm; tolerances in length ± 15 mm
  - If material is susceptible to corrosion: measure against corrosion = protective coating over 200 mm (place = according to national standards or provisions in the place of use)
  - Durability: NSS test = Neutral Salt Spray (EN ISO 9227:2022) during 240 hrs
    - No crazing of the coating or corrosion of the tested surface is allowed

European Standard EN 13877-3 (old)

- hEN 13877-3 Concrete pavements – Part 3: Specifications for dowels to be used in concrete pavements
  - 2004
  - Harmonised



EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 13877-3

December 2004

ICS 93.080.20

English version

Concrete pavements - Part 3: Specifications for dowels to be used in concrete pavements

Chaussées en béton - Partie 3: Spécifications relatives aux goujons à utiliser dans les chaussées en béton

Fahrbahnbefestigungen aus Beton - Teil 3: Anforderungen an Dübel für Fahrbahnbefestigungen aus Beton

This European Standard was approved by CEN on 20 October 2004.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: rue de Stassart, 36 B-1050 Brussels

Ref. No. EN 13877-3:2004: E

European Standard EN 13877-3 (old)

- Requirements
  - Tensile strength ≥ 250 MPa (EN ISO 15630-1)
  - D_{min} = 16 mm
  - Tolerances in length = ± 10 mm
  - Dowels shall be straight, free of burrs and other irregularities and the sliding ends sawn with no protrusions outside the normal diameter of the bar.
  - Notes
    - The length of dowels should conform to national application provisions in the place of use.
    - Before the use, half of their length at least, should be covered with a thin bituminous coating or a thin plastic sheet to prevent them from adhering to the concrete. The average thickness should be not greater than 1,25 mm.

- Durability
  - The durability shall be ensured either by a protective coating factory made, or by on site treatments as a national application provision.
  - Note: Protective measures against corrosion have to conform to national standards or provisions in the place of use.

European Standard EN 13877-3 (old)

- Conclusions and remarks
  - Old and incomplete standard
  - Very unclear about durability
  - BUT
    - Material-neutral...although the standards (e.g. for tolerances) refer to hot-rolled round steel bars
    - And it is harmonised, thus subject to CE-marking
    - Attestation level 4 = quality control by the manufacturer – no external party
    - Factory Production Control: 1/2500 dowels: tensile strength

European Standard EN 13877-3 (draft new)

- Attention: we are talking about a draft, not approved version
- Works for revision of the standard started around 2014 and went through different stages
  - Dowels and tie-bars in one standard; then separated again
  - Only steel considered; later material-neutral
- Technical work was finished and the standard was put “on hold” in 2020
  - Problems with EC – legal issues – development of new CPR
  - Impossible to get a new or revised harmonized standard approved

European Standard EN 13877-3 (draft new)

- Main change:
  - Introduction of extra performance testing
    - Tensile strength
    - Shear strength
    - Bond stress – Pull-out test
    - Durability – NSS = Neutral Salt Spray Test

- Dowels shall have a tensile strength not less than 250 MPa when tested in accordance with EN ISO 6892-1 for steel dowels or an equivalent test method for non-metallic dowels.

- Dowels shall be protected against corrosion by the application of a coating or by the use of a non-corrosive type of steel, e.g. stainless-steel or other non-corrosive material. The thickness of the coating shall be between 0,200 mm and 0,800 mm. Up to 5 mm from each end may remain uncoated.

European Standard EN 13877-3 (draft new)

- The shear strength (for the other type of materials) needs to be added. A possible testing method can be found in: https://www.gunt.de/images/download/Mechanical-materials-testing-methods-basic-knowledge_english.pdf. See the following extract:

Shear test to study the load capacity against shearing

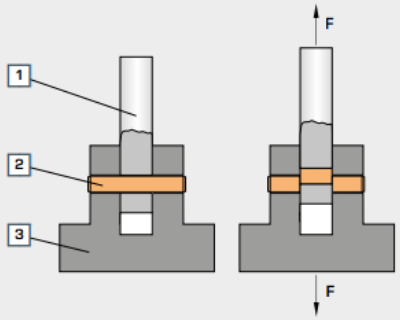
The shear test is applied when testing screws, rivets, pins and parallel keys in order to determine the shear strength of the material or the behaviour of the material under shear strain. To do this, the shear stresses are produced in the specimen by means of external shear forces until the specimen shears off. The resistance of a material against the shear stress can be determined by two different methods, the single-shear and the double-shear testing method.

In the double-shear method, the specimen is sheared off at two cross sections. In the single-shear process, the specimen only shears away at one cross section. Calculating the shear strength in the two processes differs in the cross-sectional area to be applied. The shear strength determined in the shear test is important in the design of bolts, rivets and pins, as well as for calculating the force required for shears and presses.

$$\tau = \frac{F}{2 \cdot A}$$

Shear strength in the double-shear method

τ shear strength, **F** force, **A** shearing surface



Test process in the double-shear test

1 pull strap, **2** specimen, **3** housing, **F** test load

European Standard EN 13877-3 (draft new)

- Shear strengths for glass fiber dowels are found to be between 150 and 250 MPa. For steel dowels, the shear strength is equal to 0,75 * tensile strength (http://www.werktuigbouw.nl/calculators/uts.htm). Regarding the minimum required tensile strength of 250 MPa in this standard, this would correspond to a shear strength of 187,5 MPa.

- Calculations point out that the shear stress (without fatigue) is (for airfields with low amount of dowels) equal to 110 MPa. A value of 150 MPa could be considered as a minimum.

- It is decided not to put an extra threshold in the standard; however the value of the shear strength needs to be declared together with the test-method used.

- Standards that could be used are: ASTM B769/94 (normally for aluminum but in the U.S. also used for GFRP dowels) or ISO 7961 (bolts).

European Standard EN 13877-3 (draft new)

- Shear strength
  - In the case of steel dowels, the shear strength is deemed to satisfy if the steel quality and the tensile strength comply with the requirements of this standard.
  - For other type of materials used for the dowel, the shear strength has to be declared as well as the testing method used.

European Standard EN 13877-3 (draft new)

- Bond stress
  - A pull-out test shall be carried out according to EN 13863-5.

European Standard EN 13863-6 (new - 2014)

- Concrete pavements – Part 5: Determination of the bond stress of dowels to be used in concrete pavements

  - Method developed by TU Munich
  - 3 dowels tested
  - Reference concrete (30 to 50 MPa at 7d)
  - Per dowel: 4 cycles pull/push; then pull-out
  - Calculation of average bond stress

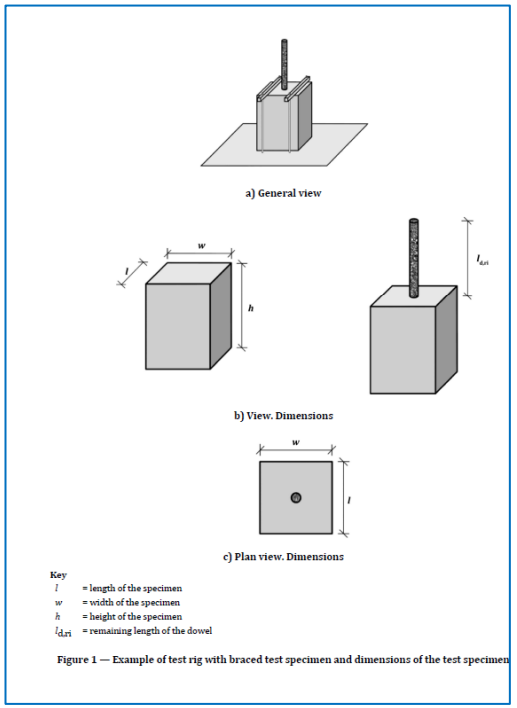


Figure 1 — Example of test rig with braced test specimen and dimensions of the test specimen

European Standard EN 13877-3 (draft new)

- Bond stress
  - A pull-out test shall be carried out according to EN 13863-5.
  - The average bond stress ($f_{d,pm,1}$) to achieve a movement of 0.25 mm, shall not exceed 0,9 MPa after the first movement of the dowel and no individual bond stress ($f_{d,pi,1}$) shall exceed 1,0 MPa.
  - Finally, each dowel shall be pulled out completely and checked for damage. The average bond stress ($f_{d,pm,5}$) shall then not exceed 0,6 MPa.
  - In case of coated dowels, the test fails if delamination is observed or if the main material of the dowel is visible in the coated area, which was embedded in the concrete during the test phase.

European Standard EN 13877-3 (draft new)

- Durability
  - The durability of the dowel shall be tested according to EN ISO 9227:2023, using the NSS-test (§ 3.2.2).
  - The test specimen can be cut from the dowel and shall have a length of minimum 150 mm. The ends can be protected. The length of the tested surface shall be 50 mm less than the length of the specimen and shall be situated in the middle of the test specimen.
  - Three test specimens shall be tested.
  - The duration of immersion is set to 240 hours.
  - The evaluation shall be done visually. No crazing of the coating or corrosion of the bar over the tested surface is allowed.

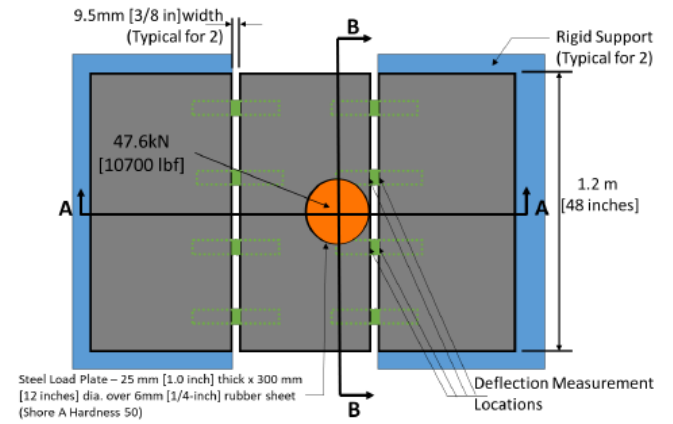
U.S. standards related to dowels

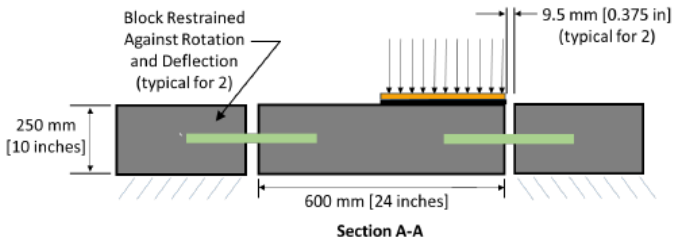
- New ACPA documents
  - ACPA T253-23a – Standard Test Method
    - Load deflection test procedure
    - Pull-out test procedure
    - Abrasion-Corrosion test procedure
    - Chemical Resistance test procedure
    - Cathodic Disbonding test procedure
    - Coating Impact resistance test procedure
  - ACPA M254-23a – Standard Specifications
    - Evaluation of structural and durability characteristics of the wide range of dowel materials and installation configurations now available.

U.S. standards related to dowels

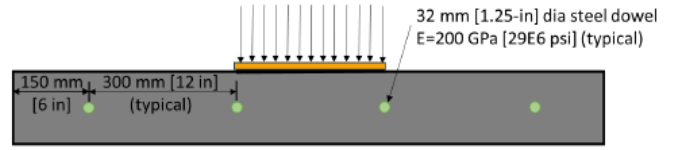
- Load deflection test procedure
  - 2 joints
  - Joint opening of 9,5 mm
  - Static load 47,6 kN
  - Deflection measured at 4 points located 15 cm on either side of the center of the load plate, for both joints
  - Max. 0,25 mm relative deflection
  - An alternative test with dynamic loading is also described

5.8. Report all measured deflections. Calculate and report all relative deflections (difference in deflection across the transverse joint at each measurement location). Report the average and standard deviation of the relative deflection for all load positions at each load level.





Section A-A



Section B-B
(Typical for Common Steel Dowel Layout)

ACPA Test Method | Dowel Bars for Concrete Street and Highway Pavement | ACPA T253-23a
October 12, 2023 | Page 7 of 25

Back to Europe...what's next

- New CPR – Construction Products Regulation 2014
- Renewal of all harmonised standards
  - Standardisation request
    - List of essential characteristics, including environmental characteristics (EPD – EN 15804)
    - Test methods
    - Classes and tresholds
  - Procedure is starting for Road Construction Products
- Possibility of "de-harmonisation"?
  - No CE-marking
  - Still possible as EN and usefull for national regulations
  - Preferred option for many countries (informal survey in our TG)

Closing remarks

- Tie-bars: EN 13877-1: ok
- Dowels: EN 13877-3 – old or new, with or without CE-marking + national provisions
- Evolution in materials and systems.
- Testing of load transfer (load deflection test): not in Europe
  - Covered by national experiences and practices
  - However interesting (and necessary) in the development of new products
- Best practices in construction!

Thank you for your kind attention