Risk management of structural performance of housing in South Africa

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ABSTRACT: In South Africa many instances of unacceptable construction quality within the home building industry are apparent throughout the entire spectrum of housing (i.e. low- to high-income). This issue forms one of the main concerns and mandates of the National Home Builders Registration Council (NHBRC). The paper highlights the role of NHBRC, the relevance of risk management and performance based codification and summarises typical structural problems which take place in South African housing. It also presents selected statistics of damage, their socio-economical implications and considers the ways of improving the situation, on the national scale.

1 INTRODUCTION

One of the biggest socio-economical challenges facing South African society is the provision of adequate housing for a large portion of its population. In response to that a rapid development programme in the housing sector took place over recent years with, amongst others, more than 1,5 million subsidised housing units built (or under construction) between 1994 and 2003.

Despite the fact that a large pool of technical and legislative information on the structural aspects of house construction (i.e. the correct applications of materials and technologies as well as the minima standard requirements) is available, unacceptable construction quality, affecting the integrity of buildings, is apparent throughout the entire spectrum of housing (i.e. low- to high income).

2 THE NHBRC

As a result of implementation of the National Housing Policy in 1994, the National Home Builders Registration Council (NHBRC) was established. The main objective of the NHBRC was then to promote the common interests of people involved in the home building industry, and also to regulate the industry. By and large, the building industry resisted the warranty programme offered by the NHBRC, and this resulted in the legislation of the Housing Consumer Protection Measures (Act No. 95 of 1998).

The first phase of the Act became effective in December 1999, at the time when the NHBRC became a statutory body. The objective of the NHBRC was then refocused to protect the interests of housing consumers.

The second phase of the Act, which became effective in April 2002, now also includes a legal requirement for developers and builders to enroll all subsidised homes to be constructed.

3 RISK MANAGEMENT AND PERFORMANCE

All new mortgaged homes and the subsidy sector houses built in the Republic of South Africa are required to comply with the provisions of the Housing Consumer Protection Measures Act. In the context of the act, the protection of the housing consumer is about managing the risk of major structural defects occurring in the provision of housing.

Research (Otway, 1985) has shown that the effectiveness and implementation of regulations largely determines the risks to which society is exposed. In South Africa, the SABS 0400 1990, a document issued by the South African Bureau of Standards contains the relevant regulations and the deemed-to-satisfy rules. These formed the basis for development of the NHBRC home building manuals. The intent of the building regulations in South Africa is to provide an acceptable level of safety, health and welfare during the design, construction and use of buildings. However, it has been observed that the prescriptive approach to safety assurance seems to work well for certain hazards but fails to address others, and furthermore it lacks mechanisms for balancing efforts to address many sources of potential risks (Mahachi, 2001).

A trend is apparent in the South African home building industry, in which developers, building owners and occupants are becoming more demanding in terms of the functionalities. The functionalities refer basically to: safety, comfort and the cost of maintenance. This trend has been observed in both the low cost and up-market houses. In order to satisfy these needs, the home builders and their professional teams, have to be innovative and be able to utilise the advancements in materials and information technologies and the performance based building codes. With this approach, the performance requirements of buildings are clearly stated and the measures to achieve them can be selected discretionally.

The performance-based building codes can be traced back to the Nordic five level structure (NKB, 1978). The Nordic five level structure consists of a hierarchy with 5 levels. At level 1, at the top are either objectives or goals. The objectives represent broad statements of what the building regulations are intended to provide, i.e. they refer to the need to safeguard people and protect adjoining buildings or other property. Other examples of objectives include health and accessibility.

At level 2 are the functional statements. The statements set out in which way a building could be expected to satisfy the objectives. In other words, functional statements can be a qualitative way of indicating what steps must be undertaken to achieve the stated objectives (or community expectations).

At level 3 are the performance requirements. These outline a suitable level of performance which must be met by building materials, components, design factors and construction methods in order for a building to meet the relevant functional statements and, in turn, the relevant objectives. Examples of the performance requirements are structural stability, fire safety, sound transmission, etc. These requirements are stated in qualitative and/or quantitative terms depending on the country.

Levels 4 and 5 contain building solutions that set the means of achieving compliance with performance requirements. Level 4 are the deemed-to-satisfy methods, and level 5 the performance-based methods (or alternative solutions). In the alternative solution method there is an opportunity to adopt any particular material, component, design factor or construction method. However, in order for the design to be approved, it must comply with the relevant performance requirement.

In South Africa, the upper three layers tend to be the mandatory provisions of building regulations, and are converted into laws by legislators. The typical deemed-to-satisfy rules are given in the NHBRC home building manuals and performance-based methods are those covered by, for example, the Agrément certification. Important questions arise from the implementation of performance-based codification regarding:

- an appropriate level of safety, or risk, at which to regulate,
- the public expectation relative to 'acceptable' risk – e.g. more than 90% of NHBRC complaints are of non-structural nature,
- education and / or training of the emerging home builder.
- The role of building codification i.e. the need to support both prescriptive deemed-to-satisfy rules as well as the performance based methods.

The current primary risk management tools available to the NHBRC are:

- the registration of home builders,
- the technical home building manuals and,
- the appointment of competent persons (e.g. engineers).

4 STRUCTURAL PERFORMANCE OF HOUSES

4.1 *NHBRC requirements*

The NHBRC technical requirements are expressed qualitatively in terms of structural strength and stability, fire, materials performance, drainage and storm water disposal. They do not, however, specify the method of construction, techniques, dimensions or materials to be used.

By law, all home builders are required to comply with the minimum building standards contained in the Home Building Manual. The Home Building Manuals are based on the standard construction procedures and recommended practices, which have proved satisfactory and acceptable over the time. Provisions have been made for alternative and/or innovative methods of construction.

4.2 *Typical problems*

Table 1 shows a breakdown of the structural problems reported to the NHBRC in all provinces of South Africa since the beginning of 2001. From the table it is apparent that most of the problems are due to settlement of foundations (24%) and failure of superstructure (42%). These problems are, however, interrelated as the settlement of foundations will, in most cases trigger the structural damage of walls. Most structural problems occur in the Western Cape (22%), Gauteng (20%) and North West (20%) provinces. (Note that that data quoted below does not reflect the proportion of houses built in the respective provinces.)

Table 1: Breakdown of structural problems

	Number of occurrences										%
	EC	FS	GP	KZN	MP	NW	NC	LP	WC	Tot	
Fdn	3	-	-	10	1	14	-	-	4	32	24
Sub-struct	1	-	-	-	3	6	-	5	10	25	18
Super Struct	7	2	24	1	2	3	-	10	10	59	42
Roof	1	-	2	-	3	1	-	4	6	17	12
Drain	1	-	-	-	-	4	-	1	-	6	4
Total	13	2	26	11	9	28	-	20	30	139	
% *	9	1	20	8	6	20	0	14	22	100	

* = percentage of the national

The key causes for structural failures have been identified as:

- improper soil classification,
- inadequate foundation design,
- design not carried out by a competent person,
- construction details not in accordance with design specifications,
- the inspector not being able to identify and prevent problems at an early construction stage, and
- late enrolments to the scheme, which result in houses not being inspected at foundation level.

4.2.1 *Ground conditions and sub-structure*

The structural damage and loss of life has been far more severe on dolomites than any other geological formation in South Africa. Dolomites underlie many of the densely populated areas housing approximately 2.5 to 3 million people.

As a result of water infiltration in dolomites sinkholes are formed. A typical sinkhole is presented in Figure 1.

Figure 1. Sinkhole formation on dolomites.

Over the years, many housing developments have been affected by sinkholes, including a case in 1964 in which a house with an entire family of five disappeared in a sinkhole 60m wide and 30m deep.

The design in dolomitic areas requires initial identification of the risk category. Dolomite land is classified into three categories: low, medium and high risk (with only the low and medium risk land being suitable for residential development). This has to be preceded by a detailed dolomitic stability and geotechnical investigation. The water, sewer and stormwater services must be designed in a way to minimize the water infiltration into the soil.

The substructure problems typically relate to inappropriate design solution, poor materials and / or lack of adherence to prescribed minima standards. An example of such situation is presented in Figure 2, in which broken bricks are used for an in-fill.

Figure 2. In-fill of a foundation.

4.2.2 *Super-structure*

The failure of superstructure typically refers to cracking and / or collapse of walls. An example of severely cracked walls is presented in Figure 2.

Figure 2. Failure of super-structure.

The failures of super-structures result from poor workmanship use of inappropriate material and technologies and lack of appropriate attention given to structural detailing (e.g. connections of external and internal walls, inadequate provision of lintels above large openings, presence of large unsupported sections of walls). The failure may also be triggered by failure of the foundation systems.

4.2.3 *Roofs*

The structural damage to roofs typically results from wind action. The wind loads generated on roofs of houses depend on their geometrical form and air-tightness (i.e. the ability of pressure equalization). Most vulnerable are roofs with small slopes (so-called flat-roofs) as opposed those with steep slopes (pitched roofs).

The air-tightness is related to the porosity of cladding (i.e. the type of material used) which can largely affect the extent of damage to roofs. For example under severe wind conditions, selected roof tiles may be displaced and broken (see Figure 3). On the other hand under similar wind conditions entire corrugated sheeting might be pulled off, or in extreme cases roof structure can also be damaged or displaced (Figure 4).

Figure 3. Damage to tiles and glazing.

Figure 4. Portion of a roof blow away.

4.3 *Socio-economic impacts*

In Table 2 a summary of costs of the remedial works undertaken in the year 2002 is given. A total value of about R4m (ca. US$550 000) was committed. More than seventy percent of that amount was spent on superstructure and less than ten percent on substructure. (In a number of cases, however, both the substructure and the superstructure had to be repaired simultaneously.)

Table 2: Costs of remedial works in 2002

Type	Rand value	%contribution
substructure	323 082	8
superstructure	2 990 611	73
roof	39 692	1
drainage	0	0
professional fees	309,543	8
accommodation	417 324	10
Total (Rand)*	4 080 252	100

* 1US$ = R7.40

As indicated in Table 2 about ten percent of the total costs was spent on accommodation. To fulfill its mandate of consumer protection and social responsibility, the NHBRC facilitates alternative accommodation to the affected people during the implementation of remedial measures (up to a certain limit).

Table 3 presents selected statistics regarding the number of conciliations conducted in 2002. The conciliation incidence per enrolment was 1,32% and 0,14% incidences resulted in claims being paid out. On average, the claims which were paid out, constituted about 30% of an average cost of a house, which is R236 000.

The enrolment fee charged by the NHBRC is derived as a 1.3% of the value of a house. For an average house (cost of R236 000), this translates to about three thousand rand. This fee was determined on the assumption that the remedial works per house should not exceed 26% and the claims incidence should not be more than 4%. From a risk management point of view, there is therefore a balance between remedial works percentage and claims incidence per enrolment.

However, with the introduction of the subsidy sector, multiple failures of housing units are inevitable, and this may increase the claims incidence to unacceptable levels. As expected, there will therefore be a cross-subsidisation between the non-subsidy and subsidy houses.

Table 3: Conciliations and claims; incidence and cost summary for 2002

Item	Value
no. of conciliations – closed	573
no. of enrolments	43 332
no. of claims paid	58
claims paid costs (net)	R4 080 252
conciliation incidence per enrolment	1,32%
claims incidence per enrolment	0,14%
average claims paid cost	R70 349
average claims paid as % of average cost of house	30%

5 RISK MANAGEMENT MEASURES

5.1 *Quality assessment system*

The quality assessment can be carried out by measuring the constructed works against workmanship standards and specifications. Such measurements have to be comprehensive, straight-forward, consistent and effective. Furthermore, the assessments have to carried out systematically and within reasonable cost and time frame.

A quality assessment system for assessing the structural performance of housing is currently under development in conjunction with the Division of Building and Construction Technology, CSIR. For several years the CSIR has been active in investigating the structural failures of houses, and in research and implementation of quality assessment systems.

Of particular relevance is the research and involvement in Conquas 21, the internationally acknowledged quality system for commercial buildings which was developed in Singapore. A study into the applicability of the system into the South African home construction market was carried out and the information which was obtained formed the basis for developing the system to be introduced at the NHBRC.

5.2 *Training of emerging contractors*

As a result of national policies and strategies, the construction of a large portion of housing in South Africa is carried out by emerging contractors.

In order to continue their business activities the emerging contractors require not only access to financing but also the following basic skills of:

- estimation and quoting,
- bookkeeping,
- management and administration, and
- home construction.

In an environment of hard competition within the construction market, the emerging sector is in a continuous 'survival mode' and it does not have the opportunity and time to acquire and develop the necessary skills.

In fact many of emerging contractors who have managed to secure substantial contracts abandoned them or have compromised the quality of the end-product by either using low quality materials or not complying with minimum technical specifications.

This situation poses a huge risk to the national warranty fund. The aim of the NHBRC is to develop a system of assessment of emerging contractors, identification of individual training needs and provision of relevant training programme. These activities will rely heavily on the implementation of the quality assessment system described in Section 5.1.

5.3 *Motivation*

The NHBRC has been mandated to encourage good building practice, and to determine criteria to be applied in the grading of home builders for the purpose of differential enrolment fees. Therefore, one of the measures to be introduced by the NHBRC to promote quality of the construction product is the grading of home builders.

Again the starting point for introduction of such a system will be the quality assessment system highlighted in Section 5.1, and relevant pilot projects are currently underway. On completion of the pilot projects, a consistent and relevant scoring system will be developed and validated to ensure accuracy and consistency of grading of home builders.

6 CONCLUSIONS

The risk of structural failures of residential housing in South Africa is determined by the effectiveness of implementation of the relevant technical regulations. This risk has to be managed proactively and specific measures in this regard are considered in the paper. At the initial stage an introduction of a comprehensive and consistent quality assessment system of houses is postulated. The information which will be obtained, will then enable the implementation of relevant strategies for training and grading of home builders.

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