RESEARCH REPORT

Hybrid Eco-Tech in the South African Built Environment: Enhancing Contextually Responsive Building Practices through Emerging Technologies

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DECLARATION OF ORIGINALITY

I declare that the mini-dissertation, Extended ways of working: design processes and Emerging technologies, which has been submitted in fulfilment of part of the requirements for the module of DIT 801, at the University of Pretoria, is my own work and has not previously been submitted by me for any degree at the University of Pretoria or any other tertiary institution.

I declare that I obtained the applicable research ethics approval in order to conduct the research that has been described in this dissertation.

I declare that I have observed the ethical standards required in terms of the University of Pretoria's ethic code for researchers and have followed the policy guidelines for responsible research.

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Date: …24 July 2023……

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Abstract

The thesis explores the notion of hybrid tectonics in the context of contemporary African architecture, investigating the dynamic interplay between global influences and local traditions. Through an extensive analysis of architectural practices and projects, this research seeks to understand how architects integrate both modern and traditional construction techniques to create sustainable and contextually responsive buildings. By delving into the complexities of design decisions and material choices, the study sheds light on the agency of architects in shaping the built environment while preserving cultural identities.

Drawing from a diverse range of case studies across the African continent, the thesis emphasizes the importance of situating architecture within its socio-cultural context. The findings reveal how the coexistence of advanced technological innovations and traditional craftsmanship contributes to the evolution of architectural language, fostering a distinctive identity that reflects both global modernity and local heritage. Ultimately, this exploration of hybrid tectonics offers valuable insights for architects, researchers, and policymakers in their pursuit of sustainable and culturally relevant architectural design in an ever-globalizing world.

Key Terms

Architectural design process

The dynamic interplay between technology and practitioners that shapes the built environment. It consists of a systematic and creative approach taken by practitioners to create and develop meaningful and impactful built environments. Technology plays a significant role in providing tools, methods, and materials that enable architects to explore innovative design solutions and address various challenges (Breen, 2018). This interplay between technology and practitioners extends beyond digital tools and includes the integration of sustainable technologies, which enable architects to address environmental concerns, and create sustainable and contextually responsive built environments.

Current building practice

The term current building practices refers to the present-day use of conventional building technologies (CBT's) (Ampofo-Anti, 2017, p. 2). This practice is associated with well-defined and well-developed means of construction that have been trusted and currently used by the construction industry for architectural practices, which can be further defined by a linear building process that considers design and construction processes as separate entities. Current building practices can therefore be critiqued for having a "reputation for its slow uptake of technology compared to other industries such as manufacturing, agriculture and entertainment" (Calitz & Wium, 2021).

Building technology

A building technology refers to the diverse range of materials, construction processes or structural systems utilised in the construction industry within the built environment. As highlighted by Wu, Wei, and Peng (2019), building technology is not a static concept but continuously evolves through ongoing development and innovation. The evolution of building technology is driven by the need to enhance construction processes, improve performance, and adapt to evolving societal, environmental, and economic demands.

Emerging building technology

An emerging building technology (EBT) encompasses a range of building technologies that extend beyond current building practices. These technologies span from low-tech local traditional techniques, such as indigenous technologies, which have not yet gained widespread adoption, to high-tech global technologies, like digital manufacturing, which are in the developing process within the South African context. EBT refers not only to new technologies but also to the ongoing evolution of existing materials, techniques, or structural systems. Wienecke (2010: 128) highlights that emerging technologies often have significant societal, environmental, or economic implications.
In the South African context, EBTs can be defined as new or continuation of a building technology within a 15-year timeframe, categorized along the spectrum of low-tech to high-tech and underdeveloped to developed. These technologies embody intrinsic value and aim to contribute to social, economic, and contextual responsiveness in the South African built environment.

Hybrid

In this study, the term *hybrid* refers to the integration of global and local tectonics within the architectural context. Initially, it signifies the simultaneous utilization of both global and local tectonic approaches during the scoping phase of the research. However, as the analysis of the case progresses, the definition of hybrid evolves to emphasize a mutual subversion between global and local tectonics, leading to their inseparability in terms of visual and physical integration. This concept of hybridity embodies an interplay of diverse tectonic elements, transcending conventional stylistic categories and resulting in a cohesive and harmonious architectural expression. According to Louw (2000: viii), hybridity in architecture involves "the fusion of diverse cultural elements and constructional systems", further enhancing its capacity to transcend traditional boundaries and embrace a more inclusive approach.

Eco-tech

Eco-tech, derived from the term *ecological technology*, refers to an approach in building practices that integrates sustainable design principles with high-tech solutions (Slessor, 1997: 7). It represents a paradigm shift towards environmentally conscious and contextually responsive building technologies and systems. Eco-tech encompasses the use of innovative materials, energy-efficient systems, renewable energy sources, waste reduction strategies, and smart building technologies to minimize the environmental impact of buildings and enhance their overall sustainability (Slessor, 1997; Breen, 2018). This concept promotes a holistic and integrated approach to sustainable architecture, aiming to create more responsive and resilient built environments (Slessor, 1997; Breen, 2018).

1.1 Background

The built environment is intricately shaped by the interplay between technology and practitioners, expressed through the architectural design process. In the contemporary era of globalization, where the world has become increasingly interconnected, the dynamics of this relationship have undergone a significant transformation. However, the advent of digital technology has ushered in a transformative shift in this relationship, leading to a departure from traditional skills and craftsmanship. This shift has profound implications for the trajectory of tectonic architecture, as proposed by Kenneth Frampton (1995: 335-376), particularly within the African context. This shift has transcended geographical boundaries, affecting architectural practices worldwide, including South Africa.

Frampton explores the relationship between technology and the practitioner in the architectural design process, highlighting the traditional interplay between the "head" (intellectual vision) and the "hand" (practical implementation) by shifting agency from human craftsmanship to digital technology (Frampton, 1995: 376). This concept emphasizes the traditional craftsmanship and manual skills involved in architectural practice and the need for a balance between intellectual and practical aspects in the design process. Loh (2017: 42) also argues that the prevalent influence of digital technology has disrupted this trajectory, resulting in a skewed architectural design process, highlighting how technology has replaced the hand as the primary agent of creation and production.

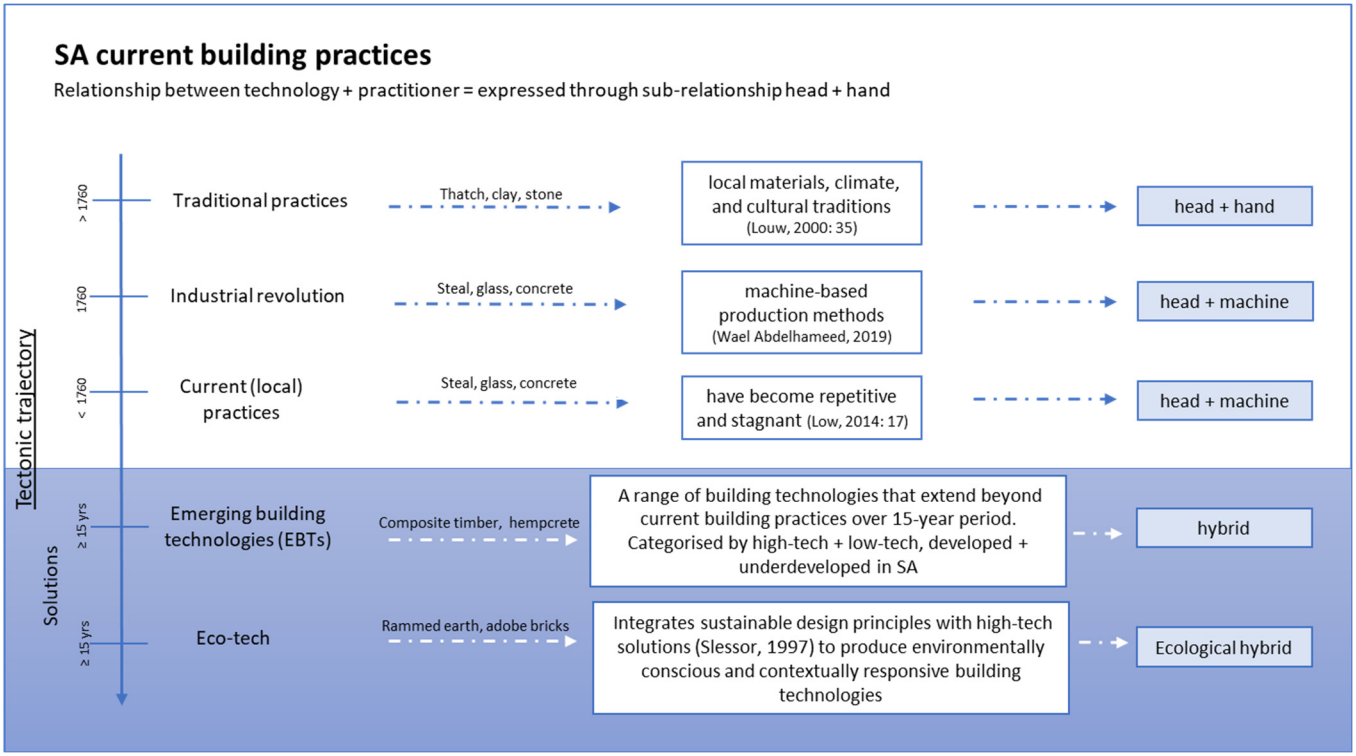


FIGURE 1 VISUAL REPRESENTATION OF THE RELATIONSHIPS DEFINED BY THE TECTONIC TRAJECTORY OF BUILDING PRACTICES IN SOUTH AFRICA (AUTHOR, 2023)

In the context of South Africa, the tectonic trajectory of building technologies has been shaped by a series of historical influences. Starting with the rich heritage of traditional handcrafted building practices as described by Louw (2000: 35) that are deeply rooted in local culture and materials. However, the timeline of South African architecture has been impacted by colonialism and the

subsequent globalizing forces, resulting in a fusion of local and global influences (Windapo & Cattell, 2013).

The industrial revolution introduced mechanization and mass production, leading to a departure from traditional manual craftsmanship and the adoption of new building technologies and materials (Wael Abdelhameed, 2019). This transformative shift in technological advancements and modes of production had a significant impact on the trajectory of architecture worldwide, disrupting traditional building practices and shaping the direction of architectural development. In the context of South Africa, Louw (2000: 36) highlights the coexistence of first world and third world architecture, reflecting the complex social and economic history influenced by global forces. This coexistence illustrates the profound influence of the industrial revolution on South Africa's architectural trajectory, shaping the adoption of new technologies and the integration of different architectural approaches.

The built environment in South Africa has a well-established foundation, as noted by the Construction Industry Development Board (2021). The current building practices in South Africa reflect a combination of traditional techniques and modern materials, driven by regulatory standards and the need for sustainable solutions (Wu et al., 2019). These practices involve the use of various construction methods, such as reinforced concrete, steel, brick, and timber, depending on the specific requirements of each project (Calitz & Wium, 2021). Building regulations play a crucial role in guiding these practices, ensuring compliance with safety, environmental, and energy efficiency standards (Construction Industry Development Board, 2021).

The South African construction industry faces several challenges that impact its performance, development, and growth, as highlighted in the study *The South African Construction Industry: Perceptions of Key Challenges Facing Its Performance, Development, and Growth* by Windapo and Cattell (2017). These challenges include low productivity and efficiency, lack of government support and investment, corruption, skills shortages, and safety concerns (Windapo & Cattell, 2017). Along with the influence of traditional practices, the forces of globalization, and the impact of the industrial revolution, Low (2014: 17) also argues that current building practices in South Africa have become repetitive and stagnant. He continues by stating that building practices often lack the integration of innovative approaches due to the limited scope and development of local knowledge.

As a result, there is an urgent need to investigate the field of building technology in South Africa, examining current practices and exploring the effective integration of technology within architectural design processes. This exploration will further develop the tectonic trajectory in South Africa, benefiting the social, economic, and environmental aspects of the built environment.

This paper aims to explore how the architectural design process can be extended and widened to respond in a more contextual manner within the South African built environment. The objective is to develop a comprehensive understanding of emerging building technologies and their potential to enhance contextual responsiveness. By examining current practices and investigating the integration of technology, this research seeks to bridge the gap between traditional and emerging approaches, fostering a more sustainable, efficient, and contextually sensitive built environment in South Africa.

The urgent need for sustainability and energy efficiency has further emphasized the importance of integrating emerging building technologies into current practices. However, it is important to recognize that simply adopting EBTs is not enough for a comprehensive solution. It requires going

beyond sustainability and addressing the broader aspects of context and innovation (Ampofo-Anti, 2017; Jekot, 2007). The current state of building practices in South Africa, coupled with the energy crisis and environmental concerns, has prompted the industry to explore eco-tech and innovative solutions to enhance building performance and reduce the ecological footprint. Sustainability, encompassing economic, social, and environmental considerations, is a key concern that hinges on the success of contextually responsive building practices.

In addition to sustainability, it is essential to consider cultural values, social inclusivity, and economic resilience in the pursuit of more contextually responsive building practices in South Africa. Therefore, this research aims to investigate the role of emerging building technologies in fostering a holistic approach that embraces these diverse aspects, aligning with the specific needs and environmental conditions of the region. By integrating emerging building technologies into the architectural design process, it becomes possible to create buildings and structures that not only prioritize sustainability but also respond to the local context, enhancing the overall contextual responsiveness of building practices in South Africa.

1.2 Research problem

The impact of globalization on the built environment presents both positive and negative implications. Loh (2017: 42) argues that the digital age has reshaped the dynamics of design and making, shifting the agency from human craftsmanship to digital technology. This shift allows for new ways of engaging with materials and establishing novel relationships between materials and the human body (Loh, 2017: 44). However, the shift of the traditional interplay between the head and the hand has also resulted in detrimental consequences, including the degradation of cultural identity and the displacement of traditional building techniques, disregarding the use of sustainable and locally available resources (Windapo & Cattell, 2017).

In the chapter *Architecture in Africa: Situated Modern and the Production* by Low (2014), he interrogates the intersection of global modern architecture and African architecture. He states that, "the challenge facing architects and planners in Africa was how to create an architecture that was modern and functional, yet also responsive to the needs, desires, and aspirations of the local people." (Low, 2014: 305).

These arguments underscore the need for a re-evaluation of building technologies within the South African built environment, where current building practices are restricted to the use of limited building technology and conventional construction techniques and building materials. Low (2014: 334) further advocates for situated modernism that represents a “hybrid” of western modernism and local cultural traditions. Nnamdi Elleh, expands on this concept by arguing that hybridity serves as a defining characteristic of contemporary African architecture, where a fusion of traditional, colonial, and modern influences are “synthesized into a new design idiom" (Elleh, 2006: 68–72).

Louw (2000: 5) delves into the importance of hybrid tectonics in evaluating how the integration of tectonic innovation can effectively reconcile the concepts of modernity and cultural identity. The integration of emerging building technologies with sustainable design principles is crucial to addressing these challenges. As seen in the work of MASS Design Group and ASA, the different tectonic strategies implemented contain a combination of tectonic and environmental strategies that play a vital role in

minimizing the ecological impact of buildings and improving their performance and comfort (Loké, 2019: 64). This approach recognizes that sustainability and cultural identity are not mutually exclusive, but rather interconnected elements that can mutually enrich and enhance each other.

To achieve this integration, it is essential to adopt a hybrid approach that combines modern technologies with local cultural traditions. By embracing emerging building technologies that incorporate sustainable principles, architects can create innovative and contextually responsive solutions. This hybrid eco-tech approach as investigated by Slessor in her book, *Eco-Tech: Sustainable Architecture and High Technology* (1997) not only harnesses the advancements offered by the digital age but also prioritizes the preservation of cultural identity and the utilization of sustainable resources.

In the South African context, this approach becomes even more critical as it allows the built environment to become adaptable, environmentally conscious, and socially and culturally relevant. By extending architectural design processes to incorporate hybrid eco-tech, architects can contribute to the development of a built environment that addresses the specific needs and challenges of the region. The aim of this research is to explore the potential of hybrid eco-tech as an extended practice that enhances the contextual responsiveness of architectural design processes in South Africa. Through this exploration, the research aims to provide valuable insights and contribute to the development of sustainable and innovative solutions for the built environment in South Africa.

1.3 Research questions

The main research question aims to frame the investigation:

Which building technologies can be considered to form part of current practices in the South African built environment and which can be considered emerging technologies?

To interpret this question, I will focus through a lens on the sub-questions:

1. How can emerging technologies contribute to making current building practices more contextually responsive?
2. What are the potential applications and benefits of hybrid eco-tech in enhancing the contextually responsiveness of current building practices in the South African built environment?

1.4 Research objectives

The primary research objective of this study is to determine the effectiveness of emerging technologies in improving the contextual responsiveness of building design and construction in South Africa. To achieve this, the study will examine, and group case studies of architecture projects built in South Africa from 2008 to the present, with a focus on how these technologies can promote sustainable and culturally sensitive design practices. The goal is to evaluate the potential of these technologies for enhancing contextual responsiveness in the field of architecture.

Schwartz explores the importance of understanding and integrating architectural tectonics into design process. He writes, “New technologies have expanded the possibilities of tectonic design, allowing architects to create structures that were once thought impossible (Schwartz, 2017: xxv). Through the

process of continued research, development, and implementation, advancements are made within the building technology field, resulting in the realm of emerging technology.

Additionally, the study aims to conduct a comprehensive literature review on current and emerging building technologies in the South African built environment. The review will encompass existing literature on building materials and techniques in the country, as well as articles that analyze South African architecture through the lens of digital making, tectonics, and sustainable advanced construction technologies. By doing so, the study aims to identify the most promising technologies that can contribute to making building design and construction practices in South Africa more contextually responsive.

Examine the potential of emerging technologies to improve the contextual responsiveness of building design and construction in South Africa, with an emphasis on how these technologies can support the use of locally available materials and traditional building practices.

2. Literature review

2.1 Introduction

The literature review delves into a comprehensive exploration of the key theories and themes that underpin the investigation of Emerging Building Technologies (EBTs) and their potential to enhance contextually responsive building practices in the South African context. The review encompasses six central theories that lay the groundwork for understanding the historical significance and evolution of tectonics (Louw, 2000: 2-58), the impact of the industrial revolution on architecture (Abdelhameed, 2019), the role of technology in architectural design, the concept of hybridity in architecture (Louw, 2000: 5), ecological design and sustainable architecture (Ampofo-Anti, 2017) and potential for eco-tech (Slessor, 1997: 4-46), and the importance of contextualism in architectural practice.

Within these theories, a set of distinct themes unfold, shedding light on various aspects relevant to the study. Traditional hand-based tectonics, for instance, elucidates the historical importance of traditional building techniques and their influence on design and construction methods. The paradigm shift from hand to machine examines the transformative impact of the industrial revolution, resulting in the adoption of new building technologies and materials.

As we delve into the realm of emerging building technologies, the theme of digital manufacturing comes to the fore, exploring the emergence of digital tools and how they influence architectural design and construction practices. The concept of hybridity in architecture emphasizes the fusion of diverse architectural expressions, while eco-tech and sustainability highlight the crucial significance of ecological design and the role of EBTs in promoting sustainable building practices (Jekot, 2007: 66-78).

Contextual responsiveness, another vital theme, stresses the significance of considering the cultural and environmental contexts within architectural design (Loh, 2017: 44-87). By integrating EBTs, architects can craft designs that are not only sustainable but also contextually relevant and responsive to the specific needs and values of the region.

Through a meticulous review of the literature surrounding these themes and theories, this study aims to develop a profound understanding of the potential of EBTs in reshaping the trajectory of architecture in South Africa, creating innovative and sustainable solutions that address the unique challenges and opportunities within the built environment.

2.2 Current theories

2.2.1 Historical Significance and Evolution of Tectonics

The theory of historical significance and evolution of tectonics, as proposed by Frampton (1995: 335-376), provides a comprehensive understanding of the trajectory of tectonics in architectural practices. In the context of South Africa, this theory highlights the profound impact of traditional hand-based tectonics on the country's architectural heritage (Louw, 2000: 35). The craftsmanship of indigenous building technologies plays a pivotal role in shaping the built environment (Gutschow, 2011: 9), reflecting the rich cultural identity and skillful craftsmanship embedded in these traditional techniques (Louw, 2000: 35).

The interplay between the “head and the hand” in the architectural design process has long been a fundamental aspect of practice (Groat & Wang, 2002) and the relationship between technology and the practitioner expressed as the architectural design process can be graphically represented as seen in figure 1 below:

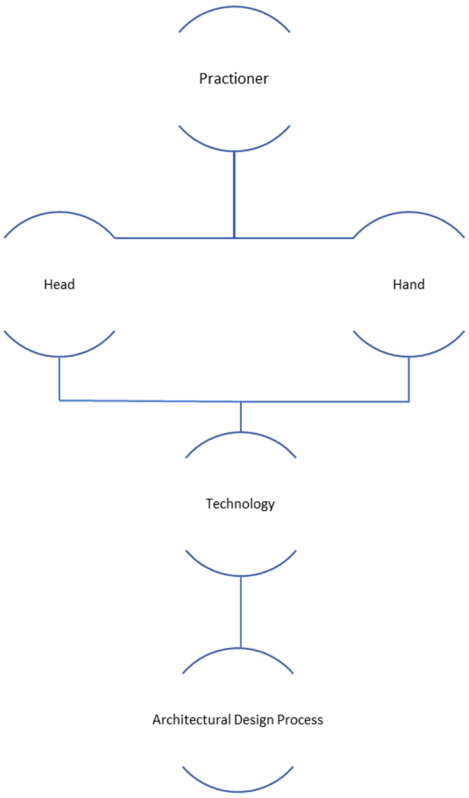


FIGURE 2 GRAPHIC REPRESENTATION OF THE RELATIONSHIP BETWEEN THE PRACTITIONER AND TECHNOLOGY, EXPRESSED AS THE ARCHITECTURAL DESIGN PROCESS (AUTHOR, 2023)

In this diagram, the relationship between technology and the practitioner is illustrated within the context of the architectural design process. The practitioner is represented as two distinct elements: the "Head" symbolises the intellectual and creative aspects, and the "Hand" represents practical implementation and craftsmanship. Both the Head and Hand components are connected to the central element of the diagram, which is the Architectural Design Process.

Technology is depicted as a separate entity that interacts with both the head and the hand. It influences the design process by providing tools, resources, and digital technologies that support and enhance the practitioner's capabilities. The diagram emphasizes the interplay between the intellectual vision of the practitioner, the practical implementation of design, and the integration of technology within the architectural design process.

However, the industrial revolution marked a paradigm shift in architectural practices worldwide, including South Africa. With the advent of mechanization and mass production, traditional handcrafted methods gradually gave way to more efficient and standardized approaches to construction (Abdelhameed, 2019). This shift revolutionized the building industry, enabling the construction of larger and taller structures with increased speed and precision.

The incorporation of new building technologies and materials during the industrial revolution significantly influenced the trajectory of architecture in South Africa. With the introduction of steel, reinforced concrete, and advanced construction machinery, architects and builders were empowered to experiment with innovative design ideas and construct monumental edifices (Abdelhameed, 2019).

The industrial revolution's impact on architectural practices extended beyond the physical construction processes; it also shaped the way architects approached design. Embracing the efficiency and standardisation offered by the new technologies and materials, architects began to design

structures that reflected the principles of modernity and progress. These buildings prioritized functionality, spatial efficiency, and utilitarianism (Frampton, 1995: 335-376).

Globalization also played a significant role in shaping the tectonic trajectory of South Africa. As the country became more interconnected with the rest of the world, architectural practices were influenced by international designs and advancements in building technologies (Elleh, 2006). Globalization facilitated the exchange of architectural ideas and construction methods, further diversifying architectural expressions in the country. However, this globalization also posed challenges, as it sometimes led to a homogenization of architectural designs, eroding the unique cultural identity and contextually responsive nature of South African architecture (Elleh, 2006).

Amid these historical and global influences, issues related to sustainability and environmental concerns have become increasingly prominent in architectural discourse (Ampofo-Anti, 2017). The demand for sustainable architecture that addresses climate change, resource depletion, and urbanization has become a critical consideration. Consequently, architects are exploring eco-tech and sustainable design solutions to minimize the ecological impact of buildings and enhance their performance and comfort (Slessor, 1997: 4).

As South Africa grapples with these tectonic shifts, the significance of preserving cultural identity, craftsmanship, and contextually responsive architectural practices becomes paramount. The theoretical framework of historical significance and the trajectory of tectonics provides a lens through which to understand the interplay between traditional hand-based tectonics, the impact of the industrial revolution, and the broader global and environmental challenges faced by contemporary architecture in South Africa. This framework informs the research's exploration of emerging building technologies and their potential to contribute to sustainable and contextually responsive building practices in the region. By critically examining the historical and present trajectories of tectonics in South Africa, the study aims to inform innovative and culturally relevant approaches to architectural design, fostering a harmonious integration of emerging building technologies with the country's environmental context.

2.2.2 The Role of Technology in Architectural Design

The theory of the role of technology in architectural design, as proposed by Frampton, delves into the transformative influence of technology on the architectural design process (Frampton, 1995: 335-376). In the contemporary architectural landscape, technology has evolved to become an indispensable tool that empowers architects to explore innovative solutions and address diverse challenges in the built environment (Frampton, 1995: 335-376). It has revolutionized how architects conceptualize, visualize, and execute their designs, enabling them to create structures that were once unimaginable (Frampton, 1995: 335-376).

Within the context of South Africa, the integration of technology into architectural design is particularly crucial in fostering contextual responsiveness. By leveraging emerging building technologies (EBTs), architects can tailor their designs to respond effectively to the unique needs and environmental conditions of the region. EBTs offer a range of possibilities, from environmentally sustainable construction materials to digital tools that enhance the precision and efficiency of design processes (Ampofo-Anti, 2017).

Integrating these technologies into current building practices can lead to the creation of more contextually responsive and culturally relevant architecture (Gutschow, 2011). The sub-question of the study aligns perfectly with the theory of the role of technology in architectural design, as it seeks to explore the potential applications and benefits of hybrid eco-tech (combining traditional and modern

technologies) in enhancing the contextually responsive nature of current building practices in South Africa.

The concept of eco-tech as explored by Slessor (1997: 4-27) involves the combination of traditional and modern technologies to create innovative and sustainable solutions for architectural design. Mozhdegani and Afhami (2017: 3) further embraces this approach, by stating architects can strike a balance between preserving cultural identity and heritage (represented by traditional building techniques) and harnessing the advancements of modern technology to address environmental concerns and enhance building performance (Elleh, 2006: 5).

The exploration of hybrid eco-tech's potential is vital in the context of South Africa, where there is a growing emphasis on sustainable development and contextually responsive architecture (Gutschow, 2011). By understanding how hybrid eco-tech can be effectively implemented, the research aims to contribute to the advancement of architectural practices that not only prioritize sustainability but also celebrate the rich cultural heritage of the region. The integration of EBTs through the hybrid eco-tech approach can serve as a transformative force, enriching the tectonic trajectory of architecture in South Africa and aligning it with the dynamic and evolving needs of the built environment (Ampofo-Anti, 2017).

2.2.3 Concept of Hybridity in Architecture

The concept of hybridity in architecture, as explored by Mozhdegani and Afhami (2017), Louw (2000), Frampton (1995: 335-376), and Slessor (1997), celebrates the dynamic interplay between diverse architectural expressions, reflecting the fusion of traditional, colonial, modern, high-tech, and low-tech influences. In the context of South African architecture, this theory emphasizes the potential of integrating global and local tectonics to create innovative and contextually responsive architectural designs (Elleh, 2006: 3). Hybridity acknowledges the rich tapestry of cultural influences in a society and recognizes that architecture can draw from various sources to form a unique and harmonious whole (Louw, 2000: 2).

The application of hybridity in architecture can be seen through the integration of high-tech and low-tech elements, reflecting the impact of globalization and the preservation of traditional craftsmanship. As South Africa embraces modern technologies and global architectural trends, it also seeks to maintain a strong connection with its indigenous building practices (Louw, 2000: 3).

In this context, the exploration of hybrid eco-tech emerges as a significant approach, combining emerging building technologies with traditional building practices to form a hybrid eco-tech (Elleh, 2006: 2). Slessor (1997: 4) highlights the importance of sustainable design solutions, promoting eco-tech as a way to minimize the ecological impact of buildings and enhance their performance and comfort.

This hybrid approach, guided by the principles of hybridity and eco-tech, emphasizes the need to design buildings that are not only sustainable but also resonate with the social and cultural fabric of the community they serve (Louw, 2000: 4). Architects can integrate eco-tech elements to enhance the energy efficiency, resource conservation, and overall environmental performance of buildings (Slessor, 1997: 5).

By adopting this hybrid eco-tech approach, architects can bridge the gap between the past and the future, preserving cultural identity and heritage while embracing the possibilities of innovation and progress (Frampton, 1995: 335-376). The exploration of hybridity in architecture and its application through hybrid eco-tech offers a transformative pathway towards creating sustainable, culturally relevant, and technologically advanced architecture in South Africa (Elleh, 2006: 4). Through this

integration of technology and tradition, architects can shape a built environment that embodies the nation's identity and values, embracing both global advancements and local wisdom (Louw, 2000: 27).

2.2.4 Ecological Technology and Sustainable Architecture Design Practices

The theory of ecological design and sustainable architecture (Ampofo-Anti, 2017) underscores the importance of sustainability and the need to address environmental challenges in architectural practice. This theory is closely linked to the sub-question of the study, as it explores how the integration of EBTs can enhance sustainability and overall building performance in the South African built environment. It also aligns with the broader context of contextual responsiveness, as sustainable architectural solutions must consider the specific environmental and cultural contexts of the region.

The theory of ecological design and sustainable architecture, as emphasized by Pacheco-Torgal et al (2020: 5), places a strong emphasis on sustainability within architectural practice. It recognizes the urgent need to address environmental challenges and minimize the ecological impact of buildings. In the context of South Africa, this theory becomes particularly relevant as the country faces issues related to climate change, resource depletion, and urbanization (Rybak, 2019).

The integration of emerging building technologies (EBTs) can play a crucial role in enhancing sustainability and overall building performance in the South African built environment. By incorporating eco-tech solutions, architects can create buildings that are more energy-efficient, environmentally friendly, and socially responsible (Slessor, 1997: 4). The exploration of hybrid eco-tech aligns with the principles of ecological design and sustainable architecture, as it seeks to combine the benefits of both traditional and modern technologies to achieve sustainable and contextually responsive building practices.

To be truly sustainable and contextually responsive, architectural solutions in South Africa must consider the specific environmental and cultural contexts of the region. The integration of EBTs allows architects to respond to local climate conditions, available resources, and cultural values, ensuring that buildings are not only environmentally friendly but also culturally relevant and socially inclusive (Louw, 2000: 29).

In the pursuit of ecological design and sustainable architecture, architects need to adopt a holistic approach that goes beyond technological advancements. They must consider the social, economic, and environmental aspects of the built environment, aiming to create architecture that promotes human well-being and ecological harmony (Ampofo-Anti, 2017). By embracing this theory and incorporating EBTs into their design processes, architects can contribute to the development of sustainable and contextually responsive building practices in South Africa, aligning with the specific needs and environmental conditions of the region (Louw, 2000: ix).

2.3 Current work in the field: Bridging the Gap and Embracing Eco-tech

2.3 a) Environmental concerns:

In recent years, there has been a notable surge in the focus on environmental issues within the architectural discourse, driving the demand for sustainable architecture in South Africa (Ampofo-Anti, 2017; Steyn, 2020; Pacheco-Torgal et al., 2020). The South African built environment is a dynamic mix of first and third-world architecture, reflecting a complex coexistence of different architectural styles and practices (Louw, 2000: 18). While the country boasts a well-established built environment (CIDB, 2021), there are challenges stemming from political and economic factors that have contributed to a

lack of experience and knowledge in certain architectural practices (Windapo & Cattell, 2013: 65-79). As a result, architectural practitioners in South Africa face the task of becoming more versatile, economically viable, and contextually responsive (Steyn, 2020).

Within this context, the integration of technology in architectural practice becomes a delicate balancing act between tradition and innovation (Louw, 2000; Low, 2014). South African architects navigate the challenges of incorporating technology while preserving cultural identity and utilizing sustainable resources (Ampofo-Anti, 2017). This involves a combination of traditional and modern materials, techniques, and structural systems that reflect a blend of labor-intensive methods and industrialized approaches (Calitz & Wium, 2021). However, compared to other industries, the uptake of technology in architectural practice has been relatively slow (Calitz & Wium, 2021).

One reason for this slow adoption is that practitioners often resort to using readily available and cost-effective "off-the-shelf" building technologies (Schmidt, 2006: 133). As a consequence, there might be limited collaboration between architectural practitioners, the building industry, and craftsmen (Schmidt, 2006: 133). To achieve sustainable and contextually responsive architectural solutions, it is essential to bridge the gap between traditional building practices and emerging building technologies (Low, 2014: 291).

Amidst these challenges, the exploration of eco-tech and its integration within the architectural design process holds promise in addressing environmental concerns and enhancing the overall sustainability of buildings (Ampofo-Anti, 2017; Pacheco-Torgal et al., 2020). By embracing eco-tech, South African architects have the potential to create innovative and sustainable solutions that respond to the region's unique cultural and environmental contexts. The following section will delve further into the current use and application of emerging building technologies in the South African built environment, shedding light on the potential benefits and challenges of incorporating eco-tech in architectural practice.

To adequately address environmental concerns in architecture, it is vital to extend our perspective beyond the context of South Africa and examine other countries with similar architectural trajectories. As highlighted by Indira Gandhi, the former Prime Minister of India, at the proceedings of the 4th International Conference on EcoMaterials (ECOMAT IV 2009), there is wisdom in both new and old technology when constructing houses. Gandhi emphasizes the importance of adapting traditional practices to suit modern societal changes while still embracing aspects of old technology that remain relevant. This sentiment reflects a broader understanding that communities have developed valuable knowledge and techniques over generations to meet their specific environmental and lifestyle needs (Calitz & Wium, 2021). As we explore emerging building technologies (EBTs) and their integration within architectural practice, adopting a balanced approach that combines the benefits of modern technology with contextually sensitive aspects of traditional practices can lead to the creation of more sustainable and comfortable living environments.

b) Emerging building technologies

Ludwig Mies Van der Rohe, a renowned architect, once remarked, 'Technology is rooted in the past, dominates the present, and extends to the future' (Von Wolf, 2023). This statement resonates with the ever-evolving nature of building technology, which continually develops and innovates over time. Wu, Wei and Peng (2019: 2) stated that building technology is a dynamic field that refuses to stand still or fade away. It constantly pushes the boundaries of what is possible and shapes the way we design and construct buildings.

Emerging building technology plays a significant role in shaping the future of architectural design and construction practices. It offers architects and designers the opportunity to explore new possibilities

and push the boundaries of what was once considered impossible. Schwartz (2017: xxv) emphasizes that advancements in technology have expanded the realm of tectonic design, enabling the creation of structures that were previously unimaginable.

The concept of emerging technology encompasses both new technologies and the continuous evolution of existing materials, techniques, and structural systems. Wienecke (2010: 128) explains that the term is often used to describe technologies that have significant societal, environmental, or economic implications. We can define this term as a new or unused, existing or under implemented building technologies within the South African context within a period of 15 years that are categorised along two frameworks of low-tech to high-tech and underdeveloped to developed. These technologies embody an intrinsic value that aims to contribute to the social, economic, and contextual developments in the South African built environment.

In the South African context, emerging building technologies can be categorized based on two frameworks: from low-tech to high-tech and from underdeveloped to developed. These technologies are characterized by their potential to bring about positive social, economic, and contextual developments within the built environment of South Africa. They embody intrinsic value and aim to contribute to sustainable and responsible architectural practices in the country.

The term 'emerging technology' encompasses new and under-implemented building technologies within the South African context. Jekot (2007: 66) furthers this notion by stating, "The inclusion of 'underdeveloped' technologies and materials in South African architecture reflects a desire to express local cultural identity and promote sustainable development, while resisting the homogenizing forces of globalization". These technologies, ranging from 'low-tech' to 'high-tech' and 'underdeveloped' to 'developed,' embody intrinsic value and contribute to the social, economic, and contextual developments in the South African built environment. By embracing a diverse range of technologies, architects and practitioners can create a built environment that is responsive to the unique cultural and environmental characteristics of South Africa, while also addressing the pressing challenges of sustainability and development.

The exploration of emerging building technologies, encompassing both high-tech and low-tech solutions, offers promising opportunities for enhancing the context responsiveness of building practices. While these advancements hold the potential to address environmental concerns and foster sustainable design, it is important to recognize that their impact alone may not fully meet the objective. Therefore, in our pursuit of contextually responsive building practices, the integration of Eco-Tech emerges as a transformative approach that seeks to harmonize technological advancements with the unique socio-cultural and environmental characteristics of the South African context. By embracing Eco-Tech, architects can further bridge the gap between emerging technologies and the contextual needs of the communities they serve, ultimately shaping a more sustainable and culturally sensitive built environment.

2.3 c) Enhancing Contextual Responsiveness and Eco-tech

Human-Dominated Ecological Systems

Behnam (2017: 1-7) emphasizes the potential of integrating human-dominated ecological systems from the past and fuse them with high-tech solutions. This approach seeks to merge traditional wisdom and knowledge with emerging building technologies, forming a harmonious synergy between the two (Louw, 2000: viii). By drawing inspiration from historical ecological systems and fusing them with innovative technologies, architects can create built environments that are deeply rooted in the local

context and sensitive to the socio-cultural and environmental needs of the community. This integration of human-dominated ecological systems and high-tech solutions as expressed by Behnam (2017) enhances the capacity of emerging building technologies to address the specific challenges and opportunities present in the South African context, fostering a more holistic and contextually responsive approach to design and construction.

Embracing Eco-Tech

In her book *Eco-tech: Sustainable Architecture and High Technology* by Catherine Slessor (1997: 3-124) the author delves into the possibility of intersecting sustainable architecture with high technology to create environmentally conscious and energy efficient designs. Slessor states that sustainable architecture should not only prioritise energy-saving strategies but must also embrace a high-tech approach as a means to "achieve optimal performance and an ecological response" (1997: 4).

The pursuit of this achievement in a sustainable architecture aligns with the principles of contextual responsiveness (Slessor, 1997). This results in a harmonious relationship with the natural, social and cultural context. Steyn (2020) furthers this notion by stating that achieving this pursuit leads to an appropriate architecture, which he defines as, "architecture that is socially, economically, environmentally and culturally appropriate to the people who use it, the community in which it is situated and the environmental context in which it exists" (Steyn, 2020).

The Interaction of Technology and the Architectural Practitioner

As previously discussed, the relationship between technology and practitioner is expressed through the architectural design process. Well-known Swiss-French architect Le Corbusier regarded technology as a "transforming force for change" as expressed in his book, *Towards A New Architecture* (1946) where he further states that the machinery of society oscillates between "amelioration, historical importance, and a catastrophe." (1946: 8). As a result, a critical aspect of the interaction between technology and the practitioner is a way in which they re-define each other.

Slessor states that in this negotiation, there can be an embrace of wider concerns, namely place-making, social responsiveness, energy use, urbanism and ecological awareness (1997: 5). She asses the work of architect Richard Rogers who said that the reconciliation of technological imperatives and opportunities with wider human and environmental concerns has become the most challenging creative problem facing architects. (1997: 7-19).

Thus, the interplay between emerging building technologies and contextually responsive architectural practices holds great potential in addressing environmental concerns and fostering sustainable design solutions. By integrating traditional wisdom, high-tech solutions, and ecological principles, architects can create innovative and contextually sensitive built environments that embody the ethos of sustainability and respect for the surrounding environment and community.

However, this concept can be expanded on by exploring the potential of combining high-tech and low-tech elements to create a more balanced and contextually responsive approach to architectural design. This hybrid approach allows for the integration of innovative technologies with traditional, time-tested practices, resulting in sustainable and adaptive solutions tailored to specific environmental and cultural contexts.

d) Enhancing Contextual Responsiveness through Hybrid Eco-Tech

Integrating High-Tech and Low-Tech in Architecture

Scholars like Bell and Wakeford propose in their book, *Expanding Architecture: Design as Activism* (2008) the integration of high-tech and low-tech elements in architecture to achieve more sustainable outcomes. High-tech solutions, such as advanced digital tools and building systems, offer precision, efficiency, and optimization. On the other hand, low-tech solutions, such as vernacular building techniques and passive design strategies, have a proven track record of adapting to local environmental conditions and reducing energy consumption (Bell & Wakeford, 2008). By blending these two approaches, architects can strike a balance between technological innovation and traditional practices, promoting environmental sensitivity and cost-effectiveness.

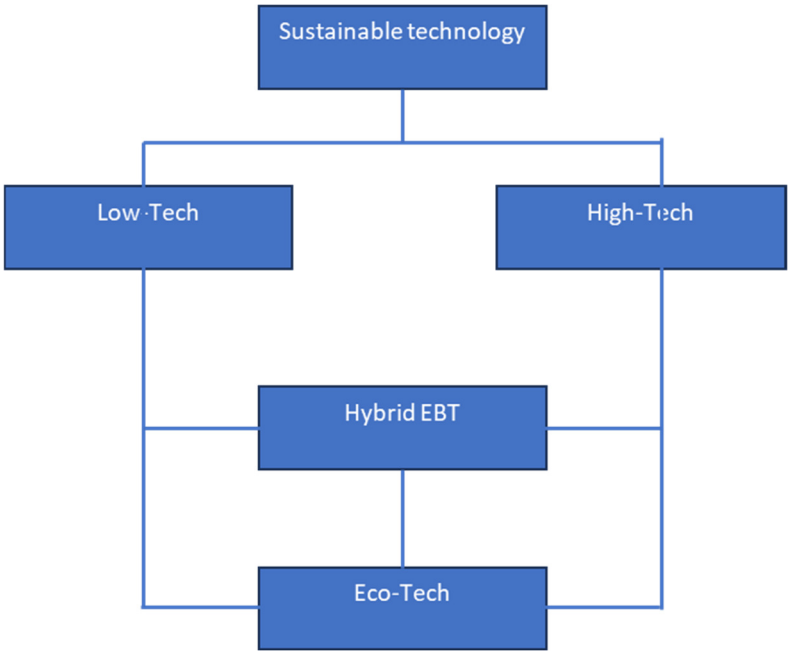


FIGURE 3 DIAGRAM EXPLAINING THE CONCEPT OF HYBRID EBTS AND THE FORMATION OF THE TERM ECO-TECH (AUTHOR, 2023)

The graphical representation visually conveys that Eco-tech embraces a spectrum of approaches, from low tech to high tech, all under the umbrella of sustainable architecture. It illustrates the idea that sustainable design can be achieved through a balanced combination of traditional, contextually responsive practices (low tech) and state-of-the-art technological advancements (high tech). While sustainable emerging building technologies (EBTs) play a crucial role in addressing environmental concerns and promoting sustainable building practices, they are not sufficient on their own to fully address the complexities of making building practices more contextually responsive. Sustainable EBTs primarily focus on minimizing the ecological footprint of buildings by incorporating energy-efficient systems, renewable materials, and waste reduction strategies.

The paths of low tech, high tech, and hybridity then converge to form "Eco-Tech" as the ultimate solution for making building practices more contextually responsive. The concept of eco-tech goes beyond the scope of sustainability and encompasses a broader perspective of creating buildings that are not only environmentally friendly but also responsive to their specific contexts. It represents a paradigm shift in building practices, going beyond the limitations of sustainable measures to embrace a holistic approach that considers the unique context, climate, and cultural identity of a place. It emphasizes the need to create built environments that are not only ecologically sensitive but also

enrich the lives of the people who inhabit them, fostering a deeper connection between humans and their surroundings.

Emphasizing the significance of hybridization in sustainable design, Grimm (2015) argues that learning from indigenous practices can inform the integration of high-tech and low-tech elements. Indigenous communities have long demonstrated an understanding of their local environments and developed practices that are resilient, adaptive, and sustainable (Grimm, 2015). By drawing inspiration from such practices and incorporating modern technologies, architects can create hybrid eco-tech solutions that prioritize cultural sensitivity and environmental stewardship.

The integration of hybrid eco-tech can enhance contextual responsiveness by offering adaptable and culturally sensitive solutions. Architectural practices that embrace hybrid eco-tech can prioritize the unique needs of the community, respond to changing environmental conditions, and promote sustainable living (Bell & Wakeford, 2008; Grimm, 2015). This approach aligns with the principles of appropriate architecture, where buildings are designed to harmonize with their users, communities, and environmental context (Steyn, 2020).

Thus, the concept of hybrid eco-tech offers a compelling and innovative approach to sustainable architecture. By combining high-tech and low-tech elements and drawing inspiration from indigenous practices, architects can create contextually responsive and environmentally conscious designs. The successful integration of hybrid eco-tech relies on a balanced understanding of modern technology, cultural heritage, and environmental considerations, fostering a harmonious and holistic approach to architectural design.

Conclusion

The literature review has delved into various key theories and themes that significantly influence architectural practices, particularly in the context of South Africa. The theory of historical significance and evolution of tectonics, as proposed by Frampton (1995: 335-376) and supported by Louw (2000: viii), highlighted the impact of traditional hand-based tectonics on the country's architectural heritage. Concurrently, the industrial revolution, as discussed by Abdelhameed (2019: 21-27), marked a paradigm shift in architectural practices worldwide, leading to the adoption of new building technologies and materials.

In the architectural design process, the interplay between technology and practitioners was emphasized by Frampton (1995: 335-376). The "head and the hand" relationship, as illustrated in Figure 1, demonstrates how technology influences the design process by providing tools and resources (Author, 2023). This interplay becomes essential in fostering contextually responsive architectural solutions through the integration of emerging building technologies (EBTs), aligning with the theoretical framework of contextual responsiveness.

The concept of hybridity in architecture, as explored by Mozhdegani and Afhami (2017) and Louw (2000: viii), showcased the potential of combining high-tech and low-tech elements to create hybrid eco-tech solutions. Slessor further elaborated on the fusion of ecological principles and high technology, defining eco-tech as an approach to achieve optimal performance and ecological responses (1997: 8). The integration of hybrid eco-tech, as exemplified by the works of Vo Trong Nghia and the "Great Wall of WA" project, demonstrates the potential to create contextually relevant and sustainable architectural designs.

The theory of ecological design and sustainable architecture, as put forth by Ampofo-Anti (2017), highlights the importance of sustainability in architectural practice. The integration of EBTs aligns with ecological design principles, enhancing sustainable building practices in the South African context. This

integration also emphasizes the significance of considering environmental and cultural contexts in architectural design, as discussed by Slessor (1997:7) and Steyn (2020).

To address environmental concerns, the works of Windapo and Cattell (2013: 1-18), Calitz and Wium (2022: 29-37), and Schmidt (2006: 133) shed light on the challenges faced by South African practitioners in incorporating technology while preserving cultural identity and utilizing sustainable resources. The need to balance tradition and innovation becomes crucial in fostering contextually responsive architectural practices.

Looking into the future, eco-tech and architectural design hold significant potential for further advancements. By adopting ecological principles and embracing innovative solutions, architects can create energy-efficient and environmentally conscious designs. However, challenges lie in finding a harmonious balance between high-tech advancements and low-tech adaptations, while also ensuring an inclusive and contextually relevant approach.

In conclusion, the literature review underscores the pivotal role of emerging building technologies in shaping sustainable and contextually responsive building practices in South Africa. The exploration of hybrid eco-tech solutions that combine high-tech and low-tech elements offers promising avenues for architects to create structures that resonate with the natural environment and the local culture. As architects continue to explore innovative approaches while adhering to sustainable principles, the field of eco-tech and architectural design is poised to create resilient and adaptive built environments for the future.

3. Research methodology

3.1 Introduction

Within the scope of our work, we adopt a research methodology that embraces the principles of "research for design" and "practice-led research" (Candy, 2006: 2). As emphasized by Loh (2019: 14), these methodologies focus on investigating and understanding the nature of architectural practice itself, seeking to generate new knowledge with direct operational significance for practitioners. However, given the nature of our study and the limited engagement with architects and their design processes, we will primarily focus on the case study method.

This study adopts a practice-led research approach, focusing on the architectural design process of practitioners. By situating technology within these design processes, our investigation aims to explore how the integration of emerging building technologies can contribute to the development of sustainable and contextually responsive building practices. Embracing the practice-led research methodology, our study recognizes the significance of understanding and addressing the challenges and opportunities inherent in architectural practice. As emphasized by Candy (2006: 2), this methodology transcends theoretical investigations and places a strong emphasis on the practical nature of architectural practice itself. Its objective is to generate new knowledge and insights that can be directly applied within the context of architectural design.

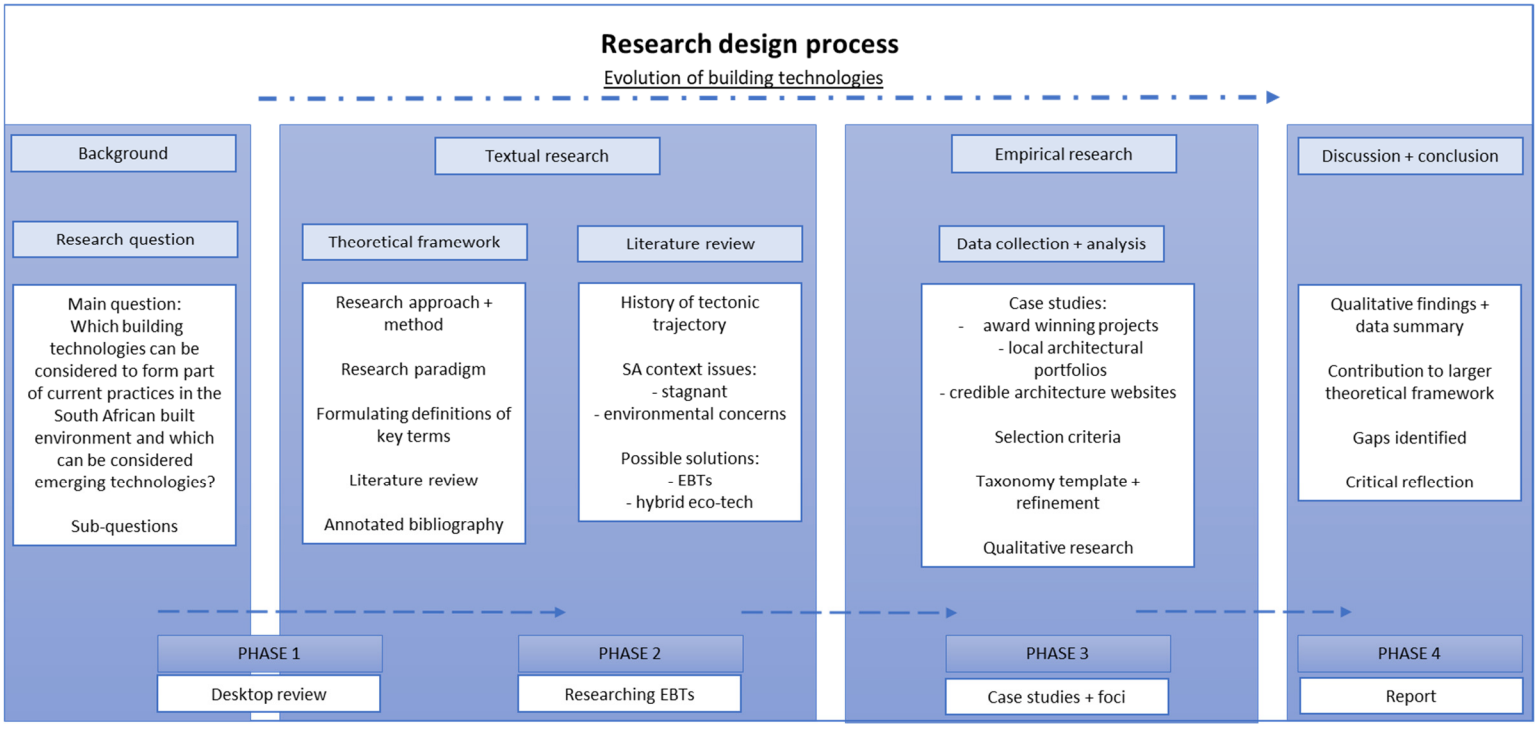


FIGURE 4 OVERVIEW OF METHODOLOGY EMPLOYED IN THE RESEARCH DESIGN PROCESS (AUTHOR, 2023)

While the "research for design" and "practice-led research" principles remain fundamental in informing our approach, we acknowledge the limitations of actively engaging with architects in their design processes. Therefore, to gain an in-depth understanding of how emerging building technologies are utilized and their impact on the built environment, we will predominantly employ the case study method. Our approach involves a detailed examination of select projects and relevant contextual factors, providing valuable insights into the integration of these technologies and their contributions to contextually responsive building practices in the South African context within the past 15 years. The case studies will serve as specific examples, exploring how emerging building technologies interact with local conditions and the inherent values they produce, shaping the trajectory of architecture in South Africa. Through a mixed-method approach involving qualitative and empirical analysis, we aim to comprehensively assess the potential of EBTs in enhancing sustainability and overall building performance in the country.

The literature review component of this study focuses on three main areas: the theory of technology, current building practices, and the architectural design process within the South African context. By examining relevant literature and scholarly works, we aim to gain a comprehensive understanding of the existing knowledge and theories surrounding these topics. This exploration will provide a theoretical foundation for our study and help identify gaps or areas for further investigation.

This study also aims to define the term "emerging building technology" within the context of the literature. By conducting a thorough review of relevant literature, we will seek to establish a clear understanding of what constitutes emerging building technology and its various manifestations within the architectural field. This definition will serve as a guiding framework for identifying and scoping the case studies included in our research. Furthermore, it will enable us to effectively address the research question by exploring how the integration of these emerging technologies influences sustainable and contextually responsive building practices in South Africa. Through this process, we seek to contribute to the existing body of knowledge and provide valuable insights into the role of emerging building technologies in shaping the future of architectural design.

In the second phase of empirical research, we will conduct case studies to gather first-hand data and insights. The purpose of these case studies is to examine specific projects that exemplify the integration of emerging building technologies in South Africa and their impact on sustainable and contextually responsive building practices. A taxonomy of criteria will be developed to guide the selection of these case studies, considering factors such as technological innovation, environmental performance, cultural relevance, and community engagement.

Site visits will be conducted to four chosen projects located in Gauteng, South Africa. These visits will provide an opportunity to observe and document the implementation of emerging building technologies in practice, as well as to engage with the architects, designers, and stakeholders involved. The selected projects will represent a diverse range of building typologies and contexts, allowing for a comprehensive analysis of the integration of emerging building technologies within the South African built environment.

Throughout this research, we will rely on a range of authoritative sources and in-text citations to support our findings and analysis. These sources may include academic journals, books, reports, and reputable online publications. By drawing upon established scholarship and empirical evidence, we aim to ensure the rigor and validity of our research, contributing to the body of knowledge in the field of architectural design and technology in the South African context.

3.2 Research design & methodology:

The research strategy employed in this study is a mixed methods approach, combining qualitative and empirical research methods (Creswell, 2014: 1-2). The qualitative component involves a literature review, examining relevant literature and scholarly works to gain insights into the theory of technology, current building practices, and the architectural design process within the South African context (Denyer & Tranfield, 2003: 672). By setting out for a deeper understanding of the theme of EBTs through existing literature, qualitative exploration helps identify gaps in existing knowledge and informs the research question and objectives.

The empirical component of the study includes conducting case studies and site visits (Yin, 2018). The purpose of these case studies is to gather firsthand data and insights on the integration of emerging building technologies in specific projects (Hancock et al., 2019). By engaging with architects, designers, and stakeholders, researchers can gain a deeper understanding of the challenges, successes, and impacts of these technologies in real-world contexts (Eisenhardt, 1989). The selection of case studies will be guided by a taxonomy of criteria, ensuring a diverse range of building typologies and contexts are represented (Creswell, 2014: 1-2).

The mixed methods approach is justified by the complex nature of the research topic, allowing for a more holistic and nuanced exploration of the integration of emerging building technologies in South Africa (Creswell 2014: 2). The qualitative component provides a theoretical framework and a broader understanding of the subject as discussed, while the empirical component offers real-world insights and practical implications (Tashakkori & Teddlie, 2010). By combining these approaches, the study aims to generate comprehensive and well-rounded findings that can contribute to both theoretical knowledge and practical applications.

The research paradigm adopted for this study is primarily a combination of interpretivism and constructivism (Crotty, 1998). Interpretivism allows for the exploration of the theory of technology, current building practices, and the architectural design process from multiple perspectives and interpretations (Guba & Lincoln, 1994). Constructivism emphasizes the active construction of knowledge through the interaction between the researcher and the research subject (Crotty, 1998). In this study, constructivism is reflected in the process of defining and understanding the term "emerging building technology" through a comprehensive review of relevant literature, actively engaging with existing knowledge and constructing an understanding based on synthesis (Hesse-Biber & Leavy, 2011).

In summary, the mixed methods approach, combining qualitative and empirical research methods, is employed in this study to comprehensively investigate the integration of emerging building technologies in South Africa. The qualitative component involves a literature review to gain theoretical insights, while the empirical component includes case studies and site visits to gather first-hand data. The research paradigm combines interpretivism and constructivism to explore multiple perspectives and actively construct knowledge. By employing this approach, the study aims to contribute to the existing body of knowledge in the field of architectural design and technology in the South African context.

3.3 Research methodology

3.3.1 Formulating key terms

To identify building practices that evolve and extend beyond current day practices, it is vital to understand what these terms mean. Prominent terms in this study include building technologies, current practice, and emerging building technologies (EBTs).

As a research group, the members collaborated to meticulously define and refine these key terms through comprehensive desktop research and sourcing credible literature sources. Over a period of 3 weeks, our collective efforts culminated in the final articulation of precise definitions for each term. Presented below are graphical representations of the step-by-step process involved in formulating the definitive understanding of "Emerging Building Technologies."

Step 1: In Figure 4, the concepts formulated during the initial draft of the definition developed by the research group are depicted. Among the crucial concepts identified were "indigenous building technologies" and "digital manufacturing," which laid the foundation for creating a graph to visualize and plot the relationships between these concepts.

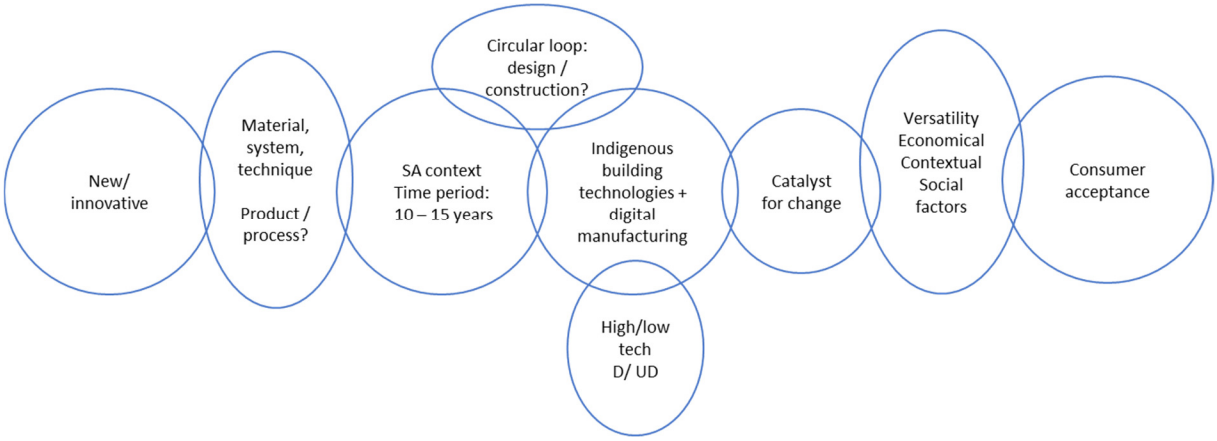


FIGURE 5 DIAGRAM DEPICTING THE CONCEPTS CREATED TO FORM THE DEFINITION OF EBTS (DIT 801, 2023)

Step 2: In Figure 5, the graph used for plotting the concept of tectonic relationships in the form of a Cartesian plane is presented. This graph played a crucial role in defining the concept of Emerging Building Technologies (EBTs), as it allowed us to visualize and understand the interconnections and correlations between different tectonic elements. The insights gained from this graph were instrumental in developing the definition of EBTs.

In the center of the Cartesian plane, we position current building practices. Surrounding this central point, the brown arrows represent the potential opportunities for building practices to be expanded and enhanced through the process of development or the adoption of new technologies. These arrows signify the potential directions in which the building practices can evolve, exploring innovative approaches and integrating emerging building technologies to address challenges and improve the overall performance and responsiveness of the built environment.

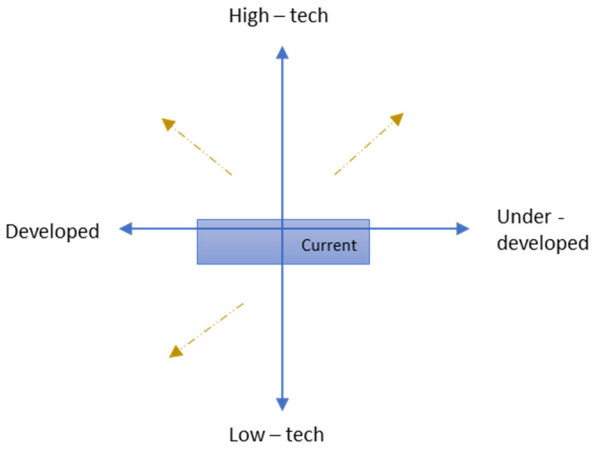


FIGURE 6 CARTESIAN PLANE DEPICTING THE PLACEMENT OF TECHNOLOGY WITHIN CURRENT BUILDING PRACTICES AND THE POTENTIAL FOR EBTS (BOTHMA, 2022).

Step 3: As the definition of EBTs evolved, it became evident that the Cartesian plane alone was insufficient for adequately capturing the degrees of building technologies. To overcome this limitation, a chart was developed, as depicted in figure 7 below. This chart employs quadrants rather than axis lines, providing a more comprehensive approach to rank and categorize building technologies.

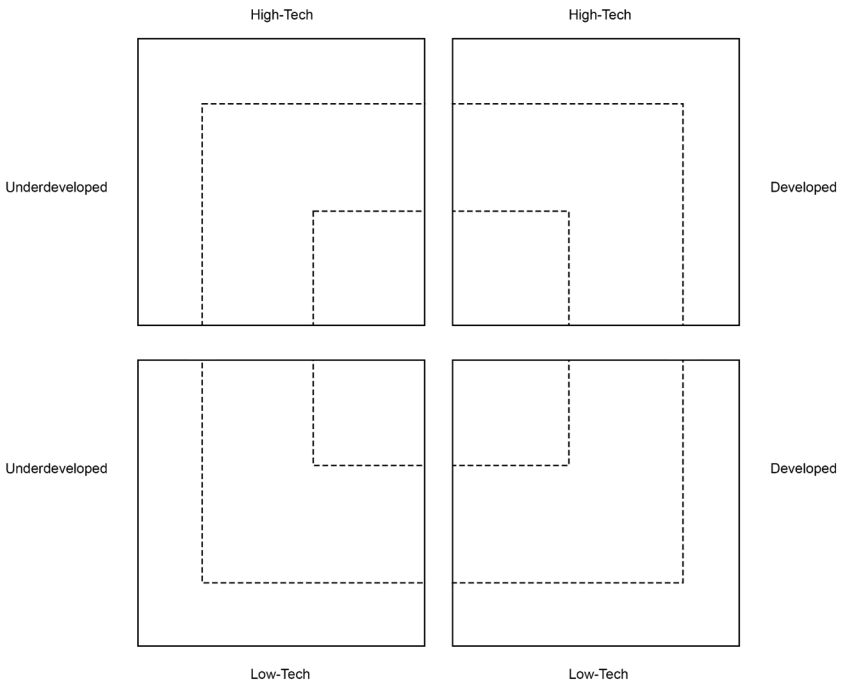


FIGURE 7 FINALISED CHART FOR WHICH BUILDING TECHNOLOGY WILL BE PLOTTED. (DIT 801, 2023)

In this chart, the quadrants represents the various degrees of emergence for building technologies. Here, technologies are classified into three distinct categories: less emerging, semi-emerging, and more emerging being on the outermost quadrant. The placement of each technology within the chart

allows for a nuanced understanding of its level of advancement and potential impact on the built environment.

3.3.2 Literature review

The first component of this study involves a systematic literature review examining relevant literature and scholarly works related to the integration of emerging building technologies in the South African context. The purpose of the literature review is to gain a comprehensive understanding of the theory of technology, current building practices, and the architectural design process within South Africa. By analysing existing literature, the study aims to establish a theoretical foundation, and inform the research question and objectives. (Webster & Watson, 2002; Khan et al., 2003). The purpose of this is to fully understand the theme of EBTs and summarise the existing knowledge and application thereof with the aim to identify gaps in knowledge that could be filled by this study.

The literature review methodology is applied by conducting a thorough search and review of academic journals, books, reports, and reputable online publications (Tranfield et al., 2003:207). The selected sources are critically evaluated and synthesized to extract key findings, concepts, and theories. This process helps to identify the existing knowledge, theories, and best practices in the field, as well as providing a context for the study (Fink, 2014).

The literature review is structured around different theories and themes, as depicted in Figure 7, which collectively form the tectonic trajectory. These key themes include traditional hand-based tectonics, the paradigm shift from hand to machine, digital manufacturing, hybrid tectonics, eco-tech, and contextual responsiveness. Together, these themes constitute the theoretical framework, providing the foundation for the argument on how Emerging Building Technologies (EBTs) can contribute to enhancing current building practices to be more contextually responsive.

Themes:	Theories:
1. Traditional Hand-Based Tectonics - Historical significance of traditional hand-based tectonics - Influence on building design and construction methods	1. Historical Significance and Evolution of Tectonics
2. Paradigm Shift from Hand to Machine - Impact of the industrial revolution - Adoption of new building technologies and materials	2. Impact of Industrial Revolution on Architecture
3, Digital Manufacturing and Emerging Building Technologies - Emergence of digital manufacturing - Influence on architectural design and construction practices	3. The Role of Technology in Architectural Design
4. Hybrid Tectonics - Concept of hybridity in architecture - Examples of hybrid architectural expressions	4. Concept of Hybridity in Architecture
5. Eco-Tech and Sustainability - Importance of sustainability and ecological design - Contribution of EBTs to sustainable building practices	5. Ecological Design and Sustainable Architecture
6. Contextual Responsiveness - Significance of context in architectural design - Integration of EBTs to respond to cultural and environmental contexts	6. Contextualism in Architecture

FIGURE 8 A REPRESENTATION OF THE STRUCTURE OF THE LITERATURE REVIEW ACCORDING TO THE THEMES AND THEORIES EXPLORED. (AUTHOR, 2023)

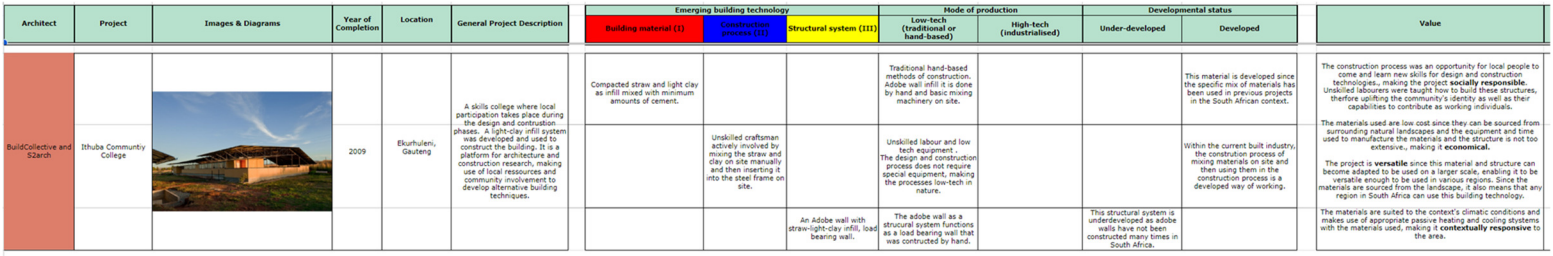
The justification for employing a literature review methodology lies in its ability to provide a solid theoretical framework for the research and establish the current state of knowledge on the subject matter (Boote & Beile, 2005:3). The literature review explores how these themes and theories

contribute to the integration of emerging building technologies in current architectural practices to achieve contextually responsive and sustainable built environments. Additionally, the literature review helps identify gaps or areas for further investigation, enabling the study to contribute to the larger theme of EBTs.

3.3.3 Case study method

During the second phase, case studies will be employed that use a mixed method approach and make use of "multiple sources of evidence" (Yin, 2009: 165). The case study methodology is utilized in this study to gather empirical data and insights on the integration of emerging building technologies in South Africa. Case studies involve an in-depth examination of specific projects or instances that exemplify the use of these technologies and their impact on sustainable and contextually responsive building practices (Yin, 2018: 59). By conducting case studies, the research aims to gain a deeper understanding of the practical implementation, challenges, successes, and outcomes of various EBTs in the South African built environment over a 15-year period.

The case studies are selected using a taxonomy of criteria that consider factors such as technological innovation in the form of i. building materials, ii. construction processes, and iii. structural systems. As seen in the figure below, the case studies are sorted and analysed according to their modes of production, developmental status and the value the projects have created. These criteria ensure a diverse range of building typologies and contexts are represented in the study, allowing for a comprehensive analysis of the integration of emerging building technologies within the South African built environment.



Architect	Project	Images & Diagrams	Year of Completion	Location	General Project Description	Emerging building technology: Building material (I)	Emerging building technology: Construction process (II)	Emerging building technology: Structural system (III)	Mode of production: Low-tech (traditional or hand-based)	Mode of production: High-tech (industrialised)	Developmental status: Under-developed	Developmental status: Developed	Value
BuildCollective and S2arch	Ithuba Community College		2009	Ekurhuleni, Gauteng	A skills college where local participation takes place during the design and contrustion phases. A light-clay infill system was developed and used to construct the building. It is a platform for architecture and construction research, making use of local ressources and community involvement to develop alternative building techniques.	Compacted straw and light clay as infill mixed with minimum amounts of cement.			Traditional hand-based methods of construction. Adobe wall infill it is done by hand and basic mixing machinery on site.			This material is developed since the specific mix of materials has been used in previous projects in the South African context.	The construction process was an opportunity for local people to come and learn new skills for design and construction technologies., making the project **socially responsible.** Unskilled labourers were taught how to build these structures, therfore uplifting the community's identity as well as their capabilities to contribute as working individuals.
							Unskilled craftsman actively involved by mixing the straw and clay on site manually and then inserting it into the steel frame on site.		Unskilled labour and low tech equipment . The design and construction process does not require special equipment, making the processes low-tech in nature.			Within the current built industry, the construction process of mixing materials on site and then using them in the construction process is a developed way of working.	The materials used are low cost since they can be sourced from surrounding natural landscapes and the equipment and time used to manufacture the materials and the structure is not too extensive., making it **economical.** The project is **versatile** since this material and structure can become adapted to be used on a larger scale, enabling it to be versatile enough to be used in various regions. Since the materials are sourced from the landscape, it also means that any region in South Africa can use this building technology.
								An Adobe wall with straw-light-clay infill, load bearing wall.	The adobe wall as a strucural system functions as a load bearing wall that was contructed by hand.		This structural system is underdeveloped as adobe walls have not been constructed many times in South Africa.		The materials are suited to the context's climatic conditions and makes use of appropriate passive heating and cooling stystems with the materials used, making it **contextually responsive** to the area.

FIGURE 9 EXAMPLE OF THE FIRST CASE STUDY CAPTURED IN THE CATALOGUE CREATED (AUTHOR, 2023)

The justification for employing case studies as a research methodology lies in their ability to provide rich and detailed insights into specific instances or projects (Yin, 2018: 59). They offer a holistic view of the integration of emerging building technologies, considering the social, cultural, economic, and environmental factors at play. The case study methodology allows for an in-depth exploration of specific contexts and provides a more nuanced understanding of the subject matter, complementing the theoretical insights gained from the literature review (Fidel, 1984: 273). It allows for the examination of the complexities and intricacies of the integration of emerging building technologies in South Africa, providing a deeper level of analysis and understanding (Eisenhardt, 1989).

Through the detailed examination of case studies, Fidel (1984: 273) explains that the research can generate valuable empirical evidence and practical implications that contribute to the existing body of knowledge in the field of architectural design and technology.

In summary, the literature review methodology is employed to establish a theoretical foundation and identify gaps in knowledge, while the case study methodology is utilized to gather empirical data and insights on the integration of emerging building technologies in South Africa. The literature review

provides a theoretical framework and context for the study, while the case studies offer real-world perspectives and in-depth analysis of specific projects. By employing these methodologies, the study aims to provide a comprehensive and well-rounded exploration of how EBTs can enhance the contextual responsiveness of building practices in South Africa.

3.4 Limitations, delineation, and assumptions of the study

3.4.1 Limitations:

This research study is limited by various factors. Firstly, time constraints may limit the amount of time available to gather and analyse data, as well as write up findings. Additionally, the availability of data on current building technologies and emerging technologies within South Africa may be limited. Moreover, the time period for this study is from 2008 to 2023, which may limit the number of projects that can be assessed due to the lack of data availability.

3.4.2 Delineations:

This research study is delimited to three specific areas: the South African context, current building technology practices, and emerging technologies. Case studies are therefore limited to projects showcasing the implementation of current building practice and emerging technology in South Africa. The time period focused on in this study is over 15 years. The reason for this is to create a new spectrum on the tectonic trajectory where 15 years are considered the time for technologies to be expanded on.

3.4.3 Assumptions:

This research study operates on certain assumptions. Firstly, the timeline for assessing emerging technologies will be from 2008 to the present, a limit of 15 years. Secondly, emerging technologies will encompass materials, techniques, and structural systems (Refer to definition). Thirdly, the definition of emerging technologies used in this study is our own and will be used to assess and compare current and emerging practices. Lastly, emerging technologies will fall under the categories of high tech, low tech with developed and underdeveloped.

3.4.4 Contextual Factors:

This research study recognizes the importance of contextual factors in promoting sustainable and culturally sensitive design and building practices in South Africa. The three spheres that are mutually exclusive within South Africa's contextual factors are social, economic, and environmental.

4. Data analysis

To facilitate the analysis, a systematic taxonomy approach was employed, wherein each case study was analysed within a catalogue created specifically for this study. This taxonomy provided a structured framework for organizing and categorizing the data based on key criteria such as extracting and sorting data from each case study according to i. building materials, ii. construction processes, and iii. structural systems identified. The catalogue further sorts this data according to the level of technological advancement, ranging from low-tech to high-tech, and the level of development, ranging from underdeveloped to developed. These frameworks enabled a comprehensive evaluation of the case studies and allowed for comparisons and insights regarding the contextual responsiveness of the practices employed.

The justification for employing these data analysis techniques lies in their ability to provide a structured and systematic approach to analyse and interpret the data collected (Guest, Namey, & Mitchell, 2013). By employing a taxonomy and the above framework, the analysis process becomes more transparent and replicable, enhancing the reliability and validity of the findings. Additionally, by organizing the data along the low-tech to high-tech and the contextually responsive values spectra, we can identify trends, patterns, and variations in the contextual responsiveness of the case studies. The collected data will be further grouped and analysed according to key themes related to the contribution of the case studies to contextual responsiveness within the South African context. This includes assessing the projects' level of sustainability, considering the social, economic, and environmental impacts of the designs. By examining these key themes, the study aims to provide a comprehensive understanding of the contextual response achieved through the integration of emerging building technologies in South Africa.

Phase 1: filtering according to codes

The case studies are filtered according to the following codes:

1.1. <contextually responsive>
1.2. <low-tech> <high-tech>

Two filtering processes are employed to identify and group data into relevant information in order to extract valuable insights into the success of incorporating EBTs into the design process. The first analysis process is to analyse the catalogue according to a quantitative method.

1.1 Each of the 50 case studies are filtered according to the values that contain the term <contextually responsive>.

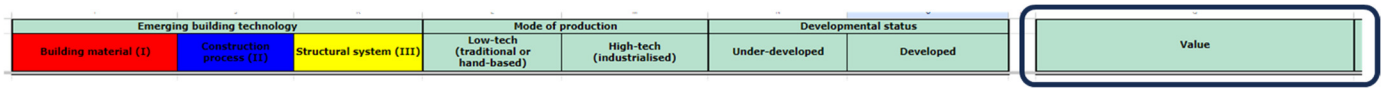
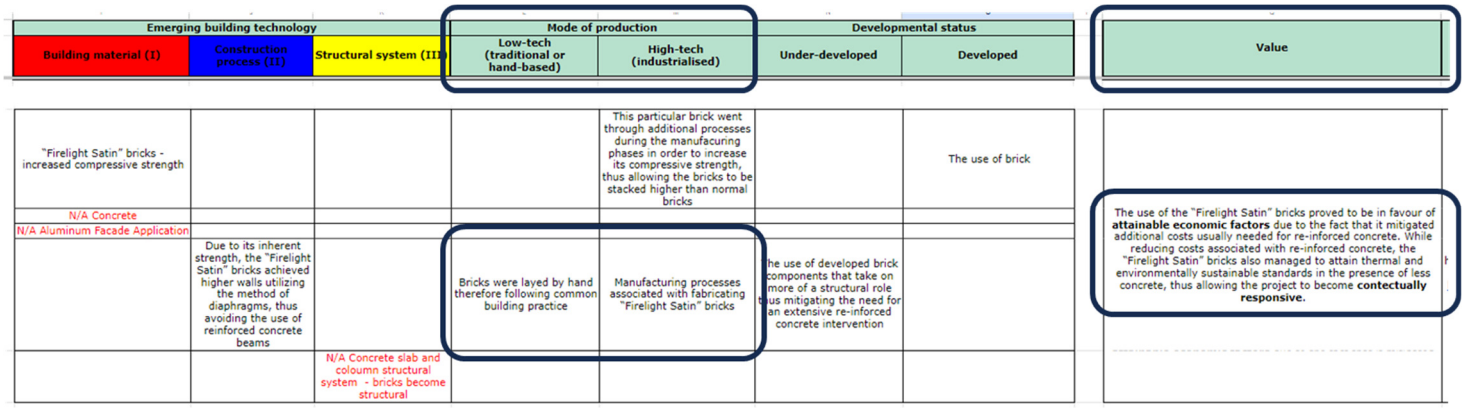


FIGURE 10 THE HEADINGS PRESENTED IN THE CATALOGUE, FOCUSING ON THE CRITERIA WITHIN THE "VALUE" COLUMN (AUTHOR, 2023)

By filtering the catalogue according to this code, 23 case studies out of the total 50 captured present values that bring a contextually responsive value. The filtered catalogue was captured and will be used for further analysis where emerging building technologies will be analysed, as seen in phase 2.

1.2 Each of the 50 case studies are then filtered according to the values that contain the terms both <low-tech> <high-tech>



Emerging building technology			Mode of production		Developmental status		Value
Building material (I)	Construction process (II)	Structural system (III)	Low-tech (traditional or hand-based)	High-tech (industrialised)	Under-developed	Developed	
"Firelight Satin" bricks - increased compressive strength				This particular brick went through additional processes during the manufacuring phases in order to increase its compressive strength, thus allowing the bricks to be stacked higher than normal bricks		The use of brick	
N/A Concrete							
N/A Aluminum Facade Application							
	Due to its inherent strength, the "Firelight Satin" bricks achieved higher walls utilizing the method of diaphragms, thus avoiding the use of reinforced concrete beams		Bricks were layed by hand therefore following common building practice	Manufacturing processes associated with fabricating "Firelight Satin" bricks	he use of developed brick components that take on more of a structural role thus mitigating the need for an extensive re-inforced concrete intervention		The use of the "Firelight Satin" bricks proved to be in favour of **attainable economic factors** due to the fact that it mitigated additional costs usually needed for re-inforced concrete. While reducing costs associated with re-inforced concrete, the "Firelight Satin" bricks also managed to attain thermal and environmentally sustainable standards in the presence of less concrete, thus allowing the project to become **contectually responsive.**
		N/A Concrete slab and coloumn structural system - bricks become structural					

FIGURE 11 AN EXAMPLE OF A CASE STUDY CONTAINING BOTH THE CODES <LOW-TECH> <HIGH-TECH> WITH THE "VALUE" COLUMN CONTAINING A CONTEXTUALLY RESPONSIVE VALUE (AUTHOR, 2023)

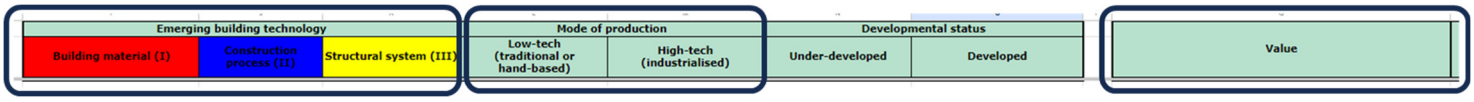
Upon filtering the catalogue based on the values of both <low-tech> and <high-tech>, it was found that 7 out of the total 50 case studies demonstrated a hybrid approach to their projects. This hybrid approach indicates a combination of low-tech and high-tech modes of production, suggesting a deliberate effort to integrate traditional and modern technologies in these projects.

Additionally, when filtering the case studies based on their contextually responsive values, it was observed that 7 out of the 23 case studies met these criteria. This indicates that approximately one-third of the projects analysed in the study were contextually responsive, considering the specific needs and environmental conditions of their respective contexts.

The presence of both hybrid approaches and contextually responsive projects among the case studies suggests a positive trend towards sustainable and contextually sensitive architectural design in the South African built environment. The integration of both low-tech and high-tech methods demonstrates a balanced and adaptive approach to construction, while the significant representation of contextually responsive projects indicates a growing awareness and consideration of local environmental and cultural contexts in architectural practice.

Phase 2: filtering according to emerging building technologies

Each of the 23 contextually responsive case studies and subsequently 7 hybrid studies are further categorised according to links found within:
i. building materials
ii. construction processes
iii. structural systems



Emerging building technology			Mode of production		Developmental status		Value
Building material (I)	Construction process (II)	Structural system (III)	Low-tech (traditional or hand-based)	High-tech (industrialised)	Under-developed	Developed	

FIGURE 12 AREAS FOCUSED ON FOR THE EXTRAPOLATION OF DATA (AUTHOR, 2023)

Of the 7 hybrid case studies:
i. 0 of 7 case studies made use of EBTs in the form of building materials.
ii. 7 of 7 case studies made use of EBTs in the form of construction techniques.
iii. 1 of 7 case studies made use of an EBT in the form of the structural system.

The analysis of the 7 hybrid case studies revealed the following findings:
i. None of the 7 case studies made use of Emerging Building Technologies (EBTs) in the form of building materials. This suggests that traditional building materials were predominantly employed in these projects, indicating a preference for familiar and locally available materials.

ii. All 7 of the case studies made use of EBTs in the form of construction techniques. This indicates a strong inclination towards adopting modern construction methods and innovative techniques in the building process. The integration of EBTs in construction techniques highlights the willingness of architects and builders to explore new approaches that enhance efficiency and quality.

iii. Only 1 of the 7 case studies made use of an EBT in the form of the structural system. This indicates a limited application of emerging structural technologies in the hybrid projects analysed. The use of EBTs in the structural system suggests potential for exploring more advanced and efficient structural solutions in future projects.

Overall, the findings suggest that while there is a significant integration of EBTs in construction techniques, there is a lack of utilization of EBTs in building materials and structural systems among the hybrid case studies. This presents an area for further investigation and exploration, as there may be untapped opportunities for enhancing sustainability and contextually responsive design through the adoption of innovative building materials and structural technologies.

Phase 3: representing the data in a diagram system

A diagrammatic system, as described in the methodology section, was utilized to categorize building technologies based on their mode of production (high-tech or low-tech) and development status (underdeveloped or developed) within the South African context. Each quadrant in the diagram represents a specific combination of these criteria. Below in figure 13, we see the colour representation for each building technology. This acts as the legend to read the diagrams to follow.

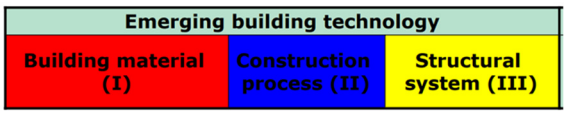


FIGURE 13 COLOUR CODED CATEGORIES USED FOR THE GRAPHICAL REPRESENTATIONS (DIT 801, 2023)

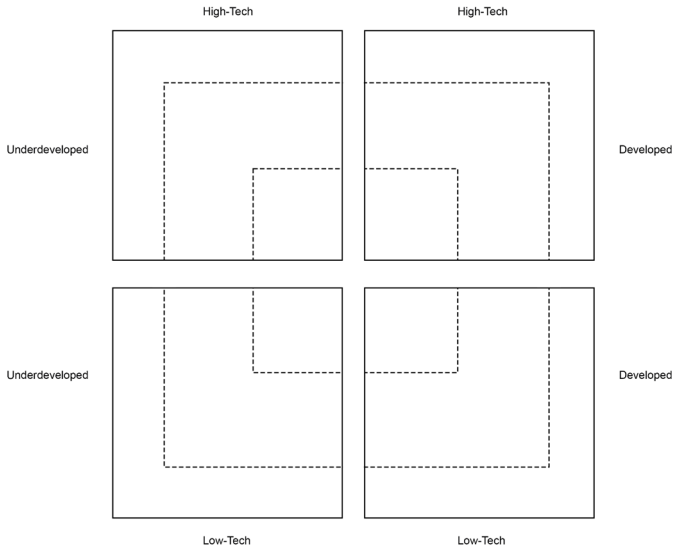


FIGURE 14 THE GRAPH USED TO PLOT THE LEVEL OF EMERGENCE OF THE TECHNOLOGIES ANALYSED IN THE CATALOGUE (DIT 801, 2023)

In the diagram, the innermost section of each quadrant signifies that the emerging building technology is relatively more common in South Africa, indicating a certain level of familiarity and adoption within the industry. Conversely, the outermost section of each quadrant denotes that the EBT is classified as extremely emergent, suggesting that it is among the first of its kind to be introduced in the region, with limited existing applications.

Furthermore, the middle quadrant indicates EBTs that lie between the two extreme classifications. These technologies demonstrate a moderate level of emergence, potentially indicating ongoing development and gradual integration within the South African building industry.

The use of this diagrammatic system allows for a comprehensive visualization of the range of emerging building technologies and their respective levels of adoption and development in the context of South Africa. This approach provides valuable insights into the current landscape of EBTs within the region and offers a foundation for understanding their potential impact on sustainable and contextually responsive building practices.

The following diagram below illustrates the total 50 case studies within the catalogue where the EBTs are captured in their respective quadrants. Figure 15, displayed below, provides a comprehensive representation of the collected data. The diagram illustrates that the distribution of EBTs in South Africa is balanced between those classified as high-tech and low-tech. However, it is noteworthy that the majority of these EBTs are underdeveloped within the South African context.

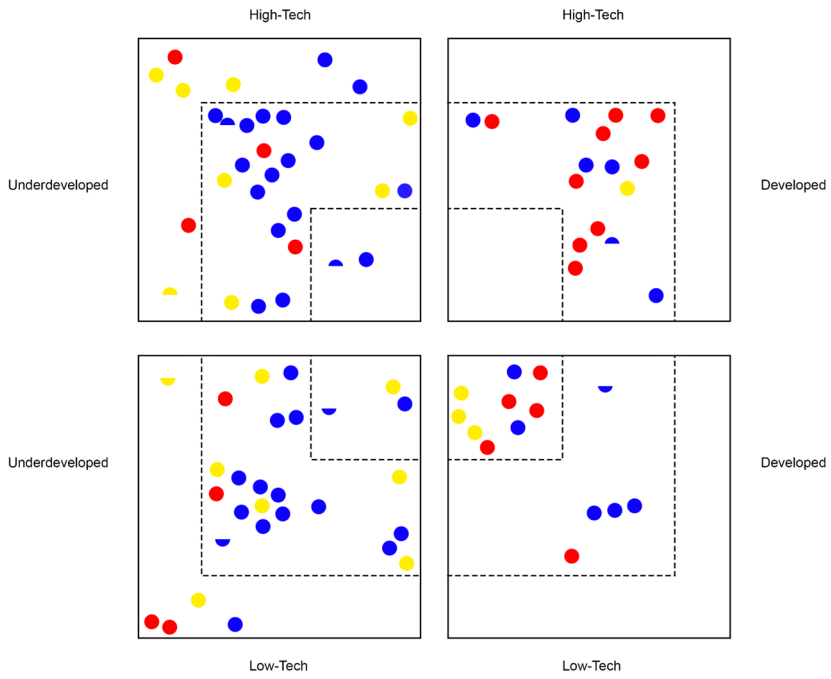


FIGURE 15 GRAPH SHOWING ALL CASE STUDIES PLOTTED ACCORDING TO THE LEVEL OF EMERGENCE OF THE TECHNOLOGIES (DIT 801, 2023)

Upon closer examination, the data reveals that there is a higher prevalence of emerging construction processes compared to materials or structural systems, as evidenced by the greater frequency of blue dots on the diagram. This suggests that innovative construction techniques are more actively explored and adopted in the country.

The diagram also indicates that most of the EBTs fall within the category of medium emergence. This means that while they are not exceptionally rare, they are also not widely prevalent within the industry. The status of these building technologies appears to be relatively unstable, with the potential to gain more prominence and integration into the South African built environment over time.

Furthermore, the predominance of underdeveloped EBTs suggests that there is substantial room for growth and adoption within the industry. As the technology and construction sectors evolve, these emerging building technologies have the potential to become more widely accepted and play a significant role in shaping the future of sustainable and contextually responsive building practices in the country.

The following diagram below (figure 16) provides a visual representation of the mode of production and development status of the construction processes used in the case studies. Among all three building technology diagrams, this one is the most populated, indicating that emerging construction processes are the most prominent among emerging building technologies in South Africa.

It is worth noting that all seven of the hybrid case studies from Phase 1 employed this construction process, further highlighting its significance and prevalence in the country's architectural practices. These can be seen by the blue semi-circles, indicating the data falls within both the low- and high-tech quadrants to form the hybrid.

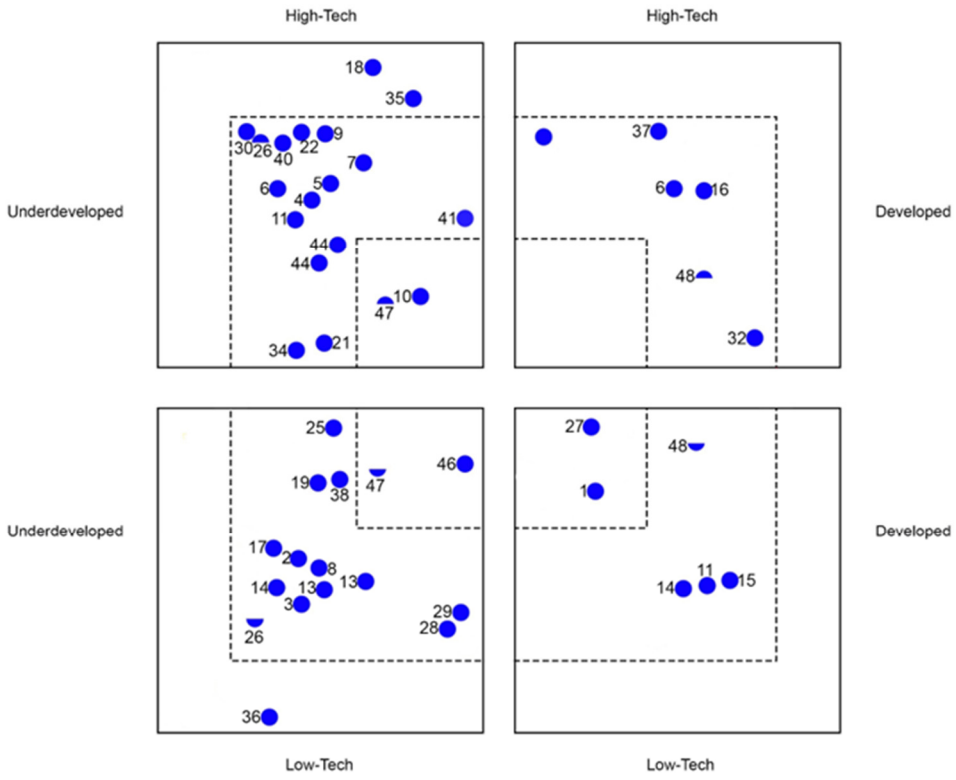


FIGURE 16 GRAPH SHOWING ALL CASE STUDIES PLOTTED ACCORDING TO THE LEVEL OF EMERGENCE OF THE CONSTRUCTION PROCESSES (DIT 801, 2023)

Upon closer examination of the data, it becomes evident that most construction processes fall within the category of medium-level emergence. This suggests that these processes are not exceedingly rare but are also not widely established within the industry. Instead, they hold a middle-ground position in terms of their adoption and integration into the South African built environment.

The prominence of emerging construction processes in South Africa underscores the industry's continuous pursuit of innovative and contextually responsive approaches to building design and construction. By blending low-tech and high-tech elements in a hybrid manner, architects and builders can achieve a balance between tradition and modernity, catering to the specific needs and environmental conditions of the region.

Figure 17 below displays a diagram depicting the emerging structural systems used in the case studies. This diagram reveals a distinct contrast in the development status of these technologies. The data shows that most structural systems classified as emerging in South Africa are both high and low-tech, however very underdeveloped.

The prevalence of underdeveloped structural systems points to a potential area for further exploration and innovation in the country's architectural practices. While emerging building technologies, such as hybrid low-tech and high-tech construction processes, have seen greater integration and application, the same level of advancement has not been achieved in the realm of structural systems.

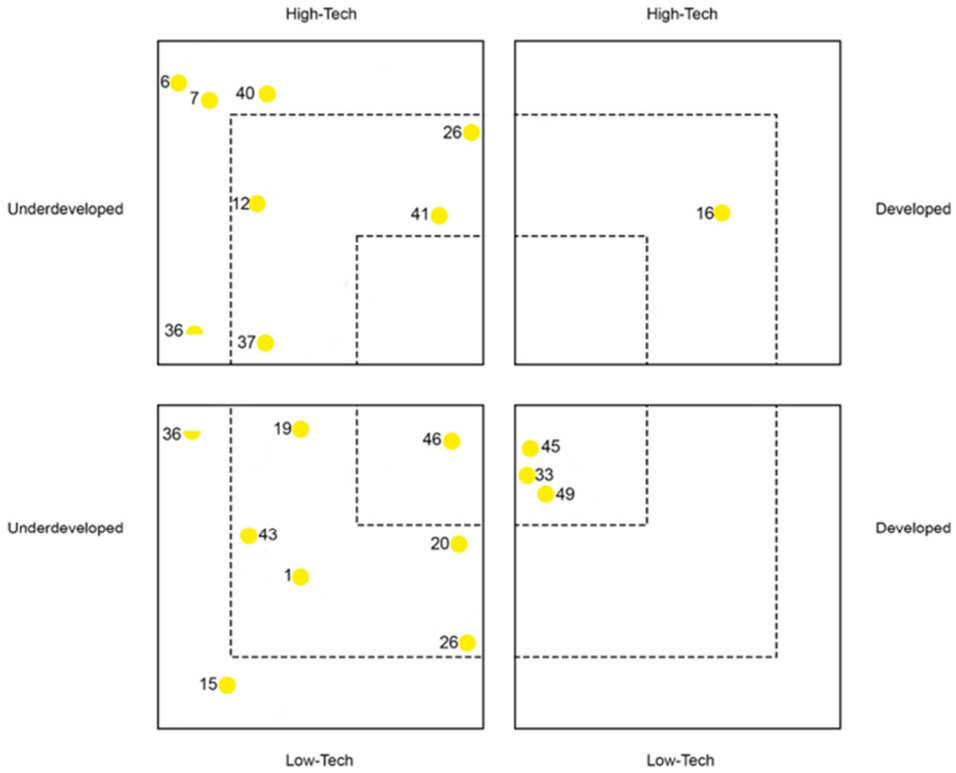


FIGURE 17 GRAPH SHOWING ALL CASE STUDIES PLOTTED ACCORDING TO THE LEVEL OF EMERGENCE OF THE STRUCTURAL SYSTEMS (DIT 801, 2023)

Notably, among the 7 hybrid case studies, project 36 stands out as the only one that adopts hybrid emerging building technology (EBT) in the form of a structural system. This finding indicates the uniqueness and innovative nature of project 36, as it combines both low-tech and high-tech elements in its structural design. However, this is 1 of 7 instances in the total of 50 case studies, suggesting that the integration of hybrid EBTs in the form of a structural system is relatively rare in the context of South Africa.

Lastly, in Figure 18, we observe the distribution of emerging building materials (represented by red dots) from the case studies. The diagram reveals that a significant portion of the emerging building materials falls within the medium range of emergence. This implies that while these materials are not extremely rare, they are also not yet widely adopted in the South African building industry.

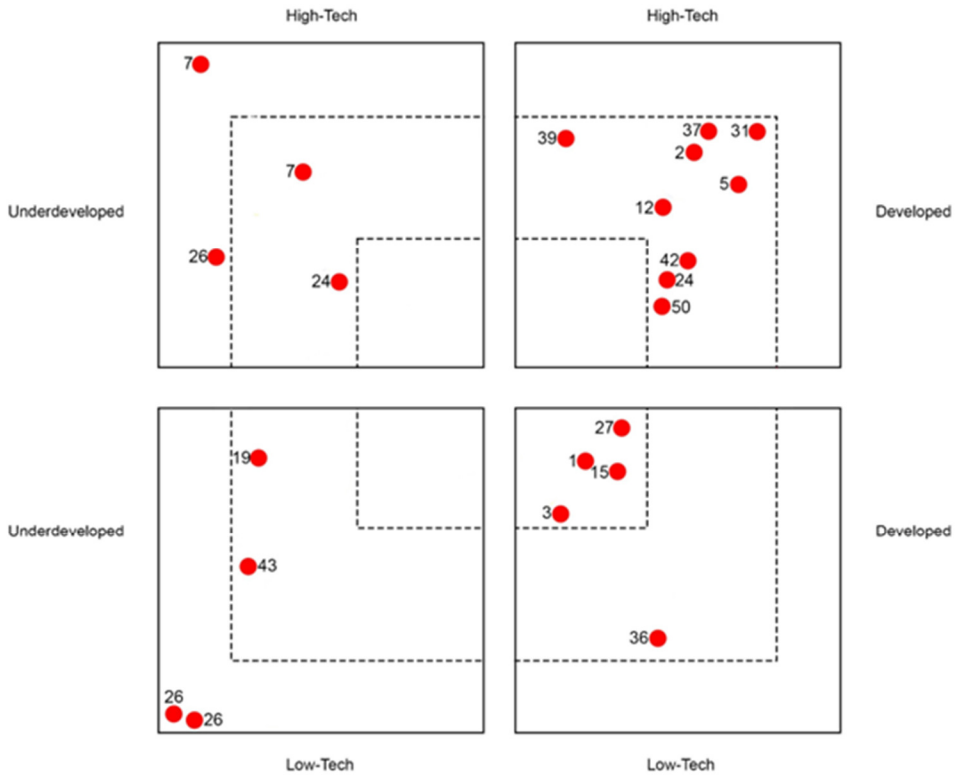


FIGURE 18 GRAPH SHOWING ALL CASE STUDIES PLOTTED ACCORDING TO THE LEVEL OF EMERGENCE OF THE BUILDING MATERIALS (DIT 801, 2023)

Notably, out of the seven hybrid case studies, none of them incorporated emerging building materials as part of their design. This finding indicates that the integration of hybrid building materials (a combination of low-tech and high-tech materials) is not commonly explored or implemented in the context of South Africa. This absence may be attributed to several factors, including the challenges of procuring and combining different types of materials, potential complexities in construction techniques, and a lack of awareness or familiarity with the benefits and possibilities of using hybrid building materials.

The analysis of specific case studies that embody both a hybrid mode of production and contextually responsive values provides valuable insights into the integration of emerging building technologies (EBTs) into the South African built environment. One such case study, Project 26: House Gardiner, designed by Paul Marais in Johannesburg, Gauteng in 2014, exemplifies a hybrid eco-tech solution that spans different levels of technological emergence in the South African context. The use of rammed earth mixed with a polymer for building materials is classified as an extreme level of emergence, indicating its novelty and rarity in the country (Simply Sustainable, 2023). While it represents a cutting-edge approach to construction, it remains underdeveloped in the context of South Africa, presenting opportunities for further exploration and advancement.

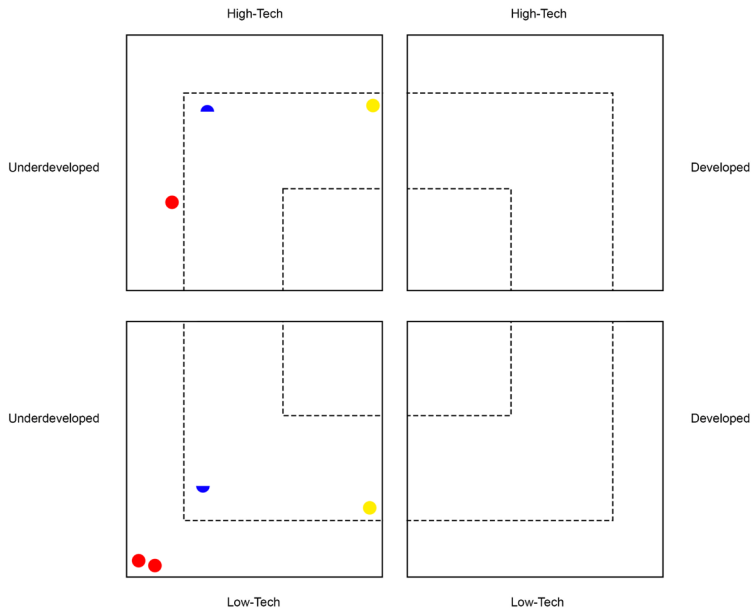


FIGURE 19 GRAPH SHOWING PROJECT 26: HOUSE GARDINER, DESIGNED BY PAUL MARAIS IN JOHANNESBURG, GAUTENG IN 2014 (AUTHOR, 2023)

On the other hand, the construction methods and structural system employed in House Gardiner fall within the medium quadrant of technological emergence. This suggests that these aspects of the project are not extremely rare but also not entirely commonplace in the South African building industry. The use of both low-tech and high-tech methods in construction, such as hand and pneumatic rammers for wall ramming (Simply Sustainable, 2023), reflects a hybrid approach that combines traditional techniques with more modern tools.

The structural system, which consists of cement-stabilized earth with a polymer-stabilized layer above, further demonstrates the integration of diverse technologies in a balanced manner. The combination of cement-stabilized earth with a polymer-stabilized layer showcases the versatility and innovation of the eco-tech solution (Simply Sustainable, 2023). While the use of cement-stabilized earth involves low-tech mixing methods by hand, the polymer-stabilized layer incorporates high-tech techniques with the use of a rotary mixer and a rammer for placement and compaction.

Overall, Project 26 embodies the principles of contextually responsive design by harnessing emerging building technologies in a thoughtful and balanced manner. The extreme emergence of rammed earth mixed with polymer as a building material presents an exciting frontier for sustainable construction in South Africa, while the medium emergence of construction methods and structural system indicates a gradual integration of innovative techniques in the industry. By navigating the interplay between low-tech and high-tech approaches, House Gardiner sets an example of how hybrid eco-tech solutions can contribute to a more sustainable, contextually responsive, and socially conscious built environment in the country.

Project 27: Soil and Serenity, designed by Veld Architects and completed in Centurion, Gauteng, in 2022, offers another compelling example of an eco-tech hybrid solution that blends low-tech and high-tech approaches while remaining contextually responsive and economically viable. The building materials used in this project include rammed earth walls made on-site, utilizing soil sourced from excavations. The construction process involves plywood formwork and a pneumatic press, making use of both low-tech and high-tech elements. The use of simple methods for constructing the walls reflects a low-tech approach, while the incorporation of industrial machines like pneumatic compressors represents a high-tech component of the project.

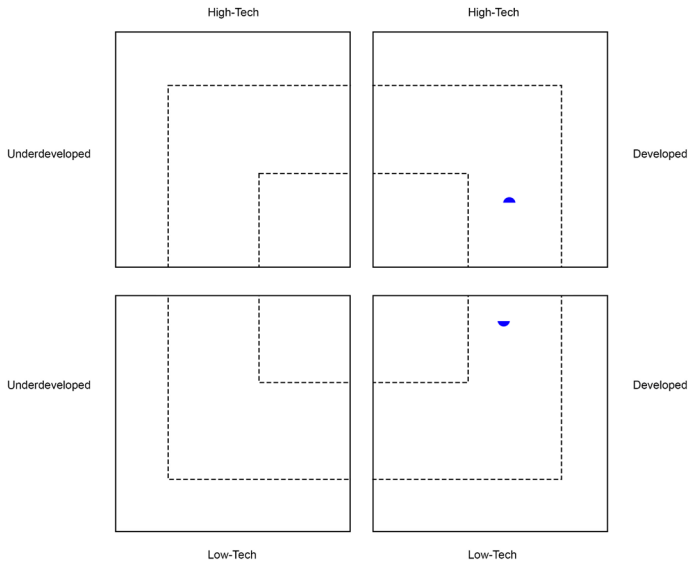


FIGURE 20 GRAPH SHOWING PROJECT 27: SOIL AND SERENITY, DESIGNED BY VELD ARCHITECTS CENTURION, GAUTENG, IN 2022 (AUTHOR, 2023)

Contextual responsiveness is emphasized in Soil and Serenity through the incorporation of locally sourced soil, paying homage to the site's surroundings and cultural context. This approach aligns with the principles discussed by Ampofo-Anti (2017) and Slessor (1997), who highlighted the importance of sustainable and contextually relevant architectural solutions.

Moreover, the project's emphasis on rammed earth as a building material reflects a shared characteristic with Project 26: House Gardiner, showcasing a continuation of the use of this sustainable and cost-effective material in the South African context. Both projects demonstrate a conscious effort to utilize locally available resources, reduce environmental impacts, and create resilient and adaptable structures (GreenBuilder, 2015).

Additionally, the employment of local labour in both projects not only enhances the social value by providing job opportunities and skills training but also fosters a deeper connection with the community and the built environment. This aspect aligns with the principles of ecological design and sustainable architecture, emphasizing the importance of socially responsive design (Slessor, 1997).

In conclusion, Projects 26 and 27 exemplify the potential of hybrid eco-tech solutions in the South African architectural landscape. By integrating both low-tech and high-tech elements, these projects demonstrate how architects can leverage emerging building technologies while honouring local traditions and resources. The use of rammed earth in both projects highlights its significance as a

sustainable and versatile building material. Furthermore, the focus on contextual responsiveness and the inclusion of local labour underscores the social, cultural, and environmental awareness that drives these innovative designs. As the building industry continues to evolve, further research and exploration into eco-tech solutions will enable architects and builders to create a more sustainable, contextually responsive, and socially inclusive built environment in South Africa.

2 Discussion

The analysis of current building practices within the South African context from the past 15 years, as shown in the catalogue, reveals a diverse range of approaches encompassing both traditional and modern materials, techniques, and structural systems. Traditional practices that have persisted over time utilize locally sourced materials like clay, thatch, and stone, reflecting a deep connection with the region's cultural heritage and sustainable resource utilization (Calitz & Wium, 2022: 29-37). For example, the Mapungubwe Interpretive Centre designed by Peter Rich in 2009 showcases the use of traditional building practices with locally sourced stones and soil, integrating historical wisdom into contemporary architecture (Rich, 2009).

It is crucial to evaluate these practices within the broader context of technological advancement. The slow uptake of technology in the construction industry, compared to other sectors like manufacturing, agriculture, and entertainment (Calitz & Wium, 2022: 29-37), suggests that traditional practices continue to hold relevance and importance in the South African built environment.

However, it is essential to recognize that modern building practices in South Africa seldom rely solely on traditional techniques, often involving a blend of traditional and modern-day approaches. The integration of modern materials like concrete, steel, and glass is common in contemporary construction, allowing architects and builders to achieve innovative design solutions and respond to evolving demands (Rich, 2009).

Both traditional and modern building practices in South Africa are regulated by the South African National Standards (SANS) and the South African Bureau of Standards (SABS), ensuring adherence to safety, quality, and environmental standards.

By assessing the current building practices in South Africa, this study contributes to the broader understanding of the interplay between tradition and innovation in the country's architectural landscape. The incorporation of both traditional and modern technologies underscores the dynamic and evolving nature of architectural practices in South Africa, as architects navigate the complexities of contextual responsiveness and sustainability.

Hybrid Eco-Tech: Fusing Low-Tech and High-Tech Approaches

The presence of hybrid eco-tech in the form of seven case studies highlights the potential of combining low-tech and high-tech approaches in architectural design and construction. This concept resonates with the ideas put forth by Behnam (2017: 1-7) regarding the integration of human-dominated ecological systems from the past with high-tech solutions. The notion of a hybrid approach, as advocated by Behnam, emphasizes the importance of drawing inspiration from traditional wisdom while embracing innovative technologies to create harmonious and contextually responsive structures.

However, the limited number of hybrid case studies incorporating both building materials and structural systems in hybrid eco-tech indicates that this approach is still relatively uncommon in the South African building industry. This finding aligns with the work of Louw (2000) and Steyn (2020), which emphasized the challenges and complexities architects face in balancing tradition and

innovation. The scarcity of hybrid building materials and structural systems suggests the need for further research and advocacy in this area to promote the widespread adoption of hybrid eco-tech principles.

Emerging Construction Processes: Key Drivers of Technological Advancement

The prevalence of emerging construction processes as the most prominent EBTs in the South African built environment reinforces the significance of technological advancement in architecture. This finding resonates with insights from Slessor (1997: 5-7), who emphasized the importance of embracing high-tech approaches to achieve optimal performance and ecological responses in sustainable architecture. The prominence of emerging construction processes underscores their role as key drivers of innovation and efficiency in building practices, providing architects with opportunities to respond to specific environmental and social needs.

Nonetheless, the lack of integration of emerging building materials among the hybrid case studies highlights a potential gap in the synergy between construction processes and materials. This finding aligns with the work of Schmidt (2006: 133), who emphasized the need for architects to work closely with the building industry and craftsmen to achieve a balanced integration of technology. Further exploration of the factors influencing the selection and utilization of building materials in hybrid eco-tech projects would provide valuable insights for architects and builders seeking to enhance the contextual responsiveness of their designs.

Future Research and Implications

The limitations of this study, such as the sample size of 50 case studies and the focus on the current state of EBTs, present avenues for future research. To gain a more comprehensive understanding of EBTs' impact on building performance and sustainability, future studies could employ a longitudinal approach to track the progress and evolution of EBTs in the South African building industry over time. Additionally, exploring the performance metrics and user experiences of projects utilizing EBTs would contribute to a more holistic understanding of their effectiveness and potential benefits.

The significance of hybrid eco-tech and the importance of emerging construction processes in the South African context call for continued research and exploration in this field. Researchers and practitioners should engage in ongoing dialogue with the literature, drawing on the insights of authors like Ampofo-Anti (2017), who underscored the importance of sustainability and environmental concerns in architectural practice. By linking the findings of this study with the broader discourse on ecological design and sustainable architecture, the building industry can leverage emerging technologies to achieve more contextually responsive and environmentally conscious designs.

The integration of emerging building technologies in the South African built environment presents both challenges and opportunities for architects and builders. The presence of hybrid eco-tech and the prevalence of emerging construction processes offer promising pathways for creating sustainable and contextually responsive structures. However, the limited adoption of hybrid building materials and the need for further research indicate the complexities of achieving a holistic integration of technology.

By drawing on the insights from the literature review and contextualizing the findings, this study provides a comprehensive understanding of the current state of EBTs in South Africa. The discussion highlights the significance of ongoing research and exploration in the field of eco-tech and architectural design. As the building industry continues to evolve, embracing the potential of emerging technologies and fostering a deeper understanding of their implications will drive innovation and progress toward a more resilient, environmentally conscious, and culturally relevant built environment in South Africa.

3 Conclusion

The culmination of the literature review, data analysis, and discussion has shed light on the significance of integrating emerging building technologies (EBTs) in the South African built environment. The study explored the historical significance and evolution of tectonics, the role of technology in architectural design, the concept of hybridity in architecture, ecological design and sustainable architecture, and contextual responsiveness. These theories provided valuable insights into the interplay between tradition and innovation, highlighting the potential for a hybrid eco-tech approach that fuses sustainable low-tech and high-tech solutions to create contextually responsive and sustainable architectural designs.

The data analysis presented a comprehensive evaluation of current building practices within the South African context, revealing a diverse range of approaches that encompass both traditional and modern materials, techniques, and structural systems. The presence of hybrid eco-tech in some case studies demonstrated the potential of combining low-tech and high-tech approaches to achieve contextually responsive and environmentally conscious designs. The prevalence of emerging construction processes emphasized the role of technological advancement in driving innovation and efficiency in building practices.

The discussion drew connections between the research findings and the broader discourse on ecological design and sustainable architecture. It highlighted the importance of ongoing research and exploration in the field of eco-tech and architectural design, while also acknowledging the challenges and complexities architects face in balancing tradition and innovation. The integration of both traditional and modern technologies underscored the dynamic and evolving nature of architectural practices in South Africa, as architects navigate the complexities of contextual responsiveness and sustainability.

Overall, the research results underscore the significance of incorporating emerging building technologies to enhance sustainable and contextually responsive building practices in South Africa. The findings contribute to a deeper understanding of the challenges and opportunities in adopting hybrid eco-tech principles, where low-tech and high-tech solutions coexist to achieve innovative and culturally relevant designs. This research offers valuable insights into the potential future developments in the field of eco-tech and architectural design, advocating for continued research and exploration to drive progress toward a more resilient and environmentally conscious built environment.

Recommendations:
Based on the research findings, several recommendations emerge for future studies and architectural practices:

Longitudinal Studies: Conduct longitudinal studies to track the progress and evolution of EBTs in the South African building industry over time. This will provide valuable insights into the long-term impact of emerging technologies on building performance and sustainability.

Performance Metrics and User Experiences: Explore the performance metrics and user experiences of projects utilizing EBTs. This will offer a more holistic understanding of the effectiveness and benefits of these technologies in real-world applications.

Promote Hybrid Eco-Tech Approaches: Promote the adoption of hybrid eco-tech principles, where low-tech and high-tech solutions are combined to achieve more contextually responsive and sustainable

designs. This will require ongoing research, advocacy, and collaboration between architects, builders, and industry stakeholders.

Collaboration and Knowledge Exchange: Encourage collaboration and knowledge exchange between architects, builders, and craftsmen to achieve a balanced integration of technology in architectural design. This will enhance the contextual responsiveness and sustainability of building practices.

In conclusion, the integration of emerging building technologies offers promising opportunities for architects and builders to create contextually responsive, sustainable, and innovative designs in the South African built environment. By embracing the potential of hybrid eco-tech principles and fostering ongoing research and exploration, the building industry can advance toward a more resilient, environmentally conscious, and culturally relevant future.

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Addendums

1: Annotated bibliography

author	title	year	Keywords	themes	Summary main concept	argument	Method	gaps
Michael Louw	The search for hybrid tectonics in contemporary African architecture	2000	Hybrid tectonics Contemporary African arch. Postcolonialism African identity Critical regionalism Vernacular arch. Sustainable design Craftsmanship Building techn. Structural expression Nb: ongoing; evolving	Exploring use of hybrid tectonics in contemporary African architecture as a means of reconciling local and global influences and forging new architectural identities. Postcolonialism and globaliz. exploring the relationship between architecture and identity in Africa and the role of critical regionalism that reflects local values and cultural contexts. Materiality and sustainability	hybrid tectonics, the combination of traditional building techniques and materials with modern technology and materials, can create a unique and sustainable architectural style that reflects the cultural identity of Africa Highlights the complexity of South African architecture due to the coexistence of first and third world architecture	potential of hybrid tectonics to create a unique and sustainable architectural style that reflects the cultural identity of Africa. It also emphasizes the importance of considering the social, economic, and environmental factors when implementing hybrid tectonics in African architecture emphasizes the need for sustainability and cultural identity in African architecture.	case studies to develop his arguments and support his ideas. The literature review is used to provide a theoretical framework for understanding hybrid tectonics in African architecture, while the case studies provide real-world examples of how hybrid tectonics can be applied in practice	The lack of critical engagement with the hybridization of tectonics in contemporary African architecture. The limited discourse on the agency of materials and construction technologies in contemp. African architecture. The limited exploration of how the inclusion of the "underdeveloped" in "developed" technologies is affecting architecture in South Africa.
Quotes:	explore the meaning and significance of hybrid tectonics in contemporary African architecture, and to assess the effectiveness of tectonic innovation in reconciling modernity and cultural identity" (p. 2). defines hybridity as "the fusion of diverse cultural elements and constructional systems, resulting in an architecture that transcends conventional stylistic categories" (p. 3) Nnamdi Elleh, who argues that "hybridity is the hallmark of contemporary African architecture, where traditional, colonial, and modern influences are synthesized into a new design idiom" (p. 5) that "sustainability is a key concern in African architecture, where climate change, resource depletion, and urbanization pose major challenges" (p. 6) author argues that "hybrid tectonics can provide a means of reconciling modernity and cultural identity in African architecture, by adapting traditional forms and techniques to contemporary building practices" "The integration of tectonic and environmental strategies is a key aspect of sustainable design, which seeks to minimize the ecological impact of buildings and enhance their performance and comfort" (p. 6). "Hybrid tectonics can help to overcome the dichotomy between tradition and modernity, by reconciling cultural identity and technological innovation in a creative and dynamic way" (p. 13). "Sustainability and cultural identity are not mutually exclusive, but rather complementary aspects of contemporary African architecture, which can enrich and enhance each other" (p. 14).							
Abimbola Olukemi Windapo and Keith Cattell	The South African Construction Industry: Perceptions of Key Challenges Facing Its Performance, Development, and Growth	2017	SA construction Industry challenges Economic devel. Productivity Govt. support Investment Corruption Skills shortages Safety standards Survey research	Challenges facing the South African construction industry: low productivity and efficiency, lack of govt. support and investment, corruption, skills shortages, and safety concerns. Impact of political and economic factors: apartheid, globalization, and the country's economic climate. Need for government support and investment: skills shortages and safety concerns: to improve its performance and growth.	the article provides valuable insights into the current state of the South African construction industry and proposes solutions for its improvement.	The impact of political and economic factors on the development of the South African construction industry is significant, including the legacy of apartheid, globalization, and the country's economic climate. emphasizes the need for government support and investment to address these challenges. The authors argue that addressing skills shortages, improving safety standards, and addressing corruption are also critical to the industry's development and growth.	a survey of industry professionals and a review of relevant literature, highlighting the importance of research in understanding the challenges facing the industry.	Lack of focus on informal sector Limited geographic scope: Lack of focus on technological advancements: role of technology in improving productivity and efficiency in the industry. Limited stakeholder engagement:
Quotes:	"A significant issue facing the South African construction industry is the low levels of productivity and efficiency" (p. 13) lack of government support and investment" (p. 25)							
chad schwartz	Introducing architectural tectonics: exploring the intersection of design and construction	2020	architectural tectonics, design, construction, collaboration, structural, material, and innovation.	importance of understanding and integrating architectural tectonics into the design process	architectural tectonics—the physical relationship between a building's design and its construction—should be an integral part of an architect's education. Understanding tectonics allows architects to better integrate structural and material considerations into their design process, resulting in more innovative and efficient buildings. importance of collaboration between designers and builders to create better buildings	The main argument of this article is that architectural tectonics—the study of the physical relationship between a building's design and its construction—is an essential part of the design process and should be an integral part of an architect's education. The article argues that understanding tectonics allows architects to better integrate structural and material considerations into their design process, resulting in more innovative and efficient buildings.	primarily conceptual and theoretical primarily qualitative, Overall, Schwartz's methodology involves synthesizing existing knowledge and using examples to illustrate his arguments. While he does not conduct empirical research, he does draw on a range of sources to support his claims and provide a comprehensive overview of the topic.	Empirical evidence: Limited focus on contemporary tectonicsCultural and regional perspectives Theoretical development
Quotes:	"Architectural tectonics, as a concept, encompasses the relationship between design and construction". "Tectonic thinking emphasizes the expression of the constructional logic and material qualities of a building" (p. 4). "In an era where architecture is frequently consumed as a commodity, tectonics can provide a necessary reminder of the value of craft, construction, and materiality in the built environment" (p. 9).advances in technology have had a significant impact on tectonic design Quotes: "New technologies have expanded the possibilities of tectonic design, allowing architects to create structures that were once thought impossible." "Architectural tectonics is the intersection of design and construction technology, and it is the foundation of successful architectural design."							
Paul loh	DIGITAL MATERIAL PRACTICE the agency of making	2017	digital material practice materiality design making digital technology integration traditional material practices properties of materials new techniques emerging field exploration development design theory architecture theory	The impact of digital technology on the agency of making and material practice The transformation of material agency in the digital age + its importance The concept of digital material practice and its potential to create new forms of materiality The integration of digital and material practices in design and making The exploration of the properties of materials and the development of new techniques and forms of materiality through digital material practice	the agency of making has shifted from the human hand to digital technology. The article explores the concept of digital material practice and its potential to create new forms of materiality, and discusses the importance of material practice in design and making. Loh also explores the properties of materials and the development of new techniques through digital material practice, and argues that this emerging field requires further exploration and development. concludes that digital technology has transformed the way we design and make, but that material practice remains a critical aspect of the process.	Digital technology has transformed the way designers and makers approach material practice and has created new forms of material agency. should be used to augment, rather than replace, traditional material practices. Has potential to facilitate a more sustainable approach to design by enabling the exploration of new materials and the development of new techniques for using them. The integration of digital and material practices in design and making can lead to new ways of thinking about the properties of materials and the potential for creating new forms of materiality.	Loh draws on a range of sources, to support his arguments about the potential of digital material practice to create new forms of materiality. Loh draws on examples from his own practice as a designer to illustrate the concepts he discusses. The article can be considered a theoretical reflection on the intersection of digital and material practices in design and making.	the emerging field of digital material practice requires further exploration and development to fully understand its potential and overcome the challenges that come with integrating digital and material practices. As such, future research could explore the development of new techniques and materials through digital material practice, as well as the practical and theoretical implications of this approach for design and making.

						Digital material practice is an emerging field that requires further exploration and development to fully understand its potential and to overcome the challenges that come with integrating digital and material practices in design and making.		
Quotes:	"In the digital age, the agency of making shifts from the hand of the craftsman to the computer, where digital tools mediate material practice." "engage with material phenomena in new ways, and create new relationships between materials and our bodies." "experiment with different techniques, and develop new forms of materiality." "Digital material practice allows us to create new forms of materiality that would not be possible through traditional methods of making, and to engage with materials in new ways that challenge our preconceptions of what is possible."							
Iain Low	Architecture in Africa: Situated Modern and the Production of Locality	2014	situated modernism locality identity heritage modernization post-colonialism globalization	Situated modernism: The idea that modern architecture should be adapted to local contexts and conditions, rather than imposing a universal style. Production of locality: The way in which architecture can contribute to the creation of a sense of place and identity, by reflecting and reinforcing local cultural and social values. African architecture: The unique challenges and opportunities of architectural practice in Africa, including issues of post-colonialism, globalization, and urbanization. African modernism represented a "hybrid" of Western modernism and local cultural traditions.	intersection between globalization and African architecture, the need to create a unique and local modernism that reflects the cultural identity and history of Africa. "situated modernism," the need to balance global influences with local cultural and historical contexts. seek to integrate modernist techniques and styles with African cultural traditions. "Producing Locality," importance of engaging with local communities and involving them in the design process to create a sense of ownership and cultural relevance. advocates for a more contextually responsive approach that takes into account the specific cultural, social, and environmental conditions of the African context.	African architecture is not simply a derivative of Western modernism but is rather a unique hybrid of traditional and modern elements that is specific to the local context. incorporated elements of traditional African architecture into their designs, such as the use of local materials and construction techniques, and how this has resulted in the production of unique and contextually specific architecture. is a product of local contexts and cultures, and its production should reflect this should be collaborative, involving local communities and stakeholders in the design process to ensure that it is culturally appropriate and responsive to local needs. importance of incorporating sustainable design principles into the production of African architecture to address pressing environmental concerns on the continent. Overall, the article argues for a reimagining of African architecture as a unique and context-specific expression of modernity that is responsive to local needs and cultures.	draws upon previous research, case studies, and personal observations to support his arguments and claims throughout the article. Therefore, it can be inferred that his approach is primarily based on qualitative research methods.	The need to explore alternative design strategies that incorporate local materials, labor, and cultural practices. The need for more research on the impact of globalization on local architectural practices and the built environment in Africa. The need to study the role of African architects and architectural education in shaping the built environment in Africa. The need for more research on the relationship between architecture and development in Africa. The need to investigate the social, economic, and cultural factors that influence the production of architecture in Africa.
Quotes:	"The challenge facing architects and planners in Africa was how to create an architecture that was modern and functional, yet also responsive to the needs, desires, and aspirations of the local people." (p. 19) " grounded in the belief that modernity is not a fixed and immutable set of ideas, but rather a fluid and dynamic process that can be shaped by local conditions and contexts." (p. 31) "Situated modernity challenges the idea that modern architecture is a universal and homogeneous style, and asserts that modernity can take on many different forms and manifestations depending on the local context." (p. 53)							
Barbara Jekot	The coexistance of the third and first world in South African architecture	2007	Globalisation Third World First World Underdeveloped Developed Critical Regionalism Hybridity Identity Authenticity Spatial dialectics Cultural plurality.	The impact of globalization The coexistence of first world and third world architecture in South Africa The use of "developed" technologies in "underdeveloped" contexts The importance of cultural context The need for architects to engage with social, economic, and political issues in their work These themes are explored through the lens of South African architecture, but have broader implications for architecture and globalization more broadly.	discusses the challenges faced by South African architects in balancing the use of "developed" technologies with the need to include the "underdeveloped" in their designs. The article examines globalization and how it has impacted architecture in South Africa, where architects are increasingly turning to indigenous design and materials to create sustainable and culturally relevant structures. Jekot argues that the coexistence of "third" and "first" world architecture in South Africa is an important development that highlights the need for architects to prioritize inclusivity and sustainability in their designs. Overall, the article highlights the challenges and opportunities of creating architecture in a rapidly changing global landscape.	South African architecture is characterized by the coexistence of the "first" and "third" worlds, where "first world" technologies and "third world" building techniques and materials are used together. The article suggests that this coexistence reflects the country's complex social and economic history, and the ongoing challenges of globalization and development. The author argues that this coexistence can lead to innovative and creative architectural solutions, but also raises questions about sustainability, cultural identity, and social equity. The article emphasizes the need for architects and planners to engage with local communities and to develop approaches that are sensitive to local contexts and needs.	case studies, critical analysis, and personal reflection.	the lack of reliable data and statistics on the informal settlements and the people living in them. This limits the ability to fully understand the social and economic dynamics of these communities and their impact on urban development. Additionally, there is a lack of research on the experiences and perspectives of the residents of these informal settlements, which is essential in understanding the effectiveness of current policies and interventions aimed at improving living conditions. Finally, Jekot also notes the need for further research on the sustainability of the current approaches to housing and urban development in South Africa, and the potential for alternative models that prioritize community participation and empowerment.
Quotes:	"Hybridity can be seen as a process of 'cultural translation' that transcends binary categories and creates new forms of cultural identity and expression" (Chapter 2). "Globalization represents a complex and multifaceted process of economic, cultural, and social integration that has both positive and negative impacts on local communities and identities" (Chapter 2). "The inclusion of 'underdeveloped' technologies and materials in South African architecture reflects a desire to express local cultural identity and promote sustainable development, while resisting the homogenizing forces of globalization" (Chapter 3). "Contemporary South African architecture reflects a 'double-edged' process of globalization, in which 'developed' technologies and paradigms coexist with 'underdeveloped' ones, but also perpetuate inequalities and power imbalances" (Chapter 4). "A more inclusive and context-specific approach to sustainable architecture is needed, one that values diversity and hybridity, and recognizes the importance of local knowledge and practices" (Chapter 4).							
Kuchena Jabulani Charles, Usiri Paul Kuchena, JC and Usiri, P.	SUSTAINABLE ADVANCED CONSTRUCTION TECHNOLOGIES	2019	Advanced Construction Technologies; Sustainability, Next generation materials,	The importance of sustainable construction technologies in promoting economic, environmental, and social sustainability in the construction industry. The various sustainable construction technologies that are available, such as green roofs, solar panels, and water conservation systems. The benefits of sustainable construction technologies, including energy efficiency, reduced environmental impact, and improved indoor air quality. The challenges and barriers to the adoption of sustainable construction technologies, such as lack of awareness, high initial costs, and resistance to change. The need for a paradigm shift in the way we think about construction, and the opportunity for businesses to benefit from the adoption of sustainable construction technologies.	the importance of sustainable construction technologies in the construction industry. these technologies can help to reduce the negative impact on the environment and improve the efficiency of construction projects. overview of various sustainable construction technologies, such as green roofs and solar panels, and discuss the challenges and barriers to adopting them. Overall, the article emphasizes the benefits of sustainable construction technologies and emphasizes the need for their adoption in the construction industry to promote economic, environmental, and social sustainability. three pillars of sustainability (economic, environmental, and social)	the adoption of sustainable construction technologies is necessary to promote economic, environmental, and social sustainability in the construction industry. The authors argue that the use of advanced and sustainable construction technologies is no longer an option but a necessity, given the negative impact of construction activities on the environment and the need to promote sustainable development. the challenges and barriers to the adoption of sustainable construction technologies, such as lack of awareness, high initial costs, and resistance to change. Overall, the article argues that the adoption of sustainable construction technologies is not only a moral	The authors draw on existing literature and research studies to support their arguments and provide examples of sustainable construction technologies that have been successfully implemented in various parts of the world. However, the article does not describe a specific research design or data collection process, as it is not a primary research study. Instead, it provides a synthesis of existing knowledge on the topic of sustainable construction technologies and their relevance to the construction industry.	Lack of awareness: High initial costs: which may discourage some businesses from making the investment. Resistance to change: within the construction industry, as traditional construction practices and materials are deeply ingrained. Lack of regulatory frameworks: The authors note that the lack of regulatory frameworks and incentives for sustainable construction can be a barrier to the widespread adoption of sustainable construction technologies.

						imperative but also a business opportunity for companies in the construction industry to promote sustainable development and benefit from the advantages that come with it.		
Quotes:	"The use of advanced and sustainable construction technologies is no longer an option, but rather a necessity" (p. 1). "Sustainable construction is about meeting the needs of the present without compromising the ability of future generations to meet their own needs" (p. 2). "The adoption of sustainable construction technologies requires a paradigm shift in the way that we think about construction" (p. 6). paper highlights the importance of sustainable construction technologies in promoting economic, environmental, and social sustainability							
G Steyn	Appropriate South African Architecture - concepts derived from vernacular traditions ad current practices	2020	urban sprawl, building types, sustainable development	appropriate architecture respects local culture and traditions while being responsive to contemporary needs and challenges. The role of vernacular architecture as a source of inspiration and knowledge for contemporary architecture. The challenges balancing local and global influences, and in addressing issues such as sustainability and social justice. The need for a more collaborative and participatory approach to architecture that involves local communities and responds to their needs and aspirations. The potential of appropriate architecture to contribute to a more inclusive and sustainable development of South African society. Challenges: urbanization, globalization, and environmental concerns.	importance of appropriateness incorporates both vernacular traditions and modern practices. architecture should be designed to be more sustainable, affordable, and appropriate for the local context, while also taking into consideration the social, cultural, and environmental aspects of the surrounding area. that incorporating appropriate design concepts can lead to more sustainable and culturally meaningful architecture in South Africa. the principles of vernacular architecture, which include using local materials, responding to the local climate, and reflecting local cultural traditions. The author emphasizes the importance of preserving and adapting vernacular architecture to modern needs.	appropriateness, which is defined as "architecture that is socially, economically, environmentally and culturally appropriate to the people who use it, the community in which it is situated and the environmental context in which it exists." The article argues that appropriate architecture should be rooted in the culture and context of the place where it is built, and that it should be sustainable, affordable, and accessible to all. The author suggests that appropriate architecture in South Africa should draw on both the knowledge and skills of local communities and the latest developments in technology and design. Solutions could be: sustainable design, green architecture, and community participation.	draws on a range of sources, including academic literature, government policies, and case studies of relevant architectural projects.	there is a lack of detailed research and documentation on appropriate and sustainable South African architecture, particularly in the context of rural areas and informal settlements. The author emphasizes the need for further research and collaboration between architects, researchers, and communities to develop appropriate and sustainable solutions for housing and infrastructure in South Africa.
Quotes:	"Appropriate architecture seeks to address the challenges of creating sustainable and culturally sensitive built environments through the integration of local culture, materials, and environment" (Chapter 1). "Vernacular architecture reflects the principles of using local materials, responding to the local climate, and reflecting local cultural traditions" (Chapter 2). "Current practices in South African architecture aim to address the challenges of urbanization, globalization, and environmental concerns through sustainable and community-oriented design" (Chapter 3). "The success of appropriate architecture lies in its ability to integrate vernacular traditions and contemporary design principles to create architecture that is responsive to the local environment and cultural traditions" (Chapter 4). "The integration of vernacular traditions and current practices in architecture is essential in creating a unique sense of place and identity in South Africa" (Chapter 5).							
Kenneth Frampton	Studies in tectonic culture : the poetics of construction in nineteenth and twentieth century architecture	1995	Tekton Contemporary practice Meaningful joining evolving poetics Modern tradition	trace the history of contemporary form as an evolving poetic of structure and construction, the book's analytical framework rests on a rethinking of the entire modern architectural tradition. The notion of tectonics as employed by Frampton-the focus on architecture as a constructional craft-constitutes a direct challenge to current mainstream thinking on the artistic limits of postmodernism, and suggests a convincing alternative a critique of the contemporary practice, in which non-architectural concepts govern and generate architectural decision. That said, much of what makes something architectural is its physicality, its structure, its constructedness. This is what makes architecture unique even among the arts. Nevertheless, tectonic is not the mere joining of parts, but rather, it is the artful and meaningful joining of parts, stimulating the mind and the senses. After all, to understand something is to understand how it is made. (1-27)	The book's ten essays and an epilogue trace the history of contemporary form as an evolving poetics of structure and construction. Frampton argues that architecture is more than scenographic and visual – it is also tactile and tectonic. Furthermore, he contends that architecture is much more than a sign or a symbol; it is, in fact, something substantial in its own right, The tectonic construction is equivalent to framing elements; its formative process is typically additive, characterized by the combining of two or more heterogeneous parts. The topos denotes stereotomic constr. , a subtractive sculpting or carving from the site mass, but conceptually resulting in a contrived permutation of the ground plane. The idea of an architecture unrelated to its site is a perversion in Frampton's view – he argues, in fact, the most prevalent foe of meaningful architecture in recent history. He continues his case for context, suggesting that architecture express both sound and silence in relation to its site. An architecture which cannot be silent is devoid of spiritual power. (1-27)	modern architecture is invariably as much about structure and construction as it is about space and abstract form. Frampton also demonstrates that the way in which these elements are articulated from one work to the next provides a basis upon which to evaluate the works as a whole. This is especially evident in his consideration of the work of Perret, Mies, and Kahn and the continuities in their thought and attitudes that linked them to the past. Frampton considers the conscious cultivation of the tectonic tradition in architecture as an essential element in the future development of architectural form, casting a critical new light on the entire issue of modernity and on the place of much work that has passed as "avant-garde."	essays and an epilogue that trace the history of contemporary form. He clarifies the various turns that structural engineering and tectonic imagination have taken in the work of such architects as Perret, Wright, Kahn, Scarpa, and Mies, and shows how both constructional form and material character were integral to an evolving architectural expression of their work.	
Quotes:	Tectonic, Frampton argues, is one out of three essential characteristics of architecture. The other two consist of the topos (the site) and the typos (the meaning). The last ingredient has been allocated with inappropriate emphasis, the author suggests, and it's the other two, associated with building craft, that Frampton decides to spend more time discussing.							

2: Catalogue

	Architect	Project	Images & Diagrams	Year of Completion	Location	General Project Description	Emerging building technology			Mode of production		Developmental status		Value	List of References
							Building material (I)	Construction process (II)	Structural system (III)	Low-tech (traditional or hand-based)	High-tech (industrialised)	Under-developed	Developed		
1	BuildCollective and S2arch	Ithuba Communtiy College		2009	Ekurhuleni, Gauteng	A skills college where local participation takes place during the design and contrustion phases. A light-clay infill system was developed and used to construct the building. It is a platform for architecture and construction research, making use of local ressources and community involvement to develop alternative building techniques.	Compacted straw and light clay as infill mixed with minimum amounts of cement.			based methods of construction. Adobe wall infill it is done by hand and basic mixing machinery on site.			This material is developed since the specific mix of materials has been used in previous projects in the South Africa context	The construction process was an opportunity for local people to come and learn new skills for design and construction technologies., making the project **socially responsible**. Unskilled labourers were taught how to build these structures, therfore uplifting the community's identity as well as their capabilities to contribute as working individuals. The materials used are low cost since they can be sourced from surrounding natural landscapes and the equipment and time used to manufacture the materials and the structure is not too extensive., making it **economical.** The project is **versatile** since this material and structure can become adapted to be used on a larger scale, enabling it to be versable enough to be used in various regions. Since the materials are sourced	Figure 1: A photo of the community college in Ekurhuleni (Wagner, 2016) Wagner, M. 2016. *Ithuba Community College,* Architecture in Development. Available from: https://a-i-d.org/project/207 [Accessed ON 25 March 2023]
								Unskilled craftsman actively involved by mixing the straw and clay on site manually and		Unskilled labour and low tech equipment . The design and construction process does not require special equipment.			Within the current built industry, the construtcion process of mixing materials on site and then using them in the construction process is a developed way of		
									An Adobe wall with straw-light-clay infill, load bearing wall.	The adobe wall as a strucural system functions as a load bearing wall that was contructed by hand.		This structural system is underdeveloped as adobe walls have not been constructed many times in South Africa			
2	Bottle2Build	School		2016	Gauteng	A project that creates buildings, especially classrooms, with empty, modular plastic water bottles as infill in a light steel frame and additional exterior material around the structure for waterproofing and thermal com fort.	Custom-made PET plastic bottles, BPA free and modular empty water bottles are made in the shape of interlocking bricks.				The plastic is manufacted in an industrialised manner with many phases in order to achieve the shape and right material consistency - strong enough to be a building material.		The production of plastic in South Africa is a develop process, since numerous products are made out of platic. It is made in a well-established industry.	Local people are active paricipants in the construction process, making them educated on how the process works. The project is **versatile** since the volume of material, construction process as well as structural system can be adapted to suit different circumstances for different projects. It is **economical** because the bottles is a low-cost building material.	Figure 2: The school with empty platic bottles as infill in the light steel frame and added exterior matrerials. Watts, K. 2016, *Bottle to Build,* Kirstty Watts Foundation. Available from: https://www.kirstywattsfoundation.org.za/fundraising/bottle-to-build/ [Accessed on 16 May 2023] Vivier, T. 2017, *Bottle 2 Build created a brick shaped water bottle so that it can be used to build schools*, Good Things Guy. Available from : https://www.goodthingsguy.com/environment/bottle-2-build-brick-bottle/ [Accessed on 16 May 2023]
								The construction process involves participants interacting with an element in the building and then taking part in the first phase of construction.		The construction process is low-tech since the construction takes place using the labourers hands.		The construction process of constructing a light steel frame with infill materials inside is not a developed procass			
									N/A Light Steel Framing System						
3	Carin Smuts Architects	GUGA S'THEBE Phase 2		2015	Langa, Western Cape	Theatre space of which falls part of a culture and heritage village . This building was redominantly made using recycled materials such as up-cycled wood and shipping containers. The building also makes use of indigenous technologies such as Adobe for insulative purposes	N/A Shipping containers							Due to the use of locally available materials, upcycled materials and the implementation of simple construction methods, project costs were kept low. Building onto this, members of the community were employed during the construction process thus letting this project pose a rather substantial **socio-economic impact**. The use of adobe is a well established form of making in South Africa letting the project become one that is **contextually responsive**	Figure 3 : Editors of Transsolar (2023) Guga S´Thebe Theater: Transsolar: Klimaengineering, Transsolar. Available at: https://transsolar.com/projects/guga-sthebe-theater-cape-town (Accessed: 18 May 2023). ARVHA Femmes Architectes (2019) Projet, Guga S'Thebe Arts, Culture and Heritage Village. Available at: https://www.femmes-archi.org/projet/?c=1031 (Accessed: 15 May 2023).
							N/A Up cycled timber facade panels								
							Adobe packed panels for insulative purposes			Manfactured by hand on site used as a means of insulation situated behind the upcycled timber facade panels		the use of "eco-materials" as a means for insulation	Manucaturing adobe by hand		
								Simple construction methods where shipping containers were strategically placed in order to create space, simple construction ment that community involvement was possible		During construction local contractors, sub-contractors and artists are involved on the building site, materials and processes were manipulated by hand on site . Many local economic opportunities are created.		Community involvement			
4	cseventysix Architects	"Writers retreat" Residence		2019	Lanseria, Gauteng	A residence that is predominantly steel in its structure. The steel structure has been designed in such a way that the site that it sits on is preserved. The entire structure also has the capability of being disassembled	Locally sourced stone waste							Floating off the ground, reducing site impact, all the building materials are responsibly sourced, having their full lifecycle considered -all steel used is recyclable and easily disassembled making the project **contextually responsive, as well as versitile** . The building functions organically having been shaped by passive design principles; ensuring maximum thermal efficiency throughout the year by means of natural ventilation flowing through clerestory windows and by the natural convection of a nearby freshwater pond. Its reliance on Passive systems for thermal comfort further highlights the **projects contextual responsiveness and economic effectiveness.**	Figure 4: The Screenwriters Retreat (cseventysix Architects, 2020) cseventysix Architects (2020) Screenwriters retreat, c76 Architects. Available at: https://www.c76.co.za/screenwriters-retreat (Accessed: 15 May 2023).
								The building was designed and constructed in such a manner that it could be disassembled if necessary - This complies with optimizing site sensitivity through circular design/ construction processes			Structural steel components were designed and machined with the aid of industrialised fabrication equipment in such a way that it allows for disassemby	Engineering and design strategies behind possible building disassembly and imperminance on a residential scale	Construction methods associated with structural steel	
									N/A Predominantly structural steel						
5	Choromanski Architects - Rod Choromanski and Dean Ramlal	uMkhumbane Museum		2017	Berea, Durban, Kwazulu-Natal	eThekwini Municipality's award-winning museum is the first new museum to be built in Durban in 100 years and also the first public cultural building constructed in the Cato Manor area.	"Firelight Satin" bricks - increased compressive strength				This particular brick went through additional processes during the manufacuring phases in order to increase its compressive strength, thus allowing the bricks to be stacked higher than normal bricks		The use of brick	The use of the "Firelight Satin" bricks proved to be in favour of **attainable economic factors** due to the fact that it mitigated additional costs usually needed for re-inforced concrete. While reducing costs associated with re-inforced concrete, the "Firelight Satin" bricks also managed to attain thermal and environmentally sustainable standards in the presence of less concrete, thus allowing the project to become **contectually responsive**.	Figure 6: uMkhumbane Museum(Editors at The Clay Brick Association of Southern Africa, 2020) Editors at The Clay Brick Association of Southern Africa (2020) Clay brick makes history at the Umkhumbane Museum , Clay brick makes history at the uMkhumbane Museum	Clay Brick Association of Southern Africa. Available at: https://www.daybrick.org.za/news/clay-brick-makes-history-umkhumbane-museum (Accessed: 22 May 2023).
							N/A Concrete								
							N/A Aluminum Facade Application								
								Due to its inherent strength, the "Firelight Satin" bricks achieved higher walls utilizing the method of diaphragms, thus avoiding the use of reinforced concrete beams		Bricks were layed by hand therefore following common building practice	Manufacturing processes associated with fabricating "Firelight Satin" bricks	The use of developed brick components that take on more of a structural role thus mitigating the need for an extensive re-inforced concrete intervention		
									N/A Concrete slab and column structural system - bricks become structural						
6	Eartworld Architects	KoSPAZA Pop-up restaurant		2021	Garsfontein Pretoria Gauteng	A complete plywood structural system - designed in detail and modelled 3-dimensionally in the architect's office – then sent to CNC (computer numerical control) machines for cutting and manufacturing of site in components and then rapidly assembled on site.	N/A Plywood							The process of CAD and prefabrication is a new way of designing and constructing in South Africa and this adds value to the built environment through effeciency in time and costs - in return that is **economical** and by providing these prefabricated elements to people with little to no skills to construct the structures are **socially repsonsive**	Figure : KoSPAZA coffee shop (Earthworld Architects & Interiors, 2021) Earthworld Architects & Interiors (2021) Kospaza, Earthworld Architects & Interiors. Available at: https://www.ewarch.co.za/post/4060/kospaza2021/ (Accessed: 01 June 2023).
								Computer Aided Design and Prefabrication Complete 3D modelling of a project and all its components to be manufactured off-site for precision and effeciency			CAD methods are high-tech due to the use of intelligent software and systems used		This process can be seen as developed in South Africa due to architectural firms using 3D modeling software	
								CNC production Plywood modules and elements are cut out by CNC machines			The use of CNC machines are high-tech due to the high industrialised components evident in the process	CNC machining of every component of a building is not common in South Africa and the whole process in under-deveoped		
									Plywood interlocking elements such as columns and rafters		plywood as a structural system with interlocking elements is high tech	using plywood for load bearing structural system is not commonly done and is underdeveloped		
7	Elliott, Paul	House Elliott		2021	Cape Town, Western Cape	Cork clad mass timber home influenced by the Japanese vernacular positioned on a relatively inacessble site	CLT timber				Machined methods of Prefabrication associated with the manufacturing of Pre-fabricated CLT mass timber elements	The manufacturing of mass timber CLT is new to South Africa with the industry only consisting of 2 factories at present		This project was inspired by the Japanese vernacular and in turn it resulted in a sustainable home made from eco friendly materials. This project stands to highlight how vernacular systems of building can benefit todays architectural discourse. Further more, the use of cork clad panels as a facade finish doubles up as insulation. This material is also water proof and mold resistant. With somany capabilities this material mitigates the need for single function material applications thus resulting in an **economic** insilative cladding system.	Figure 7: House Elliot (Danie Nel for pro Landscaper + Architect 2021) Pro Landscaper + Architect (2021) Zen: House elliott, issuu. Available at: https://issuu.com/outsideandinmag/docs/prolandscaper_nov_2021_issuu/s/13887468 (Accessed: 16 May 2023).
							Composite Amorim Cork Panels				Machined methods of Prefabrication associated with the manufacturing of composite cork panels by Amorim Cork Composites	The use of cork clad panels as a facade finish			
								Due to the inaccessibility of the site, the (CLT) floor, wall and roof elements were prefabricated and had to be delivered as individual finished components to site.			Heavy machinery such as the use of a crane was needed during the construction process of this project	The use of CLT mass timber as a structural component during the process of construction		
									Pre-fabricated CLT mass timber structural system		Machined methods of Prefabrication associated with the manufacturing of Pre-fabricated CLT mass timber elements	The manufacturing of mass timber CLT is new to south africa with the industry only consisting of 2 factories at present		
							N/A corrigated steel								

8	ELMO SWART ARCHITECTS	Wright House		2011	Ocean View, Durban, Kwazulu-Natal	Traditional thatch-roofed South African Villa Transformed with contemporary vernacular reinterpretation extention.	N/A corrigated steel cladding N/A earth packed walls N/A bamboo - wall and facade finishes N/A Gumpoles as non structural facade elements	Hybrid tectonics - The extension of the villa is defined by a series of structural steel C-Frames that are closed off with an array of gumpoles that are finished with thatch at 45 degrees. This cantelevered structure sits on earth packed walls, while bamboo and steel	N/A C-Frame structural steel members closed off with gumpole elements sitting on earth filled wall structure	Indigenous material implementation - e.g. thatch, gumpole, and bamboo	Prefabrication and parametric digital design of structural steel members used	The co-existance of vernacular building methods, in combination with modern "high tech" construction materials	The use of structural steel	This project stands to show the possibilities that exist around design and construction methods that consider traditional means of space making as well as emerging means of space making. This project ultimately goes on to showcase the **versatility** behind using eco materials such as thatch, gumpoles and bamboo in the midst of structural steel construction.	Figure 8: Wright House (Editors of Domob, 2019) Editors of Domob (2019) Organic South African villa transformed, Domob. Available at: https://domob.com/organic-villa-expansion-transforms-south-african-cottag e/ (Accessed: 16 May 2023).
9	Entity Architects & Blockhouses	Cradle Boutique Hotel		2018	Cradle of Humankind Muldersdrift North-West	6 Prefabricated pods used for vacation accommodation. Differ in size and layouts.	N/A Conventional steel, mortar and concrete	Pods are manufactured and assembled off-site in a factory with the use of CAM and CAD. Based on	N/A Structural steel frames noted		CAD and CAM extremely high-tech due to the use of intelligent software's	Prefabricating and fabrication of whole buildings not done in SOuth Africa commonly at this scale.		The **economical** value this prefamanufacturing guide to the building industry is due to the short construction periods. The products may seem to not be contextually and socially responsive due to the "generic" designs.	Figure 9 : Cradle Boutique Hotel Rd (Blockhouses (2018) Projects	Blockhouses. Available at: https://blockhouses.co.za/g roject s-2/ (Accessed: 03 June 2023). Blockhouses (2018a) Modular homes | Blockhouses. Available at: https://blockhouses.co.za/modular-homes/ (Accessed: 03 June 2023).
10	Elphick Proome Architects	Durban Christian Centre		2021	Durban, Kwa Zulu-Natal	A new worship center for a growing congregation in Durban, South Africa. The building includes a large auditorium, classrooms, offices, and a coffee shop.	N/A Virtual dome made from steel arches and covered with a translucent translucent tensile membrane	Prefabricated Aluminum cladding screen	N/A concrete column and beam		Advanced software and computational tools to model and analyze the complex geometry and structural loads of the arches to create a long span roof	This is not a common practice in South Africa, it is highly unique and has the potential to be practiced further in the country.		Contextual Responsive Values: The design responds to the local context, incorporating elements of South African architectural heritage and cultural references, while also considering the site's environmental conditions and urban context. Economical Values: The project emphasizes cost-efficiency, optimal use of resources, and long-term sustainability to ensure financial viability. Versatility: The design accommodates various functions within the center, offering flexible spaces that can be adapted for different activities and events, enhancing the center's functionality and versatility.	Figure 9: Durban Christian Centreh (ArchDaily, 2022) ArchDaily (2022) *Durban Christian Centre / Elphick Proome Architects*. Available at: https://www.archdaily.com/982406/durban-christian-centre-elphick-proome-architects (Accessed: 11 May 2023).
11	Field Architecture	Karoo Wilderness Center		2013	Karoo, Northern Cape	The center generates its own energy, harvests its own water, processes its own waste, and provides thermal comfort using no municipal water or power.	N/A Rammed earth walls (Soil, cement)	Compressing soil harvested from site in to a solid wall formwork, (pneumatic) compaction layering	N/A concrete columns	Rammed earth wall construction is low-tech as it uses straight-forward ways of excavating the soil and compressing it into formwork on site by construction workers.			Rammed earth walls are on the rise in South Africa, leans towards the more developed side.	Social Values: The project promotes ecological awareness and education, provides opportunities for community engagement and connection with nature, and supports sustainable tourism in the Karoo region. Contextual Responsive Values: The design harmoniously integrates with the surrounding Karoo landscape, respecting its natural beauty and preserving the ecological integrity. It takes inspiration from local architectural styles and materials, creating a sense of place and cultural identity. Economical Values: The project focuses on efficient use of resources, utilizes sustainable construction methods, and considers long-term economic viability by supporting local employment and tourism opportunities. Versatility: The design offers a range of	Figure 10: Elevation of the centre (Datum, 2016) Datum (2016) Karoo Wilderness Center / Field Architecture |. Available at: https://www.archdatum.com/projects/karoo-wilderness-center-field-architecture/ (Accessed: 1 April 2023).
							N/A Curved timber cladding	CAD to inform parametric roof structure			High tech as parametric modeling was used to inform the timber curves	This is more quite for the curved undersides of the roof that are cladded with thin wooden strands			
12	Frankie Pappas	House of the Big Ash		2020	Limpopo	Residential property situated in the North of South Africa's Bushveld Nature reserve. The building was built at a minimum width of 3.3 meters of which allows it to meander between the existing trees on site.	N/A Brick N/A Glazing Glulam Structural timber	N/A Living spaces are built predominantly from Hexa timber. These mass timber elements are predominantly used as the structural systems for the living spaces.	Structural systems is partially articulated through the use of glulam timber elements		Each timber structural element is glued and placed under high machine compression for compaction to form elements		The glulam manufacturing process is developed in SA	The house's long, thin shape was determined by the location of the trees so that not even one tree had to be felled during its construction. The extreme understanding of the site allowed for its preservation - this coincides with vernacular design strategies and could be useful if interpreted for the dry scape. As the house was located an hour-and-a-half drive to the nearest town, the architecture collective decided to make it an off-grid home – not connected to water or electricity networks. Water is collected an dfiltered on the roof while solar panels provide electricity. These implementations allow the project to become **contextually responsive while maintaining a suitable level of economic efficiency.**	Figure 11: House of the Big Ash (Dook+Vlei for Dezeen, 2020) Ravenscroft , T. (2020) Frankie Pappas threads skinny house through South African forest, Dezeen. Available at: https://www.dezeen.com/2020/07/06/frankie-pappas-south-africa-house-bi g-ash/ (Accessed: 16 May 2023).
13	Galland, Simon and LYT Architecture	Walmer Crèche		2021	Walmer, Gqeberha, Eastern Cape	Students from the Port Elizabeth architecture department worked together to construct this classroom structure in a rural community near the university. The structure was **built off-site** and then **dismantled and re-assembled** on the site in Gqeberha. **Recycled** building materials were used to make this classroom and careful consideration was given to what the	N/A Recycled timber material and polycarbonate	The crèche was constructed by students on campus and then dismantled and	Pre-fabrication.	The university students built this structure, making them part of the construction process, where skilled labourers	The whole structure was assembled off-site with conventional tools and techniques.	assembling the structure in an academic environment is not a developed process.	Disassembling a structure and then transporting it to site where the structure can be quickly assembled is a technique that	The building is placed on plinths with the intention of removing the structure from the surroundings to create a safe and isolated environment where the children can become immersed in a learning experience, making it **contextually responsive** . The dormitory windows is another way in which the building is contextually responsive - it allows light and air into the building but restricts one's view at eye level, to create a safe environment where the students and teacher are able to focus on the programme.	Figure 12: The Walmer Creche in Gqeberha (Berlanda, 2021 Berlanda, T. 2021. *Walmer Crèche in Gqeberha, South Africa by Simon Galland with LYT Architecture*, The Architectural Review. Available from: https://www.architectural-review.com/places/south-africa/walmer-creche-in-gqeberha-south-africa-by-simon-galland-with-lyt-architecture [Accessed on 26 March 2023] Available from: https://publication.mandela.ac.za/publication/media/Gone/documents/Educational/77Mandela_Uni_Learning_and_Teaching_Publication-(DIGITAL2).pdf [Accessed on 26 March 2023]
14	GAGS Architecture Studios	GAGS Architecture Studios		2021	Pearl Valley, Western Cape	This school design edwith macro placement of spaces in mind. Separate buildings are linked together through landscape sections along with open courtyards. Many natural materials were sourced from the context as well as indigenous design principles. Reclaimed materials were also used from the local region.	N/A Rammed earth walls (Soil, cement)	Creating a formwork with the desired curved shape, and then compacting layers of clay into the formwork to create the wall.	N/A Timber framed structure	Rammed earth wall construction is low-tech since it uses straight-forward ways of excavating the soil and compressing it into formwork on site by construction workers.			The process is developed since rammed earth walls have been constructed several times in the country.	Social Values: The project promotes sustainable education and holistic development of students by providing an environmentally conscious learning environment that fosters creativity, critical thinking, and a sense of community. Contextual Responsive Values: The design takes inspiration from the natural surroundings, incorporating local materials, passive design strategies, and biophilic elements to create a harmonious relationship between the built environment and the natural landscape, as water scarcity is apparent Economical Values: The project demonstrates a commitment to long-term cost savings through energy-efficient systems, water conservation measures, and the use of renewable materials. It also contributes to the local economy by supporting job creation and local sourcing of materials.	Figure 13: Green School within the Pearl topography (StirWorld, 2022) ArchDaily (2022) *GAGS Architecture Studios* . Available at: https://www.archdaily.com/970903/green-school-south-africa-gags-architecture-studios (Accessed: 1 April 2023). StirWorld (2022) *Green School South Africa brings boulder-like clusters into organic coexistence* . Available at: https://www.stirworld.com/see-features-green-school-south-africa-brings-boulder-like-clusters-into-organic-coexistence (Accessed: 1 April 2023). Legendary Thatching (2012) *Cape Thatch Reed Roofs Products* . Available at: https://legendarythatching.co.za/products.html (Accessed: 18 May 2023).
								Hand-knotting and binding techniques to create openings within the ceiling structure is a low-tech technique.			The use of advanced hand woven techniques to create a ceiling cladding to hide eave vents in thatch ceilings can be modified a			
							N/A Tailored Onduvit cladding								
15	GLH Architects	Wildsfontein Eco lodge Residential		2018	Vredefort, Freestate	Rammed earth walls, stone walls, steel framing system used	N/A Rammed earth walls (Soil, cement)	Both building materials are sourced from the building site and constructed through on-site labour by hand. Different techniques but both are used in the form of compacted earth - sourced from the earth on site and constructed either bricks or complete walls.	This composite	Material sourced from site and compacted by hand tools. Unskilled labourers can construct this.	The integration of an		The use of mud bricks constructed from the earth on site not widely used in South Africa Using materials from site and compacted by hand a process that is developed although not used commonly.	Reuse materials from the site, making the end product **contextually responsive** and connected to the context through	Figure 14: Wildsfontein Eco Lodge (GLH Architects, 2018) Abdel, H. 2020. Wildsfontein Eco Lodge / GLH architects, ArchDaily. Available at:
							N/A Compacted Earth Bricks (CEB) are made on site with soil from the surroundings and used instead of common fired clay bricks.			Earth from site compressed in press on site to form bricks.					

15	GLH Architects	Witkliptontein Eco lodge Residential		2018	Vredefort, Freestate	stone walls, steel framing system used to create a residnece		complete walls.						Abdel, H. 2020. Witkliptontein Eco Lodge / GLH architects, ArchDaily. Available at: https://www.archdaily.com/935202/witkliptontein-eco-lodge-glh-architects (Accessed: 03 May 2023).
									This composite structural system makes the implementation of a structural green roof possible		The integration of eco materials,,timber and steel construction in order to account for the weight of a structural green roof	The implementation of green roofs in South Africa	N/A the use of Structural steel and timber	
									The structural system is a composite system where rammed earth is implemented as the predominant load bearing wall system	Rammed earth walls are hand compacted on site				
									The structural system also makes way for earth bag construction, where earth bags are used as a structural tanking element to create a dome like space under ground	Earth bags are stacked on top of one another by hand				
16	Heatherwick Studio	Zeitz Museum of Contemporary Art Africa (Zeitz MOCAA)		2017	Cape Town, Western Cape	Custom designed space, spread over nine floors, carved out of the monumental structure of the historic Grain Silo Complex.	N/A Concrete							Social Values: The museum provides a space for the local community and visitors to engage with contemporary art and participate in cultural events. Contextual Responsive Values: The design of the museum is sensitive to its historical context, preserving the industrial heritage of the grain silo while transforming it into a modern and dynamic cultural destination. The architecture pays homage to the local context and integrates with the surrounding urban fabric. Economical Values: The project contributes to the economic development of the area by attracting tourists and creating job opportunities. it revitalizes a previously underutilized building, generating revenue for the local economy and supporting the growth of the arts and culture sector. Versatility: The museum provides flexible exhibition spaces that can accommodate a wide range of artworks and installations. The design allows for adaptable display configurations, enabling the curators to curate diverse exhibitions and accommodate changing artistic practices.	Figure 16: Zeits MOCAA (UrbanNext, 2020) UrbanNext (2020) *Zeitz MOCAA: Carving a Void Sphere in the Silo* . Available at: https://urbannext.net/zeitz-mocaa/ (Accessed: 28 March 2023).
							N/A Pillowed glass panels							
								Subtractive method of diamond saw concrete-cutting techniques are implemented to carve an interior atrium out of the existing concrete tubes			This is a high-tech technique as it allow for precise and controlled carving process of selectively removing sections of the existing concrete structure to create galleries and a central atrium whilst still preserving the structural integrity of the existing tubes.		The use of subtractive diamond cutting is used for mining which is developed in SA	
								The use of "pillowed" glazing to create curved glass walls, which required advanced glass manufacturing techniques by using computer-			The combination of precise curvature, custom shaping, and advanced manufacturing techniques makes the pillowed glass panels a high-tech element		This is a developed method used in South Africa	
									N/A reuse of existing structure					
17	Holzbau Hess	Yoga Studio		2018	Constantia, Western Cape	A yoga studio made from laminated timber columns and rafters - freeform timber structures moulded into curved structures.	N/A Laminated Pine columns and rafters							The construction process allows timber structures to become more organic while structural, making it **versatile**. Spatial qualities of structures are more creative and organic.	Figure 17: Yoga studio by Holzbau Hess (Holzbau Hess, 2018) Holzbau Hess. (2018) Yoga studio - projects, Holzbau Hess. Available at: https://holzbauhess.com/projects/free-form/yoga-studio-constantia-cape-town#content (Accessed: 05 May 2023).
								Pine timber members glued together and moulded into curved forms. This process happens off site (prefabrication) , constructed on site.		Members glued by hand and moulded into forms by clamps to designed shape.		Laminated timber rafters moulded into curved forms not common in S.A. this craft still needs to be developed.		
									N/A Portal frame like construction, only using timber as material.					
18	UJ's Faculty of Civil Engineering and the Built Environment, in partnership with the KwaZulu-Natal Department of Human Settlements and Afrisam	South Africa's first 3D printed low-cost house		2022	Johannesburg, Gauteng	South Africa has completed its first 3D printed low-cost construction home. The 3D printing technique used can build a house in less than 24 hours.	N/A Concrete							Due to its efficiency, this means of construction resulted in residential infrastructure being produced at an unprecedented rate while using 32% less of the materials required for traditional construction methods. This could be a catalyst for procucing sustainable human settlements while **strengthening the economy.**	Figure 18: South Africa's first 3D-printed low-cost home (Reporters at News24, 2023) Reporters at News24 (2023) Watch: Here's how South Africa's first 3D-printed low-cost home was constructed, News24. Available at: https://www.news24.com/news24/tech-and-trends/news/watch-heres-how-south-africas-first-3d-printed-low-cost-home-was-constructed-20230307 (Accessed: 16 May 2023).
								3D printable concrete layed in layers one on top of another by a robotic industrial printing arm. Openings were accounted for as the printing process was in session			Automated robotic printing arm utilised on site to print the main concrete structure of the low cost home. Although a smaller labour force is needed for this project, the people involved need to be highly skilled practitioners.	Automated construction practices and BIM modelling techniques		
									N/A Load bearing walls					
19	Jason Erlank Architects	Langbos Children's Centre Community centre School		2018	Gqeberha, Eastern Cape	Superadobe walls/roof create these dome structures without additional structural components.	Superadobe (Local soil mixed with a small amount of cement)			Bags filled with sand and cement		Material and mode of construction not developed in SA. Could be a new way of building structures with the earth		Teaches that one can build with the surroundings without expertise. The project makes use of the context and local craft. Sustainable solutions for construction in remote areas. Fast paced construction in remote areas, local skills and contextually responsive.	Figure 19: Construction phase of Langbos Childrens Centre (Chris Grava, 2018) Abdel, H. (2020a) Langbos Children's Centre / Jason Erlank architects, ArchDaily. Available at: https://www.archdaily.com/942147/langbos-childrens-centre-jason-erlank-architects (Accessed: 06 May 2023). Langbos children's shelter (2019) Jason Erlank. Available at: https://jasonerlank.co.za/portfolios/langbos-childrens-shelter/ (Accessed: 06 May 2023).
								Bags mixed and filled by workers. Bags are then laid by hand and fixed with barbed wire. Then plastered and painted afterwards.		Pan mixing of mixture, hand-filling the bags and lay it by hand by local workers. No expertise neccessary		Material and mode of construction not developed in SA. Could be a new way of building structures with the earth		
									"Earth bags" act as structure itself. Compression of the weight of the bags makes it compact and sturdy.	Building structurally with materials of surroundings without additional structure		Material and mode of construction not developed in SA. Could be a new way of building structures with the earth		
20	Kimwelle, Kevin	Silindokuhle Creche		2017	Joe Slovo Township, Gqeberha, Eastern Cape	The building is made out of recycled materials by local builders that constructed a section of the building as a composite wall that contains glass and concrete within a timber frame. The architect works with the "Grassroot Community" concept that enables positive change from a community, to a region, to the local context all the way to an international level.	N/A Recycled glass bottles, timber and corrugated iron used in structure							The project is **economical** because of the recycled glass bottles that they make use of to build parts of the structure. The composite wall with the glass bottle ensures natural light to enter the building for the educational programme, that lowers the need for electricity usage in the community. The project is also **socially responsible** because the different class-income groups were connected due to the contribution and donation process "...connecting the most privileged members of the city with the most marginalised." (Chapman 2019)	Figure 20: The Silindokhule Creche in Port Elizabeth (Chapman, 2019) Chapman, S. 2019. *There is ingenuity in Africa': the architect who builds with trash*, The Guardian. Available from: https://www.theguardian.com/cities/2019/oct/22/ingenuity-south-africa-architect-kevin-kimwelle-builds-with-trash [Accessed on 24 March 2023]
									N/A The construction process involved conventional techniques					
									Composite wall with glass wine bottles and concrete as infill.	The composite wall is constructed by hand by layering the glass bottles and concrete within the timber frame by hand.		Using glass bottles as part of a structural system is certainly underdeveloped in South Africa. Usually walls are constructed from conventional elements that do not let light and air through a recycled object.		
21	Krynauw, David & Khanye Architects	Kleine Rijke Restaurant		2017	Hartebeespoort, Gauteng	A restaurant timber structure - columns and trusses with brick gable ends and infill. Galvanised steel roofing	N/A S.A Pine							Cutting out members by CNC machine ensures precision with each individual member. The need to router and sand down the members to have the smoothed edges ensure the human touch to still be evident in the building.	Figure 22: Kleine Rijke interior (Vicky Gerbello, 2018) Krynauw, D. (2017) Modular Mobile Home Pods: David Krynauw, David Krynauw Design. Available at: https://www.davidkrynauw.com/build (Accessed: 07 May 2023).
								Timber members made of rafters are cut out by CNC machines. Members are then routered and sanded down to smooth curved edges by hand.			Structural elements are cut out by a CNC machineroutered for rounder edges	CNC manufactured timber structural elements are underdeveloped		
									N/A Timber columns and trusses as only structural system					
22	Krynauw, David	MODULAR MOBILE HOME		2020	N/A - Mobile products sold on request	A prefabricated mobile living pod that is bought as a whole product and delivered to any site on request	N/A S.A Pine							The use of CNC techniques to prefabricate structural timber elements opens up a wide range of possibilites. In this project specifically one sees how careful design through the use of CNC techniques results in a mobile architectural typology	Figure 23: DAVID KRYNAUW'S LIVING PODS (Editors at Visi, 2020) Krynauw, D. (2017) Modular Mobile Home Pods: David Krynauw, David Krynauw Design. Available at: https://www.davidkrynauw.com/build (Accessed: 1 June 2023).
								Structural timber members are cut out by CNC machines. Members are then routered			Structural elements are cut out by a CNC machineroutered for rounder edges	CNC manufactured timber structural elements are underdeveloped		
									N/A Timber portal frame structural method					
23	Local Studio	Hillbrow Counselling Centre		2017	Johannesburg, Gauteng	A project that provides mental health services to the Hillbrow community in Johannesburg, South Africa. The center is a compact, two-story building with an innovative design that incorporates recycled materials, natural	N/A Polycarbonate panel							Economically, the project demonstrates cost effectiveness by utilizing locally sourced and recycled materials, reducing construction expenses. The building's design also focuses on energy efficiency, utilizing natural ventilation to minimize the need for mechanical cooling systems and reducing operational costs in the long run. Engineered to be lightweight and leak-proof, withstand very high loads, and accommodate thermal expansion and contraction Socially, the Hillbrow Counselling Centre	Figure 24: Hillbrow Counceling Centre (ArchDaily, 2020) ArchDaily (2020) Hillbrow Counselling Centre / Local Studio, ArchDaily. Available at: https://www.archdaily.com/940520/hillbrow-counselling-centre-local-studio (Accessed: 11 May 2023).
									Whole building envelope is Advanced cutting techniques, CNC (Computer Numerical Control) routing		Advanced extrusion techniques, precise cutting methods of the prefabricated panels make this high-tech mode of production.		Although the method of CNC has become increasingly prevalent in SA it is still considered developed.	
									N/A Hybrid of implementing					

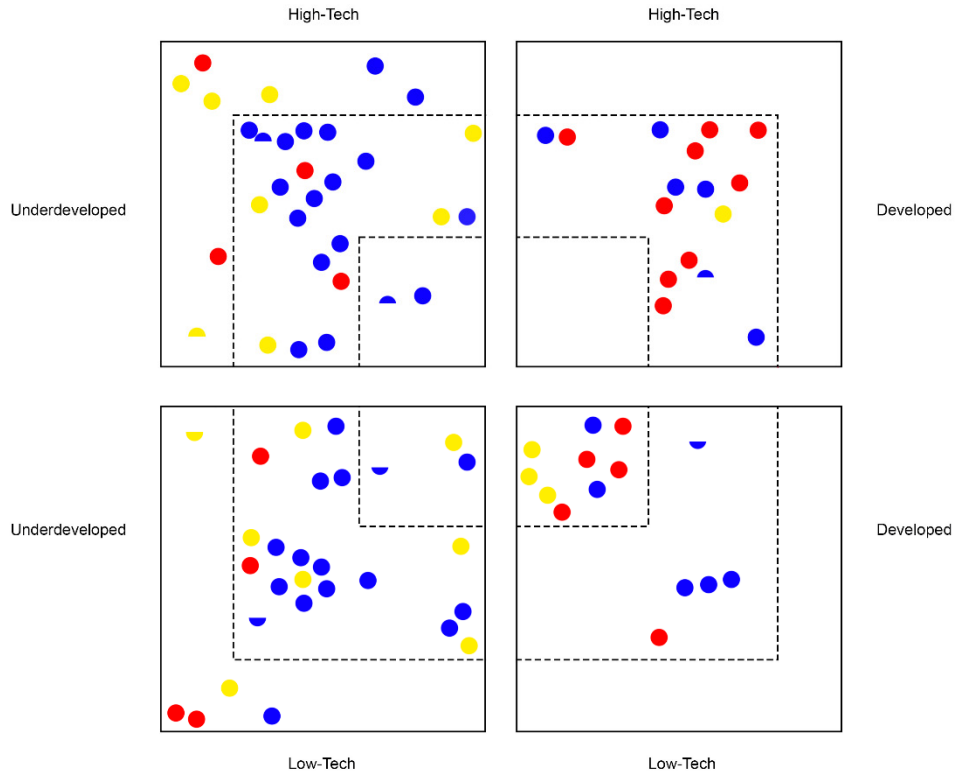
23	Local Studio	Hillbrow Counselling Centre		2017	Johannesburg, Gauteng	A project that provides mental health services to the Hillbrow community in Johannesburg, South Africa. The center is a compact, two-story building with an innovative design that incorporates recycled materials, natural ventilation, and sustainable strategies.	N/A Polycarbonate panel							Economically, the project demonstrates cost-effectiveness by utilizing locally sourced and recycled materials, reducing construction expenses. The building's design also focuses on energy efficiency, utilizing natural ventilation to minimize the need for mechanical cooling systems and reducing operational costs in the long run. Engineered to be lightweight and leak-proof, withstand very high loads, and accommodate thermal expansion and contraction Socially, the Hillbrow Counselling Centre plays a vital role in providing accessible mental health services to the community. The design prioritizes the well-being of the users by creating a welcoming and calming	Figure 24: Hillbrow Counceling Centre (ArchDaily, 2020) ArchDaily (2020) Hillbrow Counselling Centre / Local Studio, ArchDaily. Available at: https://www.archdaily.com/940520/hillbrow-counselling-centre-local-studio (Accessed: 11 May 2023).
								Whole building envelope is Advanced cutting techniques, CNC (Computer Numerical Control) routing			advanced extrusion techniques, precise cutting methods of the prefabricated panels make this high-tech mode of production.		Although the method of CNC has become increasingly prevalent in SA it is still considered developed.	
									N/A Hybrid of implementing new cladding system over the existing concrete structure					
24	Local Studio	Limpopo Youth Hostel		2019	BELA-BELA, Limpopo	A project that reimagines the traditional hostel typology. The building's primary structure is a lightweight Hebel concrete block – the biggest load-bearing structure built using this material in South Africa The Limpopo Youth Hostel project was commissioned by a Non-Profit Organization focused on advocacy training for youth.	Composite Lightweight Hebel concrete block (lightweight, autoclaved aerated concrete (AAC) block)				A high-tech mode of production, made from autoclaved aerated concrete, which is a lightweight concrete produced by mixing cement, sand, lime, and water with a small amount of aluminum powder The lightweight Design is due to the blocks undergoing an advanced manufacturing process		Hebel is a well-established building material in South Africa, having been used for various construction projects	The intrinsic value of this project lies in its focus on community development and social sustainability. By providing safe and affordable housing for young people, the project addresses issues of social inequality and creates opportunities for education and economic mobility. Additionally, the project's use of sustainable materials and innovative construction methods demonstrates a commitment to environmental sustainability and serves as a model for future development projects Locally sourced wax-treated pine that provides a natural, durable, and sustainable alternative to traditional timber cladding	Figure 24: Limpopo Youth Hostel (ArchDaily, 2020) ArchDaily (2020) *Limpopo Youth Hostel / Local Studio*. Available at: https://www.archdaily.com/940354/limpopo-youth-hostel-local-studio (Accessed: 11 May 2023).
							Composite timber (thermally modified and wax impregnation rhinowood cladding)				Thermally modified wood that is produced by heating the wood to high temperatures in a low-oxygen environment. undergoes wax impregnation where the wood is treated with a specially formulated wax solution.	The use of thermally modified wood and wax impregnation techniques has been implemented in various construction projects, however the extent of its usage is still under-developed in SA.		
								N/A manufacturing process of Hebel blocks involves advanced technologies such as autoclaving, where the blocks are cured under high pressure and temperature conditions to achieve their final strength and durability.						
									N/A Hebel blocks for load-bearing walls					
25	Malan Forster Architecture & Interior Design	House Paarman Treehouse Residential		2017	Constantia, Western Cape	Treehouse built on corten steel columns with structural elements made out of timber. Facades that move also made out of timber	N/A Corten steel (columns)							The design and construction process is socially responsive by using the skills of specialists to create a contextually responsive building in the landscape.	Figure 25: House Paarman Treehouse (Adam Letch, 2017) Tapia, D. (2020) Tree House / malan vorster architecture interior design, ArchDaily. Available at: https://www.archdaily.com/873882/tree-house-malan-vorster-architecture-interior-design (Accessed: 08 May 2023).
								Construction and design process combined where certain elements are **pre-fabricated** off-site, other made on site to be spesific to conditions.		Timber elements of the building crafted (prefabricated) by hand by carpenters off-site.		Prefabrication of majority of a building's parts are not developed in South Africa		
									N/A Corten steel plates used as columns.					
26	Marais, Paul	House Gardiner		2014	Monaghan Farm, Johannesburg, Gauteng	This design incorporates 500mm thick rammed earth walls, underground rain water tanks, a roof optimised for solar shading and rainwater harvesting and off grid living. The use of polymer stabilised foundations not only significantly reduced CO2 but also saved costs.	Structural Rammed earth walls			soil was used directly from site and locals were trained and employed		Structural rammed earth walls as the only load bearing structure to hold the building is not commonly done		Economical values: The polymer reinforced earth foundation required half of the steel of a reinforced concrete foundation, saving 46% of CO2 emissions contextually Responsive vales: This offers a sustainable and cost-effective alternative to traditional construction materials, utilizing locally available resources and reducing the environmental impact of the building process. Versatile values: The polymer has, as it major component is bitumen emulsion, provided a waterproof layer. The polymer binder enhances the structural properties of the earth, making it suitable for load-bearing walls and other structural elements. Social values: Use local skills and provide job opportunities as well as skills training. Some local members were employed by the firm and continue to still be working for them.	Figure 26: House Gardiner (Simply Sustainable, 2023) Simply Sustainable (2023) 'House Gardiner – simply sustainable'. Available at: https://simplysustainable.co.za/projects/house-gardiner/ (Accessed: 4 June 2023). Marais, P., Littlewood, J. and Karani, G. (2015) 'The Use of Polymer Stabilised Earth Foundations for Rammed Earth Construction', Energy Procedia, 83, pp. 464–473. Available at: https://doi.org/10.1016/j.egypro.2015.12.166.
							Polymer stabilised earth foundations				The mixing of the polymers required precision and were delivered in quantities	using polymer earth foundations is a very new technique and is still being studied.		
							polymer stabilised rammed earth undersurface bed			compacted the earth layers was done by a combination of		structural rammed earth floor beds is very new and not developed yet in		
								The walls were rammed from soil from the site coloured with natural oxides		compacted the earth layers was done by a combination of hand and a tamping tool	Ramming of the walls was also done with pneumatic rammers in layers no more than 75mm thick	The use of structural, load bearing rammed earth walls is still new to SA and is still being studied.	the method of compacting soil as the construction technique is developed	
								foundations made of rammed earth that were stabilised with a bitumen polymer mixture. Mixing was done in a traditional cement mixer		Traditional mixing techniques and rollers were used		the polymer solution to stabalize rammed earth is a new practice and not developed in SA	the method of compacting soil as the construction technique is developed	
								The earth floor slab construction technique required that all the services be placed underneath		It does not involve highly specalized or cutting-edge technology, only rollers for compacting the layers of earth		Services are normally installed within the floor slab, however here they were required to be placed underneath as compressing of the earth would	the method of compacting soil as the construction technique is developed	
									single story rammed earth walls: 500mm thickness and 4.2 meters in height with horizontal		reinforcing the rammed earth walls with bitumen covered stell reinforcing rods is considered to be high tech as this	The use of structural, load bearing rammed earth walls is still new to SA and is still being studied.		
									The foundations are a combination of cement-stabilised earth with a polymer-stabilised layer above.		The cementstabilised earth was mixed by hand and the polymer stabilised earth with a rotary mixer before being placed and compacted by a	Polymer stabilised earth is a technology that was developed for road building and as such was designed to beapplied at scale with the use of		
									N/A The roof was a lightweight steel structure at a ten-degree slope, with timber					
27	MMA Architects	Sandbag Houses Residential		2009	Mitchells Plain, Western Cape	Sandbag houses made out of Eco-beams as structure with sand filled bags as the infill and mass.	Sand filled bags			Bags filled by hand. No technology needed			Sand bags as construction material is a developed system, but informal, part of construction processes in SA.	Use materials from the area makes it contectually responsive. Low cost connected to this material	Figure 27: Construction of Sandbag house (MMA Architects, 2009) Fairs, M. (2018) Sand-bag houses by MMA architects, Dezeen. Available at: https://www.dezeen.com/2008/02/26/sand-bag-houses-by-mma-architects/ (Accessed: 09 May 2023).
								Bags filled with sand sourced from the area. Stacked on each other between structural elements.		Filling bags with sand by hand and placing it between structural elements. All done by unskilled labour			The use of sandbags for wall infill is developed	Use local skills and provide job opportunities as well as skills training
									N/A Eco-beams					
28	Moladi	Western Cape Education Centre		2018	Parrow, Western Cape	Concrete cast between reusable plastic formwork sheets. Plastered and painted the same as conventional way	N/A Common concrete mixture but without without stone.							Fast paced construction. Time spared in construction duration- construction costs are lowered.	Figure 28: Western Cape Education Department (Moladi, 2018) Oh, E. (2015) How the 'moladi' system is making affordable housing more accessible in South Africa, ArchDaily. Available at: https://www.archdaily.com/644369/how-the-moladi-system-is-making-affordable-housing-more-accessible-in-south-africa (Accessed: 09 May 2023).
								Setting up reusable plastic formwork rather than conventional timber/steel. These formwork systems are removed within 15 hours - a lot faster than conventional cast in-situ concrete.		Low tech. Formwork needs to be built and taken apart by hand		this mode of formwork is underdeveloped and can start a new movement in achieving faster construction		
									N/A Concrete walls with reinforcing					
							N/A Common concrete mixture but without without stone.								Figure 29: Melkbos strand Highschool (Moladi, 2019)
								Setting up reusable plastic formwork rather than conventional				this mode of		

29	Moladi	Melkbos High School		2019	Melkbosstrand, Western Cape	Concrete cast between reusable plastic formwork sheets. Plastered and painted conventionally.	N/A Common concrete mixture but without without stone.							Fast paced construction. Time spared in construction duration- construction costs are lowered.	Figure 29: Melkbos strand Highschool (Moladi, 2019) Oh, E. (2015) How the 'moladi' system is making affordable housing more accessible in South Africa, ArchDaily. Available at: https://www.archdaily.com/644369/how-the-moladi-system-is-making-affordable-housing-more-accessible-in-south-africa (Accessed: 09 May 2023).
								Setting up reusable plastic formwork rather than conventional timber/steel. These formwork systems are removed within 15 hours - much faster than conventional cast in-situ concrete.		Low tech. Formwork needs to be built and taken apart by hand		this mode of formwork is underdeveloped and can start a new movement in achieving faster construction	
									N/A Concrete walls with reinforcing				
30	NEO Architects	DOXA DEO CHAPEL		2022	Brooklyn, Pretoria, Gauteng	Pe-fabricated Chapel	N/A Internal Dry Walling							The combination of the selected lightweight material palette achieved the required acoustic, maintenance, and thermal insulating properties required. Due to these methods of construction, the final product reached completion in 5 months. This form of prefab construction could pose substantial **economic benefits** in the near future if implemented at a greater scale.	Figure 30: Doxa deo chapel (NEO Architects, 2022) Ohlhorst Lightweight Building Solutions (2022) Ohlhorst Lightweight Building Solutions on linkedin: Ohlhorst LBS Latest Project: Doxa deo chapel, brooklyn campus, Ohlhorst Lightweight Building Solutions on LinkedIn: Ohlhorst LBS Latest Project: DOXA DEO CHAPEL, BROOKLYN CAMPUS. Available at: https://www.linkedin.com/posts/ohlhorst-lightweight-building-solutions_ohlhorst-lbs-latest-project-doxa-deo-chapel-activity-6966032608023449600-dg9m/?trk=public_profile_like_view&originalSubdomain=id (Accessed: 16 May 2023).
							N/A Light Weight Steel with Cavity Batts								
							N/A Fibre Cement Board								
							N/A Terraco cementitious render finishes								
								Fully light weight construction methods where majority of the materials used are pre-fabricated and delivered as modules to site			The prefabrication and machining processes involved with manufacturing Internal Dry Walling, Light Weight Steel, Fibre Cement Board, and Terraco cementitious render finishes	Construction process where majority of the materials used to fabricate the building are prefabricated and delivered to site	
									N/A Light Steel Framework structural system				
31	Nieuw Architects	House Newlands		2023	Newlands, Cape Town, Western Cape	The architect decided to construct the building using AAC blocks, giving consideration to the different ways it could contribute to saving construction time, waste materials and amount of labourers needed on the project. The AAC blocks were modified on site, to appear more slender in the cavity wall.	Lightweight, composite Aertec AAC blocks (Autoclaved aerated concrete) - a foam concrete block that is precast and consists of water, sand, cement, aluminium powder, lime and gypsum. Aertec's CEM-SKIM 100 skimming plaster directly applied to the wall at 5mm thickness, to reduce weight even further.				The bricks undergo a heating process called 'autodaving'		The AAC blocks are relatively well-developed and have been implemented in various projects since its invention.	The construction period was shortened due to the lightness of the building materials, saving costs since labourers had to be hired for a shorter time. Another **economical** factor was the decreased amount of construction wastage that accumulated at the end of the project since the materials were modular, causing minimal excess. Although the AAC blocks are made to be modular units, the blocks can be cut along their length to appear more flattened, making it **versatile** in its application.	Figure 31: House Newlands in Cape Town (Aertec, 2023) Aertec, 2023, *House Newlands, Sans Souci Road*, Aertec. Available from: https://www.aertec.co.za/news-articles/admin/NA/house-newlands-sans-souci-road/34 [Accessed on 23 March 2023]
								N.A Construction similar to conventional brick construction					
									N/A AAC bricks as structural system similar to conventional masonry structures				
32	Paragon Architects	105 Corlett Drive		2013	Johannesburg, Gauteng	A modern office building known for its distinctive design featuring a combination of glass and Arcelor Mittal Calman cladding, creating a visually captivating and innovative architectural expression.	N/A Arcelor Mittal Calman Cladding				innovative material properties, precision manufacturing processes, integration of digital tools,	Although made of steel, the method of construction in SA is considered to be under-devevloped		Collaboration and community intergration by encoporating the community in the laying of the slate wall cladding brings a **social value** to this project. The design of the building takes into account the site's context, respecting site boundaries and creating a harmonious relationship with the surrounding environment, improving the **contextual responsiveness** of the area. **Economic Growth**: The construction and operation of the building contribute to the local economy by generating job opportunities and supporting related industries.	Figure 32: Corlette drive office (ArchDaily, 2014) ArchDaily (2014) *105 Corlett Drive / Paragon Architects*. Available at: https://www.archdaily.com/552450/105-corlett-drive-paragon-architects (Accessed: 16 May 2023).
							N/A Reflective laminated Solarshield 530 glass								
								The construction technique employed computer software to generate precise and taut cone forms, pushing the boundaries of traditional material expressions like concrete and glass			Parametric Computer Software for Form Generation that challenges the traditional expressions of materials like concrete and glass.		This is a developed practice in South Africa, and it is an emerging trend
									N/A Three conical forms comprising of a network of steel columns clad in galvanized sheeting, and a final cladding of silver Calman			advanced fabrication techniques were used for the presicion and custom desiging of the steel structure	Not yet a common practice in South Africa, but it is an emerging trend	
33	Philipp Exter	Spout Coffee		2016	Pretoria, Gauteng	The cafe is made up of two repurposed shipping containers stacked on top of one another to create a two-story space. It's the first such recycled container space in the city, and the design touches throughout the small space help the bar to stand out	N/A a pair of recycled shipping containers stacked on top of each other							The project proves to be very **economical** since the shipping containers save costs on construction time. This project is **versatile** because this structure can be repeated and linked infinitely, meaning that it is versatile in size and usage.	Figure 33: Spout Coffee Shop (Scheffer, 2017) Scheffer, D. 2017. *Spout Coffee: A Modern Container Coffee Shop In Pretori, Sprudge*. Available from: https://sprudge.com/spout-coffee-company-pretoria-112751.html [Accessed on 4 June 2023]
								N.A Conventional construction methods used					
									The shipping containers are integrated into a traditional steel building system for reinforcement, creating a hybrid structure.	An existing container that has been altered. Some sides have been cut open to insert windows and a roof has been added to the top. The structure has been altered in a low-tech manner.			This structural system has been developed since its initial discovery. The process of repearting the structure in other places is uncomplicated, thus making it easy to do, resulting in it becoming a developed building technology.
34	Pietro Russo	The Ecomo Home		2010	Franschhoek, Cape Town, Western Cape	The design is based on basic sustainable, green design principles. The ecomo home offers a low-maintenance, modern, well-designed green housing alternative.	N/A SA Pine				material is made through high tech industrial machinery	CLT is a developing material in South Africa		Contextual Responsive Values: The architectural design of the Ecomo Home is responsive to its surroundings and local context. It integrates sustainable design principles and utilizes renewable materials. Ecological: incorporate passive design strategies to optimize energy efficiency and reduce its ecological footprint. The modular construction methods creates opportunity for customization and adaptability.	Figure 34: Ecomo Home (ArchDaily, 2010) ArchDaily (2010) *The Ecomo Home / Pietro Russo* . Available at: https://www.archdaily.com/82774/the-ecomo-home-pietro-russo (Accessed: 27 March 2023).
								precision manufacturing and streamline prefabrication, where the large wood components are fabricated off-site and then assembled on-site.			the use of prefabrication and precise manufacturing of the componets is high-tech process	Prefabrication of timber panels is a not yet a developed practice in south africa	
									N/A Timber panels are load bearing used to form the walls, floors, and roof of the structure		The CLT panels are then transported to the construction site and assembled on-site using specialized connections and fastening systems.	using CLT as structural elements are under developed in South Africa. Usually used as facade components	
35	RAW Module	28 Day house Residential		2020	Sterkfontein, Krugersdorp, Nort-West	Steel modules designed and manufactured off site. Assembly on site on a slab that cured within 28 days that allows construction and finishing of buildings to be finished within 28 days.	N/A Steel framing system & Modular components							Fast paced construction where time is spared in construction duration-construction costs are lowered, making it **economical**.	Figure 35: 28 day House (Raw Module, 2020) RAW Module, 2022. Process, Raw Module. Available at: https://rawmodule.com/process/ (Accessed: 12 May 2023).
								Premanufactured modules designed using CAD are assembled on site by hand		N/A Assembly low tech. still done on site by unskilled labourers	Computer Aided Design allows predise design and production of individual modules	Premanufacturing and the modular components	N/A On site assembly and construction
									N/A Cold rolled steel & Light Steel frames				
36	Rich, Peter	Mapungubwe Interpretation Centre		2009	Mapungubwe National Park, Musina, Limpopo	Give a short description	Stabilised hand pressed soil tiles (minimal cement use)			Hand-based (as opposed to Hydraform block equipment that is powered by electricity or			Soil tiles and blocks are commonly used in SA (the challenge was to achieve the required compressive strength)	The construction process was an opportunity for local people to come and learn new skills for design and construction technologies., making the project **socially responsible**. Unskilled labourers were taught how to build these structures, therfore uplifting the community's identity as well as their capabilities to contribute as working individuals. The materials used are low cost since they can be sourced from surrounding natural landscapes and the equipment and time used to manufacture the materials and the structure is not too extensive., making it **economical.** This structural system and materials are adaptable since the material and structure can become adapted to be used on a larger scale, enabling it to be **versatile** enough to	55 Figure 36: Headquarters under construction (Ramage, Ochsendorf, Rich, Bellamy & Block, 2010: 19). Ramage, M.H., Ochsendorf, J., Rich, P., Bellamy, J.K. and Block, P., 2010. Design and construction of the Mapungubwe National Park interpretive centre, South Africa. ATDF JOURNAL, 7(1/2).
								Craftsmen following a catenary arch guide as they lay the brick layers until they meet at the vaults		Unskilled labour and and low tech equipment	The structural form-finding relies on techniques of graphic statics. A mix of commercially available CAD software (Rhinoceros), the application of graphic statics in coordinate geometry programs (Cabri or Geogebra)	Construction technique not commonly used in SA	
										Catenary vault can be described as a 3-dimensional			

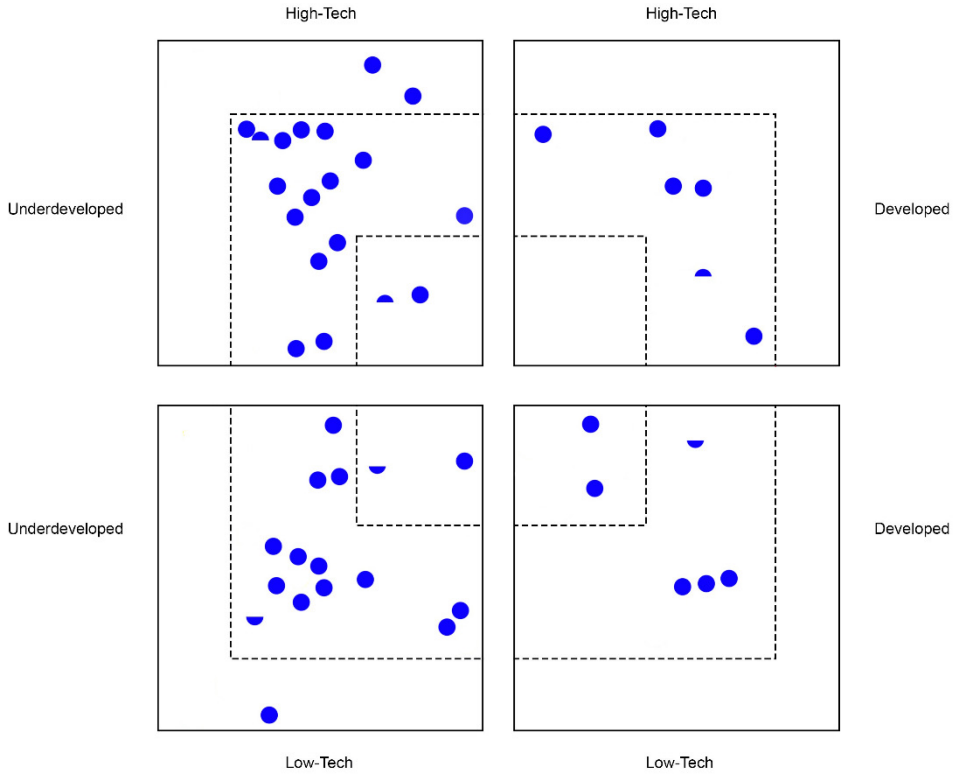
37	Rothoblaas South Africa	Residence in Constantia		2022	Constantia, Western Cape	Residence built using masonry construction for "bunker" and rest of the residence built using CLT panels and rafters	Cross Laminated Timber (CLT)				Material is made through high tech industrial machinery		CLT is a developing material in South Africa	Mass timber buildings allows projects in remote locations to be built and constructed due to off-site precice manufacturing. Faster construction times, lower costs in construction.	Figure 37: Residence under construction (Rothoblaas, 2022) O'Connor, M. (2023), ROTHOBLAS - Presentation for the University of Pretoria [online]. Pretoria South Africa: Unpublished. Available on request: RBZAPRESENTATIONTUKS11.05.2023.pdf [Accessed: 20 May 2023]
								Prefabrication (CNC) of building elements off site			The process of cutting elements to size through CNC machines highly technical		CNC machinery is a well developed practice in south africa and is developed		
									Structural components of 2nd story made out of CLT		Structural system out of CLT is high-tech due to the processes to produce the materials	Using CLT as structural elements are under developed in South Africa. Usually used as facade components			
38	Snohetta and Local Studio	Desmond Tutu Archway		2017	Cape Town, Western Cape	Steam-bent Larch woven together to form this commemorative arch.	N/A Larch timber							Creative and new way of forming timber into intricate forms - different from the conventional use of timber. Can be used as a precedent for other ways to use and introduce timber into buildings and designs.	Figure 38: Desmond Tutu Memorial (David Southwood, 2017) Lynch, P. (2018) Snohetta and local studio unveil wooden archway honoring Archbishop Desmond Tutu in South Africa, ArchDaily. Available at: https://www.archdaily.com/890412/snohetta-and-local-studio-unveil-wooden-archway-honoring-archbishop-desmond-tutu-in-south-africa?ad_medium=gallery (Accessed: 12 May 2023).
								Timber modules prefabricated by bending elements in factory with steam. Constructed (fixed) on site.		The use of steam used to bend the timber are done by hand		Underdeveloped way of manufacturing intricate timber elements.			
									N/A Non structural (loadbearing) element						
39	StudioMas & Arup	The Ridge Deloitte Cape Town		2020	Cape Town, Western Cape	6-star Green Star Design awarded commercial building	Cross laminated timber (CLT)				Structural engineered wood panels are made up of three or more layers of wood, each layer oriented perpendicular to the adjacent layer, and then pressed together and bonded with a special adhesive. Integration with services and openings are commonly pre-planned and cut using CNC routers.	Mass timber construction is relatively new to South Africa		Rapid prefabrication, fast on-site assembly and design for disassembly. Machinable and allow for a high precision. Renewable material and atmospheric carbon dioxide is trapped (CO2 store). The CLT is local, renewable, and highly durable. It requires no additional finishes to the interior or exterior, no insulation (StudioMas: online)	Figure 39: Exterior view of CLT panels (StudioMas: online). The Ridge | StudioMAS ,no date. Available at: https://studiomas.co.za/the-ridge/#theridge [Accessed: 19 April 2023]. Mass Timber Technologies .2022. Cross-laminated Timber & Glue-laminated Timber, Design Guide, Edition 1, 2022, p. 51. Available at: https://www.masstimbertech.co.za/designguide [Accessed: 19 April 2023].
								n/a Medium sized prefabricated panels not machined (CNC)							
									n/a Non-load bearing cladding to RC slab and column structure						
40	Steyn Studio	The Bosjes Chapel		2016	Worcester, Western Cape	The new chapel, set within a vineyard in South Africa, is designed by South-African born Coetzee Steyn of London based Steyn Studio. Its serene sculptural form emulates the silhouette of surrounding mountain ranges, paying tribute to the historic Cape Dutch gables dotting the rural landscapes of	N/A Concrete							Social Value: The chapel provides a space for spiritual reflection and community gathering, contributing to the social fabric of the surrounding area. Economical Value: The innovative use of concrete casting techniques allows for efficient construction processes and cost-effective solutions. These technologies streamline construction timelines and minimize material waste, optimizing the project's economic viability. Contextual Value: The chapel's design responds to its natural surroundings, taking	Figure 40: Bosjes Chapel (ArchDaily, 2020) ArchDaily (2020) *Bosjes Chapel / Steyn Studio* . Available at: https://www.archdaily.com/867369/bosjes-chapel-steyn-studio (Accessed: 17 May 2023). A.T. (2017) *'Bosjes Chapel - Architecture Today'*, 26 June. Available at: https://architecturetoday.co.uk/bosjes-chapel/, https://architecturetoday.co.uk/bosjes-chapel/ (Accessed: 17 May 2023).
								The concrete was poured in the form of shotcrete - projected at high velocity through a hose			Due to the unique form of the shell, each reinforcing bar (top and bottom) had to be individually cut and	this method has become more developed and is on the rise as it achieves desired forms.			
									Undulating concrete shell self supporting		3D parametric CAD models used to calculate the required volumes of concrete and steel for the unique concrete form	The modelling process for technical qalities is still not developed in SA			
41	Steyn Studio	'Die Spens' Bosjes		2021	Ceres, Western Cape	Indigenous methods of building were used as inspiration and indigenous plats form a big part of the landscape that surrounds the structure. The wooden trellis is placed underneath a retaining wall structure that also acts as a dome/roof garden.	N/A Timber							The oak trellis that can be bent and fixed in multiple ways makes the shape of what the structure could be **versatile**, enabling it to become adapted in different forms to both existing and new sites. The product can be applied structurally and allows opportunity for coverings to be applied or even vegetation to grow on it.	Figure 41: 'Die Spens' in Ceres (Ranjit, 2021) Ranjit, J. 2021. *Die Spens & Winkel By Steyn Studio And Square One Landscape Architects*, Parametric Architecture. Available from: https://parametric-architecture.com/die-spens-winkel-steyn-studio-square-one-landscape-architects/ [Accessed on 24 March 2023]
								A large quantity of wooden oak trellis that has been steam bent			The cutting and bending of the oak trellis includes the use of a laser cutter which would be high-tech	The construction process is under-developed due to the fact that oak is not usually cut and bent on that large scale.			
									A wooden oak trellis that has been bent and fixed in a 3D, sculpted manner that is meant to resemble the "matjiehuis" from the Khoi San indigenous houses.		The structure is high-tech since it has been tested on a digital programme to test its compatibility with other materials as well as testing to see which form would work 3 dimensionally. Computer Aided Design (CAD)	The new way in which the structure is built with its free form is underdeveloped since it has not been executed on this level many times before.	N/A The indigenous concepts from which the oak trellis was derived is a developed structure.	
42	SRLC Architects	Westcliff House			Westcliff, Johannesburg, Gauteng	Residence	N/A Bitumen							Innovative use of materials in order to create intricate sspatial experiences. The project stands to show how the innovative use of materials can result in the making of **versitile spaces**.	Figure 42: The residence done by SRLC Architects (Crewe-Brown, 2020) Crewe-Brown, M. 2020. *Westcliff Ridge Home* , Visi. Available from: https://visi.co.za/westcliff-ridge-home/ [Accessed on 10 April 2023]
							N/A Glazing								
							N/A Structural Steel								
							N/A Zinc Panel Roof Cladding								
							CLT Ceiling Panels				Prefabricated machining methods used to manucature CLT panels		Use of CLT as ceiling panels		
								N/A With specific reference to the main bedroom, its interesting form was achived through a structural steel lattice of which was packed with insulative panelling and finished in a bitumen water proofing layer. From here Zinc Panel Roof Cladding was used as the				Design processes associated with expressive form making using common material			
									N/A Structural steel latice made of hot rolled steel members of which were welded to one another to achive an interesting form						
43	SRLC Architects	Darrymple Pavilion			Westcliff, Johannesburg, Gauteng	A rentable Pavillion space in Westcliff, Johannesburg used for gatherings such as weddings and other celebrations	N/A Glazing			Lead wood was torched for protective purposes. The rough grain of the wood is still visible meaning that prefabrication and machining methods used to produce these structural elements were minimal		Use of Lead wood as a structural element in South Africa		This project displays the potential behind hybrid tectonics within South Africa. A rather modern building typology was achieved through the innovative use of indigenous building materials making the project **contextually responsive** which still pushing the bounds of architecture within South Africa.	Figure 43: The Darrymple pavilion done by SRLC Architects (Divani, 2023) Divani, M. 2023. *Dalrymple Pavilion by Silvio Rech and Lesley Carstens Architects* , Decoholic. Available from: https://decoholic.org/dalrymple-pavilion-by-silvio-rech-and-lesley-carstens-architects/ [Accessed on 10 April 2023]
							N/A Rammed earth								
							Lead Wood			Lead wood was torched for protective purposes. The rough grain of the wood is still visible meaning that prefabrication and machining methods used to produce these structural elements were minimal		Use of Lead wood as a structural element in South Africa			
								N/A Torched lead wood elements used as structural elements, fixed through nut-and-bolt articulation system							
									Lead wood used as main structural element	Lead wood was torched for protective purposes. The rough grain of the wood is still visible meaning that prefabrication and machining methods used to produce these structural elements were minimal		Use of Lead wood as a structural element in South Africa			

						system							
							Lead wood used as main structural element	Lead wood was torched for protective purposes. The rough grain of the wood is still visible meaning that prefabrication and machining methods used to produce these structural elements were minimal		Use of Lead wood as a structural element in South Africa			
44	SVA International	Ocean Sciences Campus Extensions NMU		2022	Gqeberha, Eastern Cape	a large internal veranda space, articulated as a triple-volume, multi-layered foyer space which links the main circulation spine with the more private spaces within.	N/A Anodized aluminum sun-screen panels						This project has **social value** due to the integration of the dive tank element within the main facade adds a unique character presence to the building and provides a distinctive feature that can be enjoyed by the public. **Environmental value** is contributed because the project includes several sustainable design features, such as the use of natural ventilation, rainwater harvesting, and an energy-efficient building envelope. These features help to reduce the building's environmental impact and promote sustainability. The building's design and material choices adds **contextual value** because it takes into account the local context, such as the use of anodized aluminum sun-screen panels that are resistant to the harsh coastal environment and the incorporation of the dive tank element, which relates to the building's function and location near the ocean.	Figure 44: Ocean Sciences Campus extension NMU (ArchDaily, 2012) ArchDaily (2022) *Ocean Sciences Campus Extensions NMU / SVA International* . Available at: https://www.archdaily.com/991550/ocean-sciences-campus-extensions-nmu-sva-international (Accessed: 10 May 2023).
								Parametric modeling software was used to develop the form and geometry, the panels were fabricated off-site using CNC (ArchDaily, 2023)		This is considered high-tech because of the advanced manufacturing process and properties	The construction method involved is not a developed process in SA		
								The curved and angled shapes the dive tank used advanced fabrication to achieve the desired cylindrical forms		3D modeling and digital fabrication techniques for customised and complex geometries is required to achieve the cylindrical form of the dive tank	Not yet a common practice in South Africa, but it is an emerging trend		
							N/A column and beam						
45	Tsai Design Studio	The Visserhoek School		2014	Malanshoogte, Cape Town, Western Cape	A recycled shipping container was adapted to become a classroom and is surrounded by additional elements and landscaping that is meant to contribute to the programme of the classroom.	N.A Corrugated iron material						This project is **versatile** because this structure can be repeated and linked infinitely, meaning that it is versatile in size and usage. This lost-cost and time-saving construction process enables the project to be inserted on various sites similar to this one, contributing to community upliftment, making it **socially responsible.** The container has been recycled, meaning that costs were saved on the construction materials, causing the project to be **economical.**	Figure 45: 'Visserhoek' School in Malanshoogte (Laylin, 2012) Laylin, T. 2012. *The Vissershok School is a Colorful Shipping Container Classroom for Kids in South Africa* , Inhabitat. https://inhabitat.com/the-vissershok-school-is-a-colorful-shipping-container-classroom-for-kids-in-south-africa/
								N.A Conventional construction methods used					
							Shipping containers as structural system, where an existing steel container is modified to become a school classroom.	An existing container that has been altered. Some sides have been cut open to insert windows and a roof has been added to the top. The structure has been altered in a low-tech manner.			This structural system has been developed since its initial discovery. The process of repearting the structure in other places is uncomplicated, thus making it easy to do, resulting in it becoming a developed building technology.		
46	Urban Think Tank	Residence		2014	Khayelitsha, Cape Town, Western Cape	Architects worked with the community to improve their current home structures by working toward ways of maximising the quality and space. The existing structure is expanded in volume and assembly.	N.A Corrugated iron and timber for material						The project is **contextually responsive** because the architects/builders are not removing the existing informants from their designs, but are rather using it to continue what is happening in the context and improving it. The low cost materials that are used makes this project **economical**. The people who inhabit the structure are a part of the construction process, not only to teach them the skill, but to save on labour costs. The use of this EBT makes the project **socially responsible** because the structures serve the community by meeting their needs within their social context, local people/the inhabitants are a part of the construction process. Lastly, the project is **versatile** because the structure can be adapted in multiple ways depending on what the design requires. Although the size cannot become too large in size, it is able to contain more volume with a smaller footprint due to the fact that it is a double storey structure.	Figure 46: Residence done by Urban Think Tank in Khayelitsha (Frearso, 2014) Frearson, A. 2014. *Urban-Think Tank develops housing prototype for South African slums,* Dezeen. Available from: https://www.dezeen.com/2014/03/07/empower-shack-urban-think-tank-housing-south-africa-slums/ [Accessed on 24 March 2023]
								A design-and-build workshop for architects and local residents to collaborate with the final product being a prototype that is utilised by a community (experiments that are used)		The workshop does not include the use of high-end machines or designs, the construction process is similar to normal shack construction, with the exception that it is built with an upper storey.	This way of working collaboratively is underdeveloped since the construction process usually does not include a workshop space where ideas can be tested between practitioners, builders and users.		
							Double volume residential structure wit timber frame with corrugated iron cladding.		The double storey corrugated iron and timber structure is low-tech since it does not require any special joinery and is assembled y hand and low-tech equipment.	This type of structure is currently underdeveloped since most of the current shack structures are single storey buildings and this new double stack idea has only recently been implemented.		
47	van Sittert, Bertus	Curtain House Residential		2021	Brooklyn, Pretoria, Gauteng	Brick, steel and concrete conventional residential house. Raked plaster facades with a new technique/application.	N/A Conventional brick and concrete materials						The artisinal approach to applying plaster to buildings adds another layer of craft into the building. The specific design was chosen to mimic the trees that were on site. Shows how to create new ways of adressing the facades of conventional buildings in new ways. Hybrid use of low and high tech. Combining past techniques with future processes	Figure 47: Curtain House (Bertus van Sittert, 2021) S, M. (2021) Pretoria Institute of Architects: Winners of 2021 Architect Awards announced, Building & Decor. Available at: https://www.buildinganddecor.co.za/pretoria-institute-of-architects-winners-of-2021-architect-awards-announced/ (Accessed: 02 May 2023).
								Stucko plaster scraped on facades with laser cut steel profile to create a 'tree bark' relief that turned out to look like the curtains hanging inside the house.		Act of scraping and applying plaster is hand-based process	Profile used to scrape plaster is cut out using laser cutter that is high-tech	Traditional nature of applying plaster	
							N/A Conventional (load bearing structural system) brick and concrete						
48	Veld Architects	Soil and Serenity		2022	Rhenosterspruit Conservancy, Centurion, Gauteng	A residence project where the rammed earth walls contain soil takes from the site to pay homage to the context.	N/A Soil used for the rammed earth walls						This project is **contextually responsive** because the soil that is sourced from the site pays homage to the context it is placed within. It is also **economical** due to the low maintenance that is required for the rammed earth walls (GreenBuilder 2015).	Figure 48: The residence done by Veld Architects (Veld Architects 2023) Veld Architects, 2023, *Soil and Serenity,* Veld Architects. Available from: https://www.veldarchitects.co.za/projects/soil-and-serenity/ [Accessed on 27 March 2023] Naditz, A. 2015. *Rammed Earth: Affordable, and Relatively Unknown,* Green Buillder. Available from: https://www.greenbuildermedia.com/blog/one-of-the-
								Rammed earth walls made on site by using the soil from the excavations		It is low-tech due to the fact that simple methods are used to construct the walls	It is high-tech due to the fact that industrial machines are used to construct the walls, such as pneumatic	Rammed earth walls are developed within the SA context since it has been constructed various times. It has been	
							N/A steel colourns						
49	Wall, Sean	New Jerusalem Orphanage		2013	Midrand, Johannesburg, Gauteng	Multiple shipping containers were stacked and fixed to one antoher in order to create a children's home.	N.A Corrugated iron material						The project proves to be very **economical** since the shipping containers "... are 25 percent cheaper than conventional brick and mortar homes." (Laylin, 2013) This project is **versatile** because this structure can be repeated and linked infinitely, meaning that it is versatile in size and usage.	Figure 49: Shipping container home (Laylin, 2013) Laylin, T. 2013. *New Jerusalem Orphanage is a Vibrant Shipping Container Home for South African Kids,* Inhabitat. Available from : https://inhabitat.com/new-jerusalem-orphanage-built-with-recycled-shipping-containers-makes-south-african-kids-feel-loved-again/
								N.A Conventional construction methods used					
							Shipping containers as structural system, where an existing steel container is modified to become a room in a dwelling.	An existing container that has been altered. Some sides have been cut open to insert windows and a roof has been added to the top. The structure has been altered in a low-tech manner.			This structural system has been developed since its initial discovery. The process of repearting the structure in other places is uncomplicated, thus making it easy to do, resulting in it becoming a developed building technology.		
50	WOLFF ARCHITECTS	Cheré Botha School		2017	Oakglen, Cape Town, Western Cape	A government school for children with special educational needs	N/A Brick						This project stands to show how institutional spaces such as schools don't need to rely on the over saturated use of brick and concrete. This project stands to highlight the potential of wood construction on a large scale thus presenting a level of **economic efficiency** for larger scale buildings within South Africa.	Figure 50 : Cheré Botha School (Editors at Wolff Architects, 2019) Editors at Wolff Architects (2019) Cheré Botha School, Wolff Architects. Available at: https://www.wolffarchitects.co.za/projects/all/special-needs-school/ (Accessed: 16 May 2023).
							N/A Polycarbonate panels						
							Glulam Structural timber			Each timber structural element is glued and placed under high machine compression for compaction to form elements		The glulam manufacturing process is developed in SA	
								N/A A series of educational buildings that predominantly use the structural wood "A-frame typology". These A-frames are articulated using nut-and-bolt joinery systems, and are fixed to the finished floor level using a steel base plate in conjunction with a nut-and-bolt system					
							N/A Predominantly, A-frame glulam structural wood trusses are used to create large spans of space						

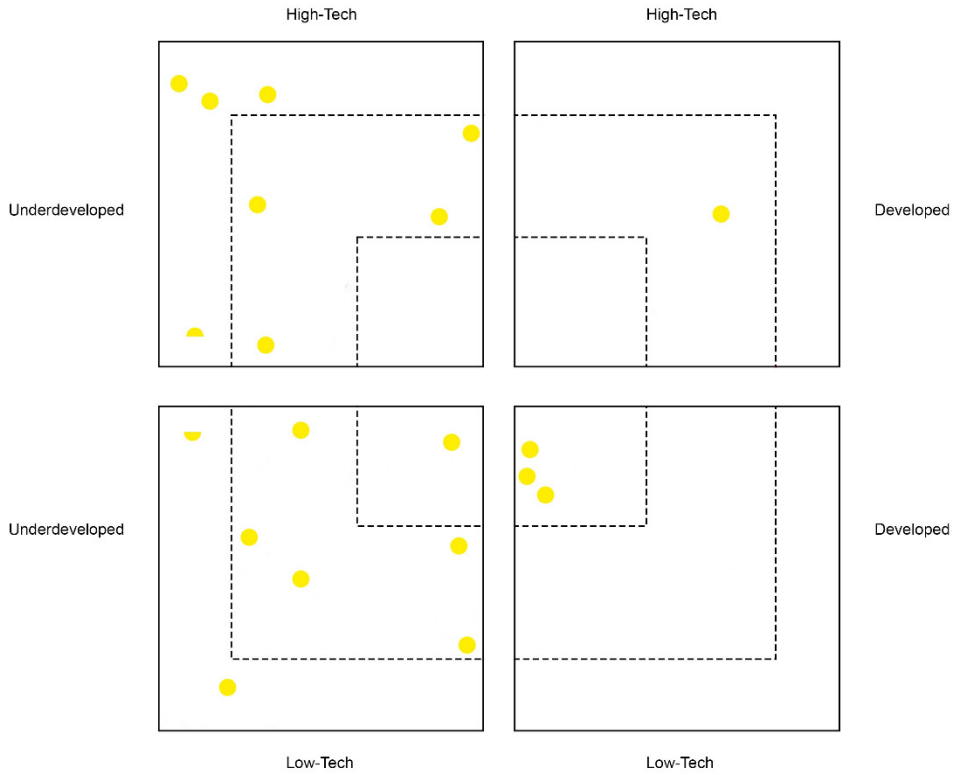
3: Graph of all case studies in the catalogue according to building materials, construction techniques and structural systems



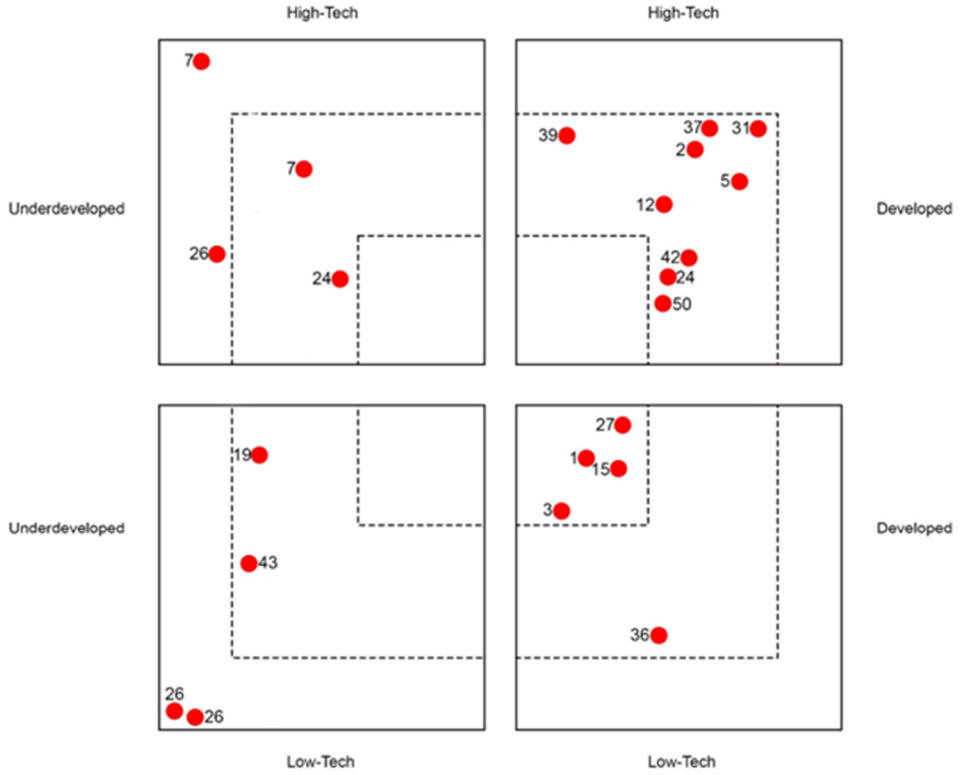
4: Graph of all case studies in the catalogue according to construction techniques



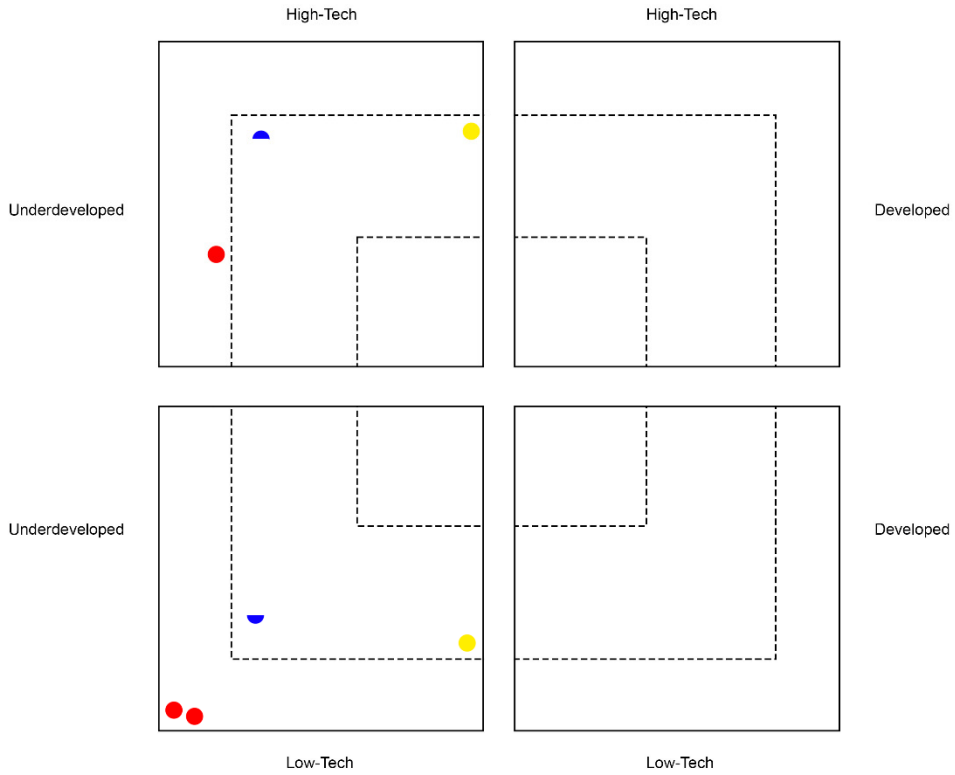
5: Graph of all case studies in the catalogue according to structural systems



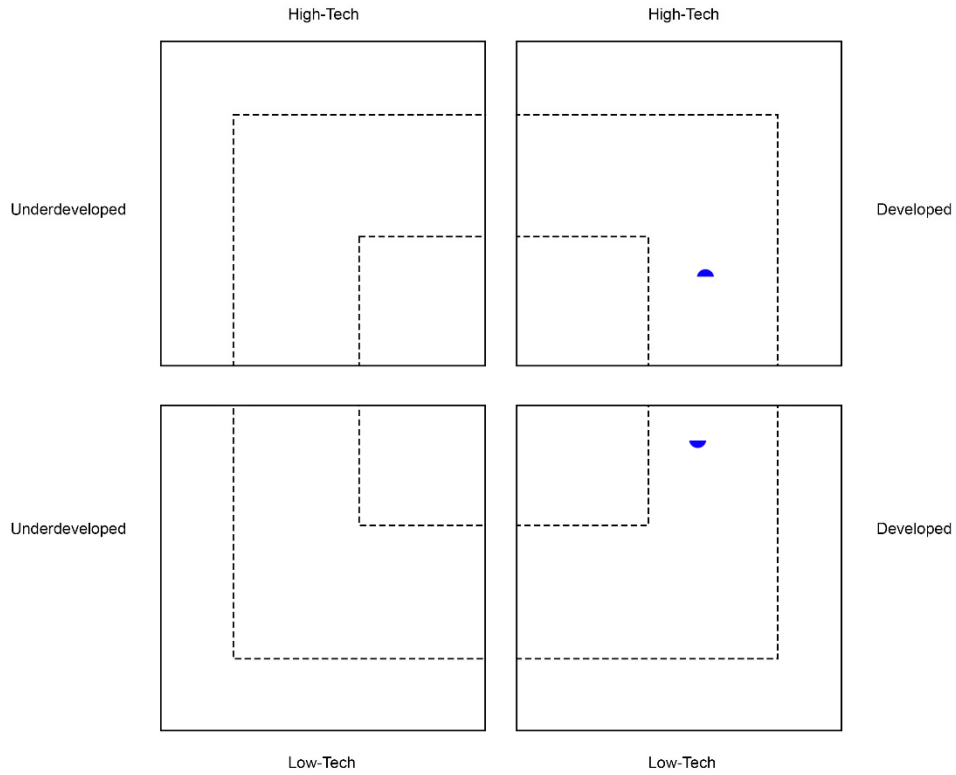
6: Graph of all case studies in the catalogue according to building materials



7: Graph of case study Paul Marais Project 26



8: Graph of case study Paul Marais Project 27



9: Catalogue according to filters using <Low-tech> <high-tech> <contextually responsive>

	Architect	Project	Images & Diagrams	Year of Completion	Location	General Project Description	Emerging building technology			Mode of production		Developmental status		Value	List of References
							Building material (I)	Construction process (II)	Structural system (III)	Low-tech (traditional or hand-based)	High-tech (industrialised)	Under-developed	Developed		
5	Choromanski Architects - Rod Choromanski and Dean Ramlal	uMkhumbane Museum		2017	Berea, Durban, Kwazulu-Natal	eThekwini Municipality's award-winning museum is the first new museum to be built in Durban in 100 years and also the first public cultural building constructed in the Cato Manor area.	"Firelight Satin" bricks - increased compressive strength				This particular brick went through additional processes during the manufacuring phases in order to increase its compressive strength, thus allowing the bricks to be stacked higher than normal bricks		The use of brick	The use of the "Firelight Satin" bricks proved to be in favour of **attainable economic factors** due to the fact that it mitigated additional costs usually needed for re-inforced concrete. While reducing costs associated with re-inforced concrete, the "Firelight Satin" bricks also managed to attain thermal and environmentally sustainable standards in the presence of less concrete, thus allowing the project to become **contectually responsive**.	Figure 6: uMkhumbane Museum(Editors at The Clay Brick Association of Southern Africa, 2020) Editors at The Clay Brick Association of Southern Africa (2020) Clay brick makes history at the Umkhumbane Museum, Clay brick makes history at the uMkhumbane Museum | Clay Brick Association of Southern Africa. Available at: https://www.claybrick.org.za/news/clay-brick-makes-history-umkhumbane-museum (Accessed: 22 May 2023).
							N/A Concrete								
							N/A Aluminum Facade Application								
								Due to its inherent strength, the "Firelight Satin" bricks achieved higher walls utilizing the method of diaphragms, thus avoiding the use of reinforced concrete beams		Bricks were layed by hand therefore following common building practice	Manufacturing processes associated with fabricating "Firelight Satin" bricks	The use of developed brick components that take on more of a structural role thus mitigating the need for an extensive re-inforced concrete intervention			
									N/A Concrete slab and coloumn structural system - bricks become structural						
8	ELMO SWART ARCHITECTS	Wright House		2011	Ocean View, Durban, Kwazulu-Natal	Traditional thatch-roofed South African Villa Transformed with contemporary vernacular reinterpretation extention.	N/A corrigated steel sheeting							This project stands to show the possibilities that exist around design and construction methods that consider traditional means of space making as well as emerging means of space making. This project ultimately goes on to showcase the **versatility** behind using eco materials such as thatch, gumpoles and bamboo in the midst of structural steel construction.	Figure 8: Wright House (Editors of Domob, 2019) Editors of Domob (2019) Organic South African villa transformed, Domob. Available at: https://domob.com/organic-villa-expansion-transforms-south-african-cottage/ (Accessed: 16 May 2023).
							N/A earth packed walls								
							N/A Bamboo -wall and facade finishes								
							N/A Gumpoles as non structural facade elements								
								Hybrid tectonics - The extension of the villa is defined by a series of structural steel C-frames that are closed off with an array of gumpoles that are finished with thatch at 45 degrees. This cantelevered structure sits on earth packed walls, while bamboo and steel sheeting work as the internal and external finishes		Indigenous material implementation - e.g. thatch, gumpole, and bamboo	Prefabrication and parametric digital design of structural steel members used	The co-existance of vernacular building methods, in combination with modern "high tech" construction materials	The use of strucural steel		
									N/A C-frame structural steel members closed off with gumpole elements sitting on earth filled wall structure						
26	Marais, Paul	House Gardiner		2014	Monaghan Farm, Johannesburg, Gauteng	This design incorporates 500mm thick rammed earth walls, underground rain water tanks, a roof optimised for solar shading and rainwater harvesting and off grid living. The use of polymer stabilised foundations not only significantly reduced CO2 but also saved costs.	Structural Rammed earth walls			soil was used directly from site and locals were trained and employed		Structural rammed earth walls as the only load bearing structure to hold the building is not commonly done and very under-developed in SA		Economical values: The polymer reinforced earth foundation required half of the steel of a reinforced concrete foundation, saving 46% of CO2 emissions contextually Responsive vales: This offers a sustainable and cost-effective alternative to traditional construction materials, utilizing locally available resources and reducing the environmental impact of the building process. Versatile values: The polymer has, as it major component is bitumen emulsion, provided a waterproof layer. The polymer binder enhances the structural properties of the earth, making it suitable for load-bearing walls and other structural elements. Social values: Use local skills and provide job oppertunities as well as skills training. Some local members were employed by the firm and continue to still be working for them.	Figure 26: House Gardiner (Simply Sustainable, 2023) Simply Sustainable (2023) 'House Gardiner – simply sustainable'. Available at: https://simplysustainable.co.za/projects/house-gardiner/ (Accessed: 4 June 2023). Marais, P., Littlewood, J. and Karani, G. (2015) 'The Use of Polymer Stabilised Earth Foundations for Rammed Earth Construction', Energy Procedia, 83, pp. 464–473. Available at: https://doi.org/10.1016/j.egypro.2015.12.166.
							Polymer stabilised earth foundations				the mixing of the polymers required precision and were delivered in quantities designed for mass preparation in large	using polymer earth foundations is a very new technique and is still being studied. This is highly under-developed in SA			
							polymer stabilised rammed earth undersurface bed			compacted the earth layers was done by a combination of hand and a tamping tool		structural rammed earth floor beds is very new and not developed yet in SA.			
								The walls were rammed from soil from the site coloured with natural oxides and stabilised with hydrated lime		compacted the earth layers was done by a combination of hand and a tamping tool	Ramming of the walls was also done with pneumatic rammers in layers no more than 75mm thick	The use of structural, load bearing rammed earth walls is still new to SA and is still being studied.	the method of compacting soil as the construction technique is developed		
								foundations made of rammed earth that were stabilised with a bitumen polymer mixture. Mixing was done in a traditional cement mixer then laid in 1.5m trenches and compacted Initial compaction was done with a rammer with the final compaction done with a plate compactor		Traditional mixing techniques and rollers were used		the polymer solution to stabalize rammed earth is a new practice and not developed in SA	the method of compacting soil as the construction technique is developed		
								The earth floor slab construction technique required that all the services be placed underneath before it was compacted with rollers.		It does not involve highly specialized or cutting-edge technology, only rollers for compacting the layers of earth		Services are normally installed within the floor slab, however here they were required to be placed underneath as compressing of the earth would damage the services, thus the earth was compacted above the services creating a hard subsurface for the	the method of compacting soil as the construction technique is developed		
									single story rammed earth walls: 500mm thickness and 4.2 meters in height with horizontal steel reinforcement		reinforcing the rammed earth walls with bitumen covered stell reinforcing rods is considered to be high tech as this transforms the walls into being the structural element holding the building up	The use of structural, load bearing rammed earth walls is still new to SA and is still being studied.			
									The foundations are a combination of cement-stabilised earth with a polymer-stabilised layer above.	The cementstabilised earth was mixed by hand and the polymer stabilised earth with a rotary mixer before being placed and compacted by a rammer.		Polymer stabilised earth is a technology that was developed for road building and as such was designed to beapplied at scale with the use of extensive plant. This was employed for housing whcih is relatively uncommon thus an under-developed method in SA			
									N/A The roof was a lightweight steel structure at a ten-degree slope, with timber beams and purlins.						
35	RAW Module	28 Day house Residential		2020	Sterkfontein, Krugersdorp, Nort-West	Steel modules designed and manufactured off site. Assembly on site on a slab that cured within 28 days that allows construction and finishing of buildings to be finished within 28 days.	N/A Steel framing system & Modular components							Fast paced construction where time is spared in construction duration- construction costs are lowered, making it **economical**.	Figure 35: 28 day House (Raw Module, 2020) RAW Module, 2022. Process, Raw Module. Available at: https://rawmodule.com/process/ (Accessed: 12 May 2023).
								Premanufactured modules designed using CAD are assembled on site by hand		N/A Assembly low tech, still done on site by unskilled labourers	Computer Aided Design allows precise design and production of individual modules	Premanufacturing and the modular components	N/A On site assembly and construction		
									N/A Cold rolled steel & Light Steel frames						
36	Rich, Peter	Mapungubwe Interpretation Centre		2009	Mapungubwe National Park, Musina, Limpopo	Give a short description	Stabilised hand pressed soil tiles (minimal cement use)			Hand-based (as opposed to Hydraform block equipment that is powered by electricity or diesel)			Soil tiles and blocks are commonly used in SA (the challenge was to achieve the required compressive strength)	The construction process was an opportunity for local people to come and learn new skills for design and construction technologies., making the project **socially responsible**. Unskilled labourers were taught how to build these structures, therfore uplifting the community's identity as well as their capabilities to contribute as working individuals. The materials used are low cost since they can be sourced from surrounding natural landscapes and the equipment and time used to manufacture the materials and the structure is not too extensive., making it **economical.** This structural system and materials are adaptable since the material and structure can become adapted to be used on a larger scale, enabling it to be **versatile** enough to be used in various regions. Since the materials are sourced from the landscape, it also means that any region in South Africa can use this building technology. The materials are suited to the context's climatic conditions and makes use of appropriate passive heating and cooling stystems with the materials used.	Figure 36: Headquarters under construction (Ramage, Ochsendorf, Rich, Bellamy & Block, 2010: 19). Ramage, M.H., Ochsendorf, J., Rich, P., Bellamy, J.K. and Block, P., 2010. Design and construction of the Mapungubwe National Park interpretive centre, South Africa. ATDF JOURNAL, 7(1/2).
								Craftsmen following a catenary arch guide as they lay the brick layers until they meet at the vaults		Unskilled labour and and low tech equipment	The structural form-finding relies on techniques of graphic statics. A mix of commercially available CAD software (Rhinoceros), the application of graphic statics in coordinate geometry programs (Cabri or Geogebra)	Construction technique not commonly used in SA			
									Timbrel Vaults (catenary arch principle)	Catenary vault can be described as a 3-dimensional version of a catenary arch (Mediterranean tradition of tile vaulting, a 600-year-old construction system that uses thin bricks to create lightweight and durable buildings)		Structural system not commonly used in SA (many international examples exist)			
47	van Sittert, Bertus	Curtain House Residential		2021	Brooklyn, Pretoria, Gauteng	Brick, steel and concrete conventional residential house. Raked plaster facades with a new technique/application.	N/A Conventional brick and concrete materials							The artisinal approach to applyling plaster to buildings adds another layer of craft into the building. The specific design was chosen to mimic the trees that were on site. Shows how to create new ways of adressing the facades of conventional buildings in new ways. Hybrid use of low and high tech. Combining past techniques with future processes	Figure 47: Curtain House (Bertus van Sittert, 2021) S, M. (2021) Pretoria Institute of Architects: Winners of 2021 Architect Awards announced, Building & Decor. Available at: https://www.buildinganddecor.co.za/pretoria-institute-of-architects-winners-of-2021-architect-awards-announced/ (Accessed: 02 May 2023).
								Stucko plaster scraped on facades with laser cut steel profile to create a 'tree bark' relief that turned out to look like the curtains hanging inside the house.		Act of scraping and applying plaster is hand-based process	Profile used to scrape plaster is cut out using laser cutter that is high-tech	Traditional nature of applying plaster			
									N/A Conventional (load bearing structural system) brick and concrete						
48	Veld Architects	Soil and Serenity		2022	Rhenosterspruit Conservancy, Centurion, Gauteng	A residence project where the rammed earth walls contain soil takes from the site to pay homage to the context.	N/A Soil used for the rammed earth walls							This project is **contextually responsive** because the soil that is sourced from the site pays homage to the context it is placed within. It is also **economical** due to the low maintenance that is required for the rammed earth walls (GreenBuilder 2015).	Figure 48: The residence done by Veld Architects (Veld Architects 2023) Veld Architects, 2023, *Soil and Serenity*, Veld Architects. Available from: https://www.veldarchitects.co.za/projects/soil-and-serenity/ [Accessed on 27 March 2023] Nadltz, A. 2015. *Rammed Earth: Affordable, and Relatively Unknown*, Green Builder. Available from: https://www.greenbuildermedia.com/blog/one-of-the-most-affordable-eco-friendly-materials-is-relatively-unknown#:~:text=The%20Advantages%20of%20Rammed%20Earth&text=environmentally%20friendly%20materials%20there%20is,never%20be%20l
								Rammed earth walls made on site by using the soil from the excavations, with plywood formwork and a pneumatic press.		It is low-tech due to the fact that simple methods are used to construct the walls.	It is high-tech due to the fact that industrial machines are used to construct the walls, such as pneumatic compressors.		Rammed earth walls are developed within the SA context since it has been constructed various times. It has been done by many practitioners and builders.		
									N/A steel coloumns						