DIT 801

A SOLUTION FOR SOUTH AFRICA'S IDENTITY CRISIS:

***Repairing South Africa's Architectural identity through** hybrid high-tech and low-tech emerging building technologies*

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ABSTRACT

In accordance with Low's *Architecture in Africa: Situated Modern and the production of locality*, it is highlighted that "the absence of a progressive and advanced construction industry" finds its proportional relations within the continent's lag in technological advancement (2014: 294). Therefore, Africa's rate of technological development is directly proportional to the rate of development of its construction industry which in turn affects South Africa's construction industry.

In addition to this, South Africa's architectural discourse seems to have been susceptible to the adoption of many polarising identities ever since the first records of civilization. Its identity has been influenced by a diverse mix including "indigenous domestic architecture (Zulu, Tswana, Khoi), Afrikaner (Dutch) and English settlements, Cape Dutch architecture, Malay architecture (Hindu and Islamic), Republican, Victorian, and Edwardian architecture subsequently ending in explorations of local modernisms, including Brutalism and the International Style" (Okoye, 2002: 382).

Understanding South Africa's complex architectural lineage in combination with limitations around the technological development of its built environment begs the question – How do practitioners within the built environment design for a new South Africa?

As human beings, we "behold, touch, listen to, and measure the world with our entire bodily existence" (Schwartz, 2016: xxvi). As a consequence, the "experiential world becomes organised and articulated around the centre of the human body" (Pallasmaa, 2007:64) through architectural expression. Considering that the implementation of a *Tectonic* architectural language instantiates a tight relationship between human beings and technology, it becomes the grounding element for authentic architectural experiences (Schwartz, 2016: xxvi).

With limited research on how the South African built environment could benefit from solving both problems simultaneously, this paper focuses on paving an alleyway to a possible solution. This study aims to investigate what aspects of hybrid high-tech and low-tech emerging building technologies could become a catalyst for revitalising the South African built environment while prioritising the instantiation of a relevant local identity in accordance with its places.

It was found that when considering the implementation of a hybrid tectonic language within South Africa's built environment the development of both high-tech and low-tech emerging building technologies should be exaggerated simultaneously with intentions of finding the best middle ground. Global trends associated with advanced manufacturing, digital fabrication, automated construction, prefabrication etc. should be explored and studied in close proximity to the potential in eco materials such as clay, thatch, cork, bamboo etc. Examples of what this would look like are as follows:

- 3D printing adobe wall systems
- Advanced manufacturing of composite thatch insulation systems
- Digital fabrication of clay building systems

DECLARATION OF AUTHENTICITY

I declare that the mini-dissertation: “A solution for South Africa’s identity crisis: Repairing South Africa’s architectural identity through hybrid high-tech and low-tech emerging building 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 ethical code for researchers and have followed the policy guidelines for responsible research.

Signature: ……  ……

Date: **24 July 2023**

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1. INTRODUCTION AND CONTEXTUALIZATION OF THE RESEARCH TOPIC

1.1 INTRODUCTION AND BACKGROUND - *Uncovering a technological divergence*

Instrumental reason

Instrumental reasoning refers to the utilisation of reason where it becomes an instrument in aid of determining the most efficient means in achieving a given end (Wolin, 2022). The development of civilization over time has never failed at preoccupying itself with the notion of "instrumental reason" (Frampton, 1993: 269). In fact, "instrumental reason" has been regarded as one of the main pillars for civil development ever since the age of enlightenment (Frampton, 1993: 269).

Civilization's development under the notion of "instrumental reason" resulted in a relentless drive towards an ever-homogenising modern environment (Modernity) (Taylor, 1999: 3). Therefore, Modernity as a civil movement, can be characterised by its deliberate attempts at distancing humans from their dependance on history, culture, and tradition (Frampton, 1983: 269, and Taylor, 1999: 4).

There is no problem with efficient civil development, however, the strict implementation of "instrumental reason" led to the desire for totality which meant that anything that was "different and *"other"* was reduced to sameness", causing a loss in identity (Wolin, 2022). This ongoing phenomenon resulted in the manifestation of "*non-places"* – Defined as places that do not represent any type, group, or class of people (Finnie cited Frampton, 1983: 17).

Understanding the effects of Instrumental reason – The industrial revolution

The 18th century saw the rise of an industrial revolution where features for development defined themselves through the spheres of technology, socioeconomics, and culture (Zeidan, 2023:1).

This revolution marked a turning point in modern history where previously agrarian methods of a handcraft dominant economy became over-run by industrious techniques of machine manufacturing (Zeidan, 2023: 1). This historical turning point marked the emergence of the machine and through rapid technological advancement the second industrial revolution of the 19th century saw the necessitation of new and improved building methods within the building industry (Finnie, 2012: 2). These revitalised methods of construction along with the development of new building materials ultimately resulted in the formation of new building typologies (Finnie cited Gillian, 2003). The effects of "Scientific discoveries and inventions" between the 18th and 20th centuries resulted in rapid changes of social structures regarding "scientific thought, art and culture, architecture, and lifestyle" (Mokyr, 1999).

One cannot separate this era's rapid technological development from its consequent downfalls. Through its mechanised nature, in combination with notions of efficiency and mass production at an unprecedented rate, the industrial revolution fashioned an overall disregard for social and contextual factors (Sennett, 2008). In Frampton's *Towards a Critical Regionalism (1983),* with specific reference to his *Six Points for an Architecture of Resistance,* it is argued by Paul Ricoeur that although universalization is considered an advancement of mankind, it also constitutes a "subtle destruction" aimed at culture and tradition, which can be defined by the basis on which people interpret their lives (Frampton, 1983: 16). Frampton goes on to introduce a critique on culture and civilization post industrial revolution and states that "Modern building is now so universally conditioned by optimised technology that the possibility of creating significant urban form has become extremely limited" (Frampton, 1993: 269). In the same vein, it is argued by Auge in *Non-Places (2008)*, that civilization's path towards an ever-increasing modernity has reached a level of "globalised homogeneity" void of culture and tradition (Merriman, 2009:27)– a universal "sameness" (Auge, 2008: xii).

The effects of industrialization on architecture

Architects, during the industrial revolution, were among the first to adopt ideas of technology and science as a pose to pre-favored ideas of "cultural legacy" (Manvi, 2017: 1). The adoption of these ideas allowed architects to embrace the rise of new building materials and their relations to rapidly developing construction techniques which ultimately brought about innovation and new forms of understanding in terms of architecture as a discipline (Menga, 2022: 105).

However, due to the industrial revolution's mechanised nature and over-emphasized concern for efficiency, multiple levels of architectural craftsmanship were stifled (Sennett, 2008). Although mass production and technological innovation had their pros at the time, what the architectural world experienced was an oversimplification of building detail due to heavy reliance on machine processing and an under-utilisation of the agrarian craftsman (Manvi, 2017: 1). Here It becomes evident that the industrial revolution's concern for efficiency forced the architectural world into a state of change that pedestalize efficiency, becoming driven by the notion of instrumental reason.

In understanding the influential weight of the industrial revolution and that it had become the avant-garde of its time, it becomes plausible to think that the world of architecture had reached its phase of being an avant-garde component to civil development as well. The problem with the avant-garde is that it comes from a place of combativeness (Heynen, 1999: 129). As stated by Heynen in *What belongs to architecture?' Avant-garde ideas in the modern movement (1999), "*the avant-garde is always struggling against something –against tradition, against the public or against the establishment" (1999: 129). Furthermore, Calinescu in *Five Faces of Modernity. Modernism, Avant-Garde, Decadence, Kitsch, Postmodernism* argues that the aesthetic attitude of "the avant-garde implies the bluntest rejection of such traditional ideas as those of order, intelligibility, and even success" (Calinescu, 1987: 124). In understanding this, it is safe to conclude that during the industrial revolution architecture made promising progress through the realms of science and technological innovation (Menga, 2022: 105), however, this was at the cost of *place* and *meaning* – concepts driven by cultural legacy (Manvi, 2017: 1).

The effects of the Industrial revolution pushed architecture towards its Modern era, and Menga in his *industrial revolution and the birth of modern architecture* argues that *"*the biggest factor in the creation of modern architecture was the Industrial Revolution." (Menga, 2022: 105). During the 20th century, this era of architecture gave rise to architects such as Le Corbusier, Mies Van Der Rohe, Frank Lloyd Wright, Peter Eisenman, and Philip Johnson, where the general consensus for what made relevant architecture was whether or not an intervention was in alignment with the phrase "form follows function" (Trisno, 2019: 2).

Influences on South African Architecture

South Africa's architectural discourse seems to have been susceptible to the adoption of many polarising identities ever since the first records of civilization. Its identity has been influenced by a diverse mix including "indigenous domestic architecture (Zulu, Tswana, Khoi), Afrikaner (Dutch) and English settlements, Cape Dutch architecture, Malay architecture (Hindu and Islamic), Republican, Victorian, and Edwardian architecture subsequently ending in explorations of local modernisms, including Brutalism and the International Style" (Okoye, 2002: 382). With the exclusion of "indigenous domestic architecture", Chipkin points out a commonality between the surveyed architectural styles in saying that they become representative of an "assemblage of imported, standardised components which were products of metropolitan serial production finding outlets overseas" (Demissie, 1997: 349 cited Chipkin, 1993: 40).

Although South Africa's built environment has been defined by multiple architectural identities from all over the world, the most notable architectural identity that South Africa has ever encountered was one that was tainted with "racial delusion" and unjust "imperial ambitions" defined by developmental standards associated with Western norms (Demissie, 1997:349). During the first two decades following the end of WWII, the African continent began its journey towards dismantling colonial administrations, while South Africa continued to suffer the stronghold of a thriving apartheid era still influenced by colonial administration (Okoye, 2002: 382). As South Africa's nationalist movement was one that subscribed to western norms, the emergent architectural style around the time was one categorised by an aesthetic built off of planes, spaces, and volumes." (Demissie, 1997:349).

This emergent international style pioneered by a young architectural collective Le Corbusier referred to as *"Le Group Transvaal"* employed a multitude of innovative building technologies that translated into abstract building typologies depicting a narrative where connotations were non-historical and ambiguous (Demissie, 1997:349). This testament to the international style becomes synonymous with the same "globalised homogeneity" (Merriman 2009:27 cited Auge: 2008) evident throughout the industrial revolution when Chipkin compares the centre of Johannesburg during the 1930s to "Chicago or Saint Louis." (Chipkin, 1993: 89).It is during this time that South Africa becomes even further removed from its cultures and traditions seeing itself become an active counterpart to the universal "sameness" (Auge, 2008: xii).

South Africa's move towards hybrid tectonics – *Regional Modernism*

Many sectors of the world received the advent of the machine as beneficial progression; however, it was at the peril of culture, tradition, and a real sense of place which Ricoeur describes as "the basis of which we interpret life, the ethical and mythical nucleus of mankind" (Frampton cited Ricoeur, 1983:16). In line with Ricoeur's quote, Low suggests that the emergent Modernist style, a product subsequent to the advent of the machine, facilitated a "cultural genocide" within the African continent where the clash between culture, tradition and the modern world was not an uncommon site of conflict amongst colonisers and the colonised (2012: 128). Louw continues in saying that Modernism as an architectural style served as a powerful toolbox for colonial power within the African context (Louw, 2021: 84). The Modern style generated continual confrontations between the world of indigeneity and the world of modernity (Louw, 2021: 84).

The strict employment of the International Style was short lived within South Africa's context (Barker, 2015 :1). In Barker's *Cape Vernacular Interpretations*, it is stated that "the demise of the Modern Movement resulted in a plethora of architectural responses" (2012:36). With reference to Louw's *The search for hybrid tectonics in contemporary African architecture: Encounters between the global and the local* (2021) it is stated that South African architectural practitioners including figures like Hellmut Stauch, Rex Martienssen, Gordon McIntosh, and Norman Eaton were all devoted to the search of a modern architectural language that could respond to South Africa's contextual factors (Louw, 2021: 85). This hybrid architectural response considered the value of employing vernacular building practices within the South African context, in combination with teachings informed by the international style (Barker, 2012:36).

This is a rather notable turning point in South Africa's Architectural endeavours considering that early industrial influences instantiated by the Global North made way for the disqualification of indigenous knowledge systems associated with Southern Africa. Wienecke states that even in South Africa's present-day built environment, "vernacular knowledge is often ridiculed and described as backward" (Wienecke, 2010: 17). This building method however was not solely based on strict replications of past archetypes, but rather critical reinterpretations of past methods that accommodated material and technological adaptations that accounted for modernity's current state (Barker, 2012: 36).

The value behind "vernacular knowledge" becomes clear when one understands how its implementation roots architecture to its specific region. Barker defines vernacular building as an architectural response authentic to physical, social, and cultural factors. It is a response that continually evolves through phenomena consistent with technological change, the arrival of a new community with different cultures and traditions; and the need for new requirements of functionality (Barker, 2012: 36). This theoretical shift afforded the reintroduction of value associated with the craftsman's hands and how this sphere necessitates the continuity of historical narratives, and the importance of cultural meaning (Barker, 2012:36).

South Africa – What identity?

At its present state, the architectural identity of South Africa's Built environment still seems sporadic and undecided with many of its features being reminiscent of foreign influences. In Marschall and Kearney's *Opportunities for Relevance: Architecture in the New South Africa (2000)* architect mentors including Jo Noero, Peter Rich, and Ora Joubert voice their concerns with the state of South Africa's urban and sub-urban realms in saying that they come across as Indistinguishable from the likes of Northern America and Western Europe (Marschall and Kearne, 2000). Furthermore, in Retief's essay *A Distinctive Architecture* for VISI 2001, a plethora of questions are posed for the reader to consider - "Who of us hasn't driven through a typical South African city landscape and wondered: What on earth is going on here? What country am I in? On which continent? On what planet?" (Retief, 2001)

Louw suggests that this phenomenon could potentially be the result of "conflicting rationalities" in architectural thinking between the global north and the global south (Louw, 2021: 251). Therefore, the uncertainty experienced within South Africa's built environment in terms of identity could be due to fundamental differences in the value systems and worldviews associated with the global north and global south which ultimately filters through to the architecture produced in the global south when these two realms collaborate (Watson 2003: 396).

Understanding South Africa's complex architectural lineage begs the question – How do practitioners within the built environment design for the new South Africa? Retief goes on to quote architect Glen Gallagher "If there were truly integrity in our buildings, it could not be the architecture of another continent. Are we building for white people to remind them where they came from, or for black people, to remind them-or are we building for the people of the new South Africa?" (Retief 2001). Building onto this, Okoye in *Architecture, history, and the debate on identity in Ethiopia, Ghana, Nigeria, and South Africa* adds to this debate on identity in asking whether or not architectural history should be centred around issues associated with materials, style, and technology… or should there be a shift towards spatial history which is complemented by teachings outlined by the histories of art? (Okoye, 2002: 382).

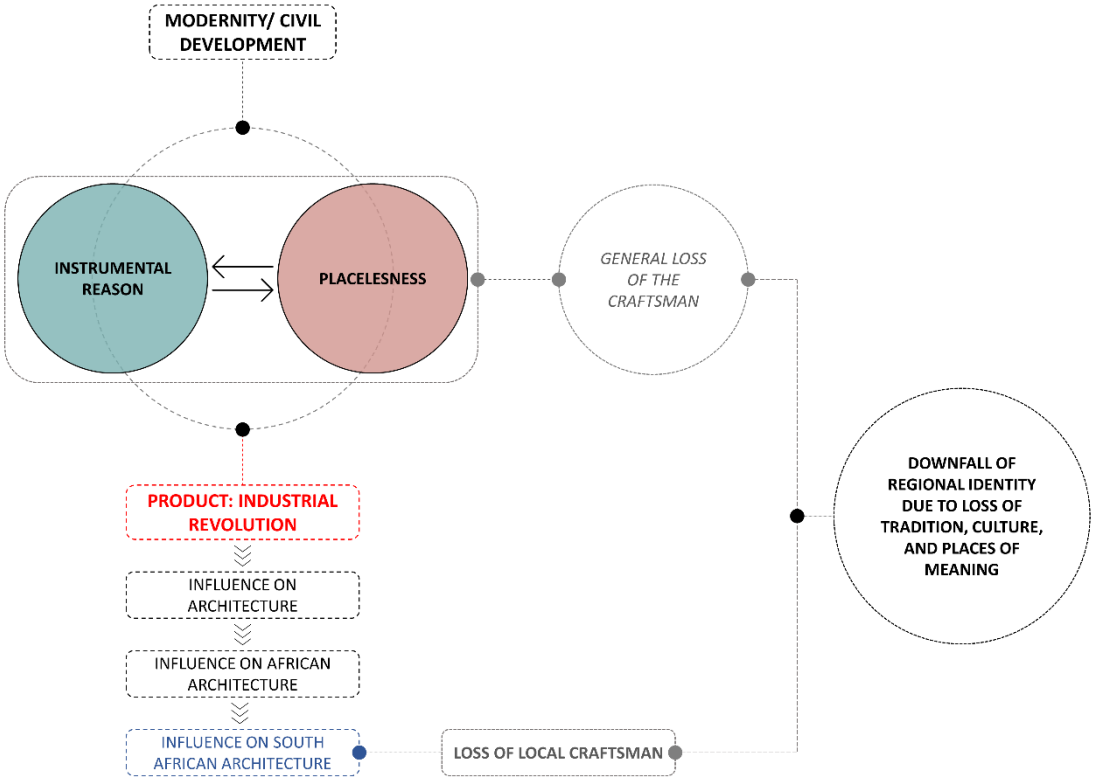

Figure 1 - The relationship between instrumental reason and placelessness and how it results in the loss of tradition, culture, and places of meaning (Author, 2023)

1.2 THEORETICAL CONTEXT - THE WORLD OF TECHNOLOGICAL INNOVATION

The world of technological innovation within the construction industry – A global perspective

Through building an understanding for processes and technologies that exist in first world countries one is able to identify knowledge gaps and differences in thinking when comparing South Africa's built environment to first world sectors. For this to be successful, the realm of technological innovation will be used as a constant variable of comparison in order to quantify the levels of difference in technological development associated with the built environment between first and third world sectors.

Before unpacking and assessing the realm of building technology and technological innovation, it becomes important to understand what specific technological sectors this area of study refers to. Rehman, Puolitaival, McMullan, and Kestle in their *Competence development in advanced and emerging construction technologies* define this area of technology as "a broad and accommodating spectrum of **advanced** construction technology" (2018: 58). Rehman, Puolitaival, McMullan, and Kestle further this definition by stipulating that advanced construction technologies are inclusive of "modern techniques and practices that comprise the latest developments and innovations in materials technology, design and construction" (2018: 58). The term advanced construction technology does not exclude existing processes and caters for both new ways of manufacturing existing products as well as the manufacturing of new products resultant of new advanced technologies (2018: 58).

McCoy and Yeganeh state that the realm of "emerging construction technologies" can be split into two major sectors: building technologies, and manufacturing processes." (2021:1). The two identified sectors can then be further categorised into 3 spheres allowing for one to understand their developmental levels, and market readiness (McCoy & Yeganeh, 2021:1). The three defined development and market readiness spheres are as follows:

- Technologies that are adopted and trusted on a mass scale
- Technologies that have begun their emergence within the construction industry and are estimated at achieving total market readiness within a time period of 5 and 10 years
- Emerging technologies in line with the digitalization of the construction industry where significant evolution is expected to happen over the next decade

(McCoy & Yeganeh, 2021:1)

Through defining this particular area of study with reference to the above-mentioned categorization strategies, McCoy & Yeganeh, have been able to set out a preliminary "blueprint" for firms to consider when adopting new technologies (McCoy & Yeganeh, 2021:1). The above-mentioned categories work as the beginning stages of an assessment criteria that helps practitioners quantify a building technology's "organisational readiness for innovation" (McCoy & Yeganeh, 2021:1).

The way in which McCoy & Yeganeh have situated their research around common practice suggests an important link that needs strengthening within the built environment. Aksamija suggests that a body of conducted research works as an informant for architectural design and conversely, "architectural design informs research since it is driven by the requirements of architectural projects" (2011: 585). Aksamija further suggests that one of the worlds leading emerging trends within the global built environment, is that of a practice-oriented research program (2011: 585). These practice-oriented research programs are rapidly gaining popularity and have become integral functioning parts of the world's leading architectural firms (Aksamija, 2011: 585). This convergence between technology and architectural design strategies has resulted in an ever-developing synergistic relationship which is rapidly changing the "traditional nature of architectural research and design." (Aksamija, 2011: 585). Through unpacking this text it is suggested that staying above the curve when considering technological advancement and prototyping, there needs to be continuous research being done parallel to project realisation. Here one begins to see the relevance of a circular design process instead of a linear one where work gets handed over to appointed professionals as the project timeline ages.

In certain parts of the world, there has even been evidence of change within educational facilities in order to accommodate for the rapid pace of technological development within the built environment. Rehman, Puolitaival, McMullan, and Kestle highlight that the digitization of processes and products is affecting all aspects of the built environment which has resulted in the need for "innovative pathways to successfully equipping our next generation of graduates to live up to the challenges of the new competence requirements in the competitive job market." (Rehman, Puolitaival, McMullan, and Kestle, 2018: 58).

New Zealand's *Unitec Institute of Technology* is an example of an educational institution that has taken on the task of restructuring their built environment faculties in order to accommodate for the digitization of the construction industry (Rehman, Puolitaival, McMullan, and Kestle, 2018: 58). The university has altered the structure of its Construction degree through introducing a new major ('*Technology'*), where theory around "advanced and emerging construction technologies across the lifecycle of buildings" has been integrated (Rehman, Puolitaival, McMullan, and Kestle, 2018: 58). In tandem with this approach, the university intends on embedding "*Construction Informatics and Digital Technology* on a broad spectrum to other existing majors within their built environment faculties (Rehman, Puolitaival, McMullan, and Kestle, 2018: 58). This paper stands to show how "a holistic approach towards cutting edge digital construction technologies" should become an interlinking process embedded within a multitude of modules pertaining to the advancement of the construction industry (Rehman, Puolitaival, McMullan, and Kestle, 2018: 58). This intentional overlap begins to develop a culture where multidisciplinary collaborative relationships become the norm, in turn routing the development of a more circular construction industry.

Challenges influencing performance development and growth of the building industry in South Africa

With reference to South Africa's built environment at its present state, it is well established and is most recognized for the way it supports existing brick, concrete, steel, and timber industries in combination with adjoining labour markets within its context (Construction Industry development board, 2021). South Africa's realms of building technologies are well regulated through the South African National Standards (SANS) as well as the South African Bureau of Standards (SABS).

It seems that a heavy reliance on well-established building technologies within South Africa's built environment has resulted in a noticeable limitation to its rate of development. In Windapo and Cattell's study entitled *The South African Construction Industry: Perceptions of Key Challenges Facing Its Performance, Development and Growth,* it was found that the key challenges threatening the development, performance and growth" of South Africa's building industry revolve around an increase in costs for building materials (Windapo & Cattell, 2013: 75). Windapo & Cattell have deducted that this increase in building material costs can be attested to the local building industry's heavy reliance on a small selection of available materials thus creating an exorbitantly high demand of which the available supply cannot cater for (Windapo & Cattell, 2013:75).

In accordance with Low's *Architecture in Africa: Situated Modern and the production of locality*, it is highlighted that "the absence of a progressive and advanced construction industry" finds its proportional relations within the continent's lag in technological advancement (2014: 294). Therefore, Africa's rate of technological development is directly proportional to the rate of development of its construction industry which in turn affects South Africa's construction industry. Windapo & Cattell touch on consequent sub-threats that are linked to the above-mentioned phenomenon. These sub-threats include "the mismatch between available skills and required skills." which links to the secondary sub-threat of local research methods and patterns (Windapo & Cattell, 2013:70) where most of the literature published on building material development has a global focus instead of a local one (Windapo & Cattell, 2013:75). Therefore, the documented "mismatch between Available Skills and Required Skills." becomes the result of an evident misalignment between theory and practice (Windapo & Cattell, 2013:70).

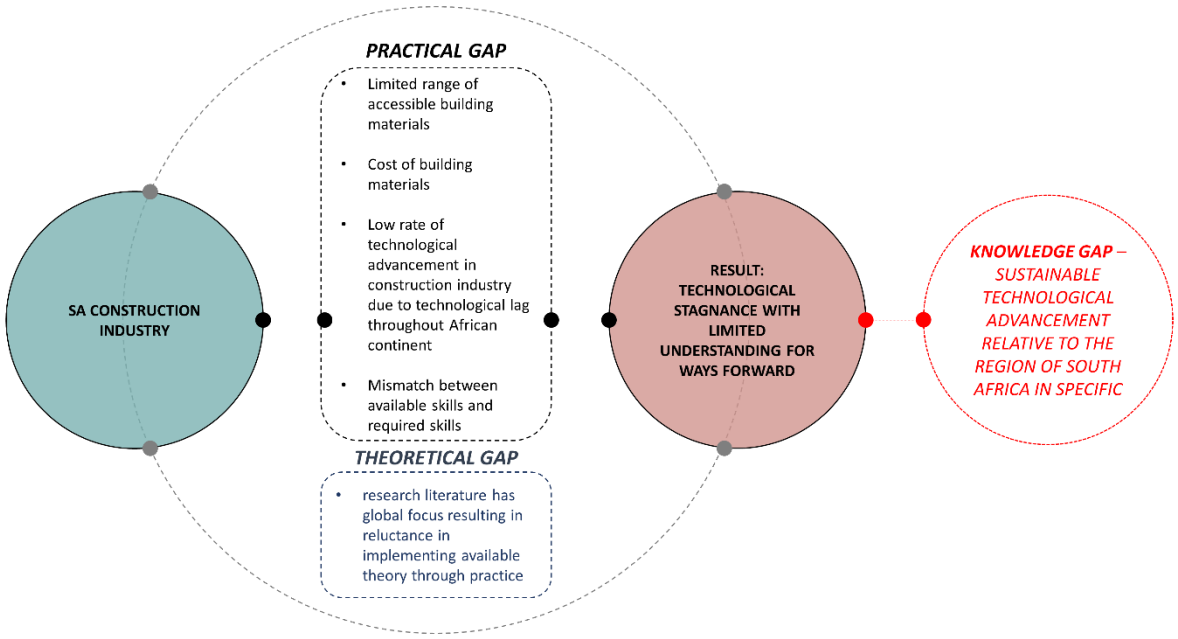

Figure 2 - Knowledge gaps associated with the South African construction industry (Author, 2023)

The world of technological innovation within the construction industry – A South African perspective

Within the South African context, it is important to note that the term "emerging" does not frequent as often as terms such as "alternative" or "innovative" as seen through the existing pool of literiture. In Wienecke's contribution to the *Department of Human Settlements Volume 1, Number1* goes on to state that "modern construction technologies" are a culmination of processes and products that are regarded more efficient and more durable than building products and processes that involve the use of "traditional materials, such as clay, wood, or thatching." (Wienecke, 2010:17). With reference to *modern construction technologies*, the processes of manufacturing and installation usually require the labour of trained personnel which in turn inflates the material price point associated with the finished product. Here Wienecke highlights the stark contrast that exists between South Africa's modern world of construction and "what was achieved over centuries by many indigenous societies, who relied on locally available materials and their own skills" (Wienecke, 2010: 17).

At the moment, South Africa's trajectory for technological innovation around construction materials and processes is defined by the term "Alternative Technology". Wienecke expands on this area of study by showing that it considers "manufacturing or production methods that are less polluting and more resource efficient than the traditional methods" whereby technological implementation "conserves or renews natural resources and are considered environmentally friendly." (Wienecke, 2010:17). Wienecke further contextualises the realm of alternative technology by breaking it up into 3 different areas of significance:

- **Intermediate technology:** Where full industrialization of technology is eventually possible. This realm of technology is concerned with the betterment and transformation of existing techniques and knowledge systems through the use, and understanding, of advanced technological techniques.
- **Appropriate technology:** Which refers to the employment of critically selected technologies and processes in response to a society's current level of development. This technological implementation strategy is built off of the principle that different geographical areas need to be treated and designed for in accordance with the particular cultural groups that inhabit its proximities.
- **Technological self-determination:** A theory in which cultural identity harmonises with technological implementation. It stresses that "every society has a technological tradition" and the integration of new technologies should be critically considered to prevent conflict and contradiction with existing traditions.

(Wienecke, 2010:17)

In understanding this, the term *emerging building technolog*y can be defined. Its definition is as follows:

> The term "Emerging building technology" refers to recent construction material developments that are inclusive of "modern techniques and practices that comprise the latest developments and innovations in material technology, design and construction" (Puolitaival, McMullan, Kestle, 2018, 58) within the last 15 years. Parallel to this, the realm of emerging building technology also considers updated ways of manufacturing existing construction materials as well as the ways in which new emerging materials are manufactured from continuously advancing material production technologies (Puolitaival, McMullan, Kestle, 2018, 59).
>
> With reference to the South African context, the conversation around emerging building technology considers the reformation of "society by making use of technology, which is environmentally sustainable, allowing for equity in the access to resources" (Wienecke, 2010, 17 - 18). The realm of emerging building technology in South Africa seeks to develop in such a manner that it encourages "the radical transformation of industrial society to facilitate a transition to a more ecologically harmonious, socially just, and economically steady-state society." (Wienecke, 2010, 17 - 18).

2. RESEARCH TOPIC LOCATED IN THE BUILT ENVIRONMENT

Technological development and innovation in and around South Africa's building industry holds potential in creating a knock-on effect that would benefit its adjacent industries. As explored through the above theoretical context, the most promising alleyway for technological development within South Africa's Built Environment seems to be through a hybrid tectonic system that considers the synergy of high and low tech building materials and practices.

In Jekot's *The coexistence of the 'third' and 'first' world in South African architecture: the inclusion of the 'underdeveloped' in 'developed' technologies in the age of globalisation* it is argued that "architecture of so-called 'first' and the 'third' world countries reflects their different characteristics and dynamics: their economical, political, social and cultural dispensations as well as their patterns of collection, production, and consumption.", and in this argument Jekot questions whether or not this should call for conflict between technological applications associated with the"first '' and "third '' world (2007: 66). Jekot critically analyses the potential for technological co-existence between the high and low tech spectrums concluding that success lies within designers reinforcing their architectural informants through aspects associated with culture and the physical environment (2007: 66). Jekot's arguments on the relations between culture, technology and intellect pose interesting departure points on how studying technological innovation in close proximity to South Africa's cultural counterparts could lead to the revitalisation of its construction industry.

In exploring the realm of technological development within the built environment on both global and local scales, it was found that South Africa shows potential for the integration of a hybridised architectural language which stands to instantiate a strong sense of identity while exploring its cultural narrative and prioritising technological development. In understanding that hybridity is "not a simple mixture of two or more elements, but that it is about the rearticulation of culture where binary systems are dismantled in order to unsettle purity or homogeneity."(Louw, 2021:268), the success behind a hybridised archetype relies heavily on a tectonic language which seeks to synthesise a critical selection of building materials and building practices.

This paper considers a research endeavour built around understanding that the " joining of elements is not simply an act of construction, but a process that helps define the space created through construction" (Schwartz, 2016: xv). This paper utilises a research topic located within the built environment seeking to uncover an appropriate tectonic attitude that considers the hybridization of culture and emerging building technologies relevant to the South African context.

A secondary research theme in aid of coming to a sound conclusion considers the potential for understanding and documenting existing design processes used by architectural practitioners within South Africa, thus leading to uncovering responsible ways in which innovative design methods could be feasibly implemented. Through this, the idea is to produce a set of processes and standards whereby practitioners consider the integration of low tech (indigenous) building systems with emerging building technologies. The intention behind furthering this research path is to redirect South Africa's linear design tendencies to a more inclusive circular design protocol that speaks to the relevance of architectural memory and identity while ensuring infrastructural longevity as well as sound technological development.

3. PROBLEM STATEMENT

South Africa's built environment has become slow in its technological development due to: the lack of required skills, existing research on the matter having a global focus, and an overall separation of design and construction processes. South Africa's built environment also seems to be becoming placeless and homogenised due to the lack of identity portrayal in correspondence with its places. With limited research on how the South African built environment could benefit from solving both problems simultaneously, this paper focuses on paving an alleyway to a possible solution. This study aims to investigate what aspects of hybrid high-tech and low-tech emerging building technologies could become a catalyst for revitalising the South African built environment while prioritising the instantiation of a relevant local identity in accordance with its places.

4. RESEARCH AIMS, QUESTIONS, AND OBJECTIVES

4.1 AIM

The principal aim of this study is to develop a definition for the term *emerging building technologies* and develop selection criteria through which projects that have employed these technologies in the South African built environment can be catalogued and analysed. Furthermore, this study aims to showcase the validity and potential behind hybridising low-tech and high-tech building materials regional to South Africa's context. The intention is to understand what aspects of technological hybridization simultaneously prioritise the instantiation of a relevant regional identity and technological development within South Africa's built environment.

4.2 RESEARCH QUESTIONS

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

- How can emerging technologies contribute to making current building practice more a) versatile, b) economical, c) contextually responsive and d) socially responsible?

- What aspects of hybridising high tech and low tech building technologies stand to enhance levels of revitalization within South Africa's built environment so as to foster a strong sense of ownership and local identity?

4.3 DELINEATION AND LIMITATIONS

This study strictly focuses on building an understanding of emerging building technologies with respect to South Africa's local context (both physical, and the state of its built environment). Therefore, the screening process for the precedent taxonomy will only consider architectural projects that are found within South Africa. This limits the study to drawing conclusions based on data collected within South Africa, thus resulting in a tailored way forward with respect to technological development, identity, and emergence specific to local contexts.

5. RESEARCH DESIGN AND METHODOLOGY

5.1 INTRODUCTION

Research context

In order to come to a conclusion on future technological development and revitalization within South Africa's built environment, it was deemed relevant to provide historical context from a technological point of view exploring all possible factors leading to the current state of South Africa's built environment.
This process was carried out through the implementation of a scoping desktop study, and the relevant information was compiled in the *Background* and *Theoretical context* portions of this paper.

How the South African built environment materialised over the centuries revealed a multitude of knowledge gaps and shortcomings with the main ones being:

- The lack of required skills in order for South Africa's built environment to develop effectively.
- Existing research on the matter having a global focus causing the reluctance in adopting knowledge through practice.
- An overall separation of design and construction processes further stifling effective development of South Africa's built environment.
- No recognizable local identity resulting in a global sameness.

Understanding these knowledge gaps helped direct this study and further informed structures of the:

- Research topic located within the built environment.
- Problem statement.
- Aim.
- Research questions.
- Delineations and limitations

Through this process it was decided that the South African built environment would benefit from exploring the realm of hybrid building technologies as this is a realm of technology that simultaneously pays attention to the instantiation of a relevant identity, as well as technological development. More specifically, this paper stands to investigate what aspects of hybrid high-tech and low-tech emerging building technologies could become a catalyst for revitalising the South African built environment while prioritising the instantiation of a relevant local identity in accordance with its places.

Having a clear understanding on the possible solution or outcome based on the background and theoretical context informed research processes for the:

- Literature review.
- Data capturing.
- Data analysis.

Research paradigm

Considering that the nature of this research paper aligns with solving problems in the real world in order to improve the environment as well as the human condition, the research paradigm most suitable for this study is the *Pragmatic paradigm* (du Toit, 2022:11). This research paradigm is not strict and allows for a combination of research designs and methods best suited for the nature of the study at hand (du Toit, 2022:11).

Research approach

With the research paradigm being defined by *Pragmatism,* this study will follow a mixed method approach that makes space for both qualitative and quantitative data to be integrated and analysed (du Toit, 2022:14).

Research design

In order to address the research topic located within the built environment, the problem statement, the aim, the research questions, and the delineations and limitations, the following research design strategies were implemented:

- Desktop study
- Case study
- Field study

(du Toit, 2022:17)

The Desktop study strategy was primarily used to populate the *Background*, *Theoretical context,* and the *Literature review (The realm of Tectonics)* portions of this paper. The Case study strategy was employed for finding viable hybrid building technology archetypes in order to populate a precedent taxonomy as a form of data collection which informed the process of finding hybrid high-tech and low-tech emerging building technologies within South Africa's context. The field study strategy was used as a secondary means in populating the precedent taxonomy as some of the buildings found were visited and manually documented.

Research method

In terms of finding the most relevant means of employing the hybrid archetype within the South African context, data collection was defined by:

- Sampling case studies against a set criterion defined by on precedent taxonomy.
- Developing the appropriate alterations to the precedent taxonomy in order to further streamline the quality of the selected case studies.

Data analysis was defined by:

- Plotting each case study captured onto a custom graph layout that would depict the architectural project's level of technological emergence.
- Extrapolating from the created graph diagrams in order to understand the levels of technological emergence.

5.2 DESKTOP STUDIES (Background, Theoretical context, Literature review, Defining emerging building technologies)

Types of literature considered during Desktop studies

The desktop study strategies employed for the *Background*, *Theoretical context*, *Literature review*, and *emerging building technologies definition* of this paper considered both grey, and peer review literature.

In order to maintain an acceptable level of academic rigour for a well-rounded meta-analysis on captured data, one must consult with the realm of peer reviewed literature. Although peer reviewed literature is seen as the main reference point for rigorous data retrieval processes, pure reliance on peer reviewed literature could end up in researcher bias (Paez, 2017:1). Lengthy submission procedures associated with peer reviewed literature due to the difficulties around publishing inconclusive or nonsignificant data sets results in the "file-drawer effect" (Paez, 2017:2). This is a phenomenon where submitted publications are left pending, withheld or are denied is due to the rule of commercial publication industries (Paez, 2017:2). The consequence of this is a one-sided data pool that only represents positive findings resulting in researcher bias (Paez, 2017:2). The effects of a one-sided data pool make it more difficult to push the envelope of the respective research field.

Grey literature defines itself as a body of literature that is not controlled by commercial publishers (Paez, 2017:1). This body of literature becomes important during the research process as the researcher becomes exposed to unpublished scholarly literature showcasing negative results experienced within the same realm of study that positive published works reside in (Paez, 2017:2). Exposure to this pool of literature allows for the researcher to consider a hybrid data collection process where grey, and peer reviewed literature are considered simultaneously, thus resulting in a more balanced set of data.

Although the regulation of scholarly grey literature is improving, it is extremely difficult to navigate its abundance which could lead to this type of information being overlooked entirely by the researcher (Rothstein et. al., 2009:105). Therefore, for a synthesised collection of peer reviewed literature, and grey literature to be successful, the instantiation of designed research algorithms and protocols become extremely important.

Instantiating a search model

In order to establish the empirical, theoretical, and conceptual background of a review, a plan or protocol for research must be designed and instantiated (Torgerson, 2003:1). In designing a search protocol or plan for the following aspects should be considered:

- Relevant research questions
- Research objectives
- Scope of the review
- Search methods, data screening and extraction

(Torgerson, 2003:1)

Through paying attention to the above-mentioned aspects, the quality appraisal and synthesis of the data collected is ensured (Torgerson, 2003:1). A rigorous search protocol must also consider the predetermination of what criteria is included or excluded in order to generate sensitive and specific search prompts (Torgerson, 2003:1). The idea is that once a high-quality literature search model is implemented, a comprehensive list of both unpublished and published work will be produced for later data synthesis (Rothstein et. al., 2009:105).

Example of how a search model would be designed and implemented (Defining emerging building technologies)

The beginning stages of search model design for the navigation of relevant literature started through understanding the knowledge gaps that exist within South Africa's built environment. As outlined by the explorative *Background* and *Theoretical context* portions of this paper, common knowledge gaps identified seem to be in line with expanding South Africa's available and trusted building technologies while ensuring their application is critically regional; as well as closing the gap between theory and practice in order to mitigate mismatches between Available Skills and Required Skills within the building industry (Windapo et. al., 2013:70). With an aim of strengthening the captured data set, search methods were enhanced through the identification of key search terms. For this to be successful the Boolean search protocol was utilised.

The identified key search terms were defined by the main research focus, "*Emerging building technology"* as well as any other synonym-phrases that were remotely comparable to the main research focus (e.g., *"Advanced technologies"*, *"Emerging construction materials"*, *"Alternative building technologies"* etc.). Supplementing the identified key search terms, secondary and tertiary search terms were identified and defined.

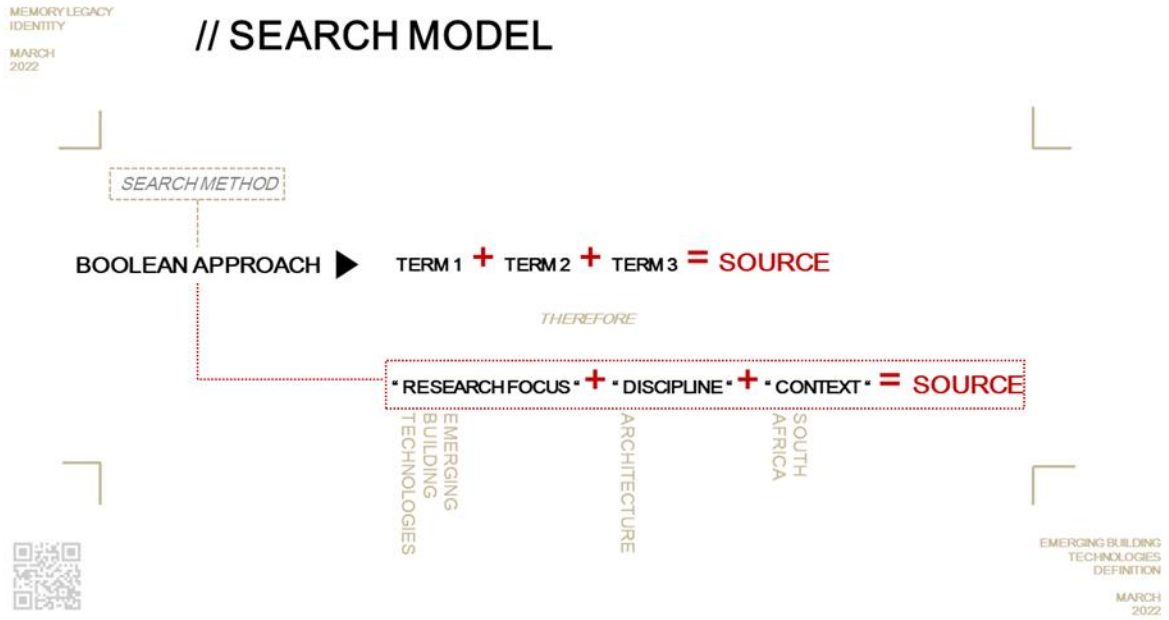

Figure 3 - Algorithmic diagram unpacking Boolean search model (Author, 2023)

Streamlining processes for instantiating secondary search terms, in line with understanding the realm of *Emerging building technology"* were carried out through identifying built environment specific disciplines that share similar concerns with technological innovation and development. (e.g., *"Construction industry"*, *"Architecture", "Industry practice"* etc.).

Defining the bounds of a tertiary search term relied on contextual delimitations specific to the South African region (e.g., *"South Africa"*). However, it was found that consistently interchanging between the South African context and the global context as a tertiary search term allowed for the cultivation of an interesting literature pool. The broadness of the implemented tertiary search term allowed for an understanding of what exists in the world at the moment, thus allowing for further identifications of possible knowledge gaps within South Africa's built environment.

These primary, secondary and tertiary search terms varied with every search-run, however their variance stayed limited to their defined themes as explained above. Making these search changes allowed for results that showcased broader methods of building technology implementation, and how educational systems all over the world have responded to the need for technological development in turn fast tracking its process.

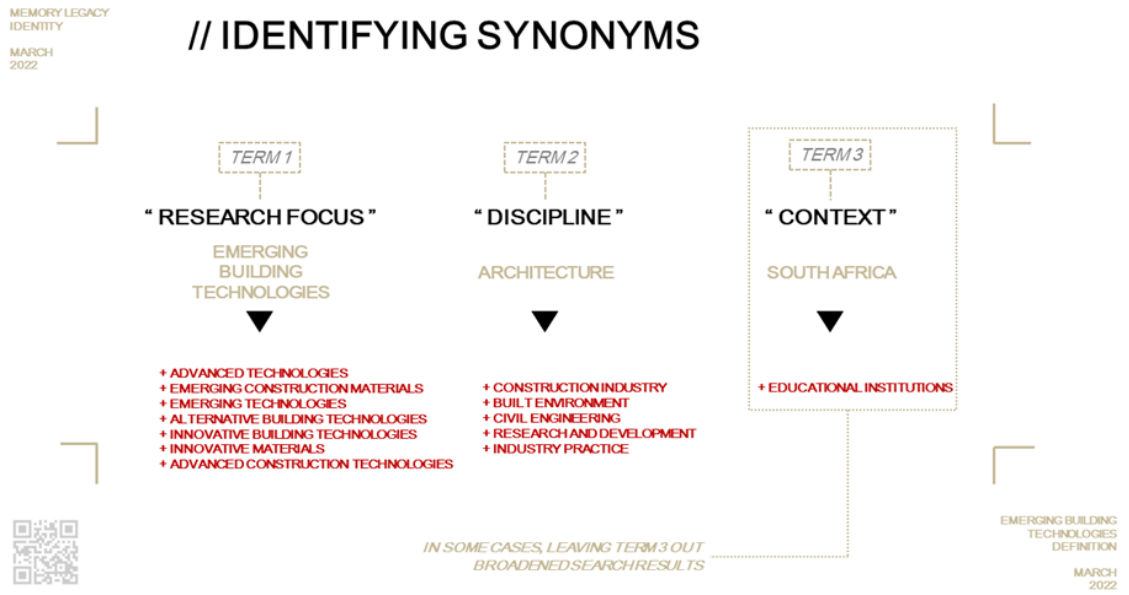

Figure 3 - Algorithmic diagram unpacking search term selection for Boolean search model (Author, 2023)

Formalising the cultivated literature

The replicability and soundness of resultant data sets depends rather heavily on the degree to which designed search protocols are implemented (Rothstein et. al., 2009:105). Therefore, the process should be thorough, clearly documented, and unbiased (Rothstein et. al., 2009:105). As an additional step for data screening, it was decided that the collected sources should be loaded into a note taking and analysis engine called *Obsidian.*

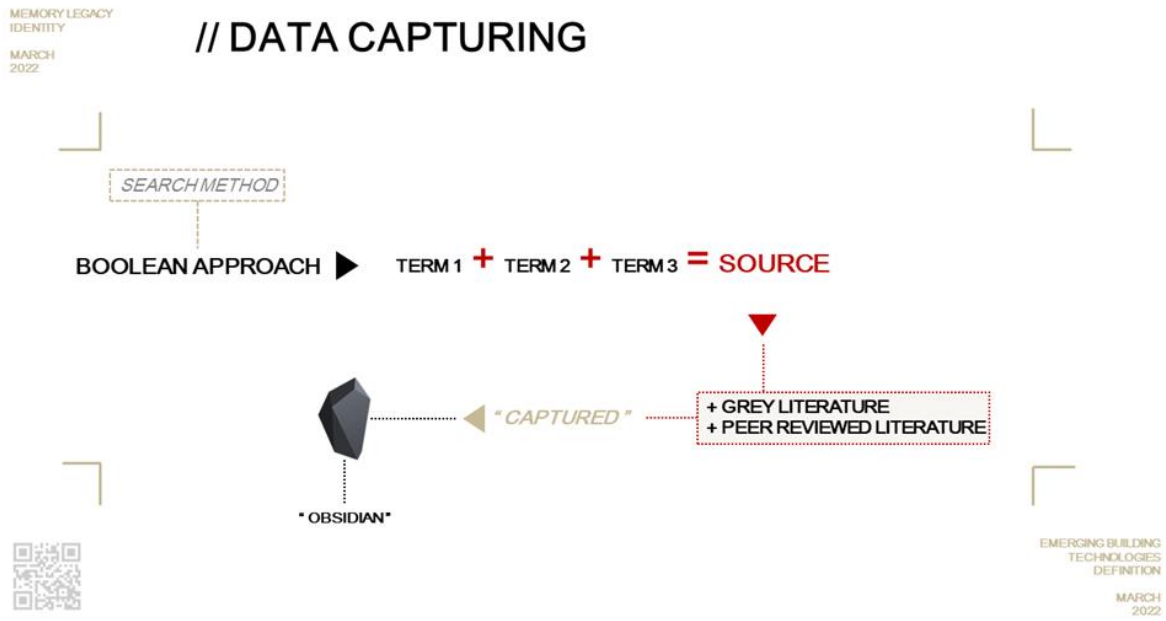

Figure 4 - Algorithmic diagram expressing types of literature captured in Obsidian (Author, 2023)

Here graphical links were made between the captured literature where the interlinking graphic produced depicted knowledge overlaps between sources thus validating their relevance in building a rigorous definition for *"Emerging building technology".*

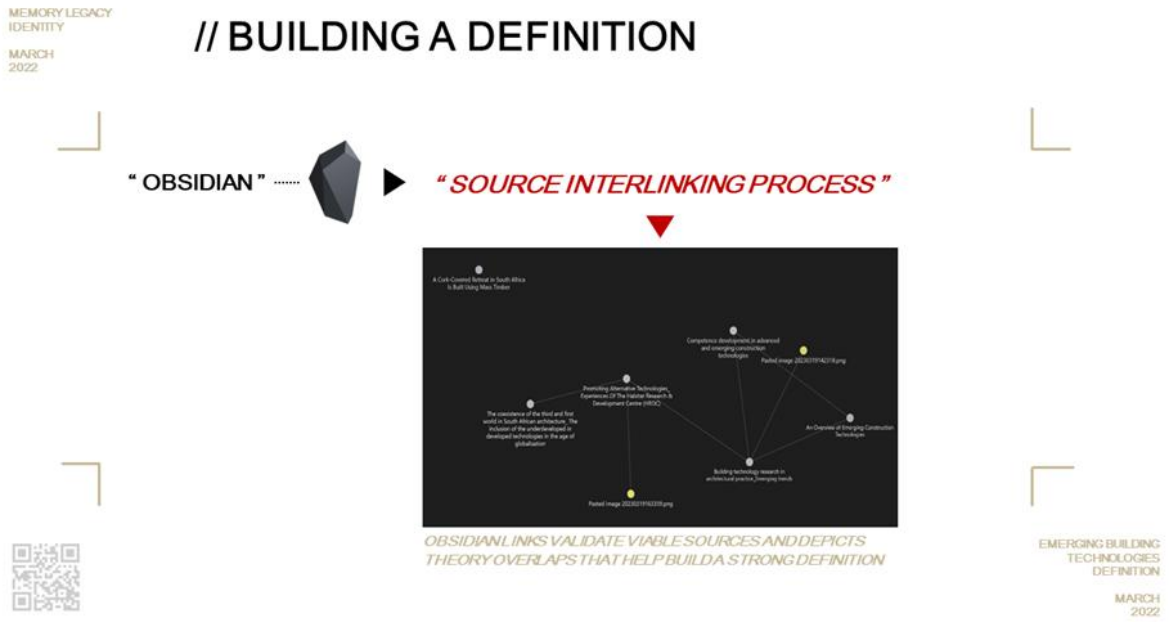

Figure 5 - Algorithmic diagram expressing graphical links between literature captured in Obsidian (Author, 2023)

From here the final definition was produced using the overlapping knowledge extracted from the interlinked sources (please see *Theoretical context* for final definition on *Emerging building technology*).

5.3 CASE STUDIES

In its essence, this paper focuses on bridging gaps between theory and practice. There are knowledge gaps that have been flagged within South Africa's built environment, and the research presented stands to show how these gaps are closed. This makes the nature of the research cultivated *practice-led research* (Candy, 2006:1). *Practice-led research* concerns itself with "the nature of practice and leads to new knowledge that has operational significance for that practice" (Candy, 2006:1).

This paper intends on cultivating knowledge about practice in order to provide information on how to advance knowledge within practice (Candy, 2006:1). The best way to move between the realms of theory and practise through research is via the use of the case study method (Breslin et. al., 2008:1).

As previously mentioned, this paper stands to investigate what aspects of hybrid high-tech and low-tech emerging building technologies could become a catalyst for revitalising the South African built environment while prioritising the instantiation of a relevant local identity in accordance with its places.

To better understand the realm of hybrid high-tech and low-tech emerging building technologies within South Africa, it was decided that a precedent taxonomy of architectural projects showcasing aspects of hybrid high-tech and low-tech emerging building technologies in present day South Africa would be necessary. In understanding the nature of emerging technologies that exist, more accurate conclusions could be drawn on the most effective way forward for the South African built environment. Data collection for this precedent taxonomy was a joint effort by a research group of 4 people and took place through the use of the Boolean search protocol (as explained above). Both peer reviewed and grey literature was consulted with for the case study data collection process.

5.4 FIELD STUDIES

A field study refers to a research method that involves data collection within the real-world setting (Garcia, 2022:1). The use of this method is often employed to explore “interactions between people, society, and the environment” without being limited by the confines of a lab or experimental setting (Garcia, 2022:1). The value of employing this research method manifests through broadened insights into processes and behaviours of what is being studied (Garcia, 2022:1).

The field study method was implemented as a sub method for data collection. This method acted as an aid to the case study data collected for the precedent taxonomy in order to broaden an understanding for existing hybrid high-tech and low-tech emerging building technologies. Through the joint effort of a 4-man research group, field study data was collected by finding viable precedents, and visiting them in real time allowing for a documentation process that considered:

- Making observations
- Asking additional questions
- Creating hypothesis’ and proposing further explanations
- Predicting future means of hybrid technological development
- Iterating previous conclusions

(Garcia, 2022:1)

5.5 FORMULATING A PRECEDENT TAXONOMY (CASE & FIELD STUDY DATA)

The design process for the formulated precedent taxonomy was once again a joint group effort. The precedent taxonomy was set up in such a way that the accumulated architectural projects would be scrutinised at multiple levels allowing the group to understand each project's strengths, weaknesses, and resultant value for South Africa's built environment. The main informants for the final precedent taxonomy are as follows:

- Constraints included in the emerging building technology definition.
- Pardo's 5 lenses of analysis when considering vernacular archetypes (2023: 1)
- Rehman et. al.'s emerging construction technologies and processes (2018: 58)
- Louw's method of evaluation criteria for precedents showcasing hybrid tectonics (2021:144)

These informants will be expanded below.

Constraints included in the emerging building technology definition

- Construction material developments that are inclusive of "modern techniques and practices that comprise the latest developments and innovations in material technology, design and construction" (Rehman et. al., 2018:58) within the last 15 years.
- Updated ways of manufacturing existing construction materials as well as the ways in which new emerging materials are manufactured from continuously advancing material production technologies (Rehman et. al., 2018:59).
- Considers the reformation of "society by making use of technology, which is environmentally sustainable, allowing for equity in the access to resources" (Wienecke, 2010, 17 - 18).
- The encouragement for "radical transformation of industrial society to facilitate a transition to a more ecologically harmonious, socially just, and economically steady-state society." (Wienecke, 2010, 17 - 18).

Through instantiating a definition for emerging building technologies within the context of South Africa, the group could evaluate construction processes, materials, and structural implementations per project and determine their level of emergence based on the constraints outlined by the definition.

Pardo's 5 lenses of analysis when considering vernacular archetypes

- Local materials used.
- Planimetric design strategy implemented for topographical and climatic conditions.
- Construction techniques and aesthetic resources
- Level of technological transmittance and adaptation over a time period
- Level of active participation from local craftsman and general users during phases of design and construction

(Pardo, 2023: 1)

Through understanding the realm vernacular archetypes, the group could evaluate construction processes, materials, and structural implementations per project and determine their level of emergence from a low-tech perspective.

Rehman et. al.'s emerging construction technologies and processes

With digitalization playing such an integral role in the built environment, there has been an emergence in a variety of construction technologies and processes including:

- Advanced Manufacturing
- Design for Manufacturing & Assembly (DfMA)
- Additive Manufacturing
- BIM and BIM Cloud Management
- Digital Fabrication
- Digital Procurement
- Prefabrication
- Offsite and Modular Construction
- Digital Surveying

(Rehman et. al., 2018: 58)

Through understanding the realm of emerging construction technologies, the group could evaluate construction processes, materials, and structural implementations per project and determine their level of emergence from a high-tech perspective.

Louw's method of evaluation criteria for precedents showcasing hybrid tectonics

With reference to Louw's methods of evaluation criteria for precedents showcasing hybrid tectonics, the following aspects will be used for the categorization of strong existing projects:

- Local climate response
- Local topographical response
- Incorporation of local materials in relation to global materials
- Integration of local or traditional labour or techniques in relation to global labour or techniques

(Louw, 2021:144)

In addition to this criteria Louw further suggests that the utilisation of a subset of evaluation criteria regarding representation could serve to gain a deeper level of understanding when categorising precedents that showcase the successful implementation of hybrid tectonics. This subset of evaluation criteria is as follows:

- Appropriate reinterpretations for local forms and patterns
- Whether or not the achieved balance between reinterpretations of global and local tectonics are unique to the context in which the project sits
- The projects' social focus and how inequality is addressed.

(Louw, 2021:144)

Resultant precedent taxonomy for case study and field study data collection

As the case study data was logged by the group, the format was altered and edited in order to make sure that each and every project added had at least one level of emergence in accordance with the following spheres:

- Building material
- Construction process
- Structural system

If the added case studies did not comply with at least one of the above spheres of emergence defined by the informants for the precedent taxonomy, they were excluded from the data set. An example of the layout for the working precedent taxonomy of architectural case studies depicting the use of hybrid high-tech and low-tech emerging building technologies within South Africa's context can be seen below:

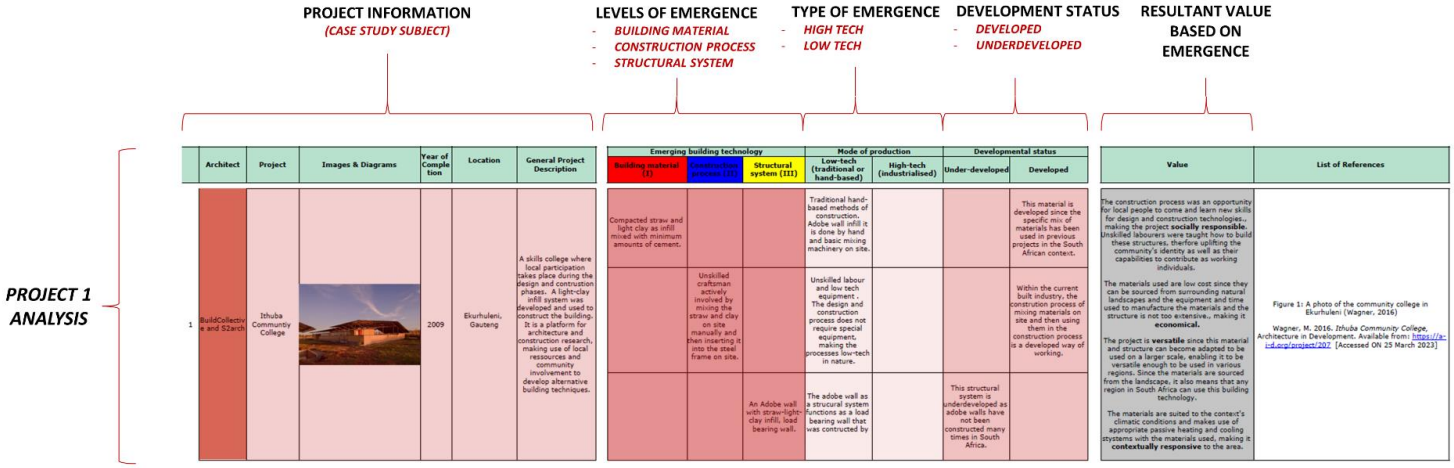

Figure 6 - Precedent taxonomy broken down and explained (Group work adapted by Author, 2023)

5.6 DATA ANALYSIS

This data analysis process has been informed by the research aim, research questions, and problem statement, therefore the following themes have been kept in mind throughout the process:

- Considerations for common building materials within South Africa's built environment
- Considerations for emerging building technologies within South Africa's built environment
- Hybrid high-tech and low-tech building technologies
- Revitalization of South Africa's built environment
- Instantiating a local identity relevant to South Africa's built environment

Due to the nature of this study revolving around the impact of emerging building technologies on the South African built environment, the case studies were analysed in accordance with the following three spheres:

- Building materials
- Construction processes
- Structural systems

A graphic was developed in order to quantify each case study on the basis of technological emergence within South Africa's built environment.

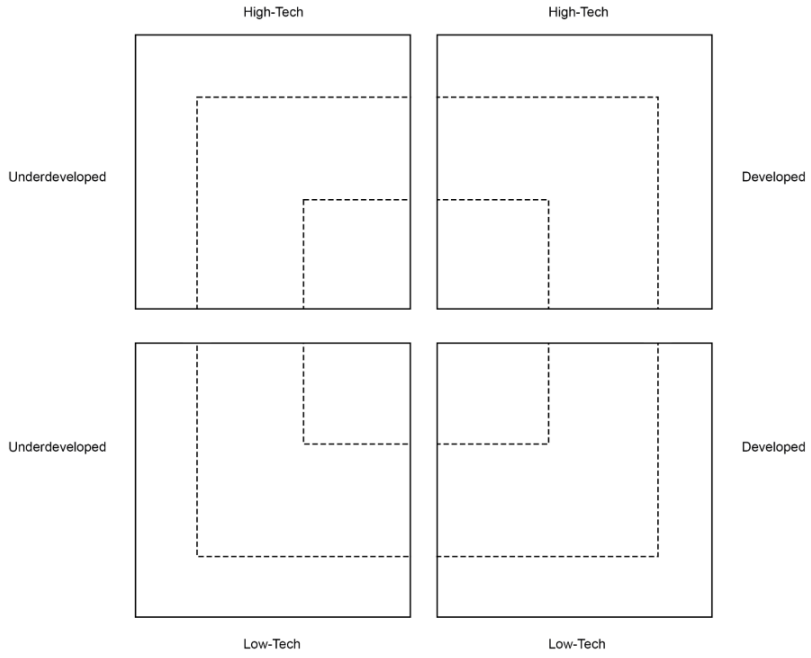

Figure 7 - Four quadrant data analysis plotting graphic (Group work, 2023)

The graphic was designed to test levels of emergence in accordance with building materials, construction processes, and structural systems in each case study captured.

The basis of technological emergence associated with building materials, construction processes, and structural systems were graphically quantified through the use of three testing criteria:

- **Nature of emergence** (building materials, construction processes, and structural systems)
- **Level of emergence** (non-emerging building technology, semi-emerging building technology, emerging building technology)
- **Status of emergence** (High-tech/ Low-tech, Developed/ Underdeveloped)

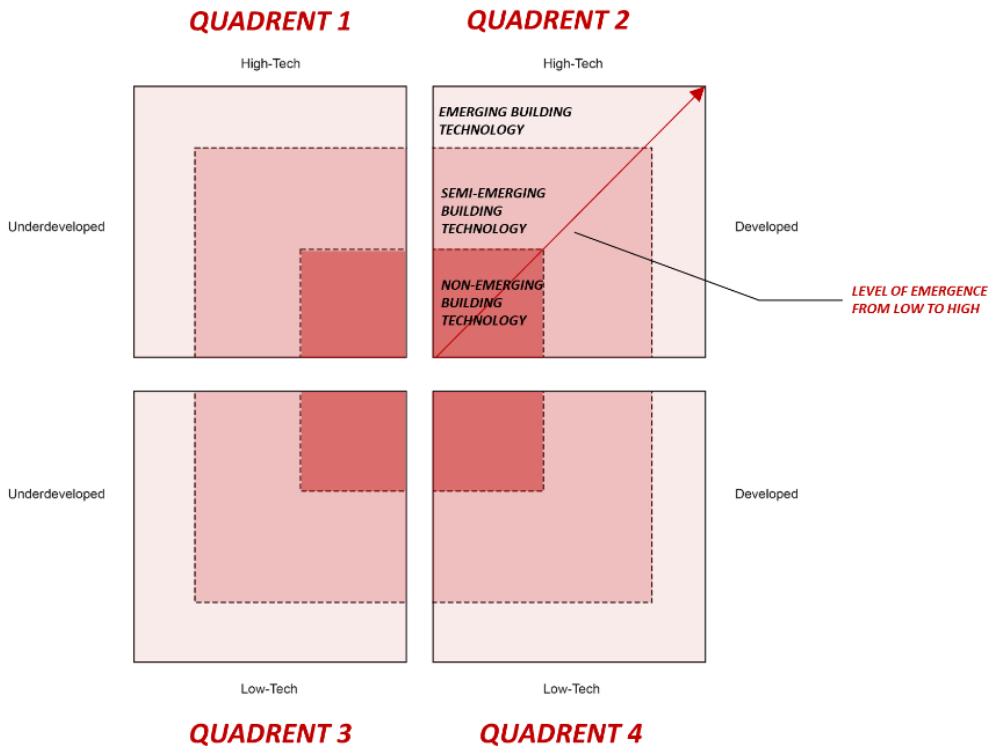

Figure 8- Four quadrant data analysis plotting graphic broken down in shades of red to depict levels of technological emergence from lowest to highest (Group work, 2023)

6. LITERATURE REVIEW - THE REALM OF TECTONICS

6.1 DEFINING TECTONICS

From the point of view of construction and the means and methods associated with constructing, there are two sub-dividing topics used to categorise construction typologies namely:

- Stereotomic – The study concerning heavy-mass architectural components.
- Tectonic – The study concerning assembled light-weight architectural components.

(Schwartz, 2016: xxviii)

In the context of this paper, the term *tectonic* introduces itself as a body of theory reinforced by a "seminal concept that defines the nature of the relationship between architectural design and its structural and material properties." (Oxman, 2010: 3). The term tectonic stands to describe the "union of construction" whereby "the communication of thought through conversation" is conveyed by means of "making through previously gained knowledge" (Schwartz, 2016: xv) in conjunction with emerging knowledge.

The origin of the term *tectonic* within this context of study is rooted in two ancient Greek words *tekton*, and *techne* (Schwartz, 2016: xxxii). The term *tekton* refers to the builder or carpenter (Indrawan et. al., 2019: 69). Over time however, the term *tekton* evolved in order to broaden the scope of its definition and became *arkchiteton* which makes reference to the master builder (Schwartz, 2016: xxxii).

The second word linked to the origin of the term *tectonic* is *techne. Techne* refers to the "mental and physical knowledge and skills of craftspeople" (Louw, 2021:xi). *Techne* concerns itself with the "arts of thought and of physical expression, which links the means of production." (Louw, 2021:xi).

Tectonic theory is dynamic and integrational standing to express an "interwoven relationship between space, function, structure, context, symbolism, representation, and construction where no single definition exists to convey the full meaning of the term" (Schwartz, 2016: xxxii). Due to the theory's "symbiotic relationship between architecture and structure" (Oxman, 2010: 3), and its strong consideration for structural expression "by encompassing the act of making" (Louw, 2021:xi), its theoretical adaptability becomes the consequence of considering value parameters associated with region, culture, tradition, and historical narratives (Schwartz, 2016: xv). *Tectonic* theory is all about critical technological implementation in relation to human beings and their most pressing needs.

6.2 UNDERSTANDING THE VALUE OF TECTONIC THEORY

Human beings, technology, and the environment

As human beings, we "behold, touch, listen to, and measure the world with our entire bodily existence" (Schwartz, 2016: xxvi). As a consequence, the "experiential world becomes organised and articulated around the centre of the human body" (Pallasmaa, 2007:64) through architectural expression. Considering that the implementation of a *Tectonic* architectural language instantiates a tight relationship between human beings and technology, it becomes the grounding element for authentic architectural experiences (Schwartz, 2016: xxvi).

Therefore, the architectural design process cannot be separated from the process of construction (making and crafting) and human perception (Indrawan et. al., 2019: 69).

During the background and introduction part of this paper, it was found that the precursor for rapid technological development was driven by instrumental reason. Instrumental reason defines itself as "the use of reason as an instrument for determining the best or most efficient means to achieve a given end" (Wolin, 2022). This philosophy of efficiency ultimately fast-tracked civilization towards a state of Modernity that was underscored with an "ever-homogenising" totalitarian nature characterised by its deliberate attempts at distancing humans from their dependance on history, culture, and tradition (Frampton, 1983: 269, and Taylor, 1999: 4).

What becomes evident in understanding this phenomenon is that when technological advancement is void of human nature (history, culture, and tradition) (Frampton, 1983: 269, and Taylor, 1999: 4), the resultant architecture becomes a "placeless" manifestation of a functional machine (Chiu, 2009:493) with no route to its tangible and intangible context ultimately being reduced to a universal sameness (Auge, 2008: xii).

In Smith's lecture on *How Architecture can Revive Identity, Community and Purpose* he suggests a correlation between community ownership and architectural longevity. He states that longevity is achieved through the provision of 3 main semantic values: Identity, community, and purpose (Smith, 2019,0:53). These 3 semantic values coincide with the top 3 tiers of Maslow's hierarchy of human needs: esteem, belonging, and self-actualization (McLeod, 2007). Smith goes on to state that successful architecture should work to provide opportunities for the community and reflect its existing identity, therefore insinuating that architectural success is found through responsible cultural integration (2019,07:05).

Community strength is complex due to its integrity being mostly based on semantic values such as culture and heritage, a sense of belonging and ownership, and an overall sense of safety. Although the built environment needs a strong economic system to sustain it, without a community that invests in the cyclical process of economic success that contributes to the built environment's progression, the physical built fabric faces severe threats of dilapidation and disfunction.

(Smith, 2019,10:00 – 12:35)

Therefore, one can deduce that if there is no correlation between the human value system and the built environment, architectural longevity is unattainable. This is why tectonic theory becomes so important. Through prioritising the human narrative in conjunction with steady technological development, an archetype categorised by the relationship between people and technology is produced, therefore sustaining architectural longevity through a strong contextual identity. To solidify this statement, Frampton suggests that the "phenomenological presence of an architectural work and its literal embodiment of form" is perhaps one of the main elements that "grounds architecture in a cultural tradition that is collective rather than individual through ways of building and place-making that are inseparable from our material history." (Frampton: 1903-1994: 375)

6.3 GLOBAL AND LOCAL TECTONICS

The origin of Tectonics and its relations with vernacular architecture (Local tectonics)

Tectonic origins reside within vernacular building traditions (Oxman, 2010: 4). Similar to tectonic theory, the vernacular defines itself through a relationship between form, structure and material which becomes a direct statement on the processes of construction that were implemented (Oxman, 2010: 4). Furthermore, vernacular architecture "can be defined as a type of regional construction influenced by geography, available materials, climate, traditions, and culture that is produced by non-experts through knowledge transmitted and enriched from one generation to the next." (Pardo, 2023: 1). Vernacular architecture has evolved over many centuries in a multitude of differing ways over the global scale due to its basis on region, culture, people, and historical narratives (Chandel, 2016: 1). In understanding this, one can argue that for architecture to be contextually relevant, the implementation of a critical tectonic language should consider an informant based off of regional vernacular teachings.

Learning from vernacular building practices through the lens of tectonic theory

For the context of this paper, vernacular architecture specifically refers to archetypes associated with indigenous people and knowledge bases home to South Africa. As explored within the background of this paper, the marginalisation of local vernacular architecture through colonial rule profoundly affected spatial practice (Low, 2014, 91). Under rule of the colonist, "indigenous architecture and the vernacular were subject to 'arrested development' with Western modernism supplanting the local." (Low, 2014, 91). As a consequence, heavy reliance on modern conventional architecture has put vernacular architecture, and indigenous knowledge bases on the verge of extinction (Chandel, 2016: 1). To let indigenous knowledge go unexplored might become a detriment, as some principles of theory and practice associated with vernacular architecture show potential for becoming viable methods of revitalization considering South Africa's built environment.

Besides heritage value, vernacular architecture can also be associated with a sound sustainability model defined by "the use of available resources, with a minimal negative environmental impact, minimization of costs, and a reduction of energy demand" (Pardo, 2023: 1). Vernacular architecture refers to a dynamic archetype that responds to context specific climatic factors through passive energy conservation techniques in order to reach levels of thermal comfort (Chandel, 2016: 1). Therefore, if these strategies for passive thermal comfort are studied and developed as reinterpreted systems for the modern context, climate related problems such as: "degradation of environment quality, indiscriminate depletion of resources, greenhouse gas emissions, high energy usage, deforestation etc." could be solved (Chandel, 2016: 1). In the same light Steyn suggests that an appropriate South African architecture could be instantiated through concepts derived from vernacular traditions while still considering current practice (2020:1).

In identifying the relationship between tectonic theory and vernacular architecture, the need for a regional tectonic language, with specific reference to the South African context, becomes apparent. The idea is not to replicate vernacular archetypes but rather use the knowledge gained as a *toolbox* for defining an appropriate *local tectonic* (Louw, 2021: ix). In order to extrapolate from the vernacular Pardo in his *Challenges and Current Research Trends for Vernacular Architecture in a Global World: A Literature Review,* suggests 5 lenses of analysis when considering vernacular archetypes:

I. Local materials used.
II. Planimetric design strategy implemented for topographical and climatic conditions.
III. Construction techniques and aesthetic resources
IV. Level of technological transmittance and adaptation over a time period
V. Level of active participation from local craftsman and general users during phases of design and construction

(Pardo, 2023: 1)

Oxman argues that the vernacular offers an "analogous source of contemporary material-based design" (Oxman, 2010: 4). Considering the relationship between vernacular architecture and tectonic theory allows one to see the potential that exists behind implementing low-tech building solutions while responding to culture traditions and historical narratives in the present day. However, this is only one side of instantiating an appropriate *local tectonic* (Louw, 2021: ix). Steyn argues that the "growth of a local building industry could be stimulated by a fusion of informal vernacular, conventional and innovative technologies" (2020:6). In order to instantiate a *local tectonic* that makes way for technological innovation and development, one needs to explore the edge of high-tech building solutions as a secondary proponent to the relevant *local tectonic*.

Tectonics in the age of digitization (Global tectonics)

The environment human beings live in today is inundated with various means of rapid communication and computation processes, and as a result architecture has become an "interface for information exchange and interaction." (Chiu, 2009:493). Digitalization is currently impacting all parts of the built environment in turn altering the ways in which design outputs are conceptualised, projects are realised, and how buildings end up being used (Rehman, Puolitaival, McMullan, and Kestle, 2018: 58). The introduction of digitalization within the built environment has allowed for the development of "digital design and fabrication technologies" of which are enabling "an expanding inter-relationship between technology and design." (Oxman, 2010:1). With digitalization playing such an integral role in the built environment, there has been an emergence in a variety of construction technologies and processes including:

- Advanced Manufacturing
- Design for Manufacturing & Assembly (DfMA)
- Additive Manufacturing
- BIM and BIM Cloud Management
- Digital Fabrication
- Digital Procurement
- Prefabrication
- Offsite and Modular Construction
- Digital Surveying

(Rehman, Puolitaival, McMullan, and Kestle, 2018: 58)

Oxman argues that the integration of digitalization in terms of design and construction has resulted in a material-based conceptualization protocol which she defines as "a computational informing process that enhances the integration between structure, material, and form within the logic of fabrication technologies (Oxman, 2010:1). The development of digital and information technologies is an ongoing process which means that the focus for architectural design is becoming inclusive of spatial and volumetric construction, as well as the integration of interface and systems software (Chiu, 2009:493). This has ultimately changed the nature of craftsmen within the built environment. Today, more than the agrarian craftsman, there is a need for craftsmen of the digital age (Klinger, 2001: 243). This type of craftsman is one who needs to be skilled with "strong design ideas, knowledge of a variety of software, and an understanding of fabrication processes." (Klinger, 2001: 243).

Changes in the nature of the craftsman as well as the approach towards constructing and designing for the built environment has resulted in a sub-category of tectonic theory called *informed tectonics.* Oxman describes this sub-category of tectonic theory as "the affinity between tectonics and digital technologies that enhances design possibilities for the integration of form, structuring and material principles." (Oxman, 2010:2). In the same vein, Klinger suggests that fostering a strong relationship between "design visualisation and fabrication processes would serve to better inform the evolution of new principles for a contemporary architecture" that becomes a driver for the identity of current times (Klinger, 2001: 243). The resultant archetype would be one characterised by dynamic structures and surfaces that are more "sensitive, intelligent, interactive, and improvisational" in their spatial nature (Chiu, 2009:493).

6.3 HYBRID TECTONICS

Defining hybrid tectonics

The term hybrid tectonics refers to a tectonic language that synthesises theoretical principles associated with both global and local tectonics. In the context of this paper, the term global tectonics refers to the realm of universal technologies including "industrialised processes of mass production, mechanised production, and digital design and production." (Louw, 2021: x). On the other hand, the term local tectonics refers to the realm of technological implementation that is defined by "the use of local materials in their natural form, locally available skills, or traditional techniques" that are within close proximity of a particular place (Louw, 2021: x).

Hernandez refers to hybridity as a useful vehicle of study that considers the particularities of sociocultural interaction between different groups in circumstances of colonialism and contemporary globalisation" (2010: 58). Louw goes on to highlight Hernandez's emphasis on hybridity in suggesting that "it is not a simple mixture of two or more elements, but that it is about the rearticulation of culture where binary systems are dismantled in order to unsettle purity or homogeneity." (Louw, 2021:268). Hybridity therefore becomes an architectural toolbox for regional tectonic expression allowing for technological development and experimentation while still depicting an appropriate identity for a particular place.

Unique technological opportunities for South Africa

In order to make way for the development of cultural identity and technological advancement, the validity behind implementing a hybridised architectural language that considers the synthesis of low-tech and high-tech building solutions seems to become plausible. Through unpacking the realm of technological advancement in combination with tectonic theory throughout this paper, a multitude of opportunities become apparent for trial in South Africa, however, it is pertinent that innovation happens with respect to its local context. Seeing that South Africa's rich historical narrative is one that includes a detailed indigenous knowledge base considering these teachings in tandem with careful reinterpretations of the global standards for technological development might serve as a promising means for innovation within South Africa's built environment.

Wienecke's perspective on South Africa's technological advancement trajectory ties in with Jekot's conceptions in that "Culture consists of the ideas, tradition, knowledge, technology, intellect, and art that is produced or shared by a particular community. It is important to understand the regional culture in order to create architecture that has roots, functions well and is long-lasting." (Jekot, 2007: 70).

However, it must be remembered that "the regional and global" perspectives do not have to be paradoxical (Jekot, 2007: 70). This therefore suggests that South Africa's technological development strategies within the built environment could benefit from understanding and reinterpreting the developmental trajectories implemented by first world entities.

Steenkamp's research on *The Benefits of Applying Vernacular Indigenous Building Techniques In Self-Help Construction for Sustainable Livelihoods and Human Settlements* concludes that "encouraging the implementation of vernacular building methods and indigenous knowledge improves the livelihoods of communities and encourages pride within." (2012: 3). Furthermore, Steenkamp suggests that the implementation of vernacular building methods "may well play an essential role in guiding architects and the built environment through the past in order to navigate back to the present and future." (2012: 3). However, the implementation of vernacular building methods cannot serve as a strict means for innovation in isolation as Low in his *Architecture in Africa: Situated modern and the production of locality* argues that "the situated modernism that arises from producing our own locality is not necessarily confined to low-income projects in rural areas that employ local skill and materials!" (2014: 296). Low further suggests that due to Africa's lower developmental status, an opportunity arises in the "possibility of producing localities that are primarily rooted in relational and contextual exigencies, as opposed to simply the spatial and the scalar.", thus resulting in building typologies that are "demonstrative of a peculiar local interpretation of a global trend"(2014: 297).

6.3 HYBRID TECTONICS AS A REVITALIZATION METHODS FOR SOUTH AFRICA'S BUILT ENVIRONMENT

This paper stands to uncover what technological development within the built environment is, how new technologies are classed, tested and implemented and how the attitude towards technological development within the built environment is changing on a global and local scale. Furthermore, the theoretical context stands to highlight the gaps in development standards between South Africa and the rest of the world. In performing this comparison, the following gaps were uncovered:

- A change in educational programs that consider the integration of new material studies and digital means of making
- Architectural firms with integrated research teams designated for the accumulation of usable knowledge on emerging materials and construction processes
- The absence of a definition for emerging building technologies (without a definition understanding a way forward for technological development becomes extremely difficult)
- A reluctance towards integrating new knowledge within the built environment due to an overall mismatch between available skills and required skills (Windapo & Cattell, 2013:70).

This paper also goes on to highlight the opportunities available for technological development within South Africa's built environment where the main alleyway of promise considers the implementation of a hybridised tectonic approach. However, for this to become a viable solution in solving the knowledge gaps identified, a precedent taxonomy needs to be implemented for the identification and categorization of what successful hybrid tectonics within the South African context might look like.

With reference to Louw's methods of evaluation criteria for precedents showcasing hybrid tectonics, the following aspects will be used for the categorization of strong existing projects:

- Local climate response
- Local topographical response
- Incorporation of local materials in relation to global materials
- Integration of local or traditional labour or techniques in relation to global labour or techniques

(Louw, 2021:144)

In addition to this criteria Louw further suggests that the utilisation of a subset of evaluation criteria regarding representation could serve to gain a deeper level of understanding when categorising precedents that showcase the successful implementation of hybrid tectonics. This subset of evaluation criteria is as follows:

- Appropriate reinterpretations for local forms and patterns-
- Whether or not the achieved balance between reinterpretations of global and local tectonics are unique to the context in which the project sits
- The projects' social focus and how inequality is addressed

(Louw, 2021:144)

Steyn argues that "the growth of a local building industry, and greater participation by communities, could be stimulated by a fusion of informal vernacular, conventional, and innovative technologies" (Steyn, 2018: online). Steyn's statement sits in contrast with the current building practice norms of South Africa's building industry. Through creating a precedent taxonomy, the idea is to understand what the nature of *emerging building technology* is within South Africa's current built environment while gaining an understanding on how the use of a hybrid tectonic could test the boundaries for technological development with respect to South Africa's context.

7. DATA CAPTURING

Data capturing was done through the use of a group-designed systematic precedent taxonomy.
Please see Annexure A for the tabulated case study data.

8. DATA ANALYSIS

8.1 ANALYSIS METHOD

This data analysis process has been informed by the research aim, research questions, and problem statement, therefore the following themes have been kept in mind throughout the process:

- Considerations for emerging building technologies within South Africa's built environment
- Hybrid high-tech and low-tech building technologies
- Revitalization of South Africa's built environment
- Instantiating a local identity relevant to South Africa's built environment

Due to the nature of this study revolving around the impact of emerging building technologies on the South African built environment, the case studies were analysed for technological emergence with respect to the following three spheres:

- Building materials
- Construction processes
- Structural systems

A graphic was developed in order to quantify each case study on the basis of technological emergence within South Africa's built environment.

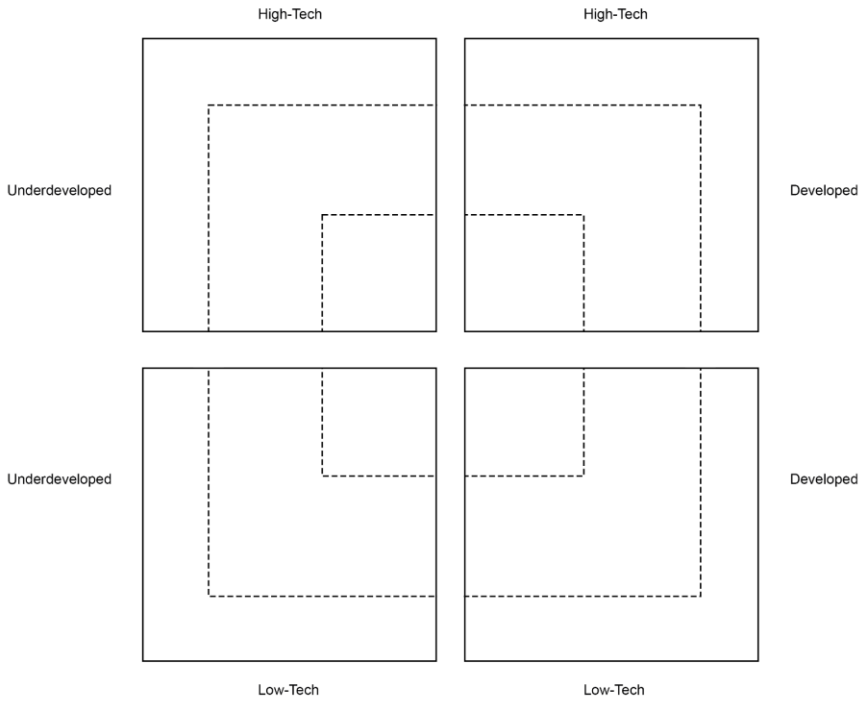

Figure 9 - Four quadrant data analysis plotting graphic (Group work, 2023)

The graphic was designed to test levels of emergence in accordance with building materials, construction processes, and structural systems in each case study captured.

The basis of technological emergence associated with building materials, construction processes, and structural systems were graphically quantified through the use of three testing criteria:

- **Nature of emergence** (building materials, construction processes, and structural systems)
- **Level of emergence** (non-emerging building technology, semi-emerging building technology, emerging building technology)
- **Status of emergence** (High-tech/ Low-tech, Developed/ Underdeveloped)

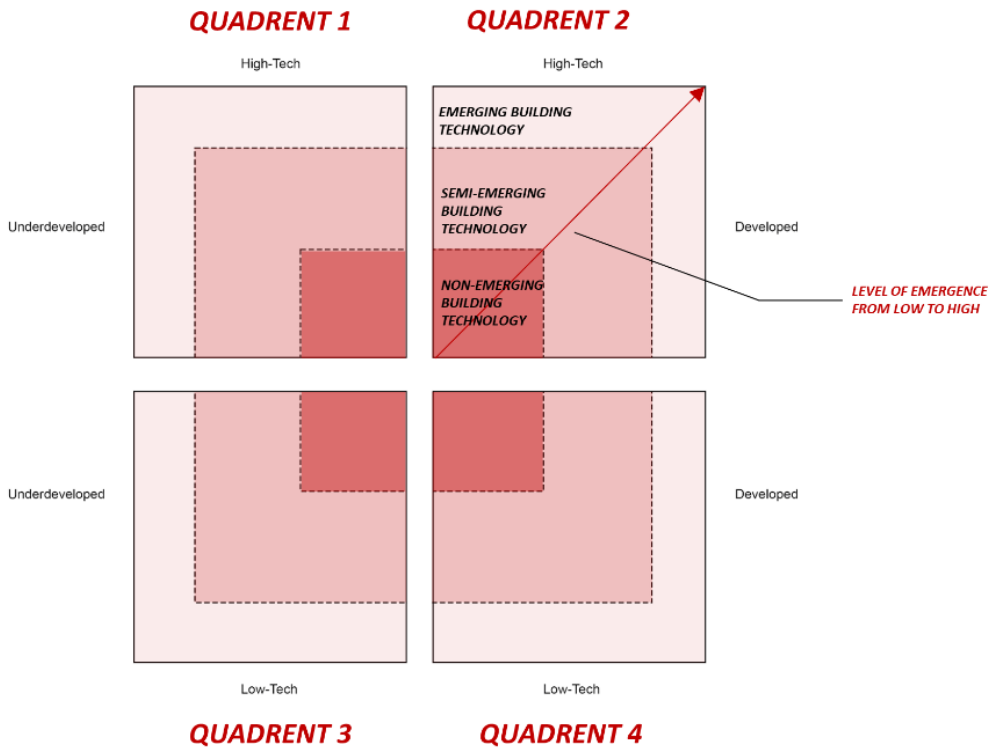

Figure 10 - Four quadrant data analysis plotting graphic broken down in shades of red to depict levels of technological emergence from lowest to highest (Group work adapted by author, 2023)

8.2 ACCUMULATED PLOTTED DATA

This graphic enabled the research team to plot each and every project found through the data capturing process via a series of colour coded dots that represent technological emergence through the lenses of:

- Building material (Red)
- Construction process (Blue)
- Structural system (Yellow)

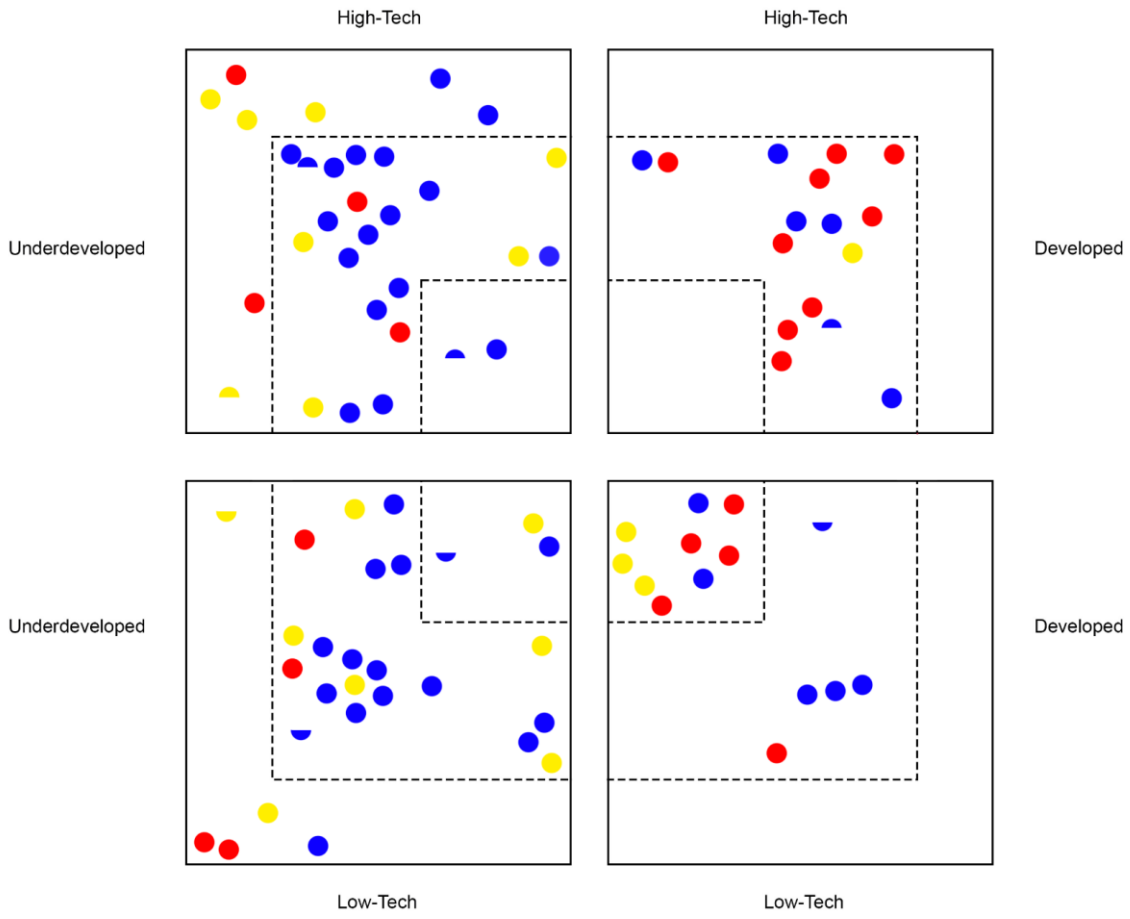

Figure 11- Accumulated case study data graphically depicting levels of technological emergence of building materials (red), construction processes (blue), and structural systems (yellow)as dot-density diagram (Group work, 2023)

8.2 DATA FILTERS

Although the above graphic depicting the accumulation of all plotted data gives some direction in understanding South Africa's tectonic discourse concerning technological emergence, further filtering allows one to understand the data at a more critical level.

Dot Density - Emerging building technology

The quadrant depicting the highest level of technological emergence is Quadrant 1 (High-tech/ Underdeveloped), Emerging building technologies. As seen by the colour codes, building materials (red), construction processes (blue), and structural systems (yellow) are all depicted. The highest dot density is held by structural systems (yellow) suggesting that South Africa's built environment is experiencing an emergence in structural system technologies.

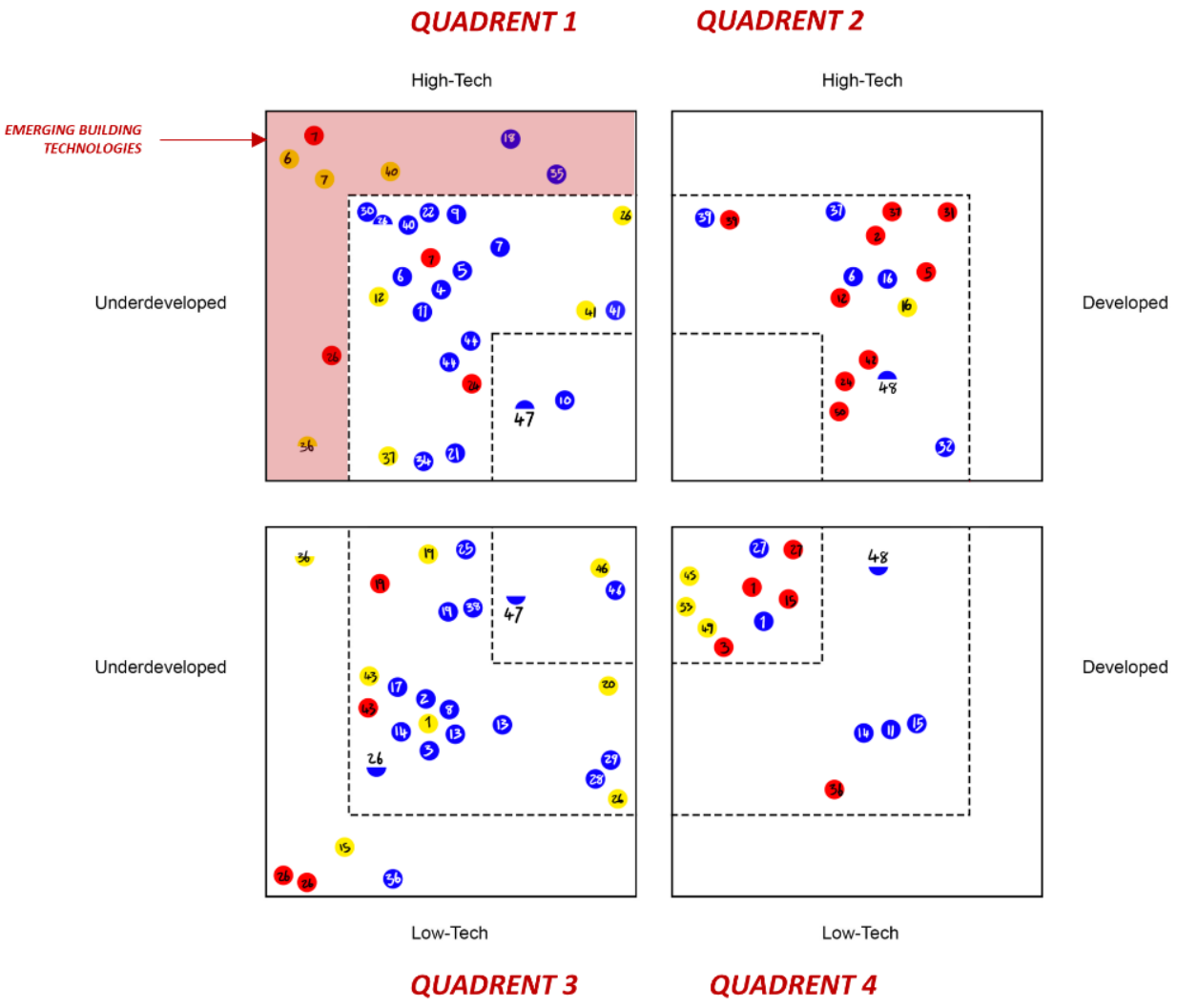

Figure 12- Dot-density diagram depicting building materials (red), construction processes (blue), and structural systems (yellow) with the highest level of emergence that are high-tech and underdeveloped (highlighted in red) (Group work adapted by author, 2023)

Dot Density - Semi-emerging building technology

The quadrant depicting the highest level of technological semi-emergence is Quadrant 1 (High-tech/ Underdeveloped), Semi-emerging building technologies. As seen by the colour codes, building materials (red), construction processes (blue), and structural systems (yellow) are all depicted. The highest dot density is held by construction techniques (blue) suggesting that South Africa's built environment is experiencing adequate growth in semi-emerging construction techniques. The gap between emerging structural systems and semi-emerging construction techniques depicts a potential gap between building technologies being developed, and the skills and knowledge needed for mass implementation.

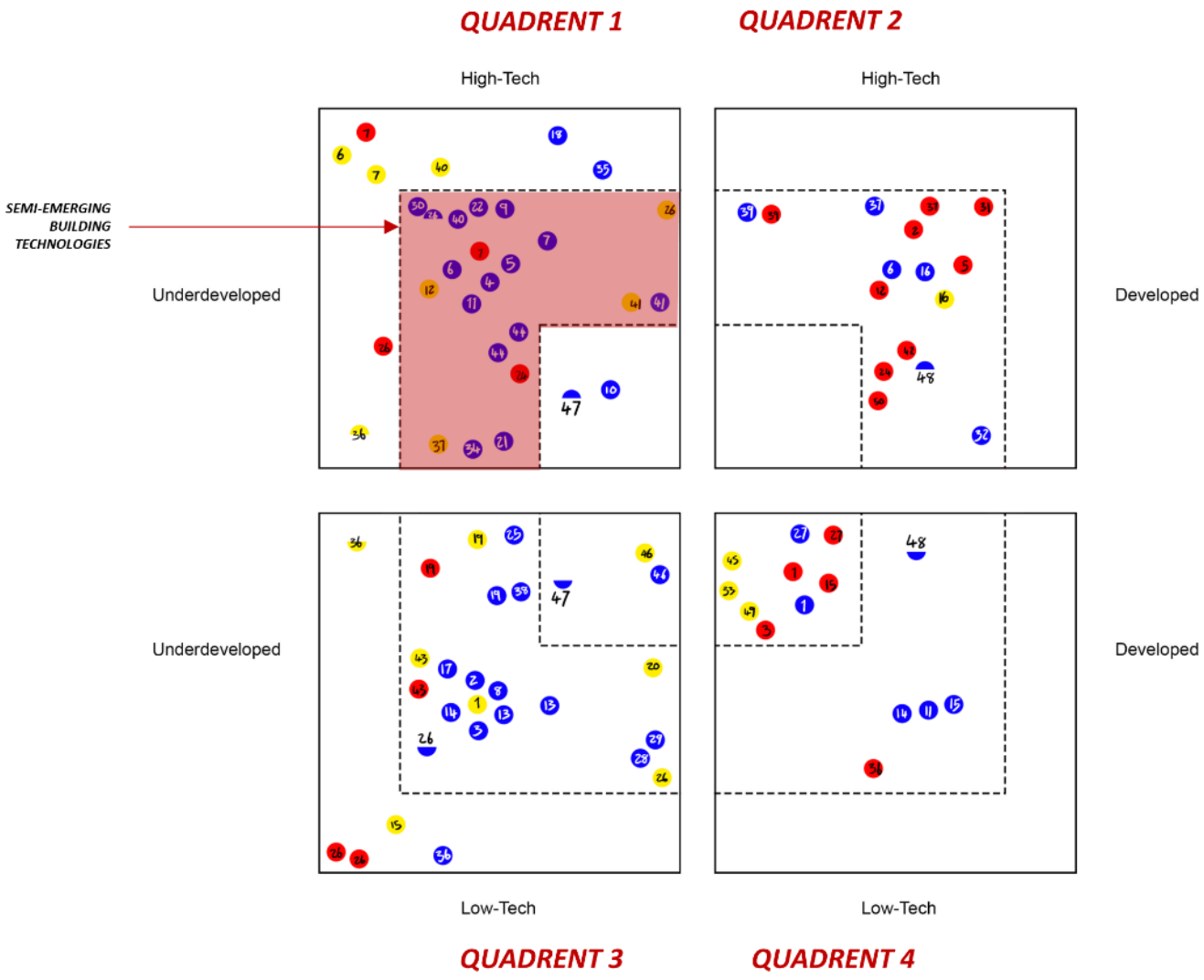

Figure 13- Dot-density diagram depicting building materials (red), construction processes (blue), and structural systems (yellow) with mid range levels of emergence that are high-tech and underdeveloped (highlighted in red) (Group work adapted by author, 2023)

Dot Density - Non-emerging building technology

The quadrant depicting the highest level of technological non-emergence is Quadrant 4 (Low-tech/ Developed), Non-emerging building technologies. As seen by the colour codes, building materials (red), construction processes (blue), and structural systems (yellow) are all depicted. The highest dot density is held by building materials (red). The projects depicted by these red dots are as follows:

Project 1 - Building material - Makes use of a mix of light clay, compacted straw and small amounts of cement in order to produce a walling infill

Project 27 - Building material - Makes use of sand filled bags as a walling module

Project 3 - Building material - Makes use of Adobe packed wall panels for insulation purposes

Project 15 - Building material - Makes use of compacted earth bricks of which are manufactured on site with earth cultivated from the surroundings

(Please refer to the precedent taxonomy in annexure A for more information on these projects)

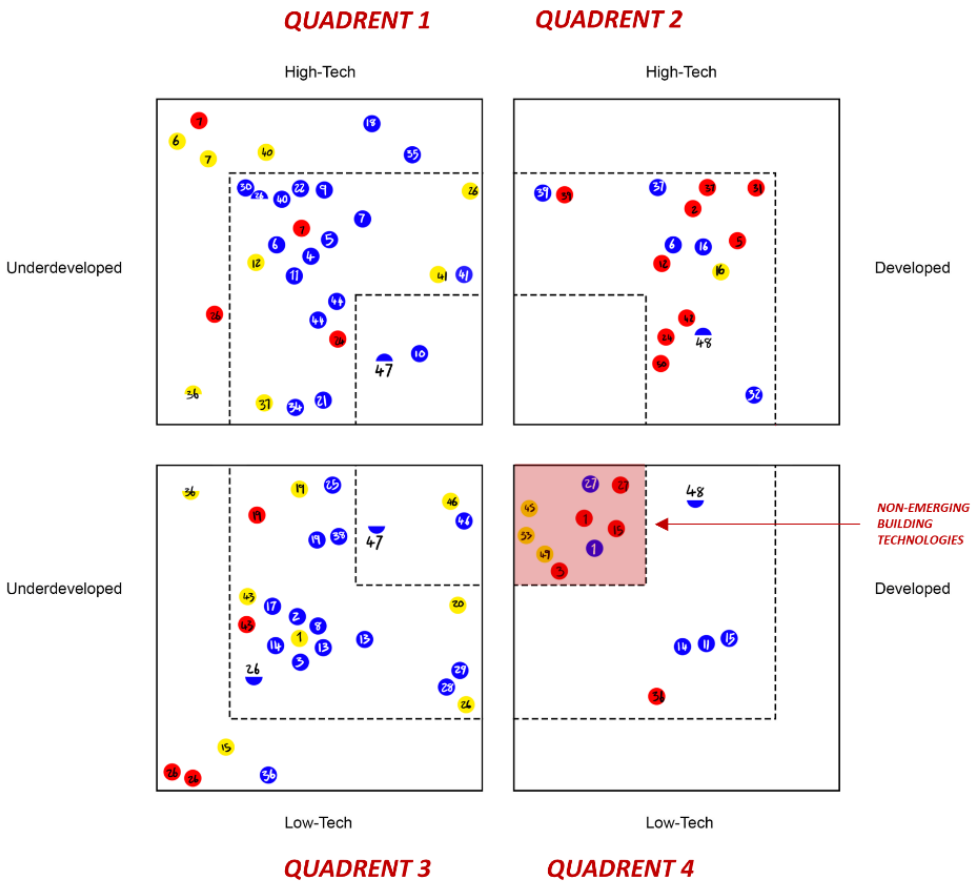

Figure 14- Dot-density diagram depicting building materials (red), construction processes (blue), and structural systems (yellow) with low range levels of emergence that are low-tech and developed (highlighted in red) (Group work adapted by author, 2023)

Although the above mentioned materials are non-emerging, they are still plotted on the graphic due to the fact that they are not commonly used materials. The techniques associated with making and using these materials is a low-tech and hand based process where the materials used are cultivated from the site (local tectonic). Therefore, In accordance with Pardo's 5 lenses of analysis when considering vernacular archetypes (Pardo, 2023: 1), one can conclude that these building materials are descendants of the vernacular archetype and have been developed over many years.

As explored through the literature review part of this paper, this realm of building technologies cannot be ignored as they are extremely important for the instantiation of a hybrid tectonic language relevant to the South African built environment. This realm of low-tech building technologies are also associated with detailed historical narratives and hold potential in aiding in the instantiation of an architectural identity relevant to South Africa.

Dot Density - Quadrants of importance (Global tectonics)

The Quadrant with the highest dot density is that of Quadrant 1. Quadrant 1 depicts a collection of materials (red), construction processes (blue), and structural systems (yellow) which are both high-tech and underdeveloped with varying levels of emergence. These materials, construction processes, and structural systems fall within *global tectonics* and if developed further could become an important proponent to the instantiation of a hybrid tectonic language relevant to the South African built environment.

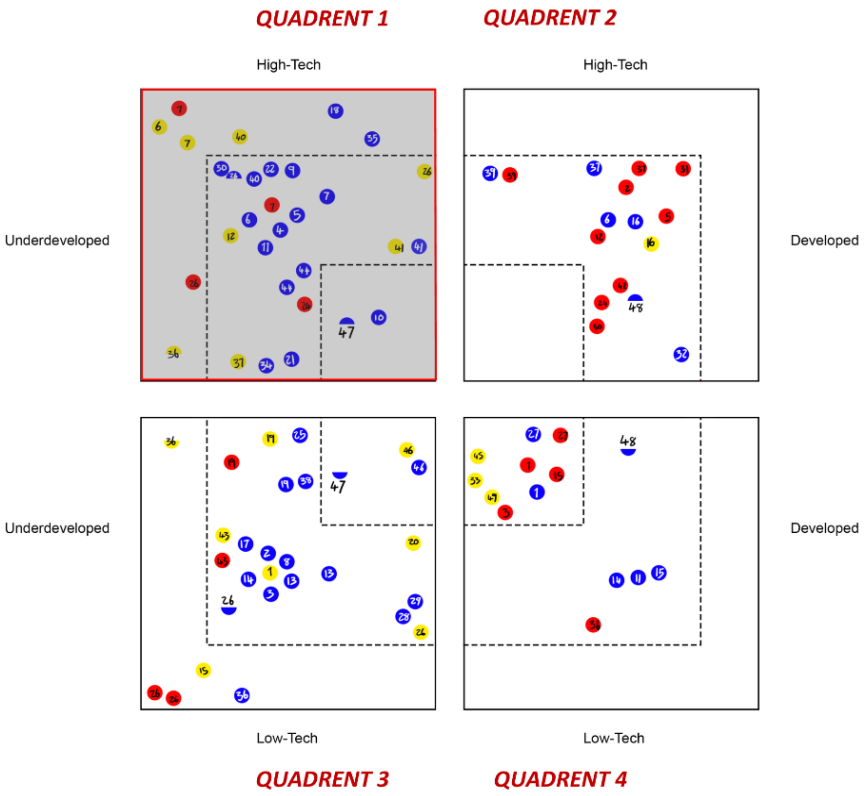

Figure 15 - Dot-density diagram depicting plotted quadrant with the highest dot - density (Group work adapted by author, 2023)

Dot Density - Quadrants of importance (Local tectonics)

The Quadrant with the second highest dot density is that of Quadrant 3. Quadrant 3 depicts a collection of materials (red), construction processes (blue), and structural systems (yellow) which are both low-tech and underdeveloped with varying levels of emergence. These materials, construction processes, and structural systems fall within *local tectonics* and if developed further could become an important proponent to the instantiation of a hybrid tectonic language relevant to the South African built environment.

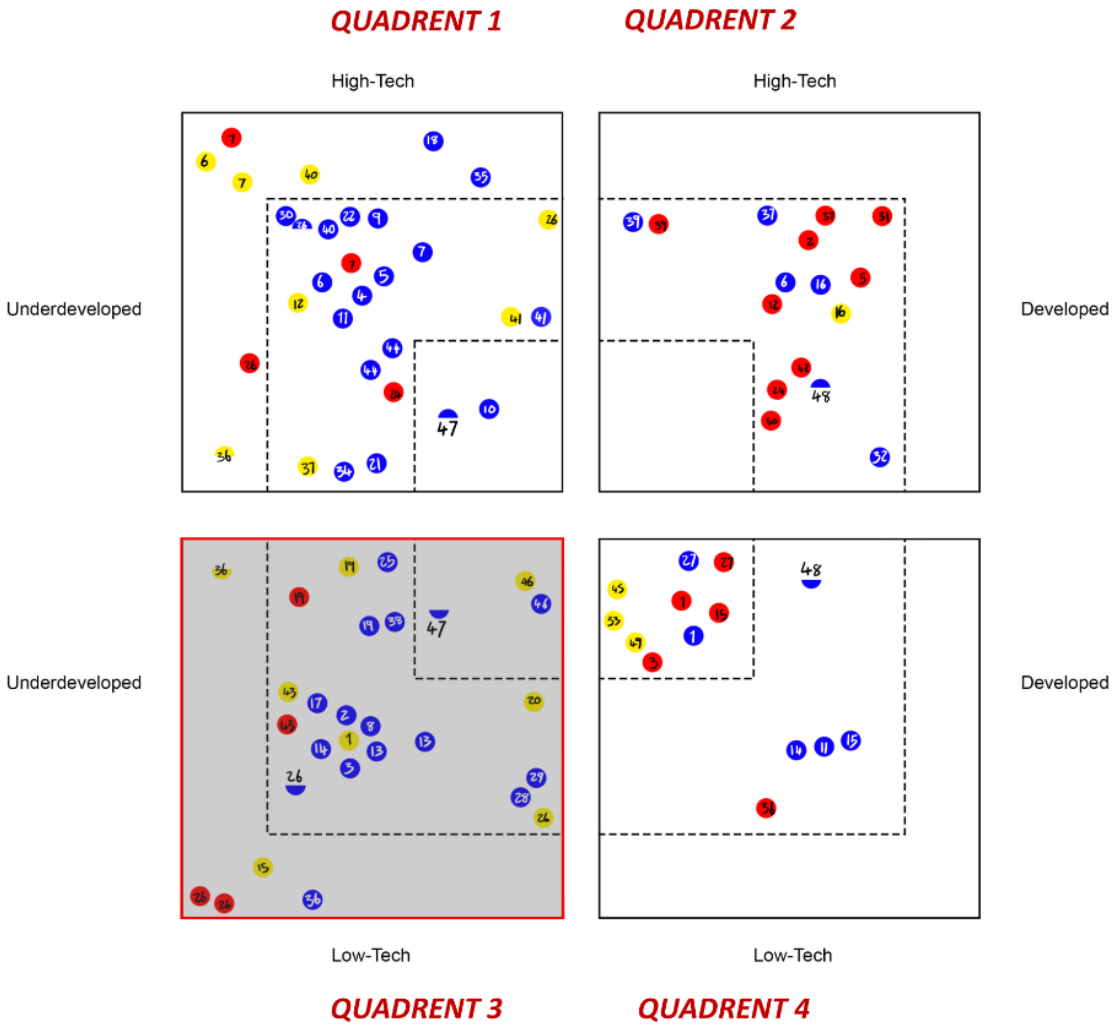

Figure 16 - Dot-density diagram depicting plotted quadrant with the second highest dot - density (Group work adapted by author, 2023)

Dot Density - By colour categorization

When considering dot density by colour categorization, it is to be seen that the blue dots representing construction process emergence have the highest density. Furthermore, the majority of these blue dots find themselves within quadrants 1 and 3. These quadrants are both associated with materials, construction processes, and structural systems that are emerging but underdeveloped. Despite the levels of emergence associated with the plotted construction processes (blue) , the diagram below clearly shows that there are more underdeveloped emerging construction processes than there are developed emerging construction processes. This validates Windapo & Cattell's arguments around "the mismatch between available skills and required skills " within South Africa's built environment (Windapo & Cattell, 2013:70).

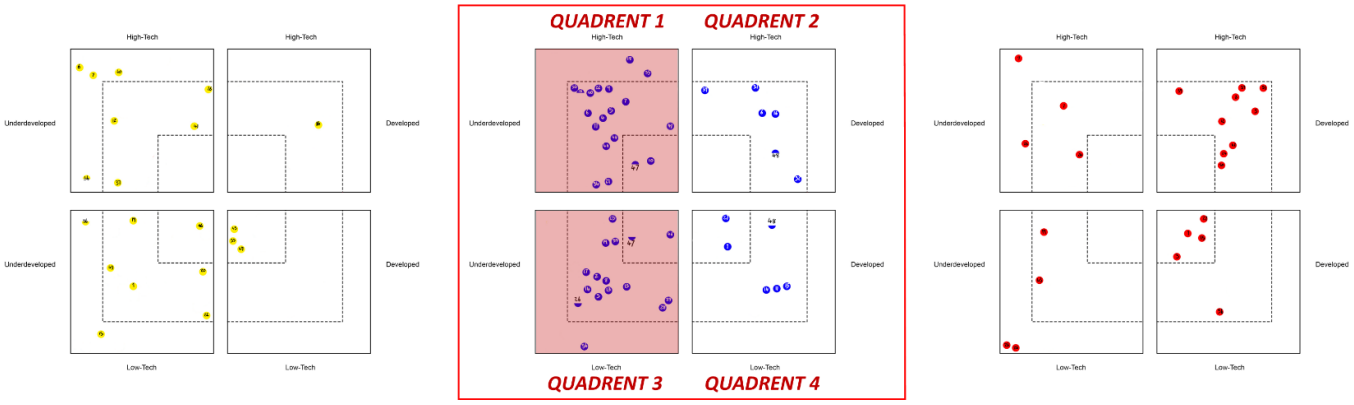

Figure 16 - Dot-density diagram depicting accumulation of emerging construction processes (blue) (Group work adapted by author, 2023)

9. DISCUSSION

9.1 STUDY INTENTION RECAP

As previously mentioned, South Africa's built environment has become slow in its technological development due to: the lack of required skills, existing research on the matter having a global focus, and an overall separation of design and construction processes. South Africa's built environment also seems to be becoming placeless and homogenised due to the lack of identity portrayal in correspondence with its places. With limited research on how the South African built environment could benefit from solving both problems simultaneously, this paper focuses on paving an alleyway to a possible solution. This study aims to investigate what aspects of hybrid high-tech and low-tech emerging building technologies could become a catalyst for revitalising the South African built environment while prioritising the instantiation of a relevant local identity in accordance with its places.

The research questions at hand are as follows:

- Which building technologies can be considered to form part of current building practice in the South African built environment, and which can be considered as emerging building technologies?
- How can emerging technologies contribute to making current building practice more a) versatile, b) economical, c) contextually responsive and d) socially responsible?
- What aspects of hybridising high tech and low tech building technologies stand to enhance levels of revitalization within South Africa's built environment so as to foster a strong sense of ownership and local identity?

9.2 OVERALL DATA INTERPRETATION

Graphical data - Interpretation of Dot Density diagrams

The analysis process undertaken for the captured case study data presents evidence of architectural projects within South Africa's built environment that stand to test its boundaries for development from both low-tech and high-tech perspectives. There seems to be significant development within both realms of global and local tectonics however, these spheres are yet to be fully understood, as most of the plotted materials, construction processes, and structural systems fall within the underdeveloped quadrants which means that mass market acceptance has not happened yet (McCoy & Yeganeh, 2021:1). There seems to be an equal emphasis on the rate of emergence for both low-tech and high- tech materials, construction processes, and structural systems. This observation validates the possibility of hybrid high-tech and low-tech emerging building technologies becoming a catalyst for revitalising the South African built environment.

Another observation made considers the rate of development within South Africa's construction industry. It was observed that the majority of the construction processes plotted were flagged as underdeveloped. This means that without a steady rate of growth through knowledge transfer and skills development within South Africa's construction industry, the instantiation of a hybrid tectonic language could be delayed in taking full effect and reaching the mass market.

Selected case study data - Unpacking successful projects

As a supplement to the produced dot density diagrams, a short list of 5 successful projects will be critically unpacked and routed back into the existing research accumulated in the *Background, Theoretical Context,* and *Literature review* portions of this paper. The intention is to uncover how hybrid high-tech and low-tech emerging building technologies make South Africa's built environment more:

- Versatile
- Economical
- Contextually responsive
- Socially responsible

After unpacking these projects in accordance with the above mentioned lenses, an informed decision will be made on what an appropriate architectural identity might look like for a revitalised South African built environment.

Project short-list

1. **Ithuba Community College by BuildCollective and S2arch (2009) - Project 1**
   This community college stands as a centre for community involvement where its program is directed at educating people on the development of alternative building techniques. The facility showcases its technological emergence through the use of load bearing adobe walls made of light clay, compacted straw, and a small amount of cement. These adobe walls were fabricated through the employment of unskilled craftsmen who worked predominantly with their hands without the need for special construction equipment. Materials were sourced locally making the project contextually responsive and economical. The use of adobe happens at an unusually large scale within this project, ultimately showcasing its versatility. *(Information extracted from Project 1 in the Precedent taxonomy, please refer to Annexure A , Project 1 for referencing regarding this information)*

   The low-tech nature of this project made the employment of unskilled craftsmen possible. Including the community during the construction process produces a sense of purpose and belonging. This ties in with Smith's lecture on *How Architecture can Revive Identity, Community and Purpose* where he suggests a correlation between community ownership and architectural longevity. He states that longevity is achieved through the provision of 3 main semantic values: Identity, community, and purpose (Smith, 2019,0:53). BuildCollective and S2arch's response to community involvement resulted in an educational facility that allowed for self actualization through a place the community could identify with. A relationship between people and technology was instantiated.
   Overall, this project does not stand to replicate a particular vernacular archetype, but rather use the knowledge gained around vernacular building as a *toolbox* for defining an appropriate *local tectonic* (Louw, 2021: ix)

Figure 18 - Ithuba Community College by BuildCollective and S2arch (2009) - Project 1 (Wagner, 2016)

2. **"Writers retreat" Residence by cseventysix Architects (2019)- Project 4**

The main goal of this residential project was to reduce physical impacts to the site upon which it was built. Therefore, this project showcases its technological emergence through the use of a disassemblable steel structure ultimately suggesting an idea for impermanent residential architecture. Furthermore, the architects involved in the project made use of recycled steel and considered the material life cycles for all other materials implemented resulting in a high level of contextual responsiveness. The project also makes use of low-tech passive thermal design strategies such as natural ventilation, and natural convection. Considering the dynamic nature of this disassemblable project, its critical response to context, use of recycled materials and low-tech passive thermal strategies, the project also becomes versatile and economically responsive.

(Information extracted from Project 4 in the Precedent taxonomy, please refer to Annexure A , Project 4 for referencing regarding this information)

The use of computer aided design associated with this project allowed for critical design decisions to be made on the disassemblable steel structure implemented. Steel components for the structure were prefabricated and delivered to site. Here it becomes evident how digitalization is currently impacting parts of the built environment (Rehman, Puolitaival, McMullan, and Kestle, 2018: 58). The introduction of digitalization within the built environment has allowed for the development of “digital design and fabrication technologies” of which are enabling “an expanding inter-relationship between technology and design.” (Oxman, 2010:1). This inter relationship between technology and design is defined by the global tectonic, where universal technologies including “mechanised production, and digital design and production.” (Louw, 2021: x) are used.

In observing the low-tech nature of the implemented passive thermal design strategies such as natural ventilation, and natural convection, as well as the use of recycled materials, one could suggest that vernacular knowledge was visited as an informant. This observation rings true when considering Pardo's suggestion that vernacular architecture can be associated with a sound sustainability model defined by “the use of available resources, with a minimal negative environmental impact, minimization of costs, and a reduction of energy demand” (2023: 1). Furthermore, the project at hand becomes comparable to Chandel’s definition of vernacular architecture as he suggests that vernacular architecture refers to a dynamic archetype that responds to context specific climatic factors through passive energy conservation techniques in order to reach levels of thermal comfort (2016: 1). Overall this project showcases a subtle but critical hybridization between the realms of local and global tectonics standing as evidence in validating the value behind implementing a hybrid tectonic language.

Figure 19 - "Writers retreat" Residence by cseventysix Architects (2019)- Project 4 (cseventysix Architects, 2020)

3. **Wright House by Elmo Swart Architects (2011)- Project 8**

This residential project showcases its emergence through the reinterpretation of vernacular informants in combination with industrialised means of production in order to produce contemporary architecture relevant to its context. The architect makes use of structural steel C-frames of which are closed off with an array of gum poles of which are finished with thatch at 45 degrees. The cantilevered structure sits on earth-packed walls with steel sheeting and bamboo act as external finishes.

(Information extracted from Project 8 in the Precedent taxonomy, please refer to Annexure A , Project 8 for referencing regarding this information)

This project celebrates the articulation of two contrasting worlds defined by high-tech global tectonics, and low-tech local tectonics. This project validates Jekot's statement that "regional and global" perspectives do not have to be paradoxical (2007: 70). Jekot critically analyses the potential for technological co-existence between the high and low tech spectrums concluding that success lies within designers reinforcing their architectural informants through aspects associated with culture and the physical environment (2007: 66). This therefore suggests that South Africa's technological development strategies within the built environment could benefit from understanding and reinterpreting the developmental trajectories implemented by first and third world entities simultaneously.

Figure 20 - Wright House by Elmo Swart Architects (2011)- Project 8 (Editors of Dornob, 2019)

4. **South Africa's first 3D printed low-cost house by University of Johannesburg's civil engineering department (2022) - Project 17**

   As part of a research project, the University of Johannesburg constructed South Africa's first 3D printed low-cost home. This project's emergence is showcased through the implementation of automated construction techniques where the main structure of a low cost home was completed within 24 hours via the use of a large scale 3D printer capable of producing large scale prints from concrete. This 3D printed low cost home was produced at an unprecedented rate and used as much as 32% less of the required materials for more common construction methods. This automated construction process could act as a catalyst for the production of sustainable human settlements while strengthening the economy.
   (Information extracted from Project 17 in the Precedent taxonomy, please refer to Annexure A ,Project 17 for referencing regarding this information)

   This 3D printed low-cost home serves as evidence for Oxman's argument that the integration of digitalization in terms of design and construction has resulted in a material-based conceptualization protocol which she defines as "a computational informing process that enhances the integration between structure, material, and form within the logic of fabrication technologies (Oxman, 2010:1). The University of Johannesburg has produced an architectural project that showcases the trajectory for development of digital and information technologies (Chiu, 2009:493). It is an ongoing process which means that the focus for architectural design is becoming inclusive of spatial and volumetric construction, as well as the integration of interface and systems software (Chiu, 2009:493). This project stands to show that the nature of the craftsmen within the built environment has changed. Today, more than the agrarian craftsman, there is a need for craftsmen of the digital age (Klinger, 2001: 243). This type of craftsman is one who needs to be skilled with "strong design ideas, knowledge of a variety of software, and an understanding of fabrication processes." (Klinger, 2001: 243).

Figure 21 - South Africa's first 3D printed low-cost house by University of Johannesburg's civil engineering department (2022) - Project 17 (Reporters at News24, 2023)

5. **Witklipfontein Eco lodge by GLH Architects (2018)- Project 14**

The emergence of this project is showcased through the use of materials cultivated on site where an archetype defined by low-tech construction and hand based labour is produced. Materials utilised for this project include rammed earth, and hand made compacted earth bricks. Both of these building materials were formulated from earth cultivated in close proximity to the site. Due to the project's low tech nature, unskilled labour was utilised. The structural system implemented makes way for earthbag construction, where earth bags were used as structural tanking elements in order to create a dome like space under ground. Besides the traditional eco materials mentioned, this project also considered the integration of timber and steel construction in order to account for the weight of a structural green roof. *(Information extracted from Project 14 in the Precedent taxonomy, please refer to Annexure A ,Project 14 for referencing regarding this information)*

This project showcases the potential for hybrid construction techniques within South Africa. Steyn argues that the "growth of a local building industry could be stimulated by a fusion of informal vernacular, conventional and innovative technologies" (2020:6).

Figure 22 - Witklipfontein Eco lodge by GLH Architects (2018)- Project 14 (GLH Architects, 2018)

10. CONCLUSION

The accumulated data and data analysis suggest evidence in the development and utilisation of both low-tech and high- tech emerging building technologies. Through closer observation it was seen that some case studies placed a heavier emphasis on depicting and developing a high-tech globalised tectonic (Figure 21), while other case studies placed the majority of their emphasis on depicting and developing a low-tech local tectonic (Figure 18, Figure 21). A tertiary case to consider is the one that sits in line with captured data depicting an almost “veiled” technological emergence where the hybrid tectonic is clear after careful study but one wouldn’t notice it at first glance. For example "Writers retreat" Residence by cseventysix Architects, makes use of high-tech digital design and fabrication techniques while also implementing passive thermal strategies reminiscent of the vernacular archetype. However, at first glance, the attitude around material articulation does not explicitly depict that of a hybrid tectonic (Figure 19).

It is to be remembered that global tectonics can be defined as the realm of universal technologies including “industrialised processes of mass production, mechanised production, and digital design and production.” (Louw, 2021: x). This means that when development within this realm takes place in isolation, the results align with high-tech breakthroughs that are beneficial to the world, in turn, portraying a general identity of universality (Louw, 2021: x) (Figure 21). This is not to say that the development of global tectonics should be ignored, however, its development in isolation still leaves one questioning the dilemma around an appropriate architectural identity for the South African built environment.

In accordance with the data collected, there seems to be a strong correlation between the employment of low-tech local tectonics and a critical response to contextual factors such as topography, culture, and historical narratives. Due to the low-tech nature of these projects, it enables the architects to incorporate unskilled labour forces (usually local people in and around the site) (Figure 18). At first glance one is able to see how the architectural intervention is of its place. The ways in which materials are articulated, and construction processes take place produces a tectonic language that tells a story about the place in which it sits. Principles associated with the local tectonics are extremely valuable in helping define an appropriate architectural identity. However, developing this realm of tectonics in isolation sidelines the necessity for technological development that competes with global standards.

Therefore when considering the implementation of a hybrid tectonic language within South Africa’s built environment either end of the spectrum should be exaggerated with intentions of finding the best middle ground. Global trends associated with advanced manufacturing, digital fabrication, automated construction, prefabrication etc. should be explored and studied in close proximity to the potential in eco materials such as clay, thatch, cork, bamboo etc. Examples of what this would look like are as follows:

- 3D printing adobe wall systems
- Advanced manufacturing of composite thatch insulation systems
- Digital fabrication of clay building systems

This allows for the coexistence of both digital and handbased craftsmen within South Africa's built environment. In this manor both realms of technological development and the instantiation of a relevant architectural identity are catered for.

In order to push the hybrid tectonic narrative within South Africa's built environment further research on the topic should consider the following themes:

- Ways in which hybrid tectonic theory and practice could be introduced into existing university level education curriculums as a means of competence and skills development
- The effects of instantiating a hybrid tectonic language within South African cities (Large scale hybrid tectonic implementation)
- The potential behind hybridising eco-materials and automated construction technologies (e.g. 3D printing adobe wall systems)
- The potential behind fast tracking the use of a hybrid tectonic language through integrating research departments within architectural firms, construction companies, engineering firms etc.

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Figure 18

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Figure 20

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Figure 21

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Figure 22

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13. ANNEXURE A

Live Precedent Taxonomy Link: https://docs.google.com/spreadsheets/d/1QQUcYHf3VfcJJ-_gq-ZCm1slW0XLF7MNRKIpk4bRGFQ/edit#gid=0