The Use of Performance Based Building Codes to Attain Sustainable Housing Objectives: The South African Approach

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THE USE OF PERFORMANCE BASED BUILDING CODES TO ATTAIN SUSTAINABLE HOUSING OBJECTIVES: THE SOUTH AFRICAN APPROACH

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Abstract

Any definition for sustainable housing must reflect emerging societal expectations captured in Agenda 21 (1992), the Habitat Agenda (1996), the Millennium Declaration (2000) and the outcomes of the World Summit (2002). A performance description for sustainable housing should accordingly be framed around the provision of adequate and affordable shelter, the avoidance of harmful effects on the environment, the conservation of natural resources and poverty relief.

This paper develops a performance description for sustainable housing and identifies which aspects of the performance descriptions can be regulated in terms of performance-based building regulations. Based on recent work done in the reinterpretation of South Africa's National Building Regulations in SANS 10400, the Application of the National Building Regulations, it suggests how performance parameters relating to fire safety, sanitation system, moisture penetration and structural safety, serviceability and durability can be established to reflect societal expectations in a developing country, in a manner which supports sustainable development objectives. The paper also outlines the performance based approach which has recently been adopted by the National Department of Housing to address the conservation of fuel and power by addressing thermal comfort and suggests how the conservation of natural resources and the provision of employment could be addressed though performance based standards linked to government mass housing projects.

The paper concludes by examining how the lessons learned and proposal in the application of performance based standards in the housing sector can be extended to other forms of buildings.

Introduction

The housing sector in South Africa accounts for more than 25% of the annual expenditure on construction and is responsible for just under 25% of the total energy demand. It also represents the fastest growing portion of the electricity load in South Africa (Soderlund and Schutte, 2003). Although housing represents one class of building occupancy, it is the occupancy class that people are very familiar with and the one that can most readily be identified with. The regulation of housing can as such have a significant impact on the promotion and attainment of societal goals.

The provision of adequate shelter for the world's ever increasing population enjoys a high priority in the agenda of most governments, particularly those in developing countries. Investing in shelter creates jobs, improves productivity and raises incomes. Increased shelter development activities trigger additional investments in building materials production, transport and marketing. These in turn generate demand in other sectors. Any investment in housing or infrastructure can thus have a multiplier effect that extends beyond the housing sector.

South Africa's housing stock, as shown in Table 1, contains large numbers of housing types that are encountered in both developed and developing countries. Accordingly the approach taken in recent years in South Africa to address sustainable development issues can have applications in both developed and developing countries.

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Table 1: Housing stock in South Africa (Census 1996)

Description	Number (millions)	%
House or brick structure on a separate stand or yard	4.33	48
Traditional dwelling/ hut/ structure made of traditional materials	1.64	18
Flat in a block of flats; town/ cluster/ semi-detached house (simplex, duplex or triplex); unit-in retirement village; house/ flat/ room, in backyard	1.36	15
Informal dwelling/ shack, in backyard or in informal settlement	1.45	16
Other including unspecified dwellings and room/ flatlet not in backyard but on a shared property	0.28	3
Total	9.06	100

This paper develops performance descriptions for sustainable housing which reflect societal goals for sustainable development embodied in Agenda 21 (1992), the Habitat Agenda (1996), the Millennium Declaration (2000) and the outcomes of the World Summit (2002). It identifies which aspects of these performance descriptions can be used to regulate housing units in terms of performance-based building regulations and suggest how societal objectives can be accommodated at a local level by establishing different levels of performance in different market sectors. It reviews the work done in South Africa in developing performance based housing standards and how this work has impacted on the reinterpretation of functional building regulations. The paper concludes by examining how the lessons learned and proposal in the application of performance based standards in the housing sector can be extended to regulation of other forms of buildings.

Sustainable Housing

The Global Agenda for Sustainable Human Settlements

Agenda 21 of the United Nations Conference on Environment and Development (UNCED) which took place in Rio de Janeiro, Brazil in 1992, identified a number of programme areas for promoting sustainable human settlement development, including "*providing adequate shelter for all* and *promoting sustainable construction industry activities*." This agenda recognizes with respect to these latter two program areas that:

a) access to safe and healthy shelter is essential to a person's physical, psychological, social and economic well-being and should be a fundamental part of national and international action; and
b) activities of the construction sector are vital to the achievement of the national socio-economic development goals of providing shelter, infrastructure and employment.

The Habitat II conference in Istanbul in 1996 led to the establishment of the Habitat Agenda. This agenda links locally available, appropriate, affordable, safe, efficient and environmentally sound construction methods and technologies that emphasize optimal use of local human resources to the concept of "sustainable construction". The United Nations' Millennium Declaration (2000) resolved to make every effort "*to embark on the required reduction in emissions of greenhouse gases*."

The United Nations, ten years after the Rio de Janeiro Earth Summit, held a World Summit on Sustainable Development in Johannesburg. The Johannesburg World Summit (2002) brought about a clearer understanding of the relationship between poverty and environmental protection and builds upon many of the resolutions made in the Millennium Declaration. This is reflected in the opening paragraphs of both the statement of the Key Outcomes and Key Commitments, Targets and Timetables from the Johannesburg Plan of Implementation. The fundamental global action associated with the international agenda for sustainable development, in which there are important linkages between poverty, the environment and the use of natural resources, is to fight poverty and to protect the environment. The basic

poverty eradication target is, by the year 2015, to halve the proportion of the world's people whose income is less than US $1 a day and the proportion of people who suffer from hunger.

One of the targets set for poverty eradication seeks to achieve a significant improvement in the lives of at least 100 million slum dwellers by 2020. The proposed actions associated with this target include:

a) improved access to adequate shelter and to basic services for the poor; and
b) the use of low-cost and sustainable materials and appropriate technologies for the construction of adequate and secure housing for the poor, taking into account their culture, climate, specific social conditions and vulnerability to natural disasters.

Performance description for sustainable housing

A performance description, in a sustainable housing context, may be regarded as a statement which provides a qualitative description of the attributes of a housing development. In line with the aforementioned agenda for human settlements, an appropriate performance description for sustainable housing is housing that (Watermeyer, 2003a):

a) "provides adequate shelter whilst satisfying fundamental human needs relating to health, safety and the well being of residents;
b) is affordable to access, maintain and live in;
c) minimises the harmful effects of housing developments on the local environment;
d) conserves and manages resources including energy and water, in its design, construction, maintenance and functioning; and
e) provides significant employment opportunities in its construction, alteration or refurbishment."

Sustainability considerations in the design, construction and deconstruction of housing units

The performance description for sustainable housing is applicable to all aspects of housing developments, viz planning, servicing and the housing unit itself. The following, however, should be considered in the design, construction, alteration and refurbishment of housing units (Watermeyer, 2003a):

a) adequacy in terms of accessibility; affordability throughout the life cycle; health and safety; thermal comfort; and vulnerability to national disasters;
b) employment potential, including their potential for poverty relief and employment;
c) energy efficiency, i.e. cooking, heating, cooling and hot water consumption energy;
d) the biodegradability and non-noxiousness of demolition waste, embodied energy, recyclability, and renewability of construction materials;
e) sanitation options; and
f) water use and savings in terms of appliances and fittings and site and design interventions such as permaculture, rain water harvesting etc.

Choices made in the structure of a housing unit (roof assembly, walls and floor) and the selection of the sanitation system have a significant impact on the degree to which housing units embrace sustainability criteria.

Recent Development in Performance Based Standards for Housing Units in South Africa

The Joint Structural Division's Code of practice

The Joint Structural Division of the SAICE and IStructE (JSD) recognised in 1999 that:

a) poor households have limited means at their disposal to access housing which provides adequate protection against the elements;
b) the South African regulatory environment was not conducive to the promotion and evaluation of indigenous forms of construction; and
c) the interpretation of the South African National Building Regulations were framed around "first" world parameters viz. low maintenance, no penetration of water into interiors, deflections which are not discernible, negligible levels of cracking, etc, i.e. around the parameters embodied in international / national codes of practice found in developed countries.

The JSD concluded that, housing units fell into one of two categories viz:

a) formal structures which are constructed in accordance with National Building Regulations; and
b) informal structures for which no standards apply or were applied.

The JSD found this situation from a health and safety point of view to be unacceptable, but realized that if different user performance levels (i.e. the technical performance criteria applicable for an intended use selected by the user) were defined, it could be possible to regulate the construction of housing units which have comparable safety standards, but have different resistances to rain penetration, behavior in fire, deflections and deviations from the horizontal and vertical, expected damage in walls and floors, maintenance cycles, and resistance to local damage/soft body impact. End users could then choose the housing solution which is within their means without compromising safety and basic health requirements. This approach would then:

a) enable poor households which have limited means at their disposal to access housing which provides adequate protection against the elements;
b) allow poorer households that access housing at a level commensurate with the means at their disposal at the time to improve their circumstances with whatever means comes to their disposal;
c) accommodate indigenous forms of construction; and
d) enable the entire South African housing stock, save for informal shacks, to be regulated.

The JSD developed a code of practice for the assessment of housing units in South Africa (JSD, 2000) which provided two user performance levels, the basic characteristics of which are as set out in Table 2. The JSD code also established technical requirements for both user performance levels and methods for establishing compliance with requirements. The fundamental differences between these two user performance levels are highlighted in Table 3.

Table 2: User performance levels adopted by the Joint Structural Division (2000)

User performance level	Basic characteristics
1	Focus is on producing basic shelter at the lowest possible initial cost recognising that shorter maintenance cycles than that contemplated in user performance level 2 may be required. Mortgage lending finance is not involved; short term loan finance may be involved*. Limited rain penetration through walls and roofs permitted in abnormal storms.
2	Focus is on producing a durable housing unit which requires infrequent maintenance. Mortgage lending finance is usually involved.

* Housing units may be constructed in terms of self help / sweat equity schemes.

Table 3: Principal differences between the two user performance levels (JSD, 2000)

Consideration	Differences between user performance levels
Characteristics of the house	User Performance Level 1 housing units will, in general, have no basements, be of single detached storey constructions, have a floor area of less than 80 m², have a maximum length between intersecting walls or members providing lateral support of 6,0m, have external doors located in such a way that an occupant does not have to move through more than one room to reach an external door in the event of a fire and boundary distance requirements to prevent the spread of fire.
Resistance to rain penetration	Limited dampness in walls or leakage at joints between components is tolerated in User Performance Level 1 housing in exceptionally severe weather conditions. Resistance to rising damp is identical in both levels
Distress in walls arising from foundation movements in walls and floors	Distress in both User Performance Levels is limited to minor damage i.e. aesthetic damage which can be readily repaired or masked during the course of normal redecoration. The severity and occurrence of minor damage in User Performance Level 1 housing units located on sites underlain by heaving clay founding horizons is, however, greater than that for User Performance Level 2 on such sites.
Deflection of members	Deflections in the case of User Performance Level 1 housing units are greater than those in User Performance Level 2 housing units and may be noticeable to a trained eye.
Resistance to local damage due to hail stones and when struck by blunt and sharp objects	User Performance Level 1 housing units have an ability to withstand local damage but not to the same extent as is the case for User Performance Level 2.
Frequency of maintenance cycles	Maintenance cycles may be more frequent in respect of User Performance Level 1.
Thermal performance	User Performance Level 1 housing is not required to have a performance which avoids condensation in the Southern Cape Condensation Problem Area but must be able to be upgraded without rebuilding the structure by means of insulation of walls, installation of ceilings, etc.
Fire safety	No distinction is made in respect of essential fire safety requirements. However the limitations in size and layout of Level 1 houses is such that occupants can readily escape to safety in the event of a fire and hence the need for fire rated external and internal walls falls away. Prevention of fire spread to adjoining properties is achieved by stipulating appropriate boundary distances in the same way as is done for Level 2 houses.

Approach adopted by the National Department of Housing

The South African Government operates a National Housing Subsidy Scheme aimed at the provision of houses to the poor. Most of the housing is developed in terms of the Project Linked Subsidy Programme (Greenfield developments) and are fully funded by government. A little over US$ 3 000 is allocated to service a site and to construct a house on that site for a beneficiary of the scheme.

The National Department of Housing commissioned the development of a generic specification for the design and construction of housing (GFSH-11, 2003) when revising its procurement arrangements. This generic specification built upon the work of the Joint Structural Division, Agrément South Africa and the International Standards Organisation's TC 59 / SC15 working group in the development of ISO 15928 (House - Description of performance).

The structure adopted in GSFH-11 is illustrated in Figure 1. User needs and performance descriptions were provided in respect of a number of housing attributes, examples of which are reproduced in Table 4. Performance parameters were framed around two user performance levels. A number of standard tests in respect of rain penetration, structural safety, serviceability and durability, sanitation and roof waterproofing were provided to enable performance to be evaluated.

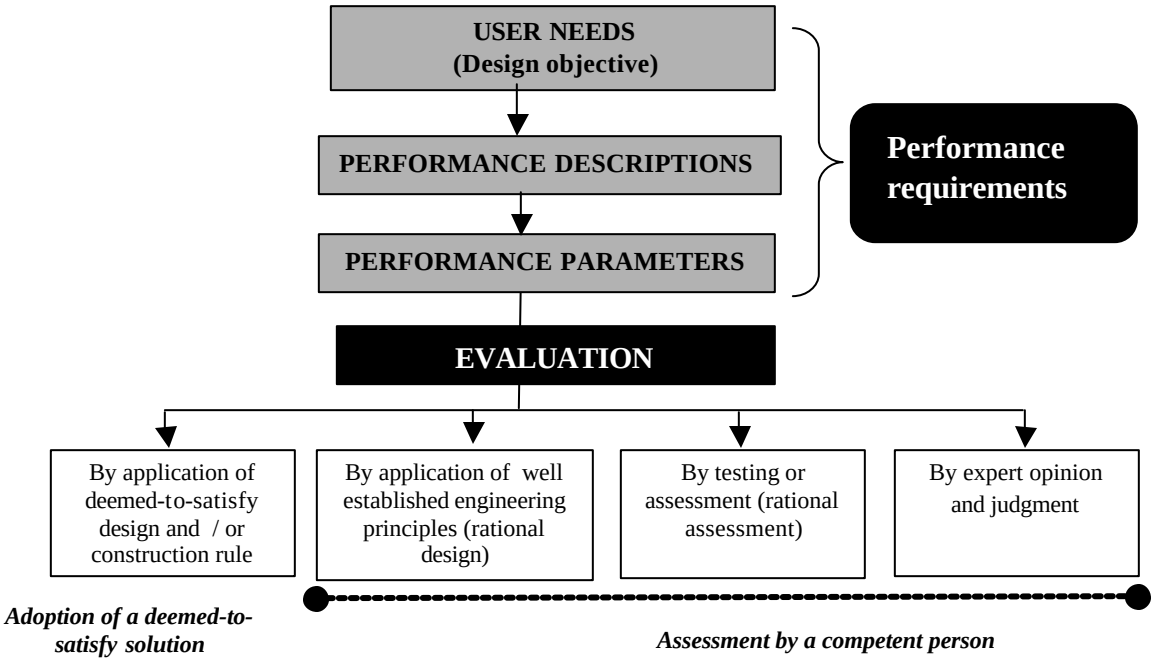

Figure 1: The performance based approach to the procurement of houses

Table 4: User needs and performance descriptions in respect of structural safety, serviceability and durability and sanitation.

User need	Performance description
Structural safety	
The risk of collapse or other kind of severe damage resulting from structural failure, which may affect the life safety of the occupants in the house or people in the vicinity of the building, shall not exceed a nominated user performance level.	The whole house and its parts shall, with an appropriate degree of reliability, have the capacity to maintain their resistance and equilibrium under all actions likely to occur during its design working life.
Structural serviceability	
The following characteristics of a house, for normal use and condition, under all expected actions, should be kept within nominated user performance levels: the functioning and appearance of the house and its components; the functioning of the occupants	The whole house and its parts shall, with an appropriate degree of reliability, have the ability to respond within established parameters, under all expected actions for normal use in terms of: a) local damage (including cracking) (which may affect the efficiency and appearance of the house and its components); b) deformation (which may affect the efficient use or appearance of the house or the functioning of the people and equipments); and c) vibration (which may cause discomfort or affect the activity of

and the equipment in the house; the comfort of the occupants, and (d) the asset value of the house.	occupants or the functioning of equipments).
Structural durability	
Changes in sectional form or mechanical properties of the construction materials over time shall not compromise the structural safety and serviceability performance of a house and its parts over their design working lives when preventative maintenance is carried out at intervals acceptable to the user.	The whole house and its parts shall, with an appropriate degree of reliability and subject to adequate periodic maintenance being effected, have the ability to fulfill its intended safety and serviceability performance in the environment in which they are located for their design working lives
Sanitation system	
The sanitation system shall be sustainable, dispose of pathogens, pollutants and contaminants in a manner that does not compromise the health and safety of the users or others and be acceptable to the community.	Sanitation systems shall with an appropriate degree of reliability over the lifetime of the structure: a) provide for privacy and protect the user and others from the weather when in use; b) prevent soil, garbage and other foreign materials from entering into the system by the action of rain, wind or animals; c) not present or cause a nuisance or a danger to health as a result of their use and operation; d) withstand all the actions to which they are likely to be subjected to; e) not leak soil water into the surrounding soil, if buried; f) be compatible with the water supply; g) be capable, where required, of carrying the design hydraulic load and drain and discharge into a municipal sewer system, a common drain or other sewage disposal system, or dispose of effluent in a safe and inoffensive manner; h) not contaminate clean water supplies or ground water unacceptably; i) be easy to use, clean and maintain; j) be able to accommodate and dispose of commonly used cleaning materials; and k) satisfy nominated parameters, depending upon the nature of the system. Sanitary fixtures shall comprise of impermeable, non-corrosive material, and have a smooth and readily cleanable surface that is free from ledges or protrusion that can be easily soiled.

South Africa's National Building Regulations

Overview

South Africa's National Building Regulations (NBR) (1990), which is based on the Nordic Model (see Figure 2), are generally functional in nature but contain some prescriptive provisions. The National Building Regulations and Building Standards Act (Act 107 of 1977) permits the Minister of Trade and Industries to make regulations regarding administrative procedures and the general health, safety and convenience of the public and occupiers of buildings. The Act does not permit the Minister to issue regulations regarding energy efficiency.

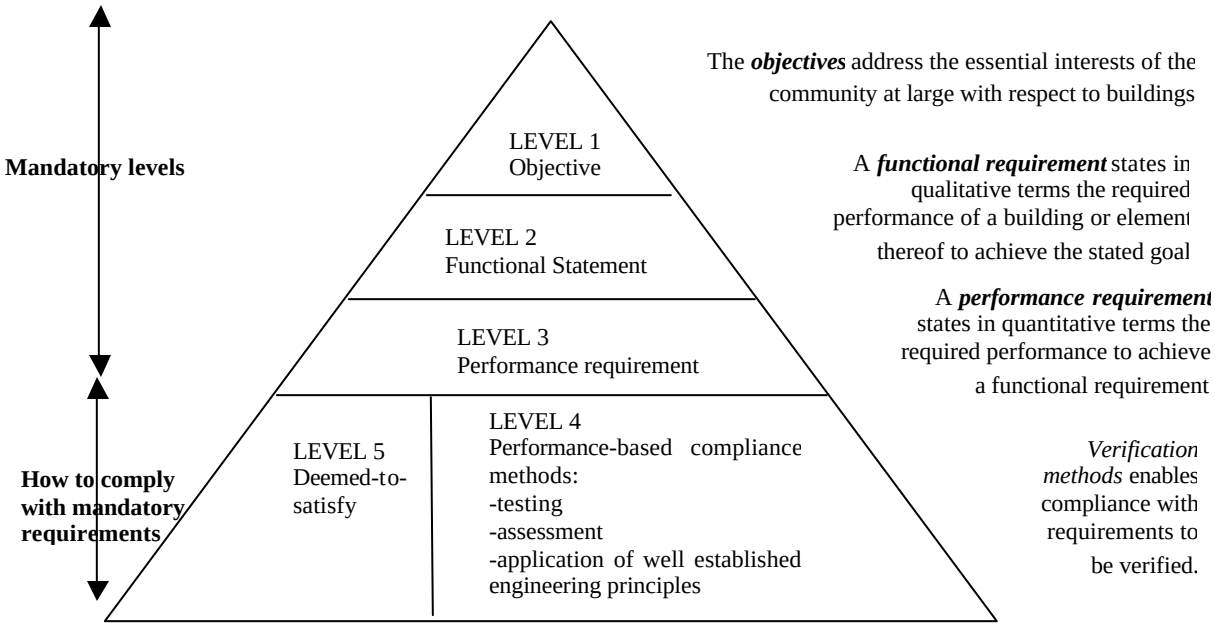

Figure 2: Nordic five level structure for performance-based codes

The NBR have been issued to regulate administrative procedures, structural design, dimensions, demolition work, public safety, site operations, excavations, foundations, floors, walls, roofs, stairways, glazing, lighting and ventilation, drainage, non-waterborne means of sanitation, stormwater disposal, facilities for disabled persons, fire protection, space heating refuse collection and fire installations. Accordingly, broad societal expectations are captured in the Act (level 1) and functional requirements are captured in the NBR (level 2).

The functional NBR are deemed-to-be-satisfied through compliance with the requirements of a South African national standard, SANS 10400:1990, the Application of the National Building Regulations. SANS 10400:1990 provides a set of deemed-to-satisfy rules to interpret functional regulations (Level 5). The rules for structural design are framed around rational designs undertaken by registered engineers in accordance with the provisions of national structural design codes for loadings, concrete, masonry, timber, steel and glazing. (Level 4). The deemed-to-satisfy rules for foundations, floors, walls and roofs are in effect prescriptive requirements for simple buildings including housing units which have concrete floors, masonry walls and timber roofing structures. There are no deemed-to-satisfy rules for traditional dwellings, the tacit assumption being that they satisfy functional requirements.

Provision is made in the regulations for local authorities, who are responsible for the enforcement of the regulations, to require a test report or evaluation certificate issued by the South African Bureau of Standards, the Council for Scientific and Industrial Research or the Agrément Board of South Africa where they are not satisfied as to the adequacy or safety in use of any construction system, method, material, article or product which is proposed to be used in the erection of any building (Level 4).

Performance requirements (Level 3) are generally lacking or understated in the regulatory framework. At the same time, a single performance level is stated or implied.

Revised Interpretation

The revised interpretation of the National Building Regulations embodied in SANS 10400:2004, which are informed by the JSD Code and the GFSH-11 generic specification, effectively convert the

functional regulations into performance-based regulations. SANS 10400 is now not merely a set of deemed-to-satisfy rules which enable compliance to be established, as it now establishes quantitative technical performance criteria, acceptable solutions and methods by which the performance of solutions can be evaluated. Levels 3, 4 and 5 of the Nordic Model are now combined into the SANS 10400 family of standards that each deal with specific attributes of a building.

The requirements of the National Building Regulations (SANS 10400-A, *General Principles and Requirements*) may now be satisfied by:

a) adhering to all the requirements of prescriptive regulations; and
b) adopting solutions in respect of functional regulations that comply with the provisions of the relevant parts of SANS 10400 or reliably demonstrating, or predicting with certainty, to the satisfaction of the appropriate local authority, that an adopted building solution has an equivalent or superior performance to a solution that complies with the requirements of the relevant part of SANS 10400.

Each part of SANS 10400 that addresses a particular part of the National Building Regulations provides the means by which the functional regulations may be satisfied by one or a combination of the following, as appropriate (see Figure 3):

a) compliance with stated design and construction rules;
b) the preparation of a rational design or the undertaking of a rational assessment by a competent person, in accordance with stated requirements; or
c) compliance with the requirements of an Agrément certificate issued by Agrément South Africa.

Regulation B1: Design Requirement
(1) Any building and any structural element or component thereof shall be designed to provide strength, stability, serviceability and durability in accordance with accepted principles of structural design, and so that it will not impair the integrity of any other building or property.
(2) Any such building shall be so designed that in the event of accidental overloading the structural system will not suffer disastrous or progressive collapse which is disproportionate to the original cause.

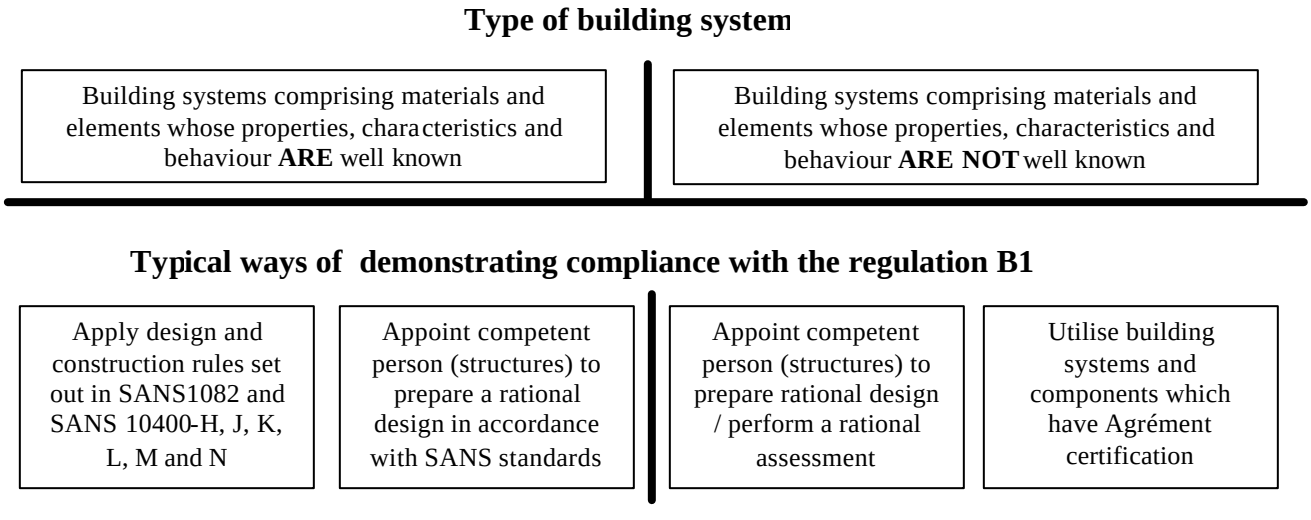

Figure 3. Ways in Regulation B1 may be satisfied

The revised interpretation of NBRs now makes provision for category A buildings. A category A building is a building that:

a) is used for places of instruction, worship, displaying and selling merchandise to the public, offices, dormitories, domestic residence and dwelling houses;
b) has no basements;
c) has a maximum length between intersecting walls or members providing lateral support of 6,0 metres; and
d) a floor area not exceeding 80 m².

Different performance parameters are provided for Category A and non-category A buildings along the lines of that provided for in the JSD code.

SANS 10400:2004 provides a platform for the development of acceptable solutions for indigenous forms of construction alongside those based on the commonly encountered engineering materials, namely concrete, masonry, timber and steel. It also allows the poor greater accessibility to a range of buildings.

The use of standards to promote energy efficient housing in South Africa

The National Department of Housing commissioned a study on energy efficient housing in South Africa in the wake of the Johannesburg World Summit. This study identified thermal performance as the driver of heating consumption requirements in low cost housing units. Natural thermal comfort frees the residents from expensive, unsafe and unhealthy space heating. Very high levels of indoor air pollution due to use of coal and biomass (wood and dung) for heating result in health problems, such as respiratory disease, accidental burns and poisonings and eye and skin irritations. It is estimated that over 60% of South Africa's population is exposed to polluted, unsafe air. The mortality rate of acute respiratory illnesses among children is reported to be 270 times greater than for children in Western Europe (Soderlund & Schutte 2003).

The final report emanating from this study recommended that National Building Regulations and Building Standards Act be amended to empower the Minister to issue NBR relating to energy efficiency to enable minimum standards to be enforced. It also recommended that incentives and programmes be put in place to (Soderlund and Schutte, 2003):

a) improve the performance of the housing stock that was performing below the minimum requirements established in the NBR; and
b) encourage performance beyond the minimum.

The final report proposed a model with the steps outlined in Table 5 as the framework within which a phased approach to the regulation of energy efficiency in housing should be implemented (Soderlund and Schutte, 2003).

Table 5: Proposed model for energy efficient housing in South Africa.
(Soderlund and Schutte, 2003)

Step	Description
1	Establish goals and objectives for energy efficiency.
2	Establish a performance description (i.e. a statement which identifies agents that affect performance in a qualitative manner and establishes how these agents affect the state of the house)
3	Establish performance parameters (i.e requirements expressed in terms of the quantitative performance of a house attribute) for the purpose of comparison for two housing sectors each housing sectors (lower income and medium / high income) that is representative of the majority of the housing stock or most commonly encountered form of house construction in each of the different climatic areas in South Africa.
4	Regulate new house construction to ensure equivalent or superior performance to the reference house.
5	Put in place programmes or incentives to upgrade / improve the performance of the existing

	housing stock in order to reduce the number of houses that have an inferior performance to the reference house
6	Put in place programmes or incentives to create a demand for performance superior to the reference house in new house construction and the existing housing stock through the introduction of a star rating scheme.
7	Monitor improvements and changes in construction practices and amend the performance parameter as necessary.

Promoting other aspects of sustainable housing

Aspects of sustainable housing such as employment during construction and the biodegradability and non-noxiousness of demolition waste, embodied energy, recyclability, and renewability of construction materials have not been regulated in terms of South Africa's NBR, nor are there any proposals to do so. The procurement system in mass government housing in South Africa is, however, geared to encourage housing developers do so.

Performance based resource standards have been developed to quantify and measure the employment generated or the use of local resources. Value for money in the evaluation of tender offers in such projects can be determined in terms of a weighted summation of the quantum of contract participation goals measured in accordance with the provisions of SANS 1914-4:2002, *Participation of targeted enterprises and targeted labour (local resources),* and SANS 1914-5:2002, *Participation of targeted labour,* the scoring of inherent construction material properties and the physical characteristics of the housing units in terms of community preferences and price (Watermeyer, 2003a and 2003b).

Proposals for a Uniform Regulatory System

Societal expectations can be articulated at a global, national, regional and local level. Building regulations, by their very nature, can only establish minimum requirements that satisfy societal expectations. Building standards can be used by building owners to procure buildings which have superior performance i.e. perform in a manner that meets their expectations.

It is recommended, in order to capture the spectrum of societal expectations in buildings in a uniform and systematic manner that:

a) Performance based standards and performance based building regulations should be developed using a four level system as illustrated in Figures 1, 2 and 4, respectively, with descriptors and contents associated with each level in accordance with Table 6.

b) A performance description for sustainable buildings which reflects global expectation should be developed to facilitate the setting of goals for buildings at a national level.

c) Law makers should provide a framework for regulating aspects of sustainable buildings, the issuing of prescriptive building regulations that are impossible to describe qualitatively and the establishment of the administrative provisions relating to the regulation of buildings.

d) International standards which establish functional requirements should be developed in respect of structural design, dimensions, demolition work, public safety, site operations, excavations, foundations, floors, walls, roofs, stairways, glazing, lighting and ventilation, energy efficiency, drainage, non-waterborne means of sanitation, stormwater disposal, facilities for disabled persons, fire protection, space heating refuse collection, water installations and fire installations.

e) National standards, informed by guidance documents, should be developed to establish performance parameters which are consistent with local societal expectations and to provide the means by which it can be established that solutions satisfy functional requirements.

f) Performance based standards should be developed to enable building owners to procure buildings that perform in the manner that they require.

g) National standards, informed by guidance documents, should be developed to establish performance parameters which are consistent with local societal expectations and to provide the means by which it can be established that solutions satisfy functional requirements.

h) Performance based standards should be developed to enable building owners to procure buildings that perform in the manner that they require.

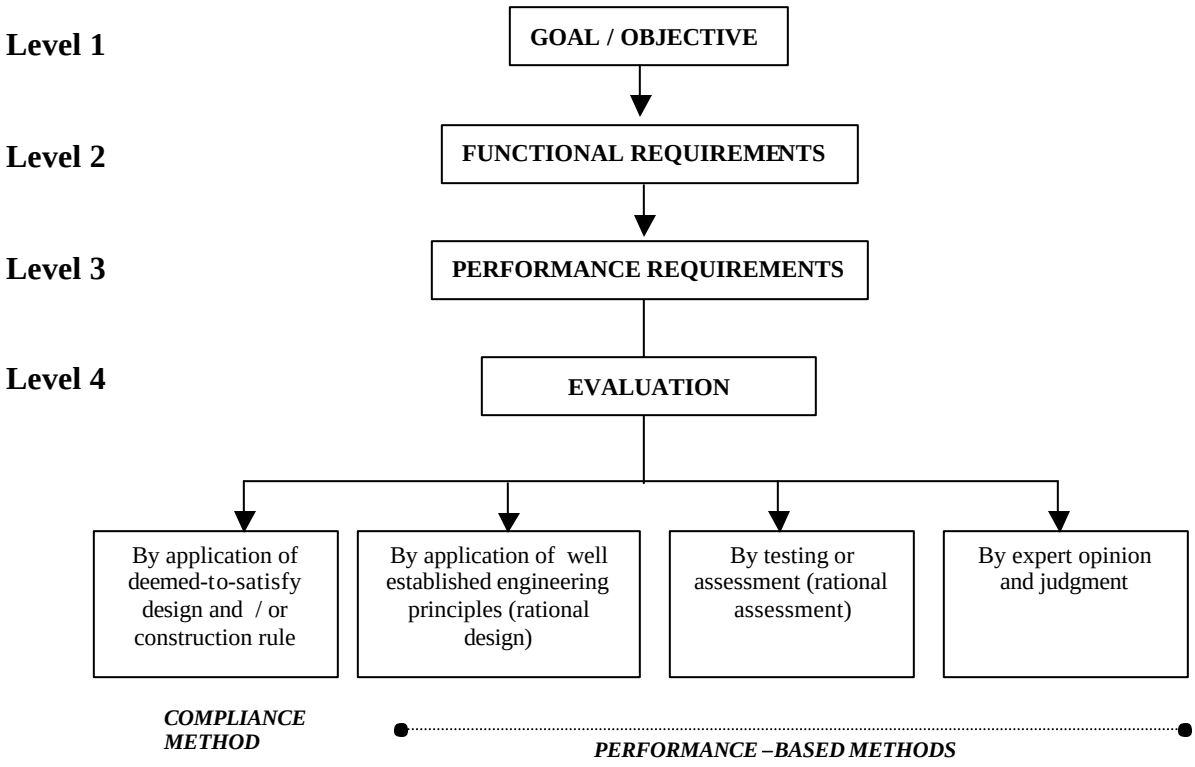

Figure 4: A four level regulatory system for building regulations

Table 6: Definitions for descriptors used to describe the levels associated with performance based codes and standards

Level	Building regulations		Building standards	
	Descriptor	Definitions	Descriptor	Definition
Level 1	Goal	A broad statement of intent that reflects societal expectations of what the regulations are intended to achieve.	User need (design objective)	A general statement of requirements for a building that may be regarded as being satisfactory by the user.
Level 2	Functional requirement	A requirement stated in qualitative terms that sets out what is required without specifying the method of construction, techniques, dimensions or materials to be	Performance description	A statement which identifies agents that affect performance in a qualitative manner and establishes how these agents affect the state of the house.

		used.		
Level 3	Performance requirement	The qualitative performance criteria which enables the functional requirements to be satisfied for a nominated level.	Performance parameter	User needs expressed in terms of the quantitative performance of a building attribute.
Level 4	Evaluation	Confirmation that the nominated performance is achieved.	Evaluation	Confirmation that the nominated performance is achieved.

These proposals necessitate that publications such as the ECE Compendium of Model Provisions for Building Regulations (ECE, 1996) be fundamentally revised and the scope of standards under development such as ISO 15928 (House - Description of performance) be expanded to include all buildings.

Conclusions

Societal expectations for sustainable human settlements are well articulated in Agenda 21 (1992), the Habitat Agenda (1996), the Millennium Declaration (2000) and the outcomes of the World Summit (2002). These expectations can be readily captured in a performance description for sustainable housing. This performance description facilitates the identification of issues that need to be considered in the design, construction and deconstruction of housing units.

Functional building regulations should be framed around structural design, dimensions, demolition work, public safety, site operations, excavations, foundations, floors, walls, roofs, stairways, glazing, lighting and ventilation, energy efficiency, drainage, non-waterborne means of sanitation, stormwater disposal, facilities for disabled persons, fire protection, space heating refuse collection, water installations and fire installations.

Functional regulations can be translated into performance based regulations though national standards should these standards establishes quantitative technical performance criteria, acceptable solutions and methods by which the performance of solutions can be evaluated. Different levels in performance can be established to provide greater accessibility to the poor to certain building occupancies or, for that matter, to address societal concerns relating to any building occupancy.

Building regulations establish minimum standards and cannot on their own be used to promote sustainable development goals relating to green house gas emissions. They need to be used in conjunction with other interventions.

Sustainable development expectations such as those relating to employment during construction and the biodegradability and non-noxiousness of demolition waste, embodied energy, recyclability, and renewability of construction materials should be addressed on a non-mandatory basis in the design and procurement of buildings.

Performance based building standards as apposed to performance based building regulations may be required to satisfy the expectations of individual building owners.

References

Economic Commission for Europe (ECE). 1996. ECE Compendium of Model Provisions for Building Regulations.. United Nations, New York and Geneva.

Joint Structural Division of the South African Institution of Civil Engineering and Institution of Structural Engineers. 2000. *Code of practice for the Assessment of Housing Units in South Africa*. SAICE/ IStructE. Johannesburg.

National Department of Housing. 2003. Generic Specification for the Design and Construction of housing: Project Linked Greenfield Subsidy Project Developments GFSH-11.

Soderlund and Schutte Pty (Ltd). 2003. Final Report on Standards for Energy Efficient Housing in South Africa. (Tender VA49/215). Department of Housing. May.

Watermeyer, RB. 2003a. Tools and techniques to facilitate the alignment of public and donor procurement systems to promote sustainable development objectives . Paper accepted for publication in the *Public Sector Procurement Law* Review, September

Watermeyer. RB. 2003b. The impact of structural engineering on the sustainability of human settlements in developing countries. Paper accepted for the Second International Conference on Structural Engineering, Mechanics and Computation, 5-7 July 2004, Cape Town, South Africa