



The Role of Universal Design in Enhancing Safety and Accessibility in Construction Sites in South-South Nigeria

Daniel Ichekani Agada,¹ Jeffery Osayande Guobadia² and Babalola Kayode Ojo³

¹Department of Building University of Uyo, Nigeria. agadaid@gmail.com

²Department of Building University of Uyo, Nigeria. jeff.guobadia@gmail.com

³Department of Building University of Uyo, Nigeria. kayodeo546@gmail.com

Doi : <https://doi.org/10.55248/gengpi.5.1024.2719>

ABSTRACT

This paper seeks to examine UD for the improvement of safety and designing construction sites in South-South Nigeria where construction safety issues and UD limitations are a concern. Many construction projects in the region present serious risks and a lack of safety features and accommodations for lower-ability workers, including disabled workers. The study points out the shortcomings in the practical application of the UD principles which could potentially solve these problems, with a focus on how UD enhances site safety as well as inclusiveness of workers. In a scoping review of literature accompanied by case studies, this research will explore how and why UD can contribute positively to the decreased accidents, increased constructability of an environment as well as the inclusion of construction workers. The guidelines provide advice for UD implementation to policymakers and construction organizations through strategies to improve safety standards in construction sites and implement design options that respect employees' abilities.

Keywords: Universal Design in Construction, Safety and Accessibility on Construction Sites, Construction Industry in South-South Nigeria, and Inclusive Design Practices for Site Safety

1.0 Introduction

1.1 Background

Nigeria's construction industry has long been experiencing safety issues which are characterized by poor safety regulation compliance, limited safety education, as well as the utilization of lower-quality materials (Ogundipe, Ogunbayo and Aigbavboa, 2023). In South-South Nigeria, a situation that could easily precipitate construction disasters is made worse by the high rate of urban development. Most construction workers, according to Ammad et al. (2021), work in risky environments with inadequate personal protective equipment hence more casualties, injuries, and deaths are common occurrences. Besides, poor site planning, few safety audits, and inadequate safety policies make these complexities worse for the workers and the visitors, who may be at risk. The problem now is that several construction companies lack a robust safety culture, and safety is the last thing companies think of, as the main concern is to finish the project and save money (Claxton, Hosie and Sharma, 2022).

Accessibility and safety play a paramount role in construction sites since they affect the health of the workers as well as the efficiency of the work done. Design for an accessible construction site allows all employees with disabilities to move around the construction site safely, and with ease, to do their work (Moon, Bake and Goughnour, 2019). Many sites in Akwa Ibom are physically inaccessible due to the absence of features such as ramps, well-lit pathways, and safety information for physically disabled individuals. Regulations including correct erection of the scaffold, fall protection, and emergency egress are usually inadequate putting the workers at the peril of getting involved in accidents (Forteza, Carretero-Gómez and Sesé, 2020). Construction site accessibility and safety not only avert workers' mishaps but also augment efficiency since several workers are unlikely to suffer work intermissions resulting from hazardous environments.

These difficulties are independently solved by Universal Design (UD) which is aimed at developing design concepts, that take into account the necessities of all individuals in an enhanced safety and functionality of the object. UD also targets factors such as ease of access to the environment, safety as well as flexibility of use to suit as many persons as possibly including the disabled (Moon, Baker and Goughnour, 2019). In the specific case of the construction industry, UD implies constructing construction sites that are safe and accommodate the variability of the workers. This may include applying ergonomic designs, simple signs, and invulnerable structures that enable the execution of safety measures and promote the efficiency of the integration of disabled people in the workplace (Kapsalis, Jaeger and Hale, 2024). Therefore, the implementation of UD assesses and promotes accessibility in construction firms in Akwa Ibim improving site access and minimizing hazardous incidences, thus conforming to safety practice in safety management internationally.

1.2 Research Problem

The construction industry in South-South Nigeria, like most other nations' construction industry, as opined by Carlsson et al. (2022), and Bailey et al. (2022), has several challenges in construction site safety and accessibility by disabled persons or other people with certain physical disability. The fact that construction work is not a static type of work that involves heavy machinery, high-risk materials, and uncertain conditions enhances the facets mentioned above. Construction sites often fall short when it comes to safety boundaries, signs, or considerations made with workers of all kinds in mind (Swuste et al., 2021; Alejo, Aigbavboa and Aghimien, 2024). Employees frequently walk on unstable and unlit floors, ramps, and stairs risking their lives on unsafe scaffold structures. This is made worse by the lack of well-laid-down infrastructure like ramps, proper stairs, and rest areas, which makes it difficult for the physically disabled to access the space. They not only endanger the lives of the workers but are also negligent of their performance in the accomplishment of tasks.

Furthermore, inadequate implementation of the integrated design concepts into construction sites poses a severe impact on both safety and accessibility (Samsudin et al., 2022). People with disability have the same right to access housing as those capable of fixing structures themselves; however, little thought about the UD, which calls for the development of spaces that can be used by everybody, is given whenever such structures are constructed. Since UD principles are not followed there are no construction sites that are friendly to workers with disabilities or any other physical challenges (Alkali, Wakawa and Husaini, 2024). This exclusion reduces their efficiency at work, puts them at high risk of having an accident, and allows them to work is often restricted. The inability to address the need for inclusive design also means that construction organizations, government, and other stakeholders deny themselves the opportunity to encourage the development of a safe and inclusive construction environment internationally, for South-South Nigeria in particular.

The purpose of this research, therefore, is to establish the value of UD in increasing safety and access to construction sites in South-South Nigeria. It aims to identify how these principles of design for anyone, which include answering the needs of the underprivileged concerning accessibility and usability can reduce risk and enhance the outcome of safety in the construction sector. More specifically, the goals involve pinpointing present-day obstacles concerning site safety and accessibility to persons with disabilities, evaluating how UD principles might assist in solving these problems, and suggesting directions on how designers might apply these principles to the construction employment context in a way that will assist a wide array of employees, including those with disabilities.

1.3 Significance of the Study

This research helps fill gaps in current knowledge about safety management and the integration of UD concepts in construction site safety. Prior literature has devoted much attention to construction site safety issues however limited literature has been directed toward the applicability of the concept of inclusive designs, particularly within the framework of developing Nigeria (Osuji, Ugbebor and Igwe, 2020). This study aims to explore the integration of UD principles including equitable use, simple and intuitive interface, and accessibility to all users, there is a research gap. The results will give insights on the way design decisions affect the safety and inclusion of diverse workers including workers with disabilities, making safety interventions a wider approach beyond the conventional hazard control.

Additionally, the study has implications for policy regarding assessment and compliance with construction sites in Nigeria. This research could also be useful to government regulators and the transportation industry by shedding light on how UD can help decrease the number of accidents by implementing more comprehensive design policies (Khan and Das, 20024). It might also help policymakers to establish and implement construction safety standards reflecting the goal to protect workers and provide equal access to construction facilities for everybody, as references to world practice. Furthermore, this research can contribute to a campaign for more investment in design education within the construction practice and an increased understanding of design requirements among professionals throughout Nigeria to improve construction environments (Aliu, Oke and Oni, 2024).

2.0 Literature Review

2.1 Overview of Universal Design (UD)

Universal Design (UD) is the design processes of products, environments, and systems in a manner that everyone can use them, and this does not require any additional changes (Schreffler et al., 2019). The idea was born in the late 20th century with Ron Mace, an architect who worked for the development of a space that could be used by all individuals without prejudice, particularly for the disabled, the elderly, and children (Sholanke, Adebayo and Alagbe, 2019). Mace's vision meant going from the current idea of designing for disabled people back to the notion of designing for all types of human diversity. Throughout the years, UD has been implemented in numerous fields in different aspects of life such as architecture, product design, transportation, and technology among others, and has ensured improvements of enhancing to accommodate the needs of everyone.

UD, according to Moore, Boyle and Lynch (2023), and Alkali, Wakawa and Husaini (2024), is based on seven assumptions that are useful in structuring the application of the concept across domains. There is **Equitable Use** which ensures that the design is usable and attractive to people of all physical capabilities, and **Flexibility in Use**, which ensures that the design works well for as many people as possible. There is also the **Simplicity and Ease of Use** principle which means that the products are to be easily understood by every single user, including those with low technical abilities. Other principles include **Perceptible Information**, whereby the design effectively communicates the required information to the users or form and fit whereby the design accommodates the dimensions of all users, regardless of their size, posture, or mobility, and **Tolerance for Error**, whereby hazards

and adverse effects of accidental actions are minimized and **Low Physical Effort**, whereby it is possible to use the design without excessive strain. Each of these principles collectively makes up the basics of UD to ensure environments that meet the needs of all people regardless of their nature.

2.2 Universal Design in the Context of Construction

Universal Design for Construction refers to making construction as comfortable and safe for all individuals irrespective of their age, disability, or ethnic Minority (Olodeoku et al., 2024). In construction site design, for example, concepts such as extending the range of the design to meet the needs of a diverse population, using a flexible design that can be adapted to various uses, and designing something that can easily be understood can translate to safe and easy access to a construction site for workers and other persons who may visit the site. Applicable subcategories of UD in construction include unobstructed, wide spaces that allow easy maneuverability for disabled persons easily adjustable mechanisms and tools due to workers' fatigue-prone nature, and conspicuous and clear signs compared to non-UD ones (Kapsalis, Jaeger and Hale, 2024). The integration of UD will allow construction sites to design spaces that can comfortably allow workers from the disabled population to work within the sites while at the same time improving site functionality and safety.

In global construction projects, various examples have been implemented with UD principles to enhance safety and access. For example, construction firms in Japan have put barrier-free designs on their sites, such as ramps, wide corridors, and accessible toilets for both employees and visitors with disability (Xu, 2022). Similar to this, construction sites in Sweden have also been constructed based on UD principles whereby for instance, construction workers are provided with ergonomic proposed designs and enclosures that can easily and smoothly adapt to the physical capability of various construction workers on site. Universal design in the United States is used more and more systematically in large-scope construction projects, especially in construction in cities, and the main concern is the possibility of accidents when working for all workers and operators to have access to all the areas of the site (Raouf and Al-Ghamdi, 2019). The above examples clearly show that UD principles do not only enhance safety and accessibility but also add value to constructing efficient and productive construction processes.

2.3 Safety and Accessibility Challenges in Nigerian Construction

The safety situation of construction sites in South-South Nigeria is a major problem due to poor compliance with safety measures, enforcement of safety regulations, and low safety consciousness of the workers (Okorie and Anugwo, 2023). Most construction companies in Nigeria fail to maintain strict standards in policy implementation and thus often experience many accidents, injuries, and even deaths. Gloves, helmets, and safety shoes are worn occasionally, and widespread noncompliance with signs regarding safety procedures holds. Simple safety check physically shows up at a company are either sporadically or taking place only on the surface (Dyrborg et al., 2022). More so, construction companies in South-South Nigeria, especially SMEs, take measures such as cost constraints over the protection of workers. Because of this apparent lack of safety consciousness combined with the laxity of regulatory authorities in placing and enforcing safety standards, many working places in these construction projects are fraught with a very high possibility of accidents and unsafe working conditions for both labour and contract workers.

Transportation on construction sites in Nigeria is a major concern specifically for persons with disabilities and those with restricted mobility (Duri and Luke, 2022). Stakeholders have established that most construction sites in Nigeria do not take into consideration the accessibility of structures under construction as well as do not have ramps, broader paths, and accessible infrastructures in place. It therefore becomes a challenge for such working disabled persons or visitors with disability to access such sites easily without risking their lives. Furthermore, there is a low understanding and practice of the Universal Design principles that should be practiced in construction (Kristl, Temeljotov Salaj and Roumboutsos, 2020). Thus, mobility issues persist both for the workers and the potential users of the constructed structures, indicating the general absence of sufficient attention to inclusiveness in construction industries all over Nigeria.

2.4 Benefits of Universal Design in Construction

The use of UD in construction is a noble idea because it improves the safety of all workers despite the state of their physical well-being. Including ergonomic designs, the UD helps to design working spaces that correspond to the range of movements that the human body is capable of, and when the working conditions and tools are not properly designed the person is likely to get an injury due to using his body in awkward positions (Crawford et al., 2020). A primary principle of UD, clear pathways, enhance mobility around the sites, and reduce incidences of accidents resulting from obstructed areas or poor sight. For instance, smooth, properly painted walkways with adequate barriers minimize the risk of developing tripping dangers in ways that will enhance mobility for the workers as well as guests (Sochor, 2021). Also, UD reflects essential aspects of design related to understanding or not drastically changing components, for instance, easily reachable controls or equipment that would otherwise end up being mishandled or leading to accidents on construction sites.

In addition, UD is very central in enhancing Diversity and Integration for a diverse workforce by including persons with disability. In this way, UD helps more construction workers, including those with physical or cognitive impairments, to be able to get on-site and be a part of the construction work (Umeokafor and Okoro, 2020). Installations like ramps, broader doors, and movable workstations allow the physically limited mobility worker to execute the tasks most efficiently and safely. For clients with hearing or sight issues, UD principles may span features of tactile signals or audible items that provide notice of the area. Finally, UD contributes to creating work conditions and a poly-functional environment for each worker; it also helps increase safety at the workplace as well as increase organizational effectiveness (Tamers et al., 2020).

2.5 Gaps in the Literature

Literature gaps indicate that there is a dearth of research in Nigeria and specifically little research on the application of UD principles to improve construction site safety and access. Previous research reveals that UD is useful in enhancing safety and promoting accessibility for everyone, however, research on its implementation in Nigeria's construction industry, South-South Nigeria inclusive is very rare (Cumming and Rose, 2022). This gap means that regarding local contextual features which include regulatory environment, culture, and availability of resources, there is still very little known about how they influence UD implementation. Moreover, the relationship between UD and safety risks particularly in Nigerian construction sites encompassing high accident frequency, and insufficient assistance to disabled workers, has remained understudied, so more contextual investigations are required.

3.0 Methodology

3.1 Research Design

This study adopts a secondary design with an emphasis on an exhaustive evaluation of case studies undertaken in South-South Nigeria (Kumara, 2022). This approach entails reviewing research papers that adopt a qualitative approach to examine related topics on safety, accessibility, and construction management. Through these case studies, the research intends to apply methodologies, findings, and context relevant to the region especially in the construction industry (Lima et al., 2021). These secondary studies contain important information specifying the ways UD principles have or can be employed to improve safety and access on construction sites, as well as comparative evaluations, and research limitations, particularly in South-South Nigeria. This method enables researchers to adopt primary accounts where the practices are situated and use secondary sources for richness and detail.

3.2 Research Method

This study utilizes a qualitative research method with the systematic literature review (SLR) framework utilizing the funnel approach identified in the research questions to assess how Universal Design (UD) can be used to improve safety and accessibility in construction sites in South-South Nigeria (Busetto, Wick and Gumbinger, 2020). SLR shows that to conduct a thorough review, both inclusion and exclusion criteria should be well defined, as well as the process of selection of the studies to be included and the process of the critical analysis of the findings (Sauer and Seuring, 2023). This method offers a strong background to the current status of UD implementation in construction, safety, and accessibility contexts. The funnel approach, starting from the identification of UD practices in other countries and refining the results down to the Nigerian and construction sites in the South-South region, enables the identification of key drivers and barriers to implementation (Shafiee et al., 2020). From this convergence, the study reveals gaps in practice and knowledge to foster a discussion on enhancing site safety and accessibility through UD principles.

3.3 Study Area

South-South Nigeria, which comprises Akwa Ibom, Rivers, Cross River, Bayelsa, Delta, and Edo states, is a prolific area in the exploration of oil and gas resources which has occasioned massive demand for infrastructural construction (Ighedosa, 2019). However, the integration of such Universal Design (UD) principles in the construction industry of this region is still very low. Unfortunately, the majority of construction work still has weak properties related to design and architecture, exceptional importance is not paid to barriers for the disabled and disabled population. Although Nigeria is gradually blurring the rural/urban divide and stepping up its speed in industrializing the country, the incorporation of UD to improve safety and accessibility in construction sites has not been a priority which is an indication of other infrastructural impediments in Nigeria's construction industry (Young, Wagenfeld and Rucker, 2019). This thus requires the enhancement of awareness and implementation of UD principles to enhance and create safer physical spaces for both public and private construction.

3.4 Data Collection Methods

The data for this research will be collected from secondary sources to establish the background on the implementation of UD in the construction industry of South-South Nigeria (Ruggiano and Perry, 2019; Li, Higgins and Deeks, 2019). Secondary data will be collected from peer-reviewed journals, industry articles, and other literature sources concerning construction safety, accessibility codes, and UD principles. These sources will provide information on current policy, legislation, standards, and other relevant guidelines (Da Costa et al., 2020). Overall, this review will assist in determining whether and in which manner UD principles are incorporated into site management practices in the region.

3.5 Inclusion and Exclusion Criteria

The inclusion criteria for this on the experience of UD in improving safety, and access on construction sites in South-South Nigeria Construction is proposing to gather only the secondary sources of data from the published scholarly articles, grey literature, government documents, and case studies that address the construction site safety, accessibility and UD in Nigeria and other developing countries (Yasin et al., 2020). Firstly, only studies published in the last 7 years (2018 – 2024) will be considered to ensure that the evidence gathered reflects the current practice settings. It will include keywords and phrases such as “**Universal Design in Construction,**” “**Safety and Accessibility on Construction Sites,**” “**Construction Industry in**

South of South Nigeria,” and **“Inclusive Design Practices for Site Safety”**, from JSTOR and Google Scholar databases (Gusenbauer and Haddaway, 2020). Excluded from this study will be information that lacks construction practices in other geographical locations that may not be relevant to Nigeria, information that is outdated, and information from non-peer-reviewed sources. Furthermore, the studies, that do not consider safety and accessibility issues of construction or did not connect with Universal Design principles, will be ignored.

Table 3.1: The Data Search Process

Keywords	First Search	Refined Search	Further Search	Refined	Adopted Themes
Universal Design in Construction	18,400	2,875	213		6
Safety and Accessibility on Construction Sites	17,700	2,189	191		6
Construction Industry in South-South Nigeria	19,278	1,070	76		4
Inclusive Design Practices for Site Safety	16,300	1,010	87		8

3.6 Data Analysis

Data analysis for this study will use thematic analysis to analyze the data collected systematically and analyze the data collected to thoroughly understand the issues to do with safety and accessibility and the extent to which UD principles are being considered in construction sites in South-South Nigeria (Braun and Clarke, 2019; Castleberry and Nolen, 2018). This process will include a thematic analysis of data collected from previous studies, particularly those that adopted interviews with selected clients, observations made during the assessment of the selected sites, and site reviews in their studies, which will help in identifying safety trends, accessibility constraints, and levels of UD deployment. The identified themes will then be matched against the identified principles of UD encompassing equitable use, flexibility, and simplification of construction to assess current construction practice's conformity to these global standards (Munaro and Tavares, 2023). This comparison will help further evaluate how UD has facilitated the improvement of safety and accessibility and show also how the construction sites in the region differ from ideal ones.

4.0 Analysis of Findings

4.1 Findings from Adopted Studies

The concept of UD in the construction industry and more specifically its application to safety and access has received increasing focus in recent literature. In their recent paper, Watchorn et al. (2021) emphasized that occupation should be recognized as a central consideration in the future development of UD in the built environment. Together, in their integrated literature review, they find that the implementation of UD goes beyond the creation of ornamented object features; it requires reconsidering the objects' useful elements inclusive to the user groups with disabilities. This concept is also supported by Young et al (2019) on the aspect of occupational therapy and interprofessional design teams for a combined approach to the implementation of UD principles into the built environment for a better safer and more effective environment.

Another factor that is worth mentioning is the legislative one regarding UD application within the construction industry. Sholanke et al. (2019) examine the extent to which building development regulatory legislation meets the needs of Ogun State, Nigeria, and states that, for construction industry stakeholders to achieve UD standards, appropriate policies are crucial. Alkali and colleagues (2024) propose that public infrastructure projects, including the proposed North East Development Commission's headquarters in Maiduguri, Borno State, must incorporate inclusive design principles. This paper suggests that for regulatory instruments to promote UD practices and outcomes such as safety for all users, there is a need for strong and vigorous enforcement.

Specifically, in terms of concerns for certain safety practices that are implemented and perceived in construction sites, Yap and Lee (2020) analyze motorist and pedestrian risk factors influencing safety outcomes. In their systematic review, they note that while PPE and hazard perception training are standard, there remains a major implementation shortfall in complete safety plans that factor in the variance in workers' circumstances. This concern is also supported by Nnaji et al. (2020) who called for the use of technology to enhance safety in construction work zones. Using the Principles of UD, their systematic review points out that the implementation of technological solutions can greatly improve safety experiences which in turn would benefit vulnerable groups, in like manner.

Furthermore, the significance of access in architecture and infrastructure is acknowledged in different research, such as Carlsson et al. (2022) and Mohapatra et al. (2024). These reviews highlight that while it is understood that there is a requirement to design and provide public-use buildings for physically handicapped people then various construction projects do not include basic components of architecture which help to allow barrier-free access to disabled people. This effectively restricts the possible range of candidates for employment as well as poses potential unsafe conditions because proper access measures that should have been put in place will lack compliance and will contribute to accidents and even injuries. In line with this, Ibrahim et al. (2022) pointed out that for the gaps in safety and accessibility to be closed, and construction engineering and management research

community to advocate for an inclusive and barrier-free construction domain that supports UD principles, the concepts of Design for Safety (DfS) have to be adopted fully.

4.2 Analysis of Findings

As a result of the multifaceted nature of architecture and construction, the concept of UD has gradually gained popularity for the improvement of the spaces for vulnerable populations. Studies have identified a research gap in UD about occupation as the key to the consideration of socially constructed aspects in built environments. This suggests that occupational therapy professionals should engage in the process of design with design professionals to generate spaces that are safe but also functionally and occupationally appropriate for their intended users. It suggests that somehow such collaboration could enhance the design gains for all occupants, and as such, designing should accommodate a variety of needs.

Another source, also consistent with the need for designing with interprofessional teams, is the scoping review by Young et al. (2019). The review explains, for example, that the relationships between architects and occupational therapists come together to create built environments that are safer for users and especially members of vulnerable and disadvantaged organizations. This form of integration is greatly important in the context of Nigeria because the construction methodology that is mainly used in the country does not acknowledge the integration of people with disabilities. These studies imply that concepts and ideas from various professions can be used to enhance the formulation of effective safety policies and features that satisfy the needs of consumers in construction projects, hence, enhancing a positive construction consumer experience.

However, the above literature review shows there is still more to be done in the actualization of UD principles across Nigeria. Sholanke et al. (2019) have done the same for Ogun State regulatory instruments for UD practices and have found that there is an existing problem with the Nigerian construction regulation that rarely ensures UD. Such a deficiency in regulation means that adequate security isn't guaranteed, and that accessibility is often poor on construction sites, as the authors pointed out by Nweke and Nouban (2020) for improving health and safety regulation and training in the construction industry. This is so because there is little knowledge or training on UD among construction professionals, as noted in various works, such as Ayegba et al. (2022), noting a lack of understanding of the concept of inclusive design or UD, in particular, to do with enhancing safety and accessibility.

In addition, the thematic review conducted by Samsudin et al. (2022) on the PtD concept also highlights the need to integrate safety concerns right from the design stage of construction projects. Such a proactive approach is compliant with UD principles and can help prevent risks that emerge because of a lack of proper safety measures. The case study highlighted by Famakin et al (2022) in the management of facilities for the elderly and Persons with Disabilities informed the paper's rationale that inclusive architecture should remain an irreducible feature in construction projects. Given the fact that Nigeria is still struggling with infrastructural development, the inclusion of the UD and PtD principles into building practices could have the added advantage of improving means of access/safety as well as creating a culture that supports the needs of everyone in the built environment.

4.3 Discussion

This research was conducted to provide empirical evidence of the effectiveness of UD in enhancing safety and access to construction sites in South-South Nigeria where typical construction projects do not account for the learning impaired or disabled persons among other groups exclusion. Some of the studies presented underline the necessity of applying UD principles to the built environment and improving safety and accessibility. For example, Watchorn et al. (2021) point out that occupation must be prioritized in UD discussions and the process must be made more oriented to users' experiences. In a similar vein, Young and colleagues (2019) explain how interprofessional design teams can improve the efficiency of UD in meeting OT solutions, stating that cooperative efforts from different actors in the building process make a UD approach valuable. Following the above principles, this research seeks to contribute to existing research and practice in the construction sector where risk management predominantly considers employable workers leaving workers with disability more vulnerable and prone to accidents.

Assessing the current issues of on-site safety and access is imperative for the construction industry in South-South Nigeria because the literature shows many weaknesses in the current laws and practices. In a similar study on building development legislation in Ogun State, Sholanke et al. (2019) point to the problem of an absence or ineffective regulation that can support UD in Nigeria. This research shall evaluate these challenges to the overall objective of the research, which is to determine how Universal Design can reduce the risk and enhance the safety of the workers. For example, Feleke and Feleke (2024) observe that UD has the potential to make the workplace safer and secure by promoting inclusive design principles on large construction projects. Furthermore, Famakin et al. (2022) have pointed out that the presence of guidelines specifically for elderly workers can help gain an understanding of how the living environment and safety for various worker categories can be improved; they stressed that accessibility issues are a factor that defines general safety performance.

To provide some indications for future practice concerning the direction of application of UD principles while working within the construction employment context, this study will refer to such findings that describe successful cases and the outcomes linked with them. For example, Carlsson et al. (2022) did a scoping review comparing accessibility to public buildings and established the starting point for exploring how similar approaches can be used for construction site safety and accessibility. In addition, Nnaji et al. (2020) and Mohapatra et al. (2024) established the positive side of technology on the enhancement of safety measures something that can go hand in hand with UD principles to come up with coordinated measures towards construction sites. In doing so, this study seeks to provide a set of guidelines for designers and policymakers to consider in the attainment of UD for the construction industry to promote the safety and accessibility of workplaces for disabled employees.

4.4 Comparative Analysis

The review of scientific papers that introduced or did not introduce the principles of UD, showed that there are considerable distinctions when it comes to changes in the safety and accessibility of construction sites. Watchorn et al., 2021 and Young et al., 2019 shed considerable light on the advantages of UD in designing solutions that promote the physical accessibility of products for all users, not least disabled ones. The results of these works stress the involvement of occupational therapists and other professionals as members of the interprofessional team when implementing UD to improve safety and access in built environments. However, recent studies by Sholanke et al. (2019) and Ibrahim et al. (2022) show that there is a lack of proper UD implementation in many construction projects in Nigeria, mainly because of inadequate commitment to the legislation and regulation and lack of understanding of the potential advantages in the long term. This gap often causes exclusionary designs that diminish the considerations of physically impaired people or anyone who needs ergonomic designs to reduce safety hazards and access barriers.

It is possible to identify the effect of UD principles on safety incidents and accessibility barriers in projects that incorporate UD principles into the design process. Hassan and Alves (2021) and Carlsson et al. (2022) find that UD greatly benefits safety by making site navigation easier, addressing risky design features, and whether routes are well-lit and unobstructed. On the other hand, the sites that do not incorporate the concepts of UD, tend to have higher incidence levels and barriers to accessibility, as presented by Mohapatra et al., (2024), where people with mobility impairments experience challenges in accessing public spaces because of the architectural barriers. Comparing construction sites that use UD and those that do not, the information obtained from sites using UD is significantly lower in accident rates as well as higher satisfaction ratings among the workers and visitors embracing the UD environment further emphasizing the significant role of UD in enhancing safety and accessibility on construction sites.

4.5 Recommendations Based on Findings

According to the conclusions made, enhancing site safety through optimal design cannot be effectively pursued through a functional application of UD principles exclusively. There is much that construction firms can do to ensure that they incorporate accessibility features including ramps, wide pathways, and comfortable working/stationary spaces for workers and clients with disability (Eastman, 2018). Safety can also be improved by such features as signs, slip-resistant features for the blind, and convenient means of escape that everyone can find. Construction sites should be designed to avoid hazards like projects with sharp corners, slippery foundations, or areas with poor lighting, and thus; UD principles are applied in making such environments safe and suitable to all (Ndiwa, 2020; Mishra, Shrestha and Aithal, 2022). In addition, involving safety officers, occupational therapists, and engineers at the early stages of construction work implies safety consciousness and accessibility with the design process that prevents future accidents among site workers.

In essence, regarding policy prospects, the government and the construction authorities in Nigeria should encourage policies to adopt the UD principle that will set higher standards for construction projects (Omopariola et al., 2024). This could include reviewing the building code to ensure there is provision for persons with disability, for instance, having barrier-free buildings, and amidst the construction period, it is necessary to practice periodical check-ups. Governments should also promote UD practices through awards, subsidies, or tax exemptions, especially for construction firms (Díaz-López et al., 2021). Furthermore, there should be awareness creation concerning UD so that people understand it is for persons with disabilities and general site user safety and efficiency. Ongoing training for architects, engineers, and site managers on integrating UD should be encouraged to develop a sector perspective (Moreno, Olbina and Issa, 2019). When implemented systematically in policies and procedures, Nigeria is positioned for major improvements in construction safety, accessibility for persons with disabilities, and UD.

5.0 Conclusion

5.1 Summary of Key Findings

The results of the study suggest that UD has the possibility of enhancing significantly safety and access on construction sites in South-South Nigeria. The essential principles of UD, which include designing for flexibility, accessibility, and ergonomic functionality, can help construction sites address the variability of workers, including the disabled ones (Narayanan and Terris, 2020). Notable elements on the site may help avoid or minimize incidents that would lead to injuries and in addition, assist in easy movement of all workforce hence increasing safety. Besides, UD application in construction also improves site access and means that those individuals who have physical restrictions can work in the outlined manner (Moon, Baker and Goughnour, 2019). Inadequate lighting, instability of the terrains, and absence of accommodation make certain workplaces dangerous, especially to the vulnerable personnel UD tips overcome these disadvantages hence lowering dangers connected to the working settings. The result of the study indicates that the practices of incorporating UD in the construction could enhance worker's safety and improve accessibility at the workplace, beneficial to both employers and employees in providing and attaining international safety standards.

5.2 Implications of the Study (Theory and Practice)

The implication of this study is a clear indication of how UD can potentially bring about improvement in safety and construction site environmental accessibility in construction projects in developing countries such as Nigeria. In this respect, the findings of the study support the argument that it is important to work towards contextualization of UD in the development context as suggested by Galkiene and Monkeviciene (2021). For example, UD promotes design for all with accommodation of; flexibility, accommodating users of different disabilities. This translates in developing countries, into

creating construction environments that are not only framed by international best practices but also shaped by factors including limited resources, poor legislation, and cultural perceptions of disability. This paper furthers theoretical knowledge about inclusive design's application to the socio-economic reality by providing an empirical illustration of how UD can prevent accidents at work, increase worker productivity, and enhance workplace accessibility for people with disabilities.

In practical terms, the study provides useful recommendations to construction managers and policymakers in Nigeria. Construction managers are urged to incorporate aspects of UD into the construction design of sites so that features such as ramps, adequate lighting, and ergonomics are incorporated as regular features in construction projects (Ochieng, Onyango and Wagah, 2021). It not only enhances protection but also provides an opportunity for workers with such constraints to work as intended. For policymakers, the work recommends increased enhancement of safety standards that adopt aspects of UD. Furthermore, the Nigerian government can start policies and constructions in those ways through which the working conditions on construction sites should be improved and the rate of accidents should be reduced so that all workers can have an equal employment environment and provisions for the most accessible built environment can be provided easily.

5.3 Limitations of the Study

This study has a few limitations that may reduce the generality of the results observed. More seriously, there are some restrictions to the scope, as the study is carried out only on construction sites located in South-South Nigeria; therefore, it can be restrained by different regulatory factors, cultural background, or even the level of construction practice in this area compared to other regions (Ranta et al., 2018). Furthermore, limited firsthand data or very recent data also come from secondary data sources and case studies derived from existing literature. The lack of field investigation and a sample size that is thought to be smaller may reduce the depth in which comprehension of the practice of UD in various construction situations is attained; therefore, some of the results may not depict the typical challenge and prospect in the Nigerian construction industry fully (Giner-Sorolla et al., 2024).

5.4 Recommendations for Future Research

Future research should consider the long-term impact that UD has on the productivity of workers, especially in construction sites in South-South Nigeria. Research could look at the effects of long-term violation with UD principles including ergonomic equipment placements and easy site plan or the consequences that have enhanced safety, productivity, and the well-being of the workers in the long run. Furthermore, the comparison of experience with UD practice in other zones, the North-Central or the South-western zone, would help compare and contrast the influence of geographical, cultural, and regulation aspects on achieving appropriate safety and accessibility. Studying these differences might assist in improving the application of UD strategies for the whole country by customizing strategies to suit certain regions within the country.

References

- Ajani, A.A. and Olapade, D.T., 2024. Building design considerations for healthy and active aging-in-place. *International Journal of Building Pathology and Adaptation*.
- Akinluyi, M.L., Awe, F.C., Yakubu, S.U. and Ajiboye, O.I., A Review of Architectural Design Standards for Urban Housing Security and Safety in Nigeria.
- Alejo, A., Aigbavboa, C. and Aghimien, D., 2024. How Can Safety Contribute to Working Conditions in the Construction Industry? A Conceptual Framework. *Sustainability*, 16(18), p.8213.
- Aliu, J., Oke, A.E. and Oni, S.B., 2024. Evaluating strategies to promote mechatronics deployment in AECO projects: a Nigerian construction practitioners' perspectives. *International Journal of Construction Management*, 24(14), pp.1540-1549.
- Alkali, A.A., Wakawa, U.B. and Husaini, I.U., 2024. Adopting Inclusive Design Principles for the Proposed North East Development Commission's Headquarters in Maiduguri, Borno State. *African Journal of Environmental Sciences and Renewable Energy*, 15(1), pp.160-169.
- Ammad, S., Alaloul, W.S., Saad, S. and Qureshi, A.H., 2021. Personal protective equipment (PPE) usage in construction projects: A scientometric approach. *Journal of Building Engineering*, 35, p.102086.
- Ashour, M., Mahdiyar, A. and Haron, S.H., 2021. A comprehensive review of deterrents to the practice of sustainable interior architecture and design. *Sustainability*, 13(18), p.10403.
- Ayegba, C., Bello, A.O., Olanrewaju, O.I., Afolabi, O. and Ihedigbo, K.S., 2022, February. A review on the awareness and challenges of building information modelling for post construction management in the Nigerian construction industry. INTERNATIONAL AFRICAN CONFERENCE ON CURRENT STUDIES.
- Bailey, S., Carnemolla, P., Loosemore, M., Darcy, S. and Sankaran, S., 2022. A critical scoping review of disability employment research in the construction industry: Driving social innovation through more inclusive pathways to employment opportunity. *Buildings*, 12(12), p.2196.
- Braun, V. and Clarke, V., 2019. Reflecting on reflexive thematic analysis. *Qualitative research in sport, exercise and health*, 11(4), pp.589-597.
- Busetto, L., Wick, W. and Gumbinger, C., 2020. How to use and assess qualitative research methods. *Neurological Research and practice*, 2(1), p.14.

- Carlsson, G., Slaug, B., Schmidt, S.M., Norin, L., Ronchi, E. and Gefenaite, G., 2022. A scoping review of public building accessibility. *Disability and Health Journal*, 15(2), p.101227.
- Castleberry, A. and Nolen, A., 2018. Thematic analysis of qualitative research data: Is it as easy as it sounds?. *Currents in pharmacy teaching and learning*, 10(6), pp.807-815.
- Claxton, G., Hosie, P. and Sharma, P., 2022. Toward an effective occupational health and safety culture: A multiple stakeholder perspective. *Journal of safety research*, 82, pp.57-67.
- Crawford, J.O., Berkovic, D., Erwin, J., Copsey, S.M., Davis, A., Giagloglou, E., Yazdani, A., Hartvigsen, J., Graveling, R. and Woolf, A., 2020. Musculoskeletal health in the workplace. *Best practice & research clinical rheumatology*, 34(5), p.101558.
- Cumming, T.M. and Rose, M.C., 2022. Exploring universal design for learning as an accessibility tool in higher education: A review of the current literature. *The Australian Educational Researcher*, 49(5), pp.1025-1043.
- Da Costa, J.P., Mouneyrac, C., Costa, M., Duarte, A.C. and Rocha-Santos, T., 2020. The role of legislation, regulatory initiatives and guidelines on the control of plastic pollution. *Frontiers in Environmental Science*, 8, p.104.
- Díaz-López, C., Navarro-Galera, A., Zamorano, M. and Buendía-Carrillo, D., 2021. Identifying public policies to promote sustainable building: a proposal for governmental drivers based on stakeholder perceptions. *Sustainability*, 13(14), p.7701.
- Duri, B. and Luke, R., 2022. Transport barriers encountered by people with disability in Africa: An overview. *Journal of Transport and Supply Chain Management*, 16, p.826.
- Dyreborg, J., Lipscomb, H.J., Nielsen, K., Törner, M., Rasmussen, K., Frydendall, K.B., Bay, H., Gensby, U., Bengtsen, E., Guldenmund, F. and Kines, P., 2022. Safety interventions for the prevention of accidents at work: A systematic review. *Campbell systematic reviews*, 18(2), p.e1234.
- Eastman, C.M., 2018. *Building product models: computer environments, supporting design and construction*. CRC press.
- Famakin, I.O., Molusiwa, R. and Aigbavboa, C., 2022. A Review of Facilities Management Guidelines for the Living Environment of the Elderly. In *Construction in the 21st Century 12th International Conference (CITC 12)* (p. 13).
- Forteza, F.J., Carretero-Gómez, J.M. and Sesé, A., 2020. Safety in the construction industry: accidents and precursors. *Revista de la construcción*, 19(2), pp.271-281.
- Galkiene, A. and Monkeviciene, O., 2021. *Improving inclusive education through Universal Design for Learning* (p. 323). Springer Nature.
- Giner-Sorolla, R., Montoya, A.K., Reifman, A., Carpenter, T., Lewis Jr, N.A., Aberson, C.L., Bostyn, D.H., Conrique, B.G., Ng, B.W., Schoemann, A.M. and Soderberg, C., 2024. Power to detect what? Considerations for planning and evaluating sample size. *Personality and Social Psychology Review*, 28(3), pp.276-301.
- Gusenbauer, M. and Haddaway, N.R., 2020. Which academic search systems are suitable for systematic reviews or meta-analyses? Evaluating retrieval qualities of Google Scholar, PubMed, and 26 other resources. *Research synthesis methods*, 11(2), pp.181-217.
- Hazlan, N.H., Radzi, A.R., Yusof, L.M. and Rahman, R.A., 2024. Universal Design Adoption in Housing: A Systematic Review and Future Directions. In *International Conference on Engineering, Project, and Production Management* (pp. 433-456). Springer, Cham.
- Ibrahim, C.K.I.C., Manu, P., Belayutham, S., Mahamadu, A.M. and Antwi-Afari, M.F., 2022. Design for safety (DfS) practice in construction engineering and management research: A review of current trends and future directions. *Journal of Building Engineering*, 52, p.104352.
- Ighedosa, S.U., 2019. Climate Change: Vulnerability of the Niger Delta Region, in Nigeria. *generations*, 1(2), pp.4-5.
- Kapsalis, E., Jaeger, N. and Hale, J., 2024. Disabled-by-design: effects of inaccessible urban public spaces on users of mobility assistive devices—a systematic review. *Disability and Rehabilitation: Assistive Technology*, 19(3), pp.604-622.
- Kapsalis, E., Jaeger, N. and Hale, J., 2024. Disabled-by-design: effects of inaccessible urban public spaces on users of mobility assistive devices—a systematic review. *Disability and Rehabilitation: Assistive Technology*, 19(3), pp.604-622.
- Khan, M.N. and Das, S., 2024. Advancing traffic safety through the safe system approach: A systematic review. *Accident Analysis & Prevention*, 199, p.107518.
- Kristl, Ž., Temeljotov Salaj, A. and Rouboutsos, A., 2020. Sustainability and universal design aspects in heritage building refurbishment. *Facilities*, 38(9/10), pp.599-623.
- Kumara, A.S., 2022. Researching with Secondary Data: A brief overview of possibilities and limitations from the viewpoint of social research.
- Lakhani, A., Zeeman, H., Wright, C.J., Watling, D.P., Smith, D. and Islam, R., 2020. Stakeholder priorities for inclusive accessible housing: A systematic review and multicriteria decision analysis. *Journal of Multi-Criteria Decision Analysis*, 27(1-2), pp.5-19.
- Li, T., Higgins, J.P. and Deeks, J.J., 2019. Collecting data. *Cochrane handbook for systematic reviews of interventions*, pp.109-141.

- Lima, L., Trindade, E., Alencar, L., Alencar, M. and Silva, L., 2021. Sustainability in the construction industry: A systematic review of the literature. *Journal of Cleaner Production*, 289, p.125730.
- Mishra, A.K., Shrestha, S.P. and Aithal, P.S., 2022. Application of Safety by Design for the Hazards Identified at the site of Burtibang Paudi-Amarai Tamghas Sandhikharka Gorusinghe 132 kV Transmission Line Project, Nepal. *International Journal of Case Studies in Business, IT and Education (IJCSBE)*, 6(1), pp.366-386.
- Mohapatra, S., Maiya, G.A., Nayak, U.U., Benny, L., Watson, J., Kinjawadekar, A. and Nandineni, R.D., 2024. Centering Social Justice and Equity in Research on Accessibility to Public Buildings for Individuals with Mobility Disabilities: A scoping review. *F1000Research*, 13, p.930.
- Moon, N.W., Baker, P.M. and Goughnour, K., 2019. Designing wearable technologies for users with disabilities: Accessibility, usability, and connectivity factors. *Journal of Rehabilitation and Assistive Technologies Engineering*, 6, p.2055668319862137.
- Moore, A., Boyle, B. and Lynch, H., 2023. Designing for inclusion in public playgrounds: a scoping review of definitions, and utilization of universal design. *Disability and Rehabilitation: Assistive Technology*, 18(8), pp.1453-1465.
- Moreno, C., Olbina, S. and Issa, R.R., 2019. BIM use by architecture, engineering, and construction (AEC) industry in educational facility projects. *Advances in Civil Engineering*, 2019(1), p.1392684.
- Munaro, M.R. and Tavares, S.F., 2023. Design for adaptability and disassembly: guidelines for building deconstruction. *Construction Innovation*.
- Narayanan, S. and Terris, E., 2020. Inclusive manufacturing: The impact of disability diversity on productivity in a work integration social enterprise. *Manufacturing & Service Operations Management*, 22(6), pp.1112-1130.
- Ndiwa, S.C., 2020. *Ergonomic risk factors among workers in building construction sites in Mombasa County* (Doctoral dissertation, JKUAT-IEET).
- Nieto, M.A. and Murzi, H., 2024, February. Challenges and opportunities to address diversity, equity, and inclusion within the professional construction industry. ASEE Conferences.
- Nnaji, C., Gambatese, J., Lee, H.W. and Zhang, F., 2020. Improving construction work zone safety using technology: A systematic review of applicable technologies. *Journal of traffic and transportation engineering (English edition)*, 7(1), pp.61-75.
- Nweke, K.I. and Nouban, F., 2020. Enforcement and Education of Health and Safety in the Construction Industry In Nigeria. *Academic Research International*, 11(4), pp.16-22.
- Ochieng, A.M., Onyango, G.M. and Wagah, G.G., 2021. Evaluation of incorporation of universal design parameters in the planning approval process of Kisumu Main Bus Terminus. *East African Journal of Arts and Social Sciences*, 3(1), pp.12-23.
- Ogundipe, K.E., Ogunbayo, B.F. and Aigbavboa, C.O., 2023, November. A Review of Barriers to Safety Incentives Design and Implementation in the Construction Industry. In *International Conference on Engineering, Project, and Production Management* (pp. 459-470). Cham: Springer Nature Switzerland.
- Okorie, V.N. and Anugwo, I.C., 2023. An overview on the measures taken to tackle COVID-19 impacts on Nigerian construction sites: A case study of the South-South geo-political zone. *Construction Safety, Health and Well-being in the COVID-19 era*, pp.59-73.
- Olodeoku, M., Alokun, A., Alagbe, O., Egwabor, J. and Buseri, J., 2024. Exploring Universal Design Principles in the Built Environment: An Empirical Review. *African Journal of Environmental Sciences and Renewable Energy*, 16(1), pp.84-98.
- Omopariola, E.D., Olanrewaju, O.I., Albert, I., Oke, A.E. and Ibiyemi, S.B., 2024. Sustainable construction in the Nigerian construction industry: unsustainable practices, barriers and strategies. *Journal of Engineering, Design and Technology*, 22(4), pp.1158-1184.
- Osuji, C., Ugbebor, J.N. and Igwe, J.C., 2020. A REVIEW ON SAFETY CLIMATE FACTORS IN NIGERIAN CONSTRUCTION SYSTEM. *GSI*, 8(2).
- Ranta, V., Aarikka-Stenroos, L., Ritala, P. and Mäkinen, S.J., 2018. Exploring institutional drivers and barriers of the circular economy: A cross-regional comparison of China, the US, and Europe. *Resources, Conservation and Recycling*, 135, pp.70-82.
- Raouf, A.M. and Al-Ghamdi, S.G., 2019. Effectiveness of project delivery systems in executing green buildings. *Journal of Construction Engineering and Management*, 145(10), p.03119005.
- Ruggiano, N. and Perry, T.E., 2019. Conducting secondary analysis of qualitative data: Should we, can we, and how?. *Qualitative Social Work*, 18(1), pp.81-97.
- Saka, A.B., Chan, D.W.M. and Olawumi, T.O., 2019. A systematic literature review of building information modelling in the architecture, engineering and construction industry-the case of Nigeria.
- Samsudin, N.S., Mohammad, M.Z., Khalil, N., Nadzri, N.D. and Ibrahim, C.K.I.C., 2022. A thematic review on Prevention through design (PtD) concept application in the construction industry of developing countries. *Safety science*, 148, p.105640.

- Samsudin, N.S., Mohammad, M.Z., Khalil, N., Nadzri, N.D. and Ibrahim, C.K.I.C., 2022. A thematic review on Prevention through design (PtD) concept application in the construction industry of developing countries. *Safety science*, 148, p.105640.
- Sauer, P.C. and Seuring, S., 2023. How to conduct systematic literature reviews in management research: a guide in 6 steps and 14 decisions. *Review of Managerial Science*, 17(5), pp.1899-1933.
- Schreffler, J., Vasquez III, E., Chini, J. and James, W., 2019. Universal design for learning in postsecondary STEM education for students with disabilities: A systematic literature review. *International Journal of STEM Education*, 6(1), pp.1-10.
- Shafiee, S., Rajabzadeh Ghatari, A., Hasanzadeh, A. and Jahanyan, S., 2020. Smart Tourism Destinations: A Systematic Review of Research Using the Paradigm Funnel Approach. *Tourism Management Studies*, 15(49), pp.33-62.
- Sholanke, A.B., Adeboye, A.B. and Alagbe, O.A., 2019. Adequacy of Ogun State Building Development Regulatory Legislation in Promoting Universal Design Practice in Nigeria. *Technology*, 10(3), pp.1639-1666.
- Sochor, J., 2021. Piecing together the puzzle: Mobility as a Service from the user and service design perspectives. International Transport Forum Discussion Paper.
- Swuste, P., Groeneweg, J., Guldenmund, F.W., van Gulijk, C., Lemkowitz, S., Oostendorp, Y. and Zwaard, W., 2021. *From Safety to Safety Science: The Evolution of Thinking and Practice*. Routledge.
- Tamers, S.L., Streit, J., Pana-Cryan, R., Ray, T., Syron, L., Flynn, M.A., Castillo, D., Roth, G., Geraci, C., Guerin, R. and Schulte, P., 2020. Envisioning the future of work to safeguard the safety, health, and well-being of the workforce: A perspective from the CDC's National Institute for Occupational Safety and Health. *American journal of industrial medicine*, 63(12), pp.1065-1084.
- Tantiyaswadikul, K., 2023. Design Thinking for Innovation in Sustainable Built Environments and the Integration of an Inclusive Foresight and Design Thinking Framework. *International Journal of Sustainable Development & Planning*, 18(3).
- Umeokafor, N. and Okoro, C., 2020. Barriers to social support in the mental health and well being of construction workers in emerging and developing economies: a systematic review.
- Watchorn, V., Hitch, D., Grant, C., Tucker, R., Aedy, K., Ang, S. and Frawley, P., 2021. An integrated literature review of the current discourse around universal design in the built environment—is occupation the missing link?. *Disability and rehabilitation*, 43(1), pp.1-12.
- Xu, M., 2022. The Role of the Built Environment on the Quality of Life for Residents in Long-Term Care Facilities in Asia: A Scoping Review.
- Yap, J.B.H. and Lee, W.K., 2020. Analysing the underlying factors affecting safety performance in building construction. *Production Planning & Control*, 31(13), pp.1061-1076.
- Yasin, A., Fatima, R., Wen, L., Afzal, W., Azhar, M. and Torkar, R., 2020. On using grey literature and google scholar in systematic literature reviews in software engineering. *IEEE access*, 8, pp.36226-36243.
- Young, D., Wagenfeld, A. and Rocker, H.V.V., 2019. Universal design and the built environment: Occupational therapy and interprofessional design teams—A scoping review. *Annals of International Occupational Therapy*, 2(4), pp.186-194.
- Zallio, M. and Clarkson, P.J., 2024. A study to depict challenges and opportunities building industry professionals face when designing inclusive and accessible buildings. *Architectural Science Review*, 67(3), pp.268-279.
- Ziaesaeidi, P. and Farsangi, E.N., 2024. The synergy of modular construction and emerging technologies. *Construction Engineering Australia*, 9(4), pp.32-35.