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IMPLEMENTING A RESIDENTIAL CONSTRUCTION QUALITY FRAMEWORK IN THE SOUTH AFRICAN BUILT ENVIRONMENT

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Abstract: *Housing is a critical socio-economic driver in the vast majority of developing countries, including South Africa. It involves many aspects such as construction quality, affordability, geographic location, long-term financing, and the environment. A key research concern is the quantification of the construction quality of houses and how this may be used to assist in the delivery of better quality houses. This article is based on studies undertaken on housing construction sites in South Africa. A construction assessment tool is developed using principles similar to those used by CONQUAS in Singapore and Malaysia. The tool thus developed is capable of measuring the quality of 'as-built' construction elements of a house against national technical standards and specifications, within reasonable time and cost. Studies on the quality of houses were then conducted on 700 houses (two low-income projects and one middle-income project). The results showed that the two low-income projects had average quality scores of 58% and 64%, while the middle-income project scored 80%. Details of the sub-elements of the scores indicated the developmental needs of the contractors involved in the projects. Using the Construction quality assessment tool, the government and other authorities can make better informed decisions when awarding contracts. If introduced and implemented correctly, the quality of the houses delivered across the entire housing spectrum can be measured and monitored, and improvement measures put in place. The data collected through this quality assessment tool will be invaluable for national authorities, regulators, and Statistics South Africa to evaluate and report if the housing stock being delivered is consistently improving. Risk assessment studies will assist the regulators in developing proper quality management strategies.*

Keywords: *CONQUAS, construction quality, housing quality, low-income houses, quality assessment, South Africa*

INTRODUCTION

The delivery of quality houses is a broad challenge in the vast majority of developing countries. In South Africa, the political process that led to democracy in 1994 provided an effective political platform for mobilizing previously disadvantaged people in securing tenure of housing. Pre-1994, housing delivery was associated with sub-quality low-income houses, and the housing developments were in areas not suitable for human settlements and far from potential workplaces. To address these concerns, the 1994 South African democratic government formulated and implemented the national housing policy and established several state entities to assist in the fast delivery of quality houses. The national housing policy and the subsidy housing programmers accommodate several government housing delivery mechanisms (South Africa, 2010). Since 1994,

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the South African housing market has been predominantly driven through the private sector, where the financial institutions primarily finance the middle- and high-income end users, and houses are delivered mainly by established homebuilders. The low-income housing market, defined as those households earning up to R3, 500 per month, has been delivered through the local or provincial governments and is mainly dominated by small and emerging homebuilders. The government subsidized housing market delivers products on a fixed house price, commonly referred to as the subsidy housing quantum, and the houses are mass-produced. The low- to middle-income end user, earning between R3, 500 and R22, 000, is partly financed by the government, and the houses are usually delivered through the social housing schemes (Butcher, 2020: 182). A low-income house is typically 40 square meters in footprint and has two bedrooms, a lounge, kitchen, and a bathroom (South Africa, 2009: 27). However, there is an apparent disparity in the quality of houses delivered in the two markets, despite the availability of information and construction guidelines. Worldwide, housing is a critical socio-economic development driver and involves several aspects, including construction quality, affordability, geographic location, environment, and long-term financing. Despite the measures put in place by the South African government over the past few decades, the quality of houses is not yet up to acceptable standards, as witnessed in many low- and middle-income housing development projects (NHBRC, 2019: 44). Several researchers and research documents (Sinha, Sarkar & Mandal, 2017: 337-340; Streimikiene, 2015: 140-145; Zunguzane, Smallwood & Emuze, 2012: 19-38, Statistics New Zealand, 2015: 13) have defined housing quality as encompassing several aspects. Some of these aspects are reasonably objective and include the dwelling type, facilities, number of rooms, and the condition of the dwelling. Subjective aspects, which are also included in housing quality, include user needs, desires, and expectations. Other researchers (Acre & Wyckmansa, 2014: 183-204, Sima, 2015: 307; Streimikiene, 2015: 140) have gone beyond housing quality and have included user satisfaction in their analysis. They define user satisfaction in line with the user's needs and aspirations compared to what was delivered physically on the ground. The minimum standards stipulated in the NHBRC Home Building Manual (NHBRC, 2015) and the national standards (SANS 10400, 2016) apply to all houses delivered in South Africa. However, the standards and guidelines are not prepared and presented efficiently, particularly for some emerging homebuilders. This substantiates a need to develop a tool that will enable the identification of training and developmental needs of homebuilders and assess if this intervention strategy does yield better results in terms of improving the quality of houses. This article recognizes the broader aspect of housing quality assessment, but it focuses on one critical element, 'construction quality'. There is minimal information on how the construction quality of houses is measured and quantified in the literature. The approach proposed in this article provides a formal, comprehensive, easy-to-use mechanism, in which housing construction quality can be quantified and measured. This article thus aims to outline local South African construction practices and benchmark international best practices on construction quality assessment of houses. The outcome of this will lead to the development of a comprehensive, straightforward, and effective assessment construction quality tool, which will enable users to assess the physical aspects of house construction that influence the quality of the 'end product', i.e., the housing top structure.

This article addresses the following key research questions:

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1. How can the physical construction quality of a house be measured and quantified and assure that the structural performance of the house meets the minimum requirements of the South African National Standards (SANS 10400, 2016)?
2. How can construction quality be monitored, and is there a progressive improvement in quality, as new entrants and technologies come into the marketplace?
3. Does training of homebuilders lead to an improvement in construction quality? If this has a positive effect, how can the impact be measured?
4. What is the difference in the quality of houses delivered for low income earners compared to those for middle- and/or high-income earners?

The answers to these questions require the development of an objective, systematic house "construction quality assessment" tool capable of measuring 'as-built' construction elements against technical standards and specifications. The quality assessment needs to be carried out systematically, rapidly, and at an affordable cost.

1. LITERATURE REVIEW

1.1 Housing delivery overview and quality of houses

Although there has been significant housing delivery in South Africa over the past decades, the trend has been declining (see Figure 1). Houses enrolled through the National Home Builders Registration Council (NHBRC) are a good indicator of houses delivered through the private sector. The NHBRC is a state entity, established through an Act of Parliament (Housing Consumers Protection Measures Act, Act 95 of 1998, as amended "The Act") (South Africa, 1998). The legislative mandate of the NHBRC is to:

- Regulate the home building industry. The Act requires all homebuilders to register with the NHBRC;
- Establish and promote ethical and technical standards. Every registered homebuilder is required to comply with the NHBRC code of ethics. All houses must be constructed in accordance with the NHBRC technical requirements, and
- Improve structural quality in the interests of housing consumers and the homebuilding industry. To achieve this, all houses must be

enrolled and inspected by the NHBRC.

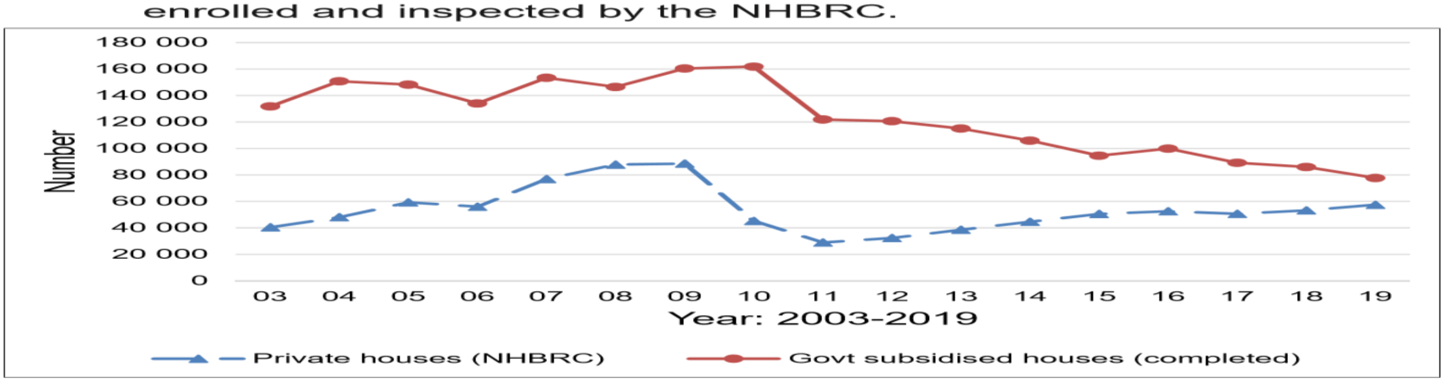

Figure 1: Housing delivery statistics in South Africa

Source: Compounded data from NHBRC Annual Reports (NHBRC, [n.d.]: online) and Department of Human Settlements reports (DHS, [n.d.]: online) Although there has been a dip in the delivery of houses in the years 2009 and 2010, due to the financial crisis and economic meltdown, the growth in

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housing delivery has shown a steady increase over the past ten years. On the other hand, there has been a decline in the houses delivered by the public sector (South African Government, 2019; NHBRC, [n.d.]: online). This explains why the housing backlog keeps on escalating, with the backlog being 2.3 million as of 2018 (Msindo, 2018: online). Since 1993, several studies have highlighted the challenges faced in the low-income housing delivery in South Africa, especially in metropolitan cities. These challenges include the impact of population growth, shortage of land, corruption, unaffordability, and poverty (Marutlulle, 2019; Bonner, Nieftagodien & Mathabatha, 2012; Jeffery, 2010; Bradley, 2003; Napier, 1993). Apart from these highlighted challenges, other researchers believe that the apartheid government initially caused the housing challenges (Setplan, 2008: 40-50; Baloyi, 2007; Eddy, 2010: 12-18). Several objections to the above statement have, however, been made and argue that these housing challenges are due to the appointment of less experienced contractors, lack of monitoring of the contractors, the poor performing construction sector, irregularities in municipalities, political issues, fraud, and corruption (Gibbon, 2010: 5; Lubisi & Rampedi, 2010: 2). South Africa has a very sound legislative, regulatory environment and good technical standards for house-construction practices compared to other countries and states. However, despite the availability of all this information and enforceable regulations, poor-quality houses are still being delivered across the entire spectrum of housing (i.e., low- to high-income houses). The NHBRC Annual Report (NHBRC, 2019) highlights the root causes for poor-quality houses as due to any of the following:

- The inadequate structural design caused by improper soil classification, resulting in an inadequate foundation solution;
- Construction details that are not built in compliance with design specifications;
- Use of unsuitable or poor-quality building materials that do not comply with South African National Standards (SANS 10400, 2016);
- General poor workmanship;
- Inadequate or non-existent service infrastructure such as storm water systems;
- Ineffective monitoring of homebuilders during construction, or
- Complete ignorance and/or lack of experience of homebuilders.

Gibbon (2010: 5) made similar observations related to substandard workmanship, inappropriate management systems, and lack of a monitoring mechanism on contractors operating in government-subsidized houses, thus contributing to poor-quality houses and delays in housing delivery. The appointment of emerging, less experienced contractors further exacerbates construction delays (Lubisi & Rampedi, 2010: 2). In a study conducted in five of the nine provinces of South Africa (i.e., Gauteng, Eastern Cape, Western Cape, Limpopo, and Mpumalanga), Mgida (2007) found that the application of unconventional building technologies, when used by emerging contractors, becomes an issue that impacts negatively on housing delivery. Unconventional building technologies are commonly referred as Innovative Building Technologies (IBTs) or Alternative Building Technologies (ABTs) and refer to building products that are certified for compliance with building regulations through a performance assessment (South Africa, 1977). The performance assessment is conducted by Agreement South Africa (ASA, [n.d]: online). The emerging contractors who use these unconventional building technologies have limited knowledge, and there is no proper training to assist them in implementing these technologies. Zunguzane *et al.* (2012) further observed that municipalities impose unskilled labor on

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the contractors, thus causing further delays to housing delivery. There is also a minimum input from engineers to monitor the quality of the top structures.

Beneficiary expectation on quality of houses in South Africa

A beneficiary refers to a household that occupies a completed house, while satisfaction in this article refers to the degree to which the end product (i.e., the house) meets the beneficiary's needs, goals and expectations. According to a study conducted in Bram Fishersville, Gauteng (Moolla, Kotze & Block, 2011: 138-140), most of the beneficiaries of low-income houses expressed their dissatisfaction with the quality of houses delivered. The vast majority of the houses had poorly built walls and unstable roofs, and the doors were poorly crafted, which resulted in them not functioning well. Most of the beneficiaries complained about poor ventilation, no air vents, and lack of kitchen and bathrooms. The study concluded that 55% of the beneficiaries were not satisfied with the functional aspects of the houses. In a study conducted in Diep loot, Gauteng (Aigbavboa & Thwala, 2012: 13), most of the low-income beneficiaries were highly dissatisfied with the lack of proper plaster finishing on the inner and outer walls of their houses. The houses were built with no ventilation system to neutralise the inner air condition during the cold and warm seasons. Studies conducted in Grahams town, Eastern Cape (Kota, 2010: 26) showed that over 50% of the beneficiaries were unhappy with roof leakages. In this case, the municipal officials had to provide the beneficiaries with plastics to cover the roof and prevent roof leakages. In a further study (Zunguzane *et al*. 2012) conducted in Wentzel Park, Alexandria, beneficiaries had to use their finances to rectify and self-assure quality on their government-subsidised low-income houses. A high percentage (46%) of the beneficiaries had to use their finances to rectify the houses and, in general, over 50% of the beneficiaries were dissatisfied with the quality of the houses. As far back as 1967, observations were made that beneficiaries consider the closeness of primary services and essential infrastructure to be of higher value than the actual physical display of the housing compartment (Turner, 1977). It was also noted that low-income houses are considered economical for beneficiaries if they are built close to places of economic activities (cities) and social infrastructure such as schools, hospitals, libraries, clinics, and recreational parks (Turner, 1977). Although the South African government adopted a similar approach in its Breaking New Ground Strategy (South Africa, 2004), it is still criticized for commencing subsidy housing projects for poor citizens in the improper informal settlements on the outskirts of cities far away from inhabitants' places of income generation and primary facilities. Thus, low-income housing beneficiaries end up selling and renting their houses and relocating back to where they were initially residing, or moving to places where it is reasonably close to workplaces and other facilities (Napier, 2009: 71-97).

Quantification of quality of houses

Research on housing quality dates as far back as 1946 (Solow, 1946: 283). Since then, research on housing quality has progressed to include several aspects, including the impact of the market value and micro neighborhoods (Kain & Quigley, 1970: 540). Furthermore, over the years, housing quality has been broadly used to define the condition of a dwelling unit, the characteristics of the physical environment, and end user satisfaction (Streinikiene, 2015: 140-142; Mridha, 2015: 42-54). In 2011, a study was done in the United Kingdom on the development of a Housing Quality Indicator (HQI, 2011). The HQI is an online toolkit designed to measure, evaluate and improve the building's design quality. The toolkit is broad and considers the location of the house, size, external environment, quality, and

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cost. Other house-quality tools in the literature include the Building for Life (CABE, 2019: online), which has 20 criteria measures compared to the HQI's ten criteria. In an article, Sinha *et al.* (2017: 337-347) provide a detailed literature review summary of techniques used to analyses housing quality. However, all these housing quality assessment tools lack detail on the measurement and quantification of the construction quality of the house. The construction quality is influenced by the design of the house, workmanship during construction, and the quality of the materials used for the house (HQI, 2011: online). Although construction quality is a subset of housing quality, it forms an essential aspect, particularly in developing countries such as South Africa, where the construction quality is poor (NHBRC, 2019). In the context of this article, construction quality is defined as compliance of the construction building elements with technical specifications that are stipulated as minimum standards in the South African National Standards (SANS 10400, 2016). The most established construction quality assessment tool found in the literature that quantifies the quality of a building is the construction quality assessment system (CONQUAS 21, 2003), launched in Singapore in 2003. After the launch, roughly 2,000 construction projects were assessed that year using the CONQUAS tool. CONQUAS is an assessment system used to measure and quantify the quality of construction building projects, referred to as the CONQUAS score. The assessment method uses a sampling technique, based on the size of the building, to measure the quality of 'selected elements' of the building. CONQUAS' latest edition focuses on quality assessment of three components, namely structural, architectural, as well as mechanical and electrical work. The literature shows that the use of CONQUAS (2003; 2017) has offered many benefits to the Singapore construction industry. After implementing the system in 2003, the CONQUAS score of Singaporean buildings improved from an average of 68% to 75% within eight years, and the target score for 2019 was set to 85.8% (BCA, 2021: online). CONQUAS (2003; 2017) seems to be a robust quality assessment tool that can consistently measure the construction quality of building projects. The principles of CONQUAS have been widely adopted in other countries such as China, Australia and Korea (Kamath & Jayaraman, 2013: 51-67). Of particular note is the adoption of CONQUAS by Industry Pembina and Malaysia (CIS, 2014: online). The central concept used by the Malaysians is similar to CONQUAS, with the main difference being on the categorization of buildings, the weightings of building elements, and the sampling guidance. A survey on quality of houses conducted in 2018 as part of The South African General Household Survey (Statistics South Africa, 2018: 34) indicated that 13.6% of South African households lived in state-subsidized houses (low-income). The survey also included statistics of the construction quality of state-housing units delivered by the government from 1994 to 2018. The level of quality was measured subjectively in terms of the household's opinion whether the walls and roofs of the dwellings were very good, good, needed minor repairs, weak, or very weak. Based on the Stats SA survey, 10.2% of the households reported that their homes had weak or very weak walls, while 9.9% reported the same for their roofing structures. However, Stats SA's approach is based on perceptions by households (end users) and 'lay-man' understanding of structural failures. For this research, it was noted that a direct application of Singapore's CONQUAS to South Africa would not be applicable as the two countries have different socio-economic conditions, geographic, technical, and political environments. Table 1 highlights and summarizes these differences.

Table 1: Summary of comparison of Singapore and South Africa

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Attribute	*Singapore*	*South Africa*
Geographic and spatial development	A small tropical island of approximately 719 square kilometers. The land surface is relatively flat, primarily urban with tall buildings.	1.2 million Square kilometers, significantly larger than Singapore by roughly 1,700 times. Geographic spread differs across the country, with some areas being mountainous and rural. Most housing developments are single or double story.
Socioeconomic and technology (2020)	A population of roughly 5.9 million. 2.9% of GDP is spent on education. A very low unemployment rate of roughly 2.2% and the standard of living is very high. The skills base is high, and the quality of education is generally high and acceptable. The usage and uptake of construction technologies to assist in construction delivery are high.	A population of roughly 54 million. 5.9% of GDP is spent on education. A high unemployment rate (Almost 30%), with more than 53 % of youth unemployed. Historical exclusivity limits the pool of skilled base, and the educational standards differ substantially across the country. Limited use of technology in construction processes and resistance to adopt the use of innovative technologies.

Notwithstanding the above progress, no formal construction quality assessment systems have been developed in South Africa and other developing countries. Such a system should be able to take the economic and construction dynamics of developing countries into account. These dynamics differ substantially from Singapore and other developed countries and will be highlighted in this article.

2. PROPOSED HOUSEBUILDING CONSTRUCTION QUALITY ASSESSMENT TOOL

Based on the experiences and the situational analysis of the South African construction industry, the approach adopted in this article to develop the South African house building construction quality assessment tool was similar in principle to the methodology used in the CONQUAS model. The similarity was mainly for the division of building elements and assigning relative weights to these elements. Housing construction quality in South Africa is mainly associated with structural failures and poor workmanship, noticeably so in low-income houses. It was thus considered necessary to focus only on structural aspects affecting the integrity of the building and the roof structure. Concerning the structural integrity, some considerations on electrical works were included in the development of the construction quality assessment tool. The following were established as the objectives of the construction quality assessment tool:

- A tool that is objective, simple, and practicable, with a capability of assessing and quantifying the quality of house construction and the performance of home builders;

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- A tool that will enable the differentiation of homebuilders based on their performance in house construction, and
- A tool that will assist in the development of homebuilders to improve the quality of their work.

Elements

The approach adopted in developing the assessment tool suitable for the South African housing construction industry was to break down the housing structure into five building elements that were then further subdivided into sub-elements, as presented in Figure 2. This division forms a substantial departure from CONQUAS regarding the number of components, the inclusion of foundations, the exclusion of separate components related to architectural finishes, and the relative allocation of

Assessment tool away from architectural issues towards structur Al works.

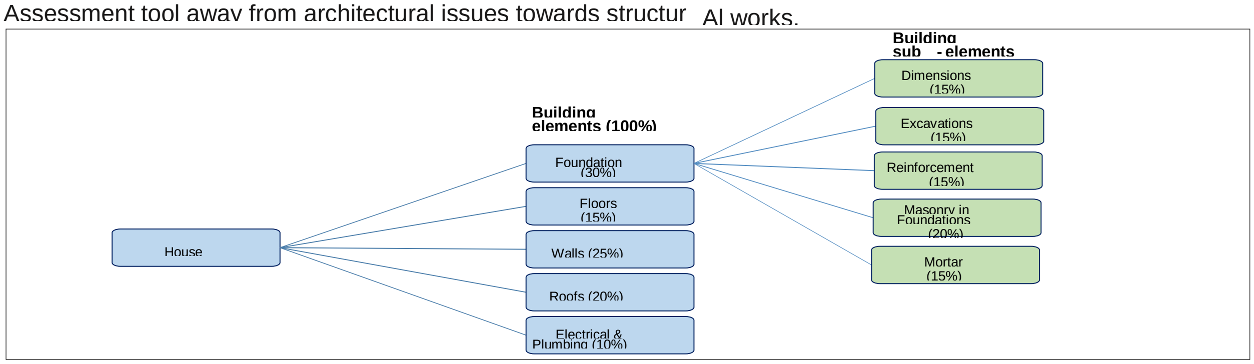

Figure 2: Building elements and sub-elements

weighting percentages. In particular, the distribution of weightings shifts the emphasis of the The weightings were based on observation of structural failures of houses in South Africa, and the actual weightings were determined using the Analytical Hierarchy Process (AHP) (Saaty, 1987). The AHP is a structured mathematical technique used to organise and analyse complex decisions. The technique was used to prioritise building elements that impact on the structural stability and integrity of a house. Thus, the performance of floors (15% weight), for example, is of less importance compared to the walls (25% weight). The electrical and plumbing works (10%) were found to have a small impact on the structure. The impact of electrical and plumbing works on the structure is due to the chasing of walls to make provision for the conduits or pipes. The highest weight of 30% was assigned to the foundation and 25% to the walling element. The sub-elements were developed from each of the building elements, as shown in Figure 2 for the foundation element. For the other elements of a building, the sub-elements are shown in detail in Table 2. Each building element was broken down into sub-elements that would influence the overall construction quality of the element. This process was based on the performance of historically completed houses, their associated failure patterns, and root causes of failure, and on-site investigations. Saaty's AHP (Saaty, 1987: 161-176) approach, coupled with homebuilder interviews, was used to allocate the sub-weights of the sub-elements.

Table 2: Building sub-elements for a typical low-income house

Item no.	*Building element and weight*	*Building sub-element*	*Building subelement weight (%)*	*Weighted average (%)*
1	Foundation	Dimensions	15	4.50

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Item no.	*Building element and weight*	*Building sub-element*	*Building subelement weight (%)*	*Weighted average (%)*
	30 %	Excavations	15	4.50
		Reinforcement	15	4.50
		Concrete	20	6.00
		Masonry in foundations	20	6.00
		Mortar	15	4.50
			100	30.00
2	Floors 15 %	Dimensions	10	1.50
		Excavations	20	3.00
		Dampproof membrane	30	4.50
		Concrete	40	6.00
			100	15.00
3	Walls 25 %	Dampproof course	15	3.75
		Masonry walls	20	5.00
		Brick force	10	2.50
		Mortar	15	3.75
		Doors and window frames	10	2.50
		Lintels	15	3.75
		Plaster	10	2.50
		Glazing	5	1.25
			100	25.00
4	Roof 20 %	Wall plate	10	2.00
		Timber	20	4.00
		Purlins, rafter beams	25	5.00
		Roof covering	15	3.00
		Bracings	15	3.00
		Roof anchors	15	3.00
			100	20.00
5	Electrical and plumbing	Sewer trenches	20	4.00
		Waterproofing	40	8.00

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	10 %	Chasing	40	8.00
			100	20.00

Assessment criteria

The assessment criteria used in CONQUAS (2003; 2017) employ a strict approach to score compliance items. A building element is assigned either a compliant and given a score of 1.0 or a non-compliant and given a score of 0. With this approach, most of South Africa's low-income houses will end up with a very low overall construction quality score. This will not be helpful, as hardly any information will be extracted from the data. An intermediate score of 0.5 was introduced to obtain reasonable scores and maintain consistency. This score allows some deviations (non-compliances) to occur, but only for those non-compliances that will not adversely affect the house's structural integrity. Other scoring systems such as Likert's five-point scale were considered inappropriate, as they allow too many non-compliances to be introduced and yield unreasonable results. A set of assessment criteria were developed, using the minimum technical standards and the South African National Standards (SANS 10400, 2016). A large pool of construction technical information was identified. The most relevant, inclusive, and accessible to a homebuilder is the NHBRC's Home Building Manuals (NHBRC, 1999; 2015). The information included in SANS 10400 (2016) tends to be sophisticated to an ordinary homebuilder and concentrates on details of issues pertinent to specific topics. Due to that, the difficulty of access, and the cost of the standards, the SANS 10400 documents are of less practical benefit to homebuilders.

RESEARCH

The proposed construction quality assessment tool developed was used to analyse the quality of 700 houses on three selected project sites located in Gauteng, South Africa. The study was undertaken on two low-income projects, shown in Table 3 as Project A (250 houses) and Project B (350 houses), and one middle-income project, shown as Project C (100 houses). In Table 3, the homebuilders are indicated with the pseudo symbols A, B, and C, due to the sensitivity and confidentiality of the information. Thus, Project A had two contractors (homebuilders) shown in Table 3 as A1 and A2, each allocated 120 and 130 houses, respectively. Similarly, project B had three contractors, B1, B2, and B3, with 80, 110, and 160 houses, respectively. However, the middle-income project had one contractor (C1) allocated 100 houses. Destructive investigations are usually costly and take longer to implement compared to visual assessment. In this study, a methodology was adopted in which an assessor would visit the site and assess (score) the various elements of the house structure without performing any destructive tests.

Assessment

Before the study, an on-site, hands-on training of the tool and an interactive calibration based on the results were conducted. The on-site inspection assessment was based on technical documentation in the form of drawings and specifications provided by the homebuilder. Several building elements were included for scoring, and assessors who used the tool were trained prior to the on-site assessment, in order to reduce subjectivity. To make the assessment easy and quick to use, very basic construction tools and instruments were used for the assessment. These included using a spirit level to measure levelness, a Schmidt hammer to obtain compressive strength of concrete, a moisture meter, a measuring tape, and a camera. A trained assessor performed on-site assessment, using the quality assessment tool

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and verified, where applicable, with technical documentation (e.g., drawings) available on-site. The skills required for an assessor are a basic technical understanding of standards and experience of site inspection of a building during construction. The assessor is required to carry out the assessment of a building element and sub-element only once. This is in line with the recommendations of CONQUAS (2017) that encourages homebuilders to excel and deliver a good product the first time. Based on observed workmanship and previously recorded structural failures, the tool was also designed to handle complex designs, construction methods, and the usage of different materials and products (e.g., unconventional building technologies) and can be used during and post-construction. Assessments of the foundation and roof sub-elements (see Table 2) of each house in the three selected project sites were conducted during construction. The final assessment (roof leak) was done six months after completion of the construction work. This process allowed the assessors to perform an objective analysis of the foundations during construction. To calculate the quality score for each house, each building element was scored, and when aggregated with other elements, it gives an overall score for the house.

Limitations

Previous research has been conducted extensively on beneficiaries' perceptions on quality of houses, as highlighted in the literature review, with hardly any work on the actual measurement and quantification of the quality of the top structure. As such, the limitations of this research are as follows:

- The quality assessment research is only for the physical top structure and foundations of a house, and
- The assessment is limited to structural aspects and does not include architectural finishes, plumbing, and electrical designs.

RESULTS AND DISCUSSIONS

Findings

Table 3 presents the scores for each project, per homebuilder, and the average score for each project. The scores varied from 54% to 80%. The average score for the low-income houses was 64%, for the middle-income, 80%, and the aggregate average score for all houses was 66%. The houses were found to have various types of defects, ranging from inferior quality walls, substandard materials to roof leaks. Interestingly, the lowincome houses constructed by each homebuilder in each project showed similar patterns of defects.

Table 3: Project scores

Project	*Homebuilder*	*Type of houses*	*No. of houses*	*Average quality score (%) (Max. 100%)*
A	A1	Low income	120	77
	A2	Low income	130	67
	Subtotal		250	72
B	B1	Low income	80	59
	B2	Low income	110	62
	B3	Low income	160	54

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	Subtotal		350	58
	Total		600	64
C	C1	Middle income	100	80
Average score			700	66

Figure 3 shows a plot of the frequency distribution of the quality of houses scores, where 100% indicates a near-perfect structurally defect-free house, complying with all relevant national standards. The scores in Figure 3 are based on the elements presented in Table 2. As shown in Figure 3, the data fits in a normal distribution curve, whereby most of the houses have scores falling between 60% and 75%. As part of this research project, a benchmarking exercise on quality scores was conducted on houses that the NHBRC identified in Eastern Cape and KwaZulu-Natal provinces (NHBRC, 2011). These houses were delivered through the government subsidized programmer and had structural problems that varied from minor to major defects. According to this exercise, scores below 50% indicated very poorly constructed houses with significant structural defects and would require the houses to be demolished and reconstructed. Scores between 50% and 60% indicated houses with major structural defects, and scores between 60% and 75% indicated houses with minor defects, while scores above 75% indicated houses with insignificant structural defects. The definitions of significant, major and minor structural defects were defined in the NHBRC Home Building Manual (NHBRC, 1999). In the NHBRC manual, the damage or structural defect to a structural element is defined in terms of ease of repair. Using the NHBRC definition in a slightly modified manner, the following was used in this research to define the defects in masonry walls of single-story houses:

- Insignificant (hairline) cracks have crack widths in walls less than 0.25mm;
- Minor defects have maximum crack widths in walls between 0.25mm and 5mm. Cracks occur internally and are not visible externally. Redecoration of the walls may be required;
- Major defects have crack widths between 5mm and 25mm.

Extensive repair works to the walls may be required, and

- Significant crack widths greater than 25mm would require major repairs, involving partial or complete demolishing of the wall.

Roughly 8% of low-income houses fell below the 50% score and required to be demolished. Of the houses, 30% scored between 50% and 60%, indicating that these houses would require major rectifications. Of the houses, roughly 36% scored between 60% and 75% and these houses would require minor rectifications to meet the local, national standards. As indicated earlier, a score above 75% indicates a house of acceptable quality standards; only 25% of the houses fall into this category. The defects on houses that scored above 75% were cosmetic and could be addressed by the house owner at minimum cost. Most of the low-income houses fell below the 75% score, with an average score of 64%. On the other hand, middle-income houses scored above 75%, with an average score of 80%. The difference in scores shows the disparity in the quality of houses delivered in the two mainstream markets. Mainly small and or emerging homebuilders with limited house building knowledge are involved in delivering low-income houses, while well-established homebuilders dominate the middle-income.

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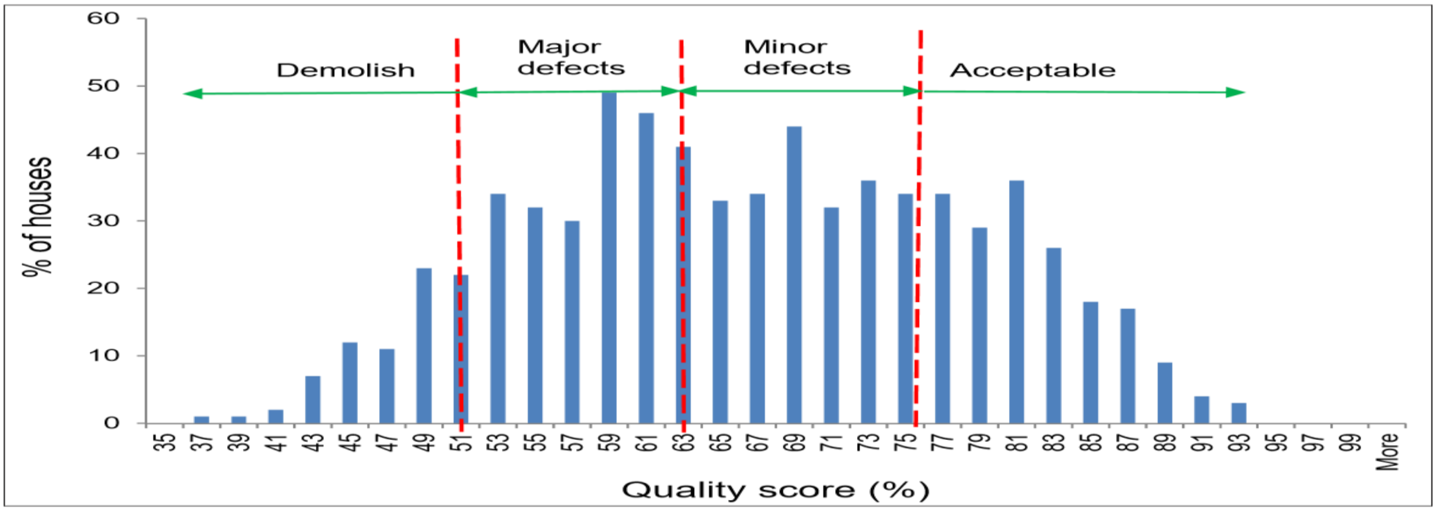

Figure 3: Distribution of structural quality scores (all houses)

Of further interest to observe is the comparison of the quality of building elements of the houses. The building elements and the sub-elements associated with these elements were defined in Figure 2 and Table 2. Each building element has a score, and when aggregated with other elements, it gives an overall score for the house. For the low-income houses, the average quality score for the roofs and walls was 55% and 65%, respectively. This was not surprising, as most of the corrugated (IBR) roof sheets commonly used for low-income houses were torn, and as a result, the roofs were leaking within six months. Some of the roofs had boulders on top to prevent them from wind uplift, or cement blocks were used to

Anchor the roof beams (see Figure 4).

Figure 4 : Typical roof anchoring system used for low-income houses

Some of the walls were observed to have poor workmanship associated with skewness and substandard cement blocks. Samples of cement blocks taken from the site for lab testing indicated that the compressive strength was far less than the 3MPa minimum prescribed in SANS 10400 (2016). The compressive strength results ranged from 2.1MPa to 3.1MPa, with a mean value of 2.5MPa. An inadequate foundation system caused wide crack openings that were observed in some of the walls. The impact of crack width was determined as per the NHBRC Home Building Manual (NHBRC, 2015) and SANS 10400 (2016). Unacceptable cracks had a high impact on the house's overall score, which would require the houses to be demolished. As shown in Figure 5, a log-normal plot represents the frequency distribution for the walls in one of the low-income housing projects. In this graph, approximately 20%

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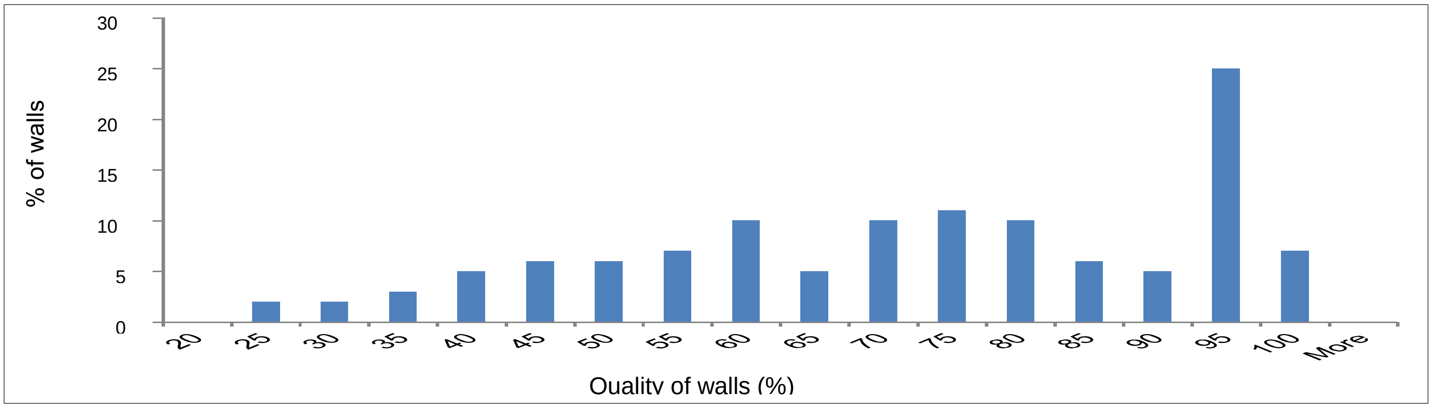
Is improving with time.



of the walls scored below 50%, and roughly 45% scored more than 75%. From the data distribution in the graph, it appears that intervention strategies are required to improve the construction quality of houses in South Africa. Thus, to improve the quality of the walls, the graph must be shifted to the right, using mechanisms such as training, effective quality control, and monitoring, and the use of better quality materials. Upon embarking on these strategies, the construction quality assessment tool can be used to re-assess the quality of houses delivered by the contractors. If the interventions are effective, the graph should shift towards the right. Relevant regulatory authorities, Stats SA, the stakeholders in the housing industry, will then be able to arguably present the housing quality statistics for South Africa and determine whether indeed the quality of housing stock

Figure 5: Percentage distribution of assessment scores for walls element much better insight is obtained by correlating building elements, as presented in Figure 6, which gives the scores for Project A. The scores of the walls are normalized against the scores of the floors. In the graph, a house is represented by a single data point, and a 45-degree regression line is drawn as shown. This line thus represents scores of equal magnitudes for both the walls and the floors. A point plotting below the unity-regression line denotes a house in which the quality of the floors is superior to the walls. Conversely, a point plotting above the diagonal line reflects the opposite situation. Figure 6 shows that most of the houses had better quality floors than walls, as most of the data points plotted below the regression line. Such type of correlation graph is useful where the project has many subcontractors. The graphs would

Figure 7: Example of poor substructure in low-income houses

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enable training interventions that are required and identify which aspects of the project should be addressed, in order to obtain a better quality house. Figure 7 presents a typical example of a poor sub-structure (floor) construction. The image shows that the floor level does not meet the minimum standard, which stipulates that the floor level must be at least 150 mm above the natural ground level. In the event of rain, the house is likely to flood, compromising the integrity of the foundation, the house, as well as the health and safety conditions of the occupants. Therefore, a developmental strategy for this homebuilder would be on the basic understanding of the impact of storm water on top structure performance. A similar comparison of walls and roofs for the same project suggests that the relative construction qualities of both elements are of a similar order of magnitude.

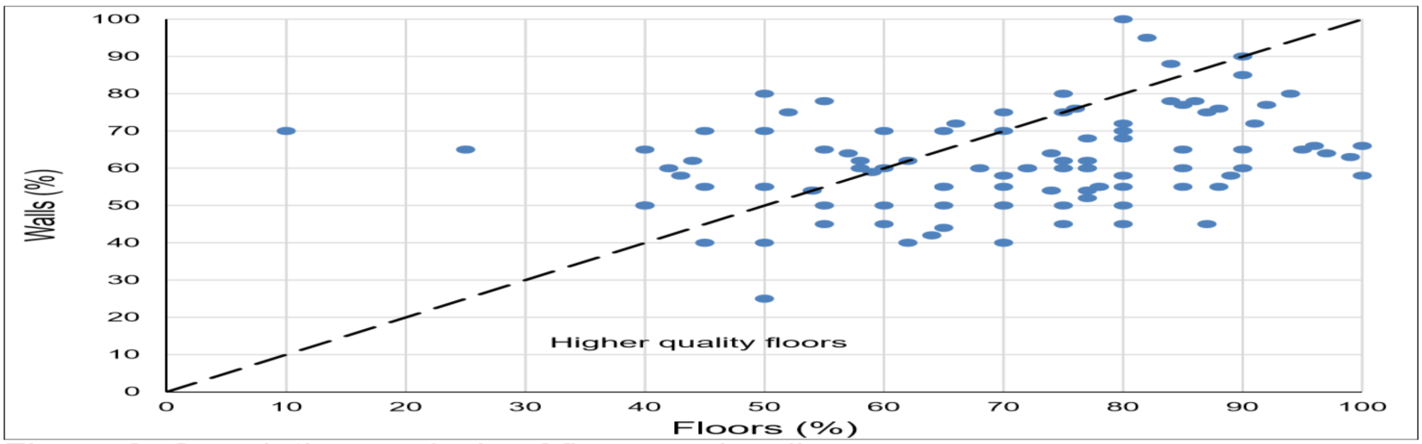

Figure 6: Correlation analysis of floors and walls

CONCLUSIONS AND RECOMMENDATIONS

South Africa has a dual housing market with an apparent disparity in the quality of houses delivered. A construction quality assessment tool was developed and presented in this article, taking into consideration the local South African conditions typical of the vast majority of developing countries. Although the tool is simple to use, it does provide an objective way of assessing and quantifying the quality of a house objectively and consistently. Implementation of the tool enables a comparison of quality outputs by various homebuilders and developers. It produces a consistent and statistically based measure of quality performance by the entire industry. When integrated with other housing quality systems, this tool will contribute to a holistic assessment of house quality. Implementing the proposed 'construction quality assessment' tool for houses will benefit several stakeholders and role players in the homebuilding industry. The proposed assessment tool is capable of assessing and quantifying the quality of a house. An analysis of the data generated by the tool identified the developmental needs of the homebuilders. The regulatory authorities, contractor/building organisations, and associations can use the assessment tool to grade the homebuilders into different categories, depending on their historical quality assessment performance scores. Good performers can use their quality assessment score, based on their performance category, to improve the quality of their products and for marketing purposes. Therefore, a potential client can benefit by being able to differentiate and appoint competent homebuilders who can deliver a better quality housing product. Using the construction quality assessment tool, the government and other authorities can make better informed decisions when awarding contracts. If introduced and implemented correctly, the quality of the houses delivered across

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the entire housing spectrum can be monitored, and improvement measures put in place. The data collected through this quality assessment tool will be invaluable for national authorities, regulators, and Statistics South Africa to evaluate and report if the housing stock being delivered is consistently improving. Risk assessment studies will assist the regulators in developing proper quality management strategies.

REFERENCES

Acre, F. & Wyckmansa, A. 2014. Spatial quality determinants for residential building innovation: A methodological approach to the development of spatial quality assessment. International Journal of Sustainable Building Technology and Urban Development, 5(3), pp. 183-204.

ASA (Agrèment South Africa). [n.d]. [Online].

Aigbavboa, C.O. & Thwala, W.D. 2012. An appraisal of housing satisfaction in South Africa low-income housing scheme. International Journal of Construction Management, 12(1), pp. 1-21, DOI: 10.1080/15623599.2012.10773181

Baloyi, B.V. 2007. Housing delivery in South Africa: A project management case study. Unpublished M. Ing. Dissertation, University of Johannesburg, South Africa.

BCA (Building and Construction Authority). 2021. CONQUAS®. [Online]. Available at:

Bonner, P., Nieftagodien, N. & Mathabatha, S. 2012. Ekurhuleni – The making of an urban region. Johannesburg: Wits University Press. https:// doi.org/10.18772/22012115430

Bradley, G. 2003. Housing. Black Business Quarterly 6(3), p. 85.

Butcher, S. 2020. Creating a gap that can be filled: Constructing and territorializing the affordable housing submarket in Gauteng, South Africa. Economy and Space, 52(1), pp. 173-199.

CABE. 2019. Building for life: The 20 criteria.

CIS (Construction Industry Standard). 2014. Quality assessment system for building construction works. Standard Industry Pembinaan. Construction Industry Development Board. Malaysia. [Online].

CONQUAS 21. 2003. The BCA Construction Quality Assessment System Singapore. 5th edition. Singapore: Building and Construction Authority.

CONQUAS. 2017. The BCA Construction Quality Assessment System. 9th edition. Singapore: Building and Construction Authority.

DHS (Department of Human Settlements). [n.d.]. Annual reports. [Online].

Eddy, G. 2010. Economic growth and education are the keys. Fast facts, 9(1), pp. 12-18.

Jeffery, A. 2010. Chasing the rainbow: South Africa's move from Mandela to Zuma. Cape Town: Art Publishers.

Gibbon, A. 2010. Serious shortcomings in housing provision despite higher construction figures. The Herald, 20 April, p. 5.

HQI (Housing Quality Indicators). 2011. [Online].

Kain, J.F. & Quigley, J.M. 1970. Measuring the value of housing quality. Journal of the American Statistical Association, 65 (330), pp. 532-548.

Kamath, A. & Jayaraman, R. 2013. CONQUAS Systems Standard for High Quality Project Management. MERC Global's International Journal of Management. ISSN 2321 (Print) and ISSN 2321-7286 (Online), Vol. 1, Issue 1. July 2013. pp. 51-67.

Kota, A. 2010. Why we protest. Mail and Guardian, 19 March, p. 26.

Lubisi, D. & Rampedi, P. 2010. Malema's R140m riches. City Press, 21 February, p. 2.

Marutlulle, N. 2019. Government contribution to housing delivery challenges in Ekurhuleni Metropolitan Municipality: An exploration. Africa's Public Service Delivery and Performance Review, 7(1), p. a215.

Mgiba, R. 2007. The extent of usage of alternative building technologies in low-cost housing and their socio-economic impact on beneficiaries. Internal Report, National Department of Human Settlements, Pretoria, South Africa.

Moolla, R., Kotze, N. & Block, L. 2011. Housing satisfaction and quality of life in RDP houses in Braamfischerville, Soweto: A South African case study. Urbani izziv, 22(1), pp. 138-143. DOI: 10.5379 / urbani-izziv-en-2011-22-01-005

Mridha, M. 2015. Living in an apartment. Journal of Environmental Psychology, 43, pp. 42-54.

Msindo, E. 2018. Housing backlog: Protests and the demand for housing in South Africa, Public Service Accountability Monitor (PSAM). [Online].

Napier, M. 1993. Housing problem in South Africa – Ideological perspectives. Forum, 2(1), p. 8.

Napier, M. 2009. Making land markets work better in South African cities and towns: Arguing the basis for access by the poor. In: Lall, S.V., Freire, M., Yuen, B., Rajack R. & Helluin, J.J. (Eds). Urban land markets. Dordrecht: Springer, pp. 71-97.

DOI:https://doi.org/10.5281/zenodo.15853835

NHBRC (National Home Builders Registration Council). [n.d]. Annual reports. [Online]. Available at: NHBRC (National Home Builders Registration Council). 1999. Home building manual, Parts 1, 2 and 3. Johannesburg, South Africa.

NHBRC (National Home Builders Registration Council). 2015. Home building manual. Johannesburg, South Africa.

NHBRC (National Home Builders Registration Council). 2019. Annual Report 2019/20. Johannesburg, South Africa.

Saaty, R.W. 1987. The analytical hierarchy process – What it is and how it is used. Mathematical Modelling, 9(3-5), pp. 161-176.

SANS 10400 (South African National Standards). 2016. The application of the National Building Regulations. Pretoria, South Africa: SABS Standards Division.

Setplan. 2008. Densification framework – Status quo: Analysis and findings document for Ekurhuleni Metropolitan Municipality, Settlement Planning Services, City of Ekurhuleni, Johannesburg, pp. 38-68.

Sima, L. 2015. Study on small apartment design in China: Evaluation on the impressions of and preferences for the floor plans. Journal of Asian Architecture and Building Engineering, 14(2), pp. 307-314. https://doi. org/10.3130/jaabe.14.307

Sinha, R.C., Sarkar, S. & Mandal, N.R. 2017. An overview of key indicators and evaluation tools for assessing housing quality: A literature review. Journal of Institution of Engineers (India), Series a 98, pp. 337-347.

Solow, A.A. 1946. Measuring the quality of urban housing environment: A new appraisal technique. The Journal of Land and Public Utility Economics, 22(3), pp. 282-293. DOI https://doi.org/10.2307/3159048

South Africa. 1977. National Building Regulations and Building Standards Act, Act No. 103 of 1977. South Africa, Pretoria: Government Printer.

South Africa. 1998. Housing Consumers Protection Measures Act, Act 95 of 1998. Pretoria: Government Printer.

South Africa. 2004. Breaking new ground: A comprehensive plan for the development of integrated sustainable human settlements. [Online].

South Africa. 2009. The National Housing Code. Volume 2. PART 3: Technical and general guidelines. [Online].

Vol. 13 No. 3 Imp. Factor: 8.878
DOI:https://doi.org/10.5281/zenodo.15853835

South Africa. 2010. National housing policy and subsidy housing programmers. Pretoria: Department of Human Settlements. [Online].

South African Government. 2019. Housing delivery statistics. [Online].

Statistics New Zealand. 2015. Measuring housing quality: Potential ways to improve data collection on housing quality in New Zealand.

Streimikiene, D. 2015. Quality of life and housing. International Journal of Information and Education Technology, 5(2), pp. 140-145.

Turner, J.F.C. 1977. Housing by people: Towards autonomy in building environment. New York: Pantheon Books.

Zunguzane, N., Smallwood. J. & Emuze, F. 2012. Perceptions of the quality of low-income houses in South Africa: Defects and their causes. Acta Structilia, 19(1), pp.19-38.