Towards a minimum standard for structural engineering work

Ron Watermeyer (F), Joint Structural Division of SAICE and IStructE, outlines the content of a generic standard for use where no registration system exists.

Introduction
There are statutory requirements in many jurisdictions for the structural safety of buildings. These in the main relate to the design and the confirmation of design intent during the construction of buildings. Statutes are commonly framed around the construction of buildings either from a building control or an occupational health and safety perspective.

There is a need to establish minimum standards for individuals who assume responsibility for performing statutory duties relating to the structural performance of structures, particularly in developing countries.

The proposed generic standard, which is set out below, establishes requirements for certifying the adequacy of a structural system or part thereof of an existing or proposed structure, the assumption of overall responsibility for the rational design, rational assessment or inspection (or any combination thereof) of a structure and the independent review of the structural performance of a structure. It is designed to be referenced by regulators and clients alike when assigning specific duties to those who are entrusted with ensuring the structural performance of a structure. It can form the basis of the client’s brief for structural engineering related services.

It also establishes the peer recognised competencies of a structural engineer, based on an analysis of the Institution of Structural Engineer’s membership examination. Passing the membership examination is accordingly one way of demonstrating competence.

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This standard establishes minimum requirements and is particularly suited for application in jurisdictions which do not have in place a registration system for structural engineers and rely on ‘competent persons’ to assume responsibility for the structural safety of buildings in terms of legislation. For example, the registration system in South Africa only recognises the civil engineering discipline and makes no provision for recognising the structural capabilities of those on its register, while up until very recently, the National Building Regulations required a ‘Professional Engineer or other approved competent person’ to assume responsibility for the structural safety of buildings where deemed to satisfy rules were not applied or were inappropriate.

The standard facilitates the establishing of specialist lists or a licensing scheme which can be linked to local registration requirements. For example the definition for a structural engineer can be linked to local registration (see listing of structural engineers on the website: www.jsd.co.za).

Comments on the proposed standards should be emailed to: watermeyer@saice.co.za.
The purpose of the study group scheme is to create opportunities for members of the Institution to exchange ideas and work on deepening and developing their knowledge of structural engineering, thus stimulating a greater interest in and promoting the art and science of structural engineering.

Members who require further information about a Study Group should contact the appropriate Convener. Membership databases are held either by the convener or by Sarah Okoye at the Institution, International Headquarters, 11 Upper Belgrave St., London SW1X 8PH. Tel: 020-7234-4550, Fax: 020-7235-4294. Email: sarah.okoye@istructe.org. Members wishing to register their membership of a Study Group should contact either the convener or Sarah Okoye as indicated below.

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Register membership with convenor.
1. Communicate the environment within which structural engineering is practiced
2. Produce viable structural solutions, within the scope of a design brief, taking account of structural stability, durability, aesthetics and cost
3. Determine and document the form and size of principal structural elements from a proposed structure
4. Specify and coordinate the use of primary structural materials
5. Communicate construction techniques and sequencing for structural engineering works

Table 1: Outcomes and assessment criteria

<table>
<thead>
<tr>
<th>Number</th>
<th>Description</th>
<th>Assessment criteria</th>
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<tbody>
<tr>
<td>1</td>
<td>Communicate the environment within which structural engineering is practiced</td>
<td>1. Professional bodies associated with structural engineering are described 2. Codes of practice regulating structural engineering are described 3. Legislation governing structures is described 4. Procurement arrangements for structural engineering works are identified</td>
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<td>2</td>
<td>Produce viable structural solutions, within the scope of a design brief, taking account of structural stability, durability, aesthetics and cost</td>
<td>1. A brief is appraised in accordance with structural engineering principles and concepts 2. Appropriate structural engineering solutions are identified 3. Two different structural designs are developed from a brief and are communicated 4. The implications of changes to design briefs are identified and communicated</td>
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<tr>
<td>3</td>
<td>Determine and document the form and size of principal structural elements from a proposed structure</td>
<td>1. Structural engineering problems are solved using a variety of suitable methods of analysis 2. Structures are appraised for overall stability, resistance to progressive collapse, fire and performance of a structure as a whole 3. Compliance with all relevant criteria for the design of primary structural materials (concrete, steel, masonry, timber) is demonstrated by calculation with all assumptions stated 4. General arrangement plans, sections and elevations are prepared for estimating purposes 5. Connection details associated with a given structure are described</td>
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<tr>
<td>4</td>
<td>Specify and coordinate the use of primary structural materials</td>
<td>1. Properties and behaviour of primary construction materials (concrete, steel, masonry, timber) are defined 2. Testing procedures are defined 3. Storage and handling procedures are described 4. Construction standards are described</td>
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<tr>
<td>5</td>
<td>Communicate construction techniques and sequencing for structural engineering works</td>
<td>1. Basic construction techniques and equipment are identified 2. Constructive programmes and construction sequencing are described 3. Site activities and safe working methods pertaining to structures are communicated</td>
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the environment in which they are located over their design working life when subject to their intended use in terms of one or more of the following:

i) external and internal environmental agents;
ii) maintenance schedule and specified component design life;
iii) changes in form or properties.

Structural safety performance – the ability of the whole structure and its parts, with an appropriate degree of reliability, to maintain their strength and stability under all actions likely to occur during its construction and design working life.

Structural serviceability performance – the ability of the whole structure and its parts, with an appropriate degree of reliability, to perform within established parameters under all expected actions for normal use in terms of local damage, deformation and vibration.

Structural system – a system of constructional elements and components of a structure which is provided to resist the loads acting upon it and to transfer such loads to the ground upon which such structure is founded.

Suitable – capable of fulfilling or having fulfilled the intended function or fit for its intended purpose.

Water retaining structure – means a structure which stores fluids including swimming pools, other than a barrier constructed to retain water in order to raise its level or reduce or prevent flooding.

Requirements

General requirements

Any person may, subject to the provisions of the section on ethics below, perform activities associated with structural engineering provided that their education, training and experience have rendered them competent to perform such activities.

Only structural engineers may:

– certify the adequacy of a structural system or part thereof of an existing or proposed structure in terms of any statutes or in response to a client or employer’s request to do so;
– assume overall responsibility for the rational design, rational assessment or inspection (or any combination thereof) of a; building, bridge, reinforced concrete cast in situ culvert, water retaining structure that retains more than 250 000 litres of fluid, silo, or tower or mast having a height exceeding 3m.
– perform rational assessments;
– independently review the structural performance of a structure.

Ethics

Structural engineers shall:

– take reasonable care to ensure the quality and safety of all structural engineering works entrusted to them and adopt a balanced, disciplined and comprehensive approach to problem solving;
– observe all applicable legislation and statutes;
– not include anything in the design of the structure necessitating the use of dangerous or hazardous materials or materials hazardous to the health and safety of persons, which could be avoided by modifying the design or by substituting materials;
– take into account the hazards relating to any subsequent maintenance of the relevant structure and make provision in the design for that work to be performed in a manner that minimises the associated risk;
– recognise that the lives and safety of the people are dependent upon engineering judgments, decisions and practices incorporated into structures;
– not accept anything in cash or in kind which prejudices independent and impartial judgment and declare to their clients or employers any interest which may influence professional judgment;
– not misrepresent their areas or levels of experience and responsibility;
– not agree to or comply with any instructions requiring dishonest action or the disregard of established norms of safety or levels of risk in design and construction;
– independently review the structural performance of a structure.
– take reasonable steps to minimise the risk of the loss of life, injury or suffering which may result from their work or the effects of their work and point out the level and significance of risk associated with their work to those affected;
– ensure, where their structural engineering judgment is ignored or rejected, that their clients or employers are informed of the possible consequences;
– report to the appropriate organisation or authority any situation of which they became aware where a structure or structural system places the safety of the public at risk.

Practice
Structural engineers shall take all reasonable steps to:
– understand and define the brief with the client;
– ensure that the client understands the scope and limitations of the service to be provided and not allow the urgency of the work to override the need for written classification of the brief;
– provide services with the skill and care normally used by professionals providing similar services.

They shall also:
– accept personal responsibility for their work and work performed under their supervision or direction;
– take reasonable steps to ensure that anyone working under their authority is both competent to carry out the assigned tasks and likewise accepts personal responsibility for their work;
– review all structural design concepts to determine that the structural concepts are complete, consistent and in general compliance with any relevant and appropriate or applicable national or international standards;
– ensure that the assumptions made and the level of reliability of rational designs or rational assessments are such that a peer review of the structural system or part thereof would arrive at a similar conclusion;
– ensure that the basic assumptions made in the software used in the analysis and design of structures or parts thereof (such as adequate lateral restraints) are actually fulfilled in reality;
– check their work either using another method or by engaging another structural engineer to do so;
– ensure that the record drawings of the structures for which they have assumed responsibility and sign thereof for which they have assumed responsibility and sign;
– parameter settings and selections including member sizes, the dimensions of members and layouts are consistent with software is based;
– the applied actions are correctly determined and modelled;
– the software is used within the limitations stated by the software supplier that has in place a quality assurance program and has evidence of software validation that substantiates the veracity of the outputs.

Use of structural engineering software
Structural engineers shall only use structural engineering software in the analysis and design of structures or parts thereof that have been independently validated or have been obtained from a software supplier that has in place a quality assurance program and has evidence of software validation that substantiates the veracity of the outputs.

Structural engineers in making use of structural engineering software in the analysis and design of structures, shall ensure that:
– the software is used within the limitations stated by the software developer and the modelling techniques upon which the software is based;
– the applied actions are correctly determined and modelled;
– the dimensions of members and layouts are consistent with the construction drawings;
– parameter settings and selections including member sizes, member properties, connections between members, supports and restraints, appropriately and reliably model the behaviour and expected performance of the structure, the member sizes, properties and connections between members; and
– account is taken of any construction actions, construction techniques or sequences in construction in the modelling of the structure.

Structural engineers shall conduct an independent check of the output of software programs to determine that the structure as modelled is in equilibrium.