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Towards A Multidisciplinary Framework to Improve the Quality of Structural Masonry in Developing Countries: Case Study of South Africa

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Abstract **-** Given the current state of structural masonry in South Africa (SA), the study titled "Towards a multidisciplinary framework to improve the quality of structural masonry in developing countries" is much required. The paper provides a foundation for the multidisciplinary framework, with the components of the framework being shaped by insights from expert interviews. This issue is not exclusive to South Africa; numerous other developing nations also lack such a framework. The intricacy of structural masonry issues cannot be reduced to a single discipline or perspective. This particular dimension is not adequately addressed in the literature. The adverse overall impact will be significant and unacceptable unless every building, particularly those constructed of structural masonry, is of the highest possible quality, as a result of the growing demand for masonry structures in the future decades. The objective of the investigation is to pinpoint the fundamental principles that are essential for the development of a preliminary multidisciplinary framework. The study concludes by introducing a novel preliminary multidisciplinary framework that is compatible with other disciplines and has the potential to be further developed and investigated.

Keywords**:** masonry construction industry; masonry structures; multidisciplinary framework; expert interviews, South Africa

1. Introduction

With the rising costs of construction and the increasing focus on environmental sustainability and energy efficiency, it is crucial to take immediate action to improve the overall quality of structural masonry. Making sure that structural masonry meets safety standards is a significant task that has important economic, environmental and energy considerations. An initiative focused on promoting sustainable construction practices is required. Effectively tackling intricate challenges or barriers in structural masonry requires a comprehensive approach that incorporates a wide range of principles, concepts and practices. The resolution of complex issues in structural masonry requires the collaboration of multiple disciplines, as working in isolation within our professional disciplines is not effective.

Having effective policies in place is essential for promoting collaboration and communication among the various disciplines engaged in structural masonry. The smooth functioning of different fields that involve different parties often depends on particular policies and frameworks, such as the National Building Regulations (NBR) and Building Standards (BS) [1]. However, this inadvertently results in an intricate web of policies within organisations, which can be challenging to put into action. However, a multidisciplinary framework can assist individuals who may not have expertise in the subject, such as clients, in effectively navigating these complexities. Smooth integration within other frameworks often requires a

common attribute. Moreover, this feature promotes comparability, guaranteeing that stakeholders' individual objectives can be achieved while still aligning with the industry's overarching goals.

The objective of this investigation is to pinpoint the fundamental principles that are essential for the development of a preliminary multidisciplinary framework. This study delves into the current state of structural masonry in South Africa (SA). Furthermore, the research reviews pertinent literature on structural masonry and proposes components for a multidisciplinary framework. This study reached conclusions about specific components that are crucial for producing high-quality structural masonry in South Africa, drawing on insights from interviews with experts in the field of structural masonry. It is worth noting that this paper is a part of a larger ongoing study aiming to improve the quality of structural masonry through developing a highly desirable, holistic Framework.

2. Structural masonry popularity in developing nations

Masonry is an incredibly versatile building material that can be used to construct a wide variety of structures, from simple residential homes to complex commercial buildings. This feature makes it an excellent choice for developing countries, which often have diverse building requirements. Masonry is widely recognised as a sustainable building material because it can be produced using locally sourced materials.

Developing countries heavily rely on masonry construction for several reasons. Masonry, being a labour-intensive building material, has the potential to create employment opportunities. Developing countries, which frequently experience high unemployment rates, greatly benefit from this. Masonry is a cost-effective building material, especially when compared to alternatives such as steel or concrete. The prevalence of masonry in developing nations may be ascribed to the accessibility of raw materials, including brick, stone and other mortar ingredients. High-quality masonry is renowned for its durability as a building material, able to withstand a wide range of severe weather conditions. Saving money and minimising the environmental impact can be achieved by reducing the reliance on imported building materials. The energy required for manufacturing and construction of certain masonry units or construction materials is relatively low, also known as embodied energy [2]. This is important for reducing carbon emissions and conserving limited non-renewable fuel resources.

3. Concerns about structural masonry in SA

A notable portion of grievances reported to the Engineering Council of South Africa (ECSA) are related to structural engineering and construction, along with its associated infrastructure Crofts [3]. The existence of structural oversights can be ascribed to the actions of rogue engineers who develop structural solutions without proper engineering justification. Architectural and structural engineering professionals often overlook the structural limitations of masonry walls, including freestanding, retaining and partition walls. In addition, Crofts [4] highlights the importance of constructing masonry façades in accordance with approved standards and in compliance with the National Building Regulations (NBR). This ensures that the façades will maintain their functionality and durability over the entire lifespan of the building. In certain instances, the contractor can be held accountable for the failure of façades, as a result of insufficient participation from a qualified individual. Crofts [4] reports that there are instances where failures occur in larger façades that have been designed in a rational manner. These failures can result in financial losses, injuries and even fatalities. The individual who is designated as the competent person, according to NBRs, may be exempted from liability. This exemption is due to a fragmented appointment that limits responsibilities to a specific member or structure. According to the guidelines set forth in the NBRs, it is the responsibility of the owner to appoint qualified individuals who have been approved by the relevant authorities to ensure compliance with the functional regulations related to a specific structural system. In addition, the owner must designate an authorised individual who will have ultimate accountability for the design of the system. This is especially important when multiple individuals are responsible for different aspects of the implementation of the system. Multidisciplinary frameworks are necessary to ensure that stakeholders possess similar attributes, thereby facilitating the achievement of each stakeholder's specific objectives while still serving the overarching goals of the industry.

de Villiers, et al. [5] examines the alignment between the loading code and the regulations of the NBRs regarding masonry walls. The study found that the geometric arrangement permitted by the deemed-to-satisfy regulations significantly significantly weakened the structure's resistance to wind forces acting perpendicular to its plane, as well as its vulnerability vulnerability to damage from earthquakes. Therefore, it is crucial to reevaluate and update the NBRs regarding the arrangements of masonry wall panels, specifically taking into account the most recent amendment to the South African loading code. In their study, de Villiers, et al. [6] identified the absence of established standards and a limited understanding of the structural performance as the primary causes of masonry failure. de Villiers [7]' study found that a notable number of affordable, single-story houses built with government funding are made using traditional masonry materials such as burnt clay and concrete. This study discovered that the absence of established and up-to-date frameworks is a major barrier to the widespread acceptance and implementation of alternative masonry units. An extensive examination is conducted to assess the regulatory structure concerning the use of masonry in South Africa, while also investigating possible ways in which alternative masonry units could potentially enter the market. It is worth pointing out that the existing regulatory framework does not effectively support the practical implementation of alternative masonry units, thus hindering their widespread and easily applicable integration. As demonstrated in this instance, stakeholders can be guided by a multidisciplinary framework to integrate knowledge and viewpoints from various disciplines, ensuring that a variety of masonry unit applications are investigated and implemented, if deemed appropriate.

The research conducted by Mahachi [8] unveils a notable dependence on entry-level material suppliers and building contractors in the low-income housing sector in South Africa, leading to substandard housing infrastructure. Furthermore, the improper characterisation of soil is a significant factor contributing to insufficient structural design, in a manner that results in an inadequate foundation solution. Additionally, the presence of construction elements, that do not meet design specifications, the use of inappropriate or substandard construction materials, subpar workmanship and the absence as well as inadequacy of service infrastructure, such as storm-water systems, also contribute to these failures. Mahachi, et al. [9] state that the construction industry has experienced significant expansion, resulting in a scarcity of skills among new entrants and a decrease in the quality of construction, particularly in masonry structures. The accuracy of the claim is supported by numerous occurrences of structural failures and substandard workmanship in the residential construction sector. The researchers of this study contend that the absence of a multidisciplinary framework that incorporates multiple disciplines in the housing infrastructure sector, which necessitates the involvement of various stakeholders for implementation and relies heavily on structural masonry that is also reliant on multiple stakeholders for design, detailing and construction, contributes to the root causes of failures within the housing infrastructure.

4. Social Engineering Framework

The research conducted by Khuzwayo, et al. [10], which was informed by a variety of published scholarly work on structural masonry within the context of South Africa, came to the conclusion that SA Structural Masonry needs to improve on several key principles, including compliance, ethics and knowledge. Their study also highlights the importance of having relevant knowledge and ethical conduct in order to achieve compliance. It emphasises the need for frameworks to be developed to support and guide the masonry construction industry (MCI) in understanding the necessary knowledge components and ethical attributes required from stakeholders to comply with National Building Regulations (NBR). Introducing a multidisciplinary framework can greatly enhance collaboration by fostering and promoting collaboration among various disciplines within MCI. A multidisciplinary framework should include a variety of disciplines among MCI stakeholders. To foster responsible and sustainable development in various sectors, it is essential to establish all-encompassing frameworks that integrate ethics, knowledge and compliance equally within the realms of engineering and the construction of structural masonry. Such a framework could provide a comprehensive approach to decision-making and project management.

5. Structural masonry industry stakeholders

The structural masonry industry encompasses two primary categories of stakeholders: external stakeholders and stakeholders. Internal stakeholders are individuals who are directly involved in the production and delivery of masonry and services. External stakeholders are comprised of individuals or entities who are impacted by the structural masonry market but do not possess direct involvement in its development or implementation. Figure 1 shows the masonry industry (MCI) stakeholders.

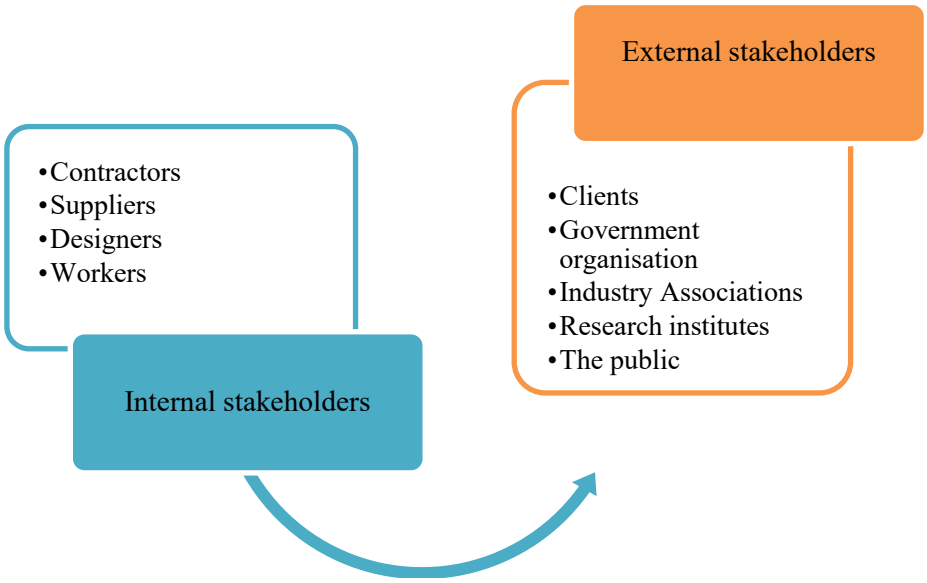

Fig. 1: MCI internal and external stakeholders.

The Department of Labor (DoL), clients, the Construction Education and Training Authority (CETA), the Engineering Council of South Africa (ECSA), the National Home Builders Registration Council (NHBRC) and the South African Bureau of Standards (SABS) are stakeholders in south Africa's MCI. The lack of a multidisciplinary framework in South Africa renders the functioning of the MCI uncertain. A multidisciplinary framework is considered appropriate when a complex issue or obstacle requires the amalgamation of knowledge and understanding from multiple disciplines. This study therefore identifies themes that are necessary and ought to be incorporated into a preliminary multidisciplinary framework.

6. Structural Masonry Frameworks

According to Crofts [11], there are two South African standards that offer a comprehensive overview of structural masonry design. The structural design principles of Limit States theory forms the foundation of these standards or frameworks. South African materials standards also regulate the production of a diverse array of masonry structures. In the sphere of construction regulations and standards, the inclusion of SANS 10400-K: Walls [12], which pertains to wall application, is a significant accomplishment. According to Watermeyer, et al. [13], structural engineers, including masonry designers, are expected to create structures that comply with pertinent regulatory frameworks and verify the design during construction. Furthermore, it is imperative that designers evaluate their operations to ensure their safety. The structural defects of residential housing in South Africa are, according to Mahachi [14], somehow influenced by the

same technical frameworks in the way they are structured. Therefore, it is essential to implement proactive risk management in order to maintain the integrity of the masonry structure.

7. Research Gap

This study identifies a gap that leads to the ineffectiveness of various existing frameworks, including the lack of compatibility between different frameworks and design standards. This suggests that a significant change in the development development and implementation of these frameworks is required. This study recognises a gap in knowledge and emphasises emphasises the significance of taking into account the specific context of the intended use of the framework. Therefore, it is crucial to have measures in place to ensure their successful implementation. Without a deep understanding of the intricacies, some nations struggle to progress in the right direction. As a result, this study recognises this as a practical knowledge gap, which [15] noted is often overlooked by some researchers. Many studies have focused on the theoretical aspects of structural masonry. However, there is a significant lack of research focusing on the difficulties associated with establishing standards for structural masonry. This is a crucial matter that deserves thorough examination, especially in the context of developing countries that have yet to achieve their sustainable development goals (SDGs). It is essential to discuss the necessary steps to effectively achieve the SDGs set by the United Nations in 2023.

8. Data collection

The study follows a qualitative research method. Experts from diverse engineering disciplines were interviewed to gain insight into the issues affecting the quality of structural masonry in South Africa. Data collection for qualitative research is unstructured and adaptable [16]. To date, this ongoing study has conducted five expert, semi-structured pilot interviews. Experts were able to express themselves freely due to the provision made relating to the adaptability and absence of constraints of the research methodology. This provided an opportunity to gather extensive data and ask insightful questions about the challenges associated with structural masonry quality.

The interview guide included a variety of structured questions for experts to answer, specifically designed to gain valuable insights into the challenges associated with building frameworks. The main author transcribed the expert interviews verbatim. Guided by the procedures provided by Rowley [17], the following steps were used to analyse the data: The researcher organised the data set, became acquainted with it, classified, coded and interpreted it, presented and documented it and finally presented the findings. A thematic analysis was conducted following the guidelines provided by Terry, et al. [18]. It provided various key themes that emerge as a result of the research to form a logical narrative [19].

In addition, as a check, the research team used NVivo 12 [20], a software application designed for qualitative data analysis, to efficiently organise unstructured mixed text data. NVivo streamlined data categorisation and arrangement by identifying recurring themes and patterns. The data was classified and organised into various thematic categories. The findings for this study are presented in narrative form and in the order in which the interviews were conducted

9. Results and discussion

Interview 1: Geotechnical/structural engineering and project implementation background

The first expert stated that there are various sites, especially the reconstruction and development programme (RDP) houses, that have numerous variables that are challenging to manage. Supervision is not carried out by a qualified individual who has the necessary expertise to conduct inspections, ideally from NHBRC or the Local Municipality. This is a common occurrence on numerous construction sites. Engineers typically charge for each visit once the initial design is complete and their fees can be quite high. Furthermore, it is common for NHBRC and Municipals to include clauses in their extensive documents that individuals must sign when taking on projects. For instance, "*I fully dedicate myself to completing all tasks and suddenly I am faced with the daunting challenge of reading 70 pages"*. How do you plan to handle this situation? "*After making a declaration, there are 6 pages outlining the planned actions*". Consequently, the Municipality and the National Home Builders Registration Council (NHBRC) absolved themselves of any accountability for the quality of the work by asserting that they had appointed personnel. It is crucial to have a comprehensive system of supervision or inspectors on

construction sites that utilise structural masonry as a construction material. These individuals should possess a deep understanding of the specific qualities and characteristics to look for in order to ensure the highest standards of safety quality.

Interview 2: Architectural/structural and project implementation background

The second expert stated that they are quite fortunate in the architectural profession; "*I am not sure about the engineers"*. As members of the architectural profession, we have a concession from the South African Bureau of Standards (SABS). "*There are approximately thirty or forty standards we can download for free"*. The expert also believed that there is often insufficient coordination between consultants leading to poor quality of detailing of structural masonry. "*I believe the level of detail needs to be improved.*" In other countries in Europe (the European Council of Civil Engineers (ECCE)) and the United States of America (USA), the American Society of Civil Engineers (ASCE) has systems in place where they maintain a certain standard in terms of monitoring activities such as detailing, reporting and so forth.

Interview 3: Structural engineering, education and training, forensic engineering and project implementation

According to the third expert, most professionals do not fully understand the Standards. Some do not even have copies due to cost issues. "*The main issue I see is that they are so expensive that the majority of people cannot afford them*." The South African Bureau of Standards (SABS) has a paywall that prevents access unless you have the funds; they are quite expensive. Furthermore, our standards have many flaws and are far from perfect. Masonry designers frequently state in broad strokes that all relevant SABS standards should apply. However, you are unable to do so. Many of them contain contradictions. The vast majority of the standards are out of date and behind the times. Furthermore, the SABS frequently makes cosmetic changes to their Standards, changing a word here and there, leaving you with the impression that you must purchase a completely new Standard, which is extremely expensive. The only legitimate way to do so is to buy it online from the SABS. "*You can still buy physical hard copies, but it is more expensive these days and they discourage it, so most people buy online."* As a result, it immediately excludes people who do not own or have access to computers and who do not have credit cards. Another issue is that even though people have access to standards, they do not read them, partly because they are not reader-friendly or user-friendly. Additional criticism levelled at the standards is that they do not always provide reasons. The standard must explain why you should do something. For example, the masonry walling Standard requires that burnt clay bricks be soaked the day before use. The question is: "Why? Why do you need to soak them beforehand?" If people do not understand why, they say, "We are not paid to pre-soak this, so why bother? Nobody is checking on us, so why bother?"

Another challenge is that most practitioners learn from what they see done on other sites or projects, which frequently leads to common mistakes. If you have only ever seen the wrong way to do something, you will continue to do it that way. The expert also believed that "*we should modularise and systematise the masonry building industry, as is done in the automobile industry, which has some merit but does not work when an architect wants to make a statement. Most architects want to make every second job they do their opus magnum and make it unique to impress other architects, while making it extremely difficult to design and build."*

In addition, the expert suggests that the industry should consider implementing minimum requirements for individuals entering the building industry, such as the need for a matriculation qualification. As an illustration, the industry might suggest that individuals interested in becoming house builders should possess the ability to comprehend a basic manual, among other skills. It is important for the industry to emphasise the necessity of a basic qualification for all individuals involved in structural masonry. It is crucial for the masonry industry to include subjects in the curriculum at universities and technical schools in order to guarantee the teaching of essential critical concepts. It would be beneficial for the industry to implement a requirement for brick layers to complete a comprehensive training course. While the quality may not be on par with previous standards, it is important to establish mandatory guidelines.

The expert also believes that not all stakeholders were meeting their obligations. The clients are not meeting their obligations, they are not always fair to the contractor or the design professionals, they do not always pay on time, they withhold money and "*everyone is getting screwed financially*," So that is where it starts and everyone in the supply chain is chain is taking shortcuts and ignoring standards. "*I mean, if a materials supplier sells plaster sand that does not meet the the National Standard, which is 1090, he jeopardises everything. It is similar to the concept that a chain is only as strong as as its weakest link. To have a successful structural masonry industry, every link in the chain must be strong and any weak weak link undermines quality. So, the design professionals are ignorant, the builders are unqualified, there are no skills, the material suppliers provide defective materials and the client is unreasonable in terms of deadlines. Everyone is guilty. The government is guilty of failing to provide conditions conducive for the continuity of work."*

The expert also states that if you purchase bricks or blocks made to South African standards, you should not have any problems. However, the expert believes that there is no longer a single manufacturer in the Republic of South Africa producing concrete block in accordance with SANS 1215 [21]. The majority of these block or brick manufacturers make no claim that their products are fit for purpose. Additionally, some standards do not specify the limit to water absorption.

Interview 4: Structural engineering, education, construction and project implementation background

The expert believes that there are insufficient guidelines or standards for dealing with hand-pressed concrete blocks on-site, which are still a challenge today. "*This must be addressed immediately by conducting conditional site assessments and looking at, particularly in poorer areas, where guys are using them or supplying local hardware stores and people are purchasing from them.*" They lack South African Bureau of Standards (SABS) or other appropriate approvals but they are still in use. *"Sometimes, you can see that those blocks have issues and some are even unfit for purpose."*

Some blocks or bricks are produced by third-party blenders and manufacturers. These individuals typically acquire a quarry or assume ownership of an existing quarry. They acquire machines from overseas at a discounted or favourable price. They commence production but the dimensions of the bricks do not precisely match the standard format bricks specified in the masonry standard. This results in dimensional out of tolerance, or dimension issues. They possess some knowledge, information and expertise in masonry; however, they are not technically inclined and have not been in the industry for an extended period of time to be aware of the necessity of knowing the basic technical specifications of their products in the event that clients, engineers, or architects request of them.

Furthermore, the global trend is to try to standardise codes; various countries, including the majority of them, are moving towards European standards (Euro codes). The entire world appears to be moving towards standardising codes and ensuring that everyone is working with the same or similar code. The standardisation of the code does not imply that we will use the same code; rather, it is done in such a way that everyone refers to the same standard, with annexures in each country to account for local conditions. As a result, the vast majority of the basic information, specifically the preambles, should be the same. So, it is the same code but with Annexures specific to each country.

There are also insufficient institutes dedicated to promoting masonry work. The expert believes that the steps to address some of the masonry issues will be taken at different levels. For example, in terms of Standards, the first step would be to establish a working society; these working societies are typically comprised of university professors, industry experts in masonry design, manufacturers, other key stakeholders, as well as contractors who are also involved in specialist masonry. This would be one way to address the issue of our standards not being updated or calibrated to reality.

In addition, all stakeholders must follow the Construction Regulations, which outline the duties and responsibilities of the client, designer and contractor. "*That, I believe, is the starting point; the client, as well as design consultants, architects, engineers, contractors and subcontractors, each have specific duties and responsibilities. For example, as a structural masonry designer, you need to be familiar with the relevant codes, standards and industry norms."*

The expert believes that low-cost developments are riskier and involve a significant trade-off between competing requirements or priorities and voices the following comments. On the one hand, we are attempting to balance aesthetics, on the other, safety and integrity and on the third, economy. When you are attempting to balance all of these competing requirements, there is a greater risk of one of them being pushed to the side. With all of these competing requirements, there is also the environment to consider; the designer does not want to overspecify and use excessive materials. There is also an

urgent need to use locally available materials to cut transportation costs and carbon emission. The engineer's primary concern is the safety of the design; and not to design to the bone. So, these are the primary competing requirements. All of these requirements or priorities must be considered while avoiding the trade-off for safety.

The expert also states that during engineering studies on campus, the codes were available for free in the University Library, gradually, from that time, the Standards have become less available and payment is required.

There is also little to no action being taken to mitigate the effects of climate change on masonry design. Our codes have not been updated and there is no industry-wide guidance on how to better account for or specify climate change resilience in our designs or masonry.

South Africa lags behind and fails to keep up with other industrial countries, such as the USA. For example, when there is a masonry panel with openings, there is little information on how to reinforce large windows and doors. "*There are definitely stipulations and guidelines in the American Standard for detailing that provide guidance on how to detail structural masonry properly in such circumstances."*

Interview 5: Architectural/structural and project implementation background

The expert claims to have used the deemed-to-satisfy rules on several projects. However, they lack flexibility. If the deemed-to-satisfy rules are too stringent, it discourages innovation. For example, deemed-to-satisfy rules appear to limit the incorporation of emerging construction materials, technologies and practices into projects due to a lack of adaptability. Furthermore, they appear to ignore local conditions, failing to consider local climate, topography, community needs and potential challenges. Projects are specified differently. Some aim for sustainability, while others are cost-effective and deemed-to-satisfy rules must include such conditions.

South Africa has effective regulations and standards. The challenge, however, is to enforce them and provide a viable environment in which they can function. There are no knowledgeable inspectors patrolling construction sites. Some of these building regulations and standards are extremely old, dating back to the 1960s. They have never been updated as new technologies emerge. New construction methods and practices have recently emerged but are not incorporated into regulations.

Structural masonry designers must understand that structural masonry, including their designs, must be inspected for compliance. An independent professional must review the work to ensure that it meets the standards. Also, when there are changes during the construction process, extreme caution must be followed. When changes occur, careful consideration is required to assess their impact.

The challenge is keeping up with the changes and revisions to some standards, which are constantly being revised without the formal notification of the professionals. A standard that has been amended must be used.

Finally, in Africa, there is an extremely poor maintenance culture. The infrastructure is either poorly or not maintained at all. There is little or no budget for maintenance. Things work differently in the United States. Building standards require that every public and private building be inspected every two years, with structural, architectural, energy and sustainability inspections and certificates issued. In South Africa, this is often overlooked.

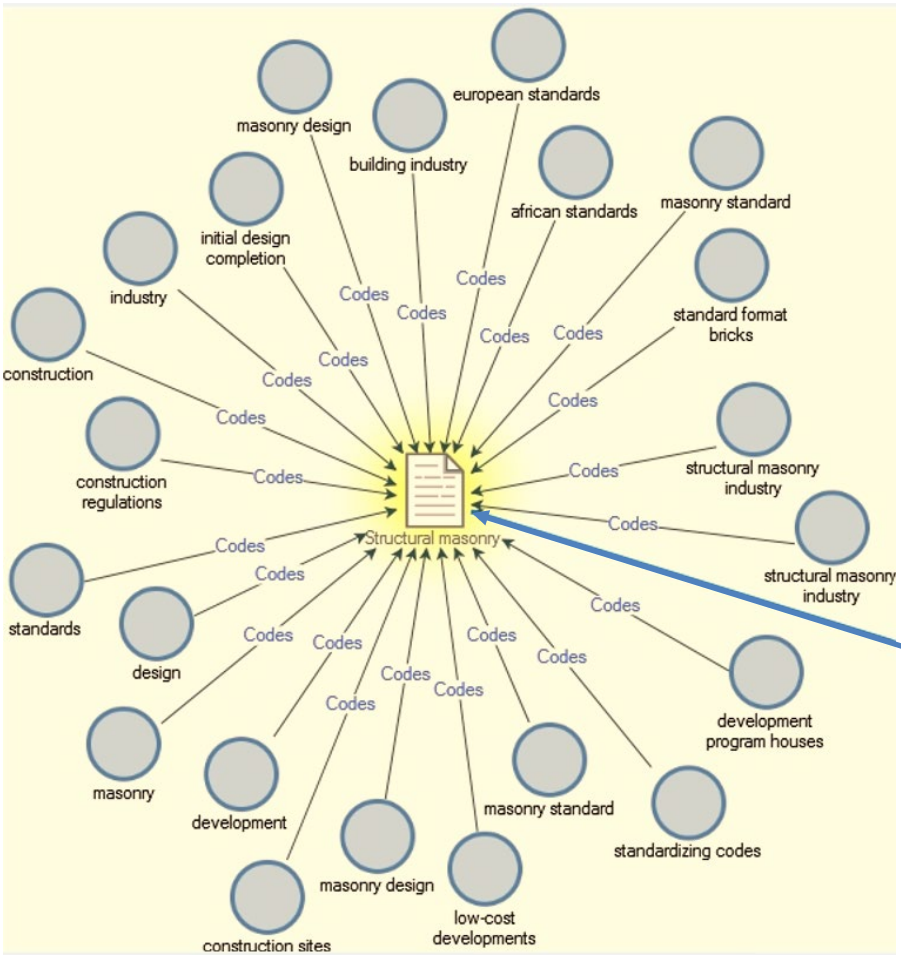

Fig. 2: NVivo 12 mind map.

The table below presents a summary of the current challenges identified by the expert interviewees.

Table 1: Summary of the current obstacles hindering the quality of structural masonry.

Theme	**Finding**	**Agreement among experts**
Building Standards/Frameworks	Inaccessible, outdated, ambiguous and not user-friendly	Expert #1, #2, #3 , #4 and #5
Construction Methods and Techniques	Inadequate, noncompliant and sometimes unnecessarily complicated.	Expert #1, #3 , #4 and #5
Design Principles	Inadequate, noncompliant and sometimes unnecessarily complicated.	Expert #1, #2, #3 , #4 and #5
Education and Training	Inadequate and inaccessible.	Expert #1, #2, #3 , #4 and #5
Materials	Noncompliant, inaccessible and costly.	Expert #1, #2, #3 , #4 and #5
Quality Control	Inadequate.	Expert #1, #2, #3 , #4 and #5

10. Proposed themes for the Structural Masonry Framework

The diagram below depicts the components that emerged from the expert interview, with some introduced during the literature review. Themes, such as Materials, Quality Control, Construction Methods and Techniques, Design Principles, Building Standards and Education and Training, must be fit-for-purpose and revolve around the core goal of developing a

framework to improve the quality of structural masonry. Future development of the multidisciplinary framework will include other critical frameworks such as those pertaining to sustainability, resilience and durability, among many other aspects that will be realised in the future.

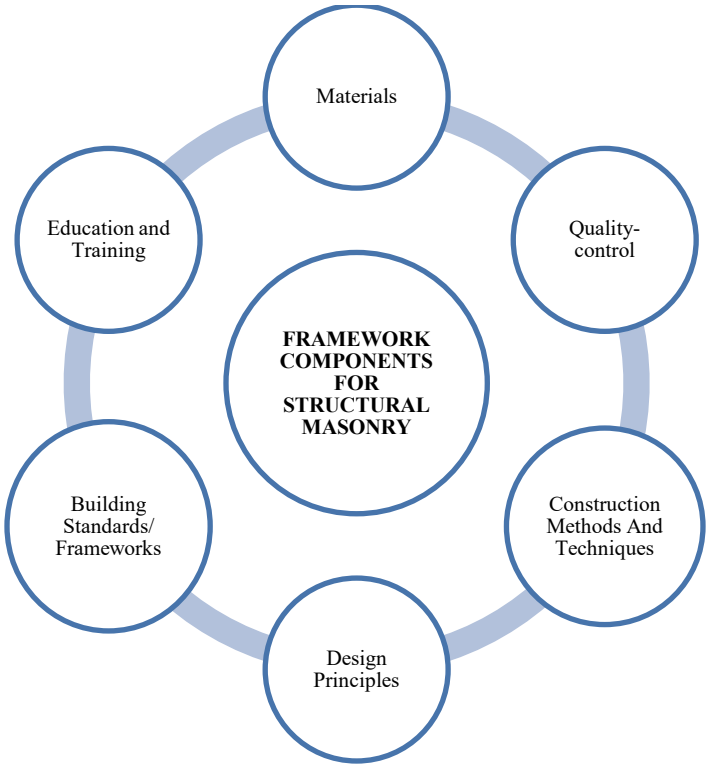

Fig. 3: Framework Components for Structural Masonry.

11. Limitation of the study

Although the study involved interviews with professionals in the field of civil engineering, particularly in structural masonry, there may be varying opinions on building frameworks. These differences can be attributed to individual experiences, such as the engineering consultants with whom they have worked, their educational background, their level of experience and the projects of which they have been part.

12. Conclusions and recommendations

The paper provides a foundation for the multidisciplinary framework, with the components of the framework being shaped by insights from expert interviews. The interviews with various experts in geotechnical, structural engineering and architecture reveal significant challenges and shortcomings in the standards and practices governing construction, particularly in South Africa. The following lessons can be drawn:

- **Supervision and Accountability:** Many construction sites lack qualified supervision, leading to poor quality control. The National Home Builders Registration Council (NHBRC) and local municipalities often absolve themselves of responsibility through hidden clauses. Thus emphasising the need for a robust system of inspectors knowledgeable in structural masonry.
- **Access to Standards:** The South African Bureau of Standards (SABS) has high costs associated with accessing standards, which limits availability for many professionals. This results in a lack of understanding and adherence to standards, which are often outdated and poorly communicated.

- **Coordination and Detailing:** There is insufficient coordination among consultants, leading to poor detailing in structural masonry. The need for improved detail and adherence to standards is emphasised, with comparisons drawn to more organised systems in Europe and the United State of America (USA).
- **Training and Qualifications:** Experts suggest implementing minimum qualifications for individuals entering the construction industry and enhancing educational curricula to include essential masonry concepts. There is a call for mandatory training for bricklayers to improve overall quality.
- **Supply Chain Issues:** The entire construction supply chain is criticised for taking shortcuts, with clients often failing to meet their obligations, which affects contractors and design professionals. The quality of materials supplied is also a concern, with many not meeting national standards.
- **Emerging Technologies and Flexibility:** Current regulations, particularly deemed-to-satisfy rules, are seen as inflexible and outdated, hindering innovation and adaptation to local conditions. There is a need for regulations to evolve alongside new construction methods and materials.
- **Maintenance Culture:** The lack of a maintenance culture in South Africa leads to deteriorating infrastructure, contrasting sharply with practices in countries such as the USA, where regular inspections are mandated.
- **Climate Change Considerations:** There is a notable absence of guidelines addressing climate change resilience in masonry design, indicating a gap in current standards.

Overall, the interviews highlight the urgent need for updated standards, better training and supervision, improved coordination among stakeholders and a shift towards a more proactive maintenance culture to enhance the quality and safety of structural masonry in South Africa.

13. Conflict of interest

The researchers affirm that they have no conflicts of interest.

14. Ethical Statement

The research was carried out with ethical approval. Ref #: 2183.

15. References

[1] NBR and BS Act 103 of 1977, "National Building Regulations and Building Standards Act 103 of 1977," in *5640*, S. A. Government, Ed., ed. Republic of South Africa: South African Government, pp. 1-17.

[2] F. Asdrubali, G. Grazieschi, M. Roncone, F. Thiebat, and C. Carbonaro, "Sustainability of building materials: Embodied energy and embodied carbon of masonry," *Energies,* vol. 16, no. 4, p. 1846, 2023.

[3] F. Crofts, "Contraventions of ECSA's Rules of Conduct over the last ten years: has there been any change in professional conduct?: structural engineering," *Civil Engineering= Siviele Ingenieurswese,* vol. 2015, no. 2, pp. 11-19, 2015.

[4] F. Crofts, "Notable masonry façade failures–who is ultimately responsible?," *Civil Engineering= Siviele Ingenieurswese,* vol. 2018, no. 2, pp. 11-16, 2018.

[5] W. I. de Villiers, G. P. A. G. van Zijl, and W. P. Boshoff, "Review of compatibility between SANS 10400 deemed-to-satisfy masonry wall provisions and loading code," *Journal of the South African Institution of Civil Engineering,* vol. 63, pp. 45-60, 2021. [Online]. Available: http://www.scielo.org.za/scielo.php?script=sci_arttext&pid=S1021-20192021000100005&nrm=iso.

[6] W. I. de Villiers, G. P. A. G. Van Zijl, and W. P. Boshoff, "Finite element analysis of single-storey unreinforced alternative masonry walls," *Advances in Structural Engineering,* vol. 24, no. 9, pp. 2011-2026, 2021/07/01 2021, doi: 10.1177/1369433221992483.

[7] W. I. de Villiers, "Computational and experimental modelling of masonry walling towards performance-based standardisation of alternative masonry units for low-income housing," Stellenbosch: Stellenbosch University, 2019.
[8] J. Mahachi, "Limiting structural damage on masonry structures due to foundation movement," 2019.
[9] J. Mahachi, L. Khanye, and A. M. Goliger, "Calibration of brick masonry partial safety factors for the South African Code," 2007.
[10] B. Khuzwayo, M. Walker, and B. Graham, "Improving South African Masonry Construction Industry," Durban University of Technology, Journal Article, 11 November 2023, 2023.
[11] F. Crofts, "The case for the adoption of Eurocode 6 in South Africa," *Civil Engineering= Siviele Ingenieurswese,* vol. 2014, no. 2, pp. 46-50, 2014.
[12] *The application of the National Building Regulations Part K: Walls,*, SANS 10400-K: Walls, 1 Dr Lategan Road Groenkloof, Private Bag X191 Pretoria 0001,, 25 March 2023 2015. [Online]. Available: https://libapp1.dut.ac.za/sabs/documents/SANS10400-K.pdf
[13] R. Watermeyer, T. Smith, and M. Visser, "The JSD list of structural engineering professionals," *Civil Engineering = Siviele Ingenieurswese,* vol. 2016, no. 2, pp. 27-28, 2016, doi: doi:10.10520/EJC188044.
[14] J. Mahachi, "Performance measurement of quality of houses: development of a building quality index for houses," in *Construction Materials and Structures*: IOS Press, 2014, pp. 1517-1523.
[15] D. A. Miles, "A taxonomy of research gaps: Identifying and defining the seven research gaps," in *Doctoral student workshop: finding research gaps-research methods and strategies, Dallas, Texas*, 2017, pp. 1-15.
[16] A. Moser and I. Korstjens, "Series: Practical guidance to qualitative research. Part 3: Sampling, data collection and analysis," *European Journal of General Practice,* vol. 24, no. 1, pp. 9-18, 2018/01/01 2018, doi: 10.1080/13814788.2017.1375091.
[17] J. Rowley, "Conducting research interviews," *Management Research Review,* vol. 35, no. 3/4, pp. 260-271, 2012, doi: 10.1108/01409171211210154.
[18] G. Terry, N. Hayfield, V. Clarke, and V. Braun, "Thematic analysis," *The SAGE handbook of qualitative research in psychology,* vol. 2, pp. 17-37, 2017.
[19] M. I. Alhojailan, "Thematic analysis: A critical review of its process and evaluation," *West east journal of social sciences,* vol. 1, no. 1, pp. 39-47, 2012.
[20] C. Houghton, K. Murphy, B. Meehan, J. Thomas, D. Brooker, and D. Casey, "From screening to synthesis: using nvivo to enhance transparency in qualitative evidence synthesis," *Journal of clinical nursing,* vol. 26, no. 5-6, pp. 873-881, 2017.
[21] *SANS 1215*, SANS 1215, Republic of South Africa, 5 May 2024 2008.