The case for the adoption of Eurocode 6 in South Africa

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BACKGROUND

During the Eurocode summit held on 8 February 2008, organised by the SAICE Joint Structural Division (JSD) and hosted by the South African Bureau of Standards (SABS) on their campus in Tshwane, the benefits for adopting Eurocodes in South Africa were highlighted. The summit was attended by representatives of major stakeholders in the materials, design and construction industries in South Africa.

The current South African National Standards covering the design, materials and construction of masonry need updating. With a clear sense of direction that the Eurocodes are the future, the South African masonry sector was in favour of aligning with Eurocode 6 (Design of Masonry Structures) and adopting the recent, advanced set of masonry standards. South Africa has based its structural masonry design codes on those of the United Kingdom where Eurocode 6 has been implemented, and we can therefore be guided with our British counterparts.

For the structural design fraternity the adoption of Eurocode 6 requires the development of South African Annexes for the various parts (four). Notably, there is a proliferation of supporting masonry and test standards accompanying the manufacturing of masonry units, ancillary components, mortar, rendering and plastering.

The smooth transition to Eurocode 6 and the future acceptance thereof can only be successful with cooperation of all the stakeholders, i.e. the designers, manufacturers and contractors. The implications for the masonry fraternity are significant, whether Eurocode 6 is adopted or not, and in both instances manpower and funding are required to take detailed work forward and to put processes in place.

The following is a summary of the current South African Standards and those in the offing in an attempt to solicit discussion by all stakeholders to ensure that the Eurocode masonry standards are accepted and used by all.

APPLICABLE SOUTH AFRICAN MASONRY STANDARDS

Structural design standards

Structural masonry design is covered in two South African standards based on Limit States principles, i.e.:

- SANS 10164-1, *The structural use of masonry Part 1: Unreinforced masonry walling.* This design standard is based on BS 5628, Part 1 and was published in 1980 with two subsequent minor amendments. This design standard has partial load factors in conflict with SANS 10160, *Basis of structural design and actions for buildings and industrial structures Part 1: Basis of structural design.* SANS 10164-1 inter alia includes testing procedures for mortar, the determination of characteristic compressive and flexural strength of masonry, the determination of water absorption of clay bricks, initial rate of absorption (of masonry units), bond strength of brickwork, flexural bond strength of damp-proof courses and short-term shear strength at damp-proof courses.
- SANS 10164-2, *The Structural use of masonry Part 2: Structural design and requirements for reinforced and prestressed masonry.* This design standard is based on BS 5628, Part 2, and was published in 1992 with one amendment. BS 5628 was withdrawn in the UK on 31 March 2010 leaving Eurocode 6 as the primary code for masonry design.

Materials standards

The manufacturing of the different masonry units available in South Africa is covered in the following standards, i.e.:

- SANS 227, *Burnt clay masonry units.* This design standard was published in 1986 with subsequent minor editorial amendments. This standard includes the following testing procedures for fired clay (burnt clay) masonry units: dimensions, warpage, compressive strength, efflorescence test, soundness test, water absorption, water soluble salts and moisture expansion.
- SANS 1215, *Concrete masonry units.* This design standard was published in 1984 with six subsequent amendments; the last two amendments in 2013 are currently being circulated for comment. This standard includes testing procedures for dimensions, squareness, compressive strength, drying shrinkage, expansion on re-wetting and soundness.
- SANS 285, *Calcium silicate masonry units.* This design standard was published in 1971 with one subsequent amendment. This standard includes testing procedures for dimensions, compressive strength, drying shrinkage and efflorescence.
- Supporting standards include SANS 523, *Limes for use in building,* which was published in 1994 (with three subsequent revisions) and SANS 1090, *Sand for plaster and mortar,* which was published in 1976.

Construction standards

The applicable construction standards are:

- SANS 10249, *Masonry walling*, which was published in 1993 with a subsequent revision.

- SANS 10145, *Concrete masonry construction*, which was published in 1978 with four subsequent revisions of which the last is currently circulating for comment.
- SANS 2001-CM1, *Construction works Part CM1: Masonry walling*, which was published in 2007.
- SANS 2001-EMI, *Construction works Part EM1: Cement plaster*, which was published in 2004.

National Building Regulations

SANS 10400-K, *The Application of the National Building Regulations, Part K: Walls* was published in 2005. The functional regulations contained in the National Building Regulations and Building Standards Act 1977 (Act No 103 of 1977) given in SANS 10400, Part K, shall be deemed to be satisfied when meeting these performance requirements.

IMPLICATIONS TO MAINTAIN STATUS QUO (NON-IMPLEMENTATION OF EUROCODE 6)

The current design standards that were compiled more than thirty years ago require updating, i.e. SANS 10164-1 and 2. SANS 10164-1, T*he structural use of masonry Part 1: Unreinforced masonry walling* is the only South African design standard where partial safety factors for loading and accidental damage are published whilst belonging in the appropriate loading standard, i.e. SANS 10160-1. Unreinforced masonry is a brittle material and the requirements for robustness and accidental damage are more onerous. This aspect requires special attention to ensure acceptable reliability indices before used with confidence (SANS 2394:2004 – General principles on reliability for structures).

All material standards, together with testing methods, will be reviewed, i.e. SANS 227, SANS 1215 and SANS 285. Revising material standards will be based on acceptable standards. All supporting standards such as SANS 523 and SANS 1090 require some editing.

The oldest to the most recent construction standards require review, i.e. SANS 10249, SANS 10145, SANS 2001-CM1, SANS 2001-EMI, including the recently published SANS 10400-K, *The application of the National Building Regulations, Part K: Walls.* The latter requires review with respect to the durability of foundation walls.

APPLICABLE EUROPEAN MASONRY STANDARDS

Eurocode 6

Eurocode 6 relates to buildings and other civil engineering works, and covers reinforced, prestressed and confined masonry. The four documents make up BS EN 1996 and were first published in 2005 and 2006, and cover the rules for reinforced and unreinforced masonry, structural fire design and detailed rules for lateral loading. Eurocode 6 therefore comprises the following parts; each part has a corresponding National Annex:

BS EN 1996-1-1: *Rules for reinforced and unreinforced masonry*
BS EN 1996-1-2: *Structural fire design*
BS EN 1996-2: *Selection of materials and execution of masonry*
BS EN 1996-3: *Simplified calculation methods for unreinforced masonry structures*

The supporting UK National Annexes were first published by BSI in June 2007.

Supporting standards

The manufacturing of the different masonry units available in South Africa is essentially covered in three South African Standards (SANS 227, 1215 and 285); testing methods are fragmentally given in design and materials standards. A comprehensive set of manufacturing specifications and test methods form supporting and auxiliary standards when the Eurocode 6 is implemented, i.e.:

Masonry units

EN 771-1: *Specification for masonry units – Part 1: Clay masonry units*
EN 771-2: *Specification for masonry units – Part 2: Calcium silicate masonry units*
EN 771-3: *Specification for masonry units – Part 3: Aggregate concrete masonry units (Dense and light-weight aggregates)*
EN 771-4: *Specification for masonry units – Part 4: Autoclaved aerated concrete masonry units*
EN 771-5: *Specification for masonry units – Part 5: Manufactured stone masonry units*
EN 771-6: *Specification for masonry units – Part 6: Natural stone masonry units*

Test methods for masonry units

EN 772-1: *Methods of test for masonry units – Part 1: Determination of compressive strength*
EN 772-2: *Methods of test for masonry units – Part 2: Determination of percentage area of voids in masonry units (by paper indentation)*
EN 772-3: *Methods of test for masonry units – Part 3: Determination of net volume and percentage of voids of clay masonry units by hydrostatic weighing*
EN 772-4: *Methods of test for masonry units – Part 4: Determination of real and bulk density and of total and open porosity for natural stone masonry units*
EN 772-5: *Methods of test for masonry units – Part 5: Determination of the active soluble salts content of clay masonry units*
EN 772-6: *Methods of test for masonry units – Part 6: Determination of bending tensile strength of aggregate concrete masonry units*
EN 772-7: *Methods of test for masonry units – Part 7: Determination of water absorption of clay masonry damp proof course units by boiling in water*
EN 772-9: *Methods of test for masonry units – Part 9: Determination of volume and percentage of voids and net volume of clay and calcium silicate masonry units by sand filling*
EN 772-10: *Methods of test for masonry units – Part 10: Determination of moisture content of calcium silicate and autoclaved aerated concrete units*
EN 772-11: *Methods of test for masonry units – Part 11: Determination of water absorption of aggregate concrete, manufactured stone and natural stone masonry units due to capillary action and the initial rate of water absorption of clay masonry units*
EN 772-13: *Methods of test for masonry units – Part 13: Determination of net and gross dry density of masonry units (except for natural stone)*

EN 772-14: *Methods of test for masonry units – Part 14: Determination of moisture movement of aggregate concrete and manufactured stone masonry units*
EN 772-15: *Methods of test for masonry units – Part 15: Determination of water vapour permeability of autoclaved aerated concrete masonry units*
EN 772-16: *Methods of test for masonry units – Part 16: Determination of dimensions*
EN 772-18: *Methods of test for masonry units – Part 18: Determination of freeze-thaw resistance of calcium silicate masonry units*
EN 772-19: *Methods of test for masonry units – Part 19: Determination of moisture expansion of large horizontally perforated clay masonry units*
EN 772-20: *Methods of test for masonry units – Part 20: Determination of flatness of faces of masonry units*

Ancillary components

EN 845-1: *Specification for ancillary components for masonry – Part 1: Ties, tension straps, hangers and brackets*
EN 845-2: *Specification for ancillary components for masonry – Part 2: Lintels*
EN 845-3: *Specification for ancillary components for masonry – Part 3: Bed joint reinforcement of steel meshwork*

Test methods for ancillary components

EN 846-2: *Methods of test for ancillary components for masonry – Part 2: Determination of bond strength of prefabricated bed joint reinforcement in mortar joints*
EN 846-3: *Methods of test for ancillary components for masonry – Part 3: Determination of shear load capacity of welds in prefabricated bed joint reinforcement*
EN 846-4: *Methods of test for ancillary components for masonry – Part 4: Determination of load capacity and load-deflection characteristics of straps*
EN 846-5: *Methods of test for ancillary components for masonry – Part 5: Determination of tensile and compressive load capacity and load displacement characteristics of wall ties (couple test)*
EN 846-6: *Methods of test for ancillary components for masonry – Part 6: Determination of tensile and compressive load capacity and load displacement characteristics of wall ties (single end test)*
EN 846-7: *Methods of test for ancillary components for masonry – Part 7: Determination of shear load capacity and load displacement characteristics of shear ties and slip ties (couplet test for mortar joint connections)*
EN 846-8: *Methods of test for ancillary components for masonry – Part 8: Determination of load capacity and load-deflection characteristics of joist hangers*
EN 846-9: *Methods of test for ancillary components for masonry – Part 9: Determination of flexural resistance and shear resistance of lintels*
EN 846-10: *Methods of test for ancillary components for masonry – Part 10: Determination of load capacity and load deflection characteristics of brackets*
EN 846-11: *Methods of test for ancillary components for masonry – Part 11: Determination of dimensions and bow of lintels*
EN 846-13: *Methods of test for ancillary components for masonry – Part 13: Determination of resistance to impact, abrasion and corrosion of organic coatings*

Mortar

EN 998-1: *Specification for mortar for masonry – Part 1: Rendering and plastering mortar*
EN 998-2: *Specification for mortar for masonry – Part 2: Masonry mortar*

Methods of test for mortar

EN 1015-1: *Methods of test for mortar for masonry – Part 1: Determination of particle size distribution (by sieve analysis)*
EN 1015-2: *Methods of test for mortar for masonry – Part 2: Bulk sampling of mortars and preparation of test mortars*
EN 1015-3: *Methods of test for mortar for masonry – Part 3: Determination of consistence of fresh mortar (by flow table)*
EN 1015-4: *Methods of test for mortar for masonry – Part 4: Determination of consistence of fresh mortar (by plunger penetration)*
EN 1015-6: *Methods of test for mortar for masonry – Part 6: Determination of bulk density of fresh mortar*
EN 1015-7: *Methods of test for mortar for masonry – Part 7: Determination of air content of fresh mortar*
EN 1015-9: *Methods of test for mortar for masonry – Part 9: Determination of workable life and correction time of fresh mortar*
EN 1015-10: *Methods of test for mortar for masonry – Part 10: Determination of dry bulk density of hardened mortar*
EN 1015-11: *Methods of test for mortar for masonry – Part 11: Determination of flexural and compressive strength of hardened mortar*
EN 1015-12: *Methods of test of mortar for masonry – Part 12: Determination of adhesive strength of hardened rendering and plastering mortars on substrates*
EN 1015-17: *2000 Methods of test for mortar for masonry – Part 17: Determination of water-soluble chloride content of fresh mortars*
EN 1015-18*: Methods of test for mortar for masonry – Part 18: Determination of water absorption coefficient due to capillary action of hardened mortar*
EN 1015-19*: Methods of test for mortar for masonry – Part 19: Determination of water vapour permeability of hardened rendering and plastering mortars*
EN 1015-21*: Methods of test for mortar for masonry – Part 21: Determination of the compatibility of one-coat rendering mortars with substrates*

Methods of test for masonry

EN 1052-1*: Methods of test for masonry – Part 1: Determination of compressive strength*
EN 1052-2*: Methods of test for masonry – Part 2: Determination of flexural strength*
EN 1052-3*: Methods of test for masonry – Part 3: Determination of initial shear strength*
EN 1052-4*: Methods of test for masonry – Part 4: Determination of shear strength including damp proof course*
EN 1052-5*: Methods of test for masonry – Part 5: Determination of bond strength by the bond wrench method*

Design thermal values

EN 1745:
Masonry and masonry products – Methods for determining design thermal values

Rendering and plastering

EN 13914-1:

Design, preparation and application of external rendering and internal plastering – External rendering

EN 13914-2:

Design, preparation and application of external rendering and internal plastering – Part 2: Design considerations and essential principles for internal plastering

EN 15824:

Specifications for external renders and internal plasters based on organic binders

CEN/TR 15123:

Design, preparation and application of internal polymer plastering systems

CEN/TR 15124:

Design, preparation and application of internal gypsum plastering systems

CEN/TR 15125:

Design, preparation and application of internal cement and/or lime plastering systems

CEN/TR 15225:

Guidance on Factory Production Control for the CE Marking (Attestation of Conformity 2+) of designed masonry mortars

IMPLICATIONS OF IMPLEMENTING EUROCODE 6

BS EN 1996-1-1: Rules for reinforced and unreinforced masonry

A wide range of different masonry materials and configurations will be introduced based upon the proportion and direction of holes or perforations, web thicknesses, etc.

The characteristic compressive strength of masonry is presented in the form of an equation, using the normalised strength of the masonry and the strength of the mortar. The normalised strength relates the compressive strength of the masonry unit determined by test to a standardised shape and moisture content. Structural reliability safety indices have to be revisited.

The designation of mortars has also changed with the need for a declaration based on strength rather than mix proportions.

The compressive strength used for masonry units is the normalised compressive strength which is either declared by the manufacturer or obtained by using EN 771 series. The manufacturing industry in South Africa has to adopt the new supporting standards. Some of these EN standards have already been accepted by the SABS/TC 81 committee.

The manner in which eccentricities on walls are analysed now includes an initial eccentricity to allow for inaccuracies in the construction of the masonry. Concentrated loads are also handled differently in Eurocode 6. Lateral load design, however, remains unchanged.

Ancillary components will be dealt with in a more coherent way and suitable values of material partial safety factors will be introduced.

BS EN 1996-1-2: Structural fire design

Fire design will largely remain in the form of tables similar to those contained in BS 5628 Part 3. The fire resistance of a loadbearing wall now comprises two values, depending on how highly loaded the wall is, and is further enhanced if the wall is plastered. It is foreseen that this standard will be read in



conjunction with SANS 10400-T: 2011, i.e. *The Application of the National Building Regulations, Part T: Fire Protection.*

BS EN 1996-2: Selection and execution of masonry

Part 2 of Eurocode 6 contains information of a very general nature on materials and execution. It deals with the selection of material, factors affecting the performance and durability of masonry, resistance of buildings to moisture penetration, storage, preparation, the execution and protection of masonry. Micro conditions of exposure to which masonry is subjected are divided into five classes. Part 2 will replace several of the existing South African standards.

BS EN 1996-3: Simplified calculation methods for unreinforced masonry structures

Part 3 deals with simplified calculation methods for unreinforced masonry. It is foreseen that this part will be read in conjunction with the National Building Regulations, i.e. SANS 10400-K, *The Application of the National Building Regulations, Part K: Walls.*

THE WAY FORWARD

Under the rules of the CEN (European Committee for Standardisation) all National Standards Bodies have to withdraw conflicting National Standards and publish the CEN standard once a standard has been adopted by weighted majority voting. The Eurocodes were designed to work as a coherent set and contain certain Nationally Determined Parameters, which have to be addressed in a National Annex published separately from the Eurocode itself. The National Standards Body is only allowed to publish each Eurocode in its entirety, and the National Annex can only address the specific points raised in the Eurocode pertaining to South Africa.

The implementation of Eurocode 6 therefore will have significant implications for the structural design fraternity, i.e. National Annexes have to be written and appropriate target levels of reliability will be established before the new standards can be used with confidence. The manufacturing industry as a whole has to adopt the use of the new manufacturing and testing standards. Expertise, manpower and funding are required. Future masonry research needs to be identified.

If the adoption of Eurocodes 6 is deemed to be too onerous for South Africa, and existing standards require revision and updating, the demand on expertise, manpower and funding should not be relaxed.

Please share your views

In an attempt to make the transition to Eurocode 6 fully consultative and to allow room for debate, further guidance is sought from all engineering design, construction and manufacturing stakeholders. Please share your opinions with the author or post your comments on the Joint Structural Division's website (www.jsd.co.za) to ensure that the resulting set of new standards will be acceptable to all and will have widespread usage throughout South Africa. If there is no opposition, all resources will be channelled in favour of the transition to Eurocode 6. □

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