PROPOSED NEW SOUTH AFRICAN LOADING CODE SANS 10160

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1. INTRODUCTION

During 1995 a seminar was held under the auspices of the South African Institution of Civil Engineering to investigate the introduction of a limit states design code of practice for geotechnical engineering in South Africa. It was found that South Africa would lack the resources to develop such a code of practice and therefore the adoption of Eurocode ENV 1997 was considered. Incompatability in the basis of structural design in SABS 0160:1989 (1) and ENV 1990 respectively led to the conclusion that the adoption of ENV 1997 as the limit states design code of practice for geotechnical engineering in South Africa was not feasible at that stage.

Based on the findings of the above mentioned seminar the South African National Conference on Loading (2) was convened by the South African Institution of Civil Engineering in 1998 to deliberate on the future of the South African loading code. During this loading code conference the decision was taken to review the South African Loading Code SABS 0160:1989. The primary guidelines given by the South African National Conference on loading for the revision of SABS 0160:1989 were that the loading code should serve all the local material codes and that it should be referenced to ISO-standards. Consequently the subcommittee of *SABS SC 5120.61M Construction Standards – Bases for Structures* was established and the working group WG61M was convened by the South African Institution of Civil Engineering. The background to the revision, including its need, basis for the proposed standard and motivation for the changes are reported here.

The guidelines and considerations that were applied by the working group based on the primary requirements set by the National Loading conference in the revision of SABS 0160:1989 are as follows :

- International harmonisation of the revised standard not only utilises the international structural engineering technology basis of practice and research, but also implicitly extends the basis of agreement on the application of such technology to derive standardised design procedures. Such harmonisation also facilitates the treatment of situations beyond the scope of the standard by referring to harmonised standards.
- Harmonisation of materials based design is facilitated by the formulation of the basis for the design of structures, not only in the treatment of actions and the resistance of structures, but more importantly to ensure consistency between structures consisting of different materials, even more so if this occurs in the same structure. Such harmonisation is for instance important to the inclusion of geotechnical actions in the proposed standard.
- The scope of the proposed standard is determined by the scope of structures provided for; basis of structural design, including target levels of reliability; actions to be considered; related materials based standards; the function of the standard with regard to specifying standards for structural safety and a code for sound design practice. As a general point of departure the scope of the existing SABS 0160-1989 is maintained, with some incremental development of the consistency of reliability and actions to be considered.
- The scope of structures of SABS 0160:1989 is maintained, but with some more explicit indication that industrial structures similar to buildings are included. The clear formulation

of the general principles applied in the standard to derive design rules and the achievement of levels of reliability should enable designers to judge on whether specific structural configurations fall within the scope of this standard, and to assist in the treatment of such design if this is not the case.

- Reference levels and consistency of reliability on which the present standard is based are generally maintained, except where there is judged to be deficiencies in present practice which need remediation; whilst a concerted effort is made to improve the consistency of reliability through refined classification and treatment of situations requiring reliability differentiation, including the role and importance of quality management considerations.
- Actions on structures provided presently in SABS 0160:1989 need to be critically reassessed in terms of their models and representative values with a view to updating, with specific reference to seismic actions. Provision for geotechnical actions on structures, particularly relating to foundation design and the interface between building and geotechnical structures have been identified as a specific deficiency in the present standard.
- Materials design standards presently referring to SABS 0160:1989 should be able to use the revised standard; clear guidelines should however be provided for implementation during future revision of materials based design standards to realise the enhanced harmonisation of structural design practice as envisaged above.
- Capturing of sound structural design practice in the standard, not only as an aid to practitioners, but also to provide the basis for the design of sound and economic structures is maintained as an objective of the standard by providing clear guidance to this effect, albeit in the form of informative procedures. Whereas this facet of the standard primarily referred to the provision of serviceability criteria, consideration of aspects of execution of the structure and provision for accidental design situations are also related to the optimised design of structures.

The publication of the normative (EN) version of the Eurocode Standard for structural design, which is presently in progress, afforded the opportunity to use the Eurocode Standards EN 1990 and EN 1991 as the primary reference code for the revision of SABS 0160:1989. The decision of using the Eurocodes EN1990 and EN1991 as the primary reference codes is also supported by a bi-lateral agreement between CEN and SABS.

2. SELECTION OF EUROCODE AS PRIMARY REFERENCE CODE

The Eurocode Standard for structural design consists of ten Standards, EN 1990 to EN 1999, with 58 separate Parts in total. In the review of the SABS 0160:1989 code the emphasis is placed on EN 1990 *Basis of Structural Design*, six Parts of EN 1991 *Actions on Structures* and one Part each from EN 1997 *Geotechnical Design* and EN 1998 *Design Provisions for Earthquake Resistance of Structures* to be used as primary reference standards. A summary of the selected Parts from Eurocode to be used as reference standards during the revision of SABS 0160:1989 is given in Table 2.1 on the next page.

Progress made during the development of Eurocode is captured in the publication of the normative EN Standards which started in 2002 and is expected to be completed by the end of 2006 [(3)]. Following the publication of a National Annex for each Part by the member countries, the national standards are to be replaced by Eurocode after a five year period of co-existence.

Eurocodes provide design procedures for an extensive range of structures, structural materials and design situations in a comprehensive and integrated set of Standards. The structures cover the comprehensive range of civil engineering works, although for specialist structures mainly the principles of design are specified, whilst application rules are developed into practical procedures for the more conventional classes of structures. In addition to standard structural materials of

TABLE 2.1 Relationship between Sections in SANS 10160 and Eurocode Parts

Proposed SANS 10160 Sections		Reference Eurocode Part	
1-3	Scope, Normative references, Terms		
4	Basis of structural design	EN 1990	Basis of structural design
5	Self-weight and imposed loads	EN 1991-1-1	General actions – Densities, self-weight, imposed loads for buildings
6	Wind actions	EN 1991-1-4	General actions – Wind actions
7	Thermal actions	EN 1991-1-5	General actions – Thermal actions
8	Actions during execution	EN 1991-1-6	General actions – Actions during execution
9	Accidental actions	EN 1991-1-7	General actions – Accidental actions due to impact and explosions
10	Actions induced by cranes and machinery	EN 1991-3	Actions induced by cranes and machinery
11	Seismic actions	EN 1998-1	Design provisions for earthquake resistance of structures: General rules, seismic actions and rules for buildings
12	Geotechnical actions	EN 1997-1	Geotechnical design: General rules
13	Design assisted by testing	EN 1990	Annex : Design assisted by testing

concrete, steel, composite steel/concrete, timber and masonry; geotechnical structures are included. Accidental design situations are included generally, and developed into more detailed procedures for structural fire design and seismic effects.

The downside of the comprehensive nature of Eurocode is that it consists of a complex system with a large number of Parts. This is complicated further by allowance for national options, and the schemes that are used to accommodate these options in a consistent manner. In spite of its contribution to the complexity of Eurocode, the alternative options demonstrate the degree to which consensus is reached and to identify the parameters which are dependent on environmental conditions or critical to safety standards.

2.1 Motivation for the selection of Eurocode as the primary reference code

Two general considerations relate to the application of a reference in the revision of SANS 10160, which are the need for a reference standard and the merit of Eurocode to fulfill this function.

- **Limited resources** : Proper revision of SANS 10160 is only possible when sufficient resources are available for that purpose, which is presently not the case. The alternative is to base the revision on a selected reference standard.
- **Technology base** : As a recently developed and formulated set of structural design standards, Eurocode provides a wide range of consistent and up to date models and procedures that can be considered. The options that are provided for and allowed clearly reveal the manner in which provision should be made for local environmental and regulatory conditions.

From these two general considerations, the following arguments led to the process of formulating the proposed SANS 10160 by considering the related Eurode specifications.

2.1.1 Extended range of actions with updated models

Eurocode provides updated models for existing actions in SABS 0160:1989, which are self weight and imposed loads, wind actions, actions induced by cranes and machinery and seismic actions, together with actions not presently provided for in SABS 0160:1989, which are thermal actions, actions during execution, accidental actions and geotechnical actions on building structures.

Eurocode also provides for actions outside the present scope of the proposed SANS 10160, which are actions caused by fire, actions on containment structures, actions on bridges and actions on towers and masts.

2.1.2 Basis of structural design

ISO 2394 *General principles on reliability for structures* (4) is transformed into an operational basis in EN 1990:2002 for the design of structures to be complied with in the treatment of actions and their effects as well as for resistance according to the materials based design standards. The guideline given by the South African National Conference on Loading for the revision of SABS 0160:1989 that the revised standard should be referenced to the relevant ISO-Standard is therefore effectively adhered to.

2.1.3 Revision and extension of standards

Reference to Eurocode for the revision of SABS 0160:1989 provides the basis for the future extension of SANS 10160, for example the inclusion of fire design. The reference to Eurocode also provides the opportunity of considering the revision of the South African materials standards in the future according to the relevant standard of Eurocode as well as considering the introduction of new standards in South Africa, for example a standard for composite steel/concrete structures and a standard for the design of liquid retaining structures.

2.1.4 Harmonisation of structural design

Alignment to Eurocode will provide harmonisation to a significant component of international practice representing the most important trade block to South Africa. Eurocode will replace the British Standards, which served traditionally as the default reference to South African structural design standards.

2.2. Application of the reference to Eurocode

Whilst taking SABS 0160:1989 as basis for the revision, the general procedure for using Eurocode as the primary reference code consists of the selection of the appropriate specifications from Parts of Eurocode and to condense them in a single standard. This procedure can be summarised to consist of the following steps:

2.2.1 Scope and reliability

The present standard SABS 0160:1989 provides the basis for the scope of structures and levels of reliability to be used in the proposed SANS 10160. The revision is used to improve the consistency of reliability at the current level of reliability across the range of design situations.

2.2.2 Reference to Eurocode

The models from Eurocode Standards are adapted by the selection of appropriate options, provision for local conditions and calibrated to existing practice, whilst rectifying some identified deficiencies of the present SABS 0160-1989. The general Eurocode layout and format is used and adapted. Sufficient consistency with Eurocode is maintained to use the Eurocode procedures for situations outside the scope of the proposed SANS 10160.

2.2.3 Simplification

A concerted effort is made to fully utilise the limited scope of the proposed SANS 10160, the selection of appropriate alternatives, incorporating all normative provisions from the national annexes into the main body of the code and condensing the different Parts into a single standard format with limited procedures in order to achieve a significant simplification of SANS 10160.

3. REVISION OF SABS 0160-1989 AND THE IMPLICATIONS OF CHANGES

The proposed SANS 10160 consists of a Foreword, three introductory sections and ten normative sections. The Foreword and the sections as well as the implications of the proposed changes and additions are described briefly.

3.1 Foreword

The foreword to the proposed SANS 10160 provides an outline of the purpose of the standard, its function, general reference basis and the normative framework. The purpose of the foreword is to provide the context for the use and the future development of the standard. These features are summarized in Table 3.1.

Table 3.1 Foreword defining the context of the standard

Section	Basis for application of revision	Reference
Foreword	o **Motivation:** The revision of the standard is motivated. o **Function:** The extended function of the standard and the general basis for structural design is introduced. o **Reference base:** The use of SABS 0160:1989 and Eurocode as reference base is explained.	
Motivation for revision and the way in which it is implemented	o **Periodical major update:** Basis for structural design, actions, load models and application rules need to be revised periodically to incorporate development from research and practice. o **Use with existing materials standards:** The use of the proposed SANS 10160 with material design standards should improve reliability of structures through improved treatment of design situations and actions. o **Basis for revision of materials standards:** The basis for the future revision of the materials standards is supplied to improve the consistency between SANS 10160 and these standards. o **Harmonisation of design standards:** The standard should contribute to improved international harmonisation of structural design.	South African National Conference on Loading (1998)
General function of revised standard	o **General basis for structural design:** Material independent basis of design is specified to be applicable to structural design in general, and therefore also to all materials based design standards. o **Harmonisation of structural design:** A common basis for design should improve consistency between the materials standards as such.	EN 1990
Reference to Eurocode	o **Reference to Eurocode:** The reference to Eurocode as motivated and described in this paper is noted.	Eurocode Parts
Normative basis	o **Structural engineering practice:** The standard expresses consensus on sound engineering design practice for safe, functional and economic structures. o **Regulatory function:** Reference to this standard to fulfil regulatory requirements by regulatory authorities or building regulations. o **Normative status of specifications:** Different normative levels of specification apply for the clauses: • Requirements of principle "shall" be met without any alternative being allowed; • Procedures that are generally accepted to satisfy principle requirements "should" be followed, whilst allowing equivalent alternative procedures • Informative notes within the normative text provide background and explanatory information. • Informative Annexes provide more extensive information for consideration by the designer.	

3.1 Introductory sections

The introductory sections 1 to 3 define the scope of structures provided for, the normative references related to this standard, and the terms, definitions and symbols used in the various sections. The main features, considerations and reference on which these sections are based, are summarised in Table 3.2.

Table 3.2 Main features and reference base for introductory sections

Section	Basis for application of revision	Reference
1. Scope	The standard provides for the design of the following structures: o **Structures:** Buildings and industrial structures, excluding bunkers, silos, tanks, towers, chimneys, masts, bridges and earth retaining structures not related to buildings. o **Actions:** General actions on such structures, excluding actions due to fire, internal pressures, hydrodynamic and geotechnical effects not related to buildings.	SABS 0160:1989
2. Normative references	Normative references refer to o **Structural materials standards:** Design standards for structural concrete, steel, timber, masonry and glazing o **Complementary standards:** ISO and Eurocode standards provide a reference basis and can also be applied outside the scope of the proposed SANS 10160.	Various structural design standards
3. Terms, definitions and symbols	Listed together in this Section: o **General list per topic:** When terms, definitions and symbols used in more than one Section o **List per Section:** When terms, definitions and symbols used only in that Section.	Self referenced

3.2 Basis of design

The basis for the design of structures consists of the specification of a reliability framework within which partial factor based limit states design procedures are used to prove compliance with generally specified reliability requirements for structural performance. All these elements are present in the existing SABS 0160:1989. Consistency of reliability can however be improved by the extension of the specification of all these elements of the basis of structural design. The following three specifications for actions and general requirements were identified where there is a need for improvement:

- o Basis for seismic actions and design for earthquake resistance;
- o The need to include geotechnical actions on structures;
- o Reliability basis for structural resistance and guidelines to material standards.

The general features of the basis of structural design consisting of reliability levels in accordance with differentiated requirements and design situations for which partial factor based Limit States Design (pfLSD) methods are used to prove compliance, as applied in the proposed SANS 10160 are summarised in Table 3.3.

Table 3.3 General features of the revised basis for structural design

Section 4	Basis for application of revision	Reference Base
Basis of structural design	o **Compliance requirements:** This section defines the general requirements for structural reliability and the design rules to be followed to comply with these requirements: o **Reliability levels:** Improvement in the consistent achievement of the reference level of reliability is defined as an objective with the revision of the standard.	SABS 0160:1989 EN 1990

TABLE 3.3 (Continued)

	o **Reliability framework:** An elaborate reliability framework is defined in terms reliability management and differentiation, o **Partial factor based limit states design:** The pfLSD method is formally specified, consisting of design situations with appropriate action combination schemes, partial factors; specified basic variables; including guidelines for the reliability requirements of structural resistance.	
Level of reliability	**Level of reliability:** Maintain level of reliability to the equivalence of β_t = 3,0 for the reference case, without any systematic adjustment.	SABS 0160:1989
Reliability framework	**Consistent reliability framework:** A more elaborate partial factor based limit state design (pfLSD) framework improves consistency of reliability, whilst the overall general level is maintained: o Ultimate limit state design situations extended to provide for transient, persistent, accidental, seismic conditions. o Serviceability limit state differentiates between reversible and irreversible situations. o Explicit reliability definition of basic variables for various actions, material properties and geometry are provided. o Guidelines are provided for application of principles of reliability differentiation, management and calibration. o Specification of generic materials based resistance reliability requirements.	EN 1990 SABS 0160:1989

Extension of Limit State Design procedures to provide for the elaborate system of action combination schemes and partial factors results in the Eurocode design compliance procedures to be referred to a partial factor method (PFM). The terminology of partial factor based limit states design (pfLSD) for the procedure is used here to reflect the combined use of these two main features; continuity with the generally accepted terms of limit states design is maintained, whilst its extension into a more elaborate reliability framework is indicated. The elements of pfLSD as it is applied in the proposed SANS 10160 are summarised in Table 3.4.

Table 3.4 Elements of the partial factor based Limit States design procedure

Topic	Basis for application of revision	Reference
Action combination schemes	**Differentiated action combinations schemes:** Provide for an extended range of design situations o ULS: Structural; geotechnical; o Beyond ULS: Accidental; seismic. o SLS: Irreversible, reversible; quasi-permanent	EN 1990
ULS Structural action combination scheme	**Improved consistency of reliability:** Modification of twin expression for combination of permanent and variable actions: o Modification of format according to Eurocode; o Reliability levels according to current standard; o Modification of present partial factors; o Maintain use of point in time value for combined variable action.	EN 1990 SABS 0160:1989A
Partial action and combination factors	**Extended range of partial factors:** The range of partial action and combination factors are increased to provide for: o Improved reliability differentiation; o Extended range of design situations with associated combination schemes; o Extended range of actions provided for.	

TABLE 3.4 (Continued)

Geotechnical actions	**Combination scheme for geotechnical actions:** Introduce a combination scheme for treatment of geotechnical actions: o Geotechnical actions on structures; o Structural actions on foundations.	EN 1990 EN 1997-1
Serviceability limit state	o **Normative requirements:** Compliance to serviceability requirements are maintained; including the requirement that appropriate serviceability criteria should be applied. o **Serviceability criteria:** Although material independent serviceability criteria are provided informatively, the requirement to comply to these criteria is specified normatively, allowing justified deviations from these criteria.	SABS 0160:1989
Serviceability criteria	**Revision of deflection limits:** Deflection limits were revised to take account of formal introduction of serviceability design situations (irreversible, reversible, quasi-permanent); and updated: o Criteria tabulated as a function of design situation; deflection component and actions to be considered.	SABS 0160:1989

3.3 Self weight and imposed loads

The basis for the formulation of Section 5 of the proposed SANS 10160 and its main features are summarised in Table 3.5. The revision consists primarily of some changes to the informative list of densities for the calculation of self weight, and the revision of the specified values which are presented in an adapted Eurocode specification format.

Table 3.5 Basis for the revised specification of self weight and imposed loads

Section 5	Basis for application of revision	Reference
Self-weight and imposed loads	**General approach:** The general approach taken is to o **Present Standard:** Use the present standard for the values specified. o **Eurocode:** Use Eurocode as basis for the scope of imposed loads, the format and layout of the sections, the way in which the loads are specified. o **Modifications:** Modifications to improve the format and values where warranted.	EN 1991-1-1
Self weight	o **Representative value** Self weight as a permanent action with formalisation of the representative value determined from expected value of densities and nominal dimensions o **Densities** Informative tables of densities combined from Eurocode and present standard.	
Imposed loads	o **Format of specifications** Eurocode format of specified values simplified. o **Imposed floor loads** Modified classification and values: • Eurocode occupancy classes, modified; • Specified values thoroughly revised due to indications of systematically low values; • Combination values revised. o **Imposed roof loads** Values modified to differentiate between transient and persistent situations. o **Additional imposed loads** Provide for fork lifts; helicopter landings on buildings.	

3.4 Wind actions

The selection of an appropriate reference model for the revised specification of wind actions was an involved process during which alternative international wind action standards were considered. Finally the selection of EN 1991-1-3 *General actions – Wind actions* not only brought closure to the selection process, but also contributed to the validation of the selection of Eurocode as reference to the standard as a whole.

The reliability basis for wind action specification consists of the following:

- Application of the Eurocode wind action models to the South African wind climate is done on the basis that the reliability basis is not adjusted systematically;
- The more extensive sets of pressure coefficients from Eurocode are however considered to represent more advanced results from research, and applied as such, although coefficients are generally higher, particularly for local pressures.

The application of the Eurocode models for wind action to the South African wind climate and a degree of maintaining existing practice resulted an a major revision of the specification. A summary of the way in which the specification developed is provided in Table 3.6.

Table 3.6 Basis for the revised specification of wind actions

Section 6	Basis for application of revision	Reference
Wind actions	Due to the extensive nature of the specification of wind actions, separate papers are presented to describe the general wind engineering considerations taken into account; the way in which it is applied; comparisons of the implication of the concept wind action specifications with present practice.	EN 1991-1-3 SABS 0160:1989
Wind action model	**Eurocode Wind action model:** The Eurocode wind action models for a limited scope of structures are used as basis: o Models are specified for only a restricted scope of structures, where static equivalent actions can be applied; o For situations beyond this scope, particularly to provide for aero-elastic effects, Eurocode models could be applied, using South African wind climate specification as indicated below.	EN 1991-1-3
Wind climate	**Wind climate:** The presentation of the South African wind climate is maintained and modified to the Eurocode model: o The present South African 3 second gust free stream wind climate is converted to equivalent 10 minute average values of the Eurocode model; o The present terrain categories are modified to provide a more even distribution of conditions, by deleting category IV and inserting an interpolated category between II and III; o Procedures for determining shielding effects are included to provide for conditions covered by the present terrain category 4, which is omitted; o Exponential pressure profiles are maintained.	SABS 0160:1989

3.5 Thermal action

Provision for the effects of temperature changes and differentials allow for the proper treatment of thermal actions as indirect variable actions, providing for both climatic and operational thermal conditions.

The specifications provide for the determination of characteristic climatic extreme temperatures (maximum and minimum), including radiation effects, and the structural effects thereof, for use according to the design procedures of Section 4 of the revised standard.

- Climatic effects are based on information from TMH-7 (5);

- o Guidance on radiation effects is based on Eurocode procedures where there is a lack of specific information;
- o Treatment of the structural effects of temperature changes and differentials are based on Eurocode procedures.

The basis for the consideration of thermal actions for structures exposed to temperature changes are summarised in Table 3.7.

Table 3.7 Basis for the specification of thermal actions

Section 7	Basis for Specifications	Reference
Thermal actions	o **Basic requirements:** Thermal actions due to climatic and operational temperature changes which may cause thermal movement and/or stresses shall be considered; o **Classification:** Thermal actions treated as variable indirect; o **Representative temperatures:** Climatic and operational temperatures to be taken into account. • Characteristic values for temperatures are the 50 year return values (annual exceedance p = 0,02) - Shade air maximum and minimum taken from TMH-7; adjusted for other reference periods; - Adjusted for solar radiation effects; • Initial temperature T_0 is taken as the temperature at restraint. o **Representation of actions:** - Uniform temperature changes ΔT_u - Linearly varying across section ΔT_M - Between different parts ΔT_p o **Design situations:** Overstressing of the structure is treated through: - Provision of movement joints - Including effects of thermal strain in the design	EN 1991-1-4 TMH-7

3.6 Actions during execution

The introduction of transient design situations in Section 4 provides the basis for the specification of actions during the execution of the construction works, allowing for:

- o Actions on the partially completed works;
- o Transient manifestation of general variable actions with appropriate reference periods;
- o Actions due to the execution process; including temporary works;
- o Provision for the reconstruction or demolition of the works.

The main features of the provisions for actions during execution are summarised in Table 3.8

Table 3.8 Basis for specification of actions during execution of the construction works

Section 8	Basis for Specifications	Reference
Actions during execution	Provide for the occurrence of transient general and construction actions which apply to the partially completed structure during execution of the works: o **Design assumptions:** Compliance with assumptions on which the design is based; o **Basic requirements:** Sustain actions, maintain robustness and integrity: - Actions on partially completed structure; - Noting imperfections and boundary conditions; o **Duration:** The duration of the activity (<3 days – > 1 year) is related to a return period for the action (2 – 25 years) o **Classification:** Actions are classified in terms of: Variation in time, direct/indirect application, fixed/free distribution; static/dynamic nature;	EN 1991-1-6

TABLE 3.8 (Continued)

	o **Construction loads**: Provide for: • Handling; geotechnical; prestressing, pre-deformation; temperature, shrinkage & hydration • Personnel; storage of movable items; non-permanent equipment; moveable heavy machinery; accumulation of waste materials.	

3.7 Accidental actions

The identification of accidental design situations in Section 4 allows for the proper treatment of an array of conditions and actions which can not be fully provided for economically, but nevertheless requires consideration. The development of the basis for the treatment of accidental design situations is one of the prominent advances achieved by Eurocode, particularly when it is taken together with structural fire design as one of the specific cases of accidental situations. Specification for earthquake resistance and seismic actions is another specific type of accidental situation.

The logical basis for structural design to treat accidental design situations consists of the following:

- Accidental actions or design situations are considered to have only a small probability to occur within the economic life of the structure; structures can therefore not be designed to provide resistance to accidental situations economically.
- The basis for structural design is to ensure an acceptable level of risk, where the consequences of failure are traded for the low probability of occurrence of such an event.
- Practical design measures include accepting localised damage, but ensure that it will not endanger the overall load bearing capacity of the structure, at least for an appropriate period of time to allow for emergency measures, particularly evacuation; as well as provide sufficient robustness through redundancy, strengthening of key elements and provision of sufficient ductility to absorb strain energy.
- A general principle to follow is that the consequences of failure should not be disproportionate with its cause.

The most pertinent aspects of the provisions for accidental actions in the proposed SANS 10160, as derived from EN 1991-1-7, are summarised in Table 3.9.

Table 3.9 Basis for specification of accidental design situations and actions

Section 9	Basis for Specifications	Reference
Accidental actions	o **Adaptation:** The Eurocode Part was scaled down to provide only for building and similar structures, with the application of some rationalisation and simplification. o The scope of actions for which provision is made include the following: • **General strategies:** Treatment of accidental actions in accordance with Section 4 consist of accidental actions requiring consideration are identified through risk assessment, following measures to reduce its probability of occurrence and consequences to acceptable levels of risk. • **Consequences of localised failure :** treated as unidentified accidental actions and provision for sufficient robustness in agreement with consequence classification of the building is made • **Specific accidental actions:** - **Impact:** Actions from impact of vehicles, fork lift trucks, hard landing of helicopters on building roofs. - **Internal explosion:** Considering pressures from internal explosions from combustible materials, excluding explosives.	EN 1991-1-7

3.8 Actions induced by cranes and machinery

The specifications of SABS 0160:1989 for actions induced on the structure supporting overhead travelling cranes were evaluated and compared to international standards. The specifications were found to be very simplistic and in most cases conservative. The possibility of using Eurocode as the reference standard for the specification of actions induced by overhead travelling cranes was considered because it represented a recent standard which was derived from the highly rated standard DIN 15018:1984 Pt 1. This consideration also contributed ultimately to using Eurocode as the reference standard

The main characteristics of the specified load models, the reliability basis for the specified procedures and comparison to existing practice are summarised in Table 3.10.

Table 3.10 Revised specifications of actions induced by overhead travelling cranes

Section 10	Basis for application of revision	Reference
Actions induced by overhead travelling cranes	**General basis:** Eurocode load models and procedures were generally applied as the basis for the specifications, with the following adjustments: o **Load models:** The Eurocode load models are modified to improve the consistency of reliability, particularly with regard to horizontal action effects; • The present model for crane wheel – rail misalignment is retained; o **Fatigue actions:** Eurocode specifications for fatigue actions are not applied. o **Partial factors:** The use of the present partial factors is retained based on a reliability assessment.	EN 1991-3

Actions induced by overhead travelling cranes in the proposed SANS 10160 are described in detail by JS Dymond [(6)].

The specifications for the induced harmonic dynamic effects applied to structures supporting stationary rotating machines, as presented in Section 10.4 of the proposed SANS 10160, are summarised in Table 3.11.

Table 3.11 Basis for specification of actions induced by stationary rotating machines

Section 11	Basis for Specification	Reference
Actions induced by machinery	Actions from machinery are classified as permanent, variable static and variable dynamic, and accidental actions which are represented by various models. o **Permanent actions** during service include the self-weight of all fixed and moveable parts and static actions from service o **Variable static actions** during service include the actions from service and imposed loads o **Variable dynamic actions** from machinery during normal service are dynamic actions caused by accelerated masses o **Accidental actions** may occur from accidental magnification of the eccentricity of masses, short circuit or mis-synchronisation between generators and machines or impact effects from pipes by shutting down.	EN 1991-3

3.9 Seismic actions

The specification of structural design requirements to provide resistance against earthquakes is one of the sections of SABS 0160:1989 which needs the most attention. The specifications only apply to small parts of the country and are generally considered to be too severe by practitioners.

The difficulty of separating seismic actions and resistance against earthquakes is also recognised by Eurocode, where a separate Standard EN 1998 *Design provisions for earthquake resistance of structures* is concerned with this topic, of which the Part EN 1998-1 *General rules, seismic actions and rules for buildings* applies to the revision of section 11 of the proposed SANS 10160.

Seismic actions in the proposed SANS 10160 are described in detail by J Wium [7].

3.10 Geotechnical actions

A new section on geotechnical actions on buildings and industrial structures based on EN 1997-1 : *General rules : Geotechnical design* is introduced to provide for actions on these structures caused by vertical earth loading, earth pressure and water pressure . The partial load factors and load combination scheme for these geotechnical actions will be developed within the reliability framework of the proposed SANS 10160.

The most appropriate design approach for South African conditions and design practice of the three approaches provided for in EN 1997-1 : *General rules : Geotechnical design* has been selected. The provisions for geotechnical actions in the proposed SANS 10160 will be based on design approach 1 from EN 1997-1.

3.11 Design assisted by testing

A brief normative section is provided to allow for design assisted by testing, and specifying the requirements. An informative annex provides guidance on the planning of the testing program, including the derivation of representative and/or design values; and specifying the statistical procedures to be used for this purpose. Since testing is a vital source of information for the determination of representative or design parameters, its specification is required to ensure proper levels of reliability. The main features of the requirements and guidelines of the accompanying annex are summarised in Table 3.13.

Table 3.13 Requirements and guidelines for the application of testing in structural design

Section 13	Basis for application of revision	Reference
Design assisted by testing	o **Basis for testing:** The scope and format of EN 1990 are used for the specification, all provisions of the SABS 0160:1989 are included. o **Requirements:** Determination of representative or design values based on testing is allowed, provided that the level of reliability for the design situation should be achieved. • Statistical uncertainty, including those as the result of a limit number of tests, should be taken into account; • Appropriate partial factors should be applied. • Planning, execution and assessment of the results should be carried out with the required competence	EN1990 Annex D SABS 0160:1989
Guidance on testing	o **Planning:** Provision should be made for a test plan to define the objectives of the testing, prediction of the results; specification of test specimens and sampling; loading; measurement; reporting. o **Design values:** Characteristic values could be derived to be used with partial factors, or design values with appropriate reliability could be determined directly. o **Statistical evaluation:** Guidelines are provided for statistical treatment of results, with reference to the more extensive procedures of EN 1990 and ISO 12491.	

4. CONCLUSION

Although the scope of structures provided for and the general level of reliability of the current SABS 0160:1989 is maintained in the proposed SANS 10160, the provisions for the basis of design, actions, load models and procedures are substantially revised, updated and extended.

The revision benefited substantially from the extensive development of the Eurocode Standards. Whilst maintaining sufficient compatibility with Eurocode to be able to use it for situations beyond the scope of SANS 10160, the local standard is simplified substantially in comparison to its reference.

The extended reliability framework and range of design situations are resulting in an improved consistency of reliability and are allowing for reliability differentiation as well as an additional limit state for accidental design situations.

The substantially extended information on wind pressure coefficient determination is providing a more realistic representation of a wide range of structural configurations. The introduction of the section on actions during execution meets the need for urgent attention to this important part of structural design, as clearly demonstrated by a number of recent failures during construction. The most important aspect of the section on accidental actions is the focus which is placed on improving the structural robustness and integrity in the case of accidental actions with an unidentified cause. The section on thermal loading puts this aspect of structural design influenced by environmental climatic conditions into perspective. The crane load models, as included in the proposed SANS 10160 Section 10, are based on the mechanics of the movement of the crane resulting in more realistic actions induced by the crane at generally lower levels of effects on the supporting structure as compared to the provisions in SABS 0160:1989. The section on the actions induced by stationary machinery is limited to rotating machines which induce harmonic dynamic effects in one or more planes. The section on seismic actions addresses not only the actions caused by eathquakes and mining induced seismicity but also gives guidelines for effective design of buildings against seismic actions. The provision for geotechnical actions in terms of limit states on structures closes an important gap in the design procedures for buildings and industrial structures.

The draft Standard therefore represents a significant advancement and improvement in structural design practice. It incorporates improved and extended specifications for structural design requirements and actions, which are calibrated to present South African practice, and extensively assessed within the limits of available resources.

The proposed SANS 10160 also provides a platform for the possible future alignment of structural steel and composite design to Eurocode, the introduction of extensive structural fire design and other standardised procedures.

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