2024 SRS FBESS

FRC FBESS

STUDENT RESEARCH SYMPOSIUM

Resilient Built Environment : Navigating Global Transformations with Innovative and Sustainable Practices

26th JULY 2024

EXTENDED ABSTRACTS

BUILT ENVIRONMENT AND SPATIAL SCIENCES

FACULTY RESEARCH CELL | FACULTY OF BUILT ENVIRONMENT & SPATIAL SCIENCES

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RESILIENT BUILT ENVIRONMENTS: NAVIGATING GLOBAL TRANSFORMATIONS WITH INNOVATIVE AND SUSTAINABLE PRACTICES

FACULTY OF BUILT ENVIRONMENT AND SPATIAL SCIENCES

EXTENDED ABSTRACTS

SOUTHERN CAMPUS
GENERAL SIR JOHN KOTELAWALA DEFENCE UNIVERSITY
SRI LANKA

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Message from the Vice Chancellor

It is with great pleasure that I extend my warmest greetings to the third Student Research Symposium organized by the Faculty Research Cell of the Faculty of Built Environment and Spatial Sciences at General Sir John Kotelawala Defence University. The symposium marks a pivotal moment in our Academic Calendar fostering a culture of research excellence among the undergraduates, preparing them for the challenges and opportunities of the future.

The theme of this year's symposium, "Resilient Built Environments: Navigating Global Transformations with Innovative and Sustainable Practices" resonates deeply with the current global landscape. As we face unprecedented challenges such as climate change, urbanization, and resource scarcity, the need for innovative and sustainable practices in our built environments becomes increasingly urgent.

I wish to express my sincere gratitude to the Rector of the Southern Campus Major General Robin Jayasuriya, the Dean of the Faculty of Built Environment and Spatial Sciences Dr. AH Lakmal, and all members of the Research Cell for their dedication and hard work in organizing this significant event.

Further, I would like to commend the participants and presenters for their efforts in advancing knowledge and addressing critical issues in the field of Built Environment and Spatial Sciences. I hope they will take full advantage of this opportunity to exchange ideas, collaborate with peers, and further enrich their academic journey.

I extend my best wishes for a successful and productive symposium. May your contributions leave a lasting impact on our academic community and beyond.

Rear Admiral HGU Dammika Kumara, VSV, USP, psc, MMaritimePol, BSc (DS)
Vice Chancellor
General Sir John Kotelawala Defence University

Message from the Rector – Southern Campus

In an era marked by profound global shifts, the resilience of our built environments emerges as pivotal in fostering sustainable innovation. As we confront the challenges of climate change, urbanization, and dwindling resources, the importance of sustainable practices within our built landscapes becomes increasingly evident.

It is with great pleasure that I extend my warmest greetings to the Student Research Symposium 2024, organized by the Faculty Research Cell of the Faculty of Built Environment and Spatial Sciences (FBESS) at General Sir John Kotelawala Defence University (KDU). This symposium serves as a platform for our future professionals in the built environment to showcase their innovative ideas, fostering a culture of research and enhancing their skills in pursuit of sustainable development goals.

The FBESS has consistently fostered a research-friendly environment, facilitating funding opportunities and hosting events such as conferences and symposiums. These initiatives underscore our commitment to nurturing a community of young researchers who will shape the future of our nation. Under the theme "Resilient Built Environments: Navigating Global Transformations with Innovative and Sustainable Practices," the 3rd Student Research Symposium promises to be a showcase of insightful research and collaborative learning.

I commend the Faculty Research Cell for their dedication in organizing this symposium, which has provided undergraduates with a platform to broaden their research horizons and integrate a robust research culture into their academic journey. As the Rector of the KDU Southern Campus, I am confident that this symposium will inspire and empower our students to continue striving for academic and professional excellence.

I extend my best wishes to all participants—students, faculty members, and guests. May your contributions and experiences at SRS 2024 be enriching and impactful, setting the stage for future advancements in the field of built environment and spatial sciences.

Robin Jayasuriya RSP, ndc, psc
Major General
Rector- KDU Southern Campus

Message from the Dean – Faculty of Built Environment and Spatial Sciences

The Student Research Symposium 2024, organized by the Faculty of Built Environment and Spatial Sciences (FBESS) at the General Sir John Kotelawala Defence University (KDU) - Southern Campus marks the third consecutive year of celebrating the research achievements of the undergraduates from the realm of Built Environment and Spatial Sciences. In the face of pressing global challenges such as climate change, urbanization, and resource scarcity, there is an increasing need for innovative practices within our built landscapes. The conference theme aligns with these critical issues, providing undergraduates with a platform to showcase their explorations and propose innovative solutions for creating a sustainable environment.

This year, we are proud to feature research studies from 12 undergraduate participants, whose work has been rigorously assessed by a panel of experienced academics and an editorial committee. The Faculty of FBESS remains committed to nurturing a vibrant research culture within our institution. We believe that supporting students in their research endeavors not only enhances their academic skills but also prepares them for future postgraduate research pursuits. Through this symposium, students have the opportunity to present their findings and engage with diverse perspectives from the academic and professional communities.

I extend my heartfelt appreciation to the Faculty Research Cell for their unwavering dedication and effort in organizing this event. Their commitment has been instrumental in ensuring the success of the Student Research Symposium, providing a platform for our students to shine.

I invite all members of our academic community to join us in celebrating the accomplishments of the aspiring undergraduate researchers at the Student Research Symposium 2024. Let us continue to foster a spirit of innovation and excellence in research.

Dr. AH Lakmal
Dean
Faculty of Built Environment and Spatial Sciences

Message from the Chair – Faculty Research Cell

I am delighted to convey my greetings as the Chair of the Faculty Research Cell (FRC) of the Faculty of Built Environment, Southern Campus of the General Sir John Kotelawala Defence University, on the occasion of the Student Research Symposium 2024. This event stands as a testament to our commitment to celebrating the achievements of our talented student researchers and providing them with a promising platform to explore the vast spectrum of research contributing to our nation's sustainable development.

The symposium serves a pivotal role by allowing students to showcase their innovative ideas and advanced research projects to a diverse audience comprising peers, academia, and esteemed guests. Beyond fostering intellectual exchange, this gathering helps students to enhance their presentation skills, refine research methodologies, and receive invaluable feedback from various perspectives. The presentations at SRS2024 will cover a wide array of disciplines, offering insights into the diverse research pursuits.

I extend heartfelt appreciation to the supervisors and mentors whose guidance and support have been instrumental in nurturing these budding researchers. Their dedication has been crucial in shaping the future generation of scholars in their respective fields. Additionally, I commend the members of the Faculty Research Cell for their exceptional efforts in meticulously organizing this symposium, ensuring its success as a meeting ground for bright minds.

To all presenters, authors, and participants, whether joining us physically or virtually, I extend my best wishes. May SRS2024 prove to be an enriching, inspiring, and rewarding experience for all involved. Let us continue to draw inspiration from and contribute to the vibrant research culture within our academic community.

Dr. (Archt.) HT Rupasinghe
Chair - Faculty Research Cell
Faculty of Built Environment and Spatial Sciences

Message from the Keynote Speaker

In today's world, we find ourselves at a critical juncture, grappling with the urgent need to heal the planet from the damage caused by anthropogenic activities since the dawn of industrialization. Green technologies have emerged across various fields as a means to address these man-made issues. Sustainability, once primarily viewed from an environmental perspective, has now evolved into a powerful financial tool. Investments in sustainability initiatives are yielding returns through innovative concepts like carbon credits, carbon trading, and green financing. These advancements underscore the importance of integrating sustainability into the core of our economic systems, promoting a harmonious balance between ecological preservation and financial growth.

In this rapidly advancing world, research and development in sustainability are crucial across all sectors to drive progress. It is within this context that I am deeply honored to be the Guest Speaker at the Students' Research Symposium 2024, themed "Resilient Built Environment: Navigating Global Transformations with Innovative and Sustainable Practices" This symposium provides a wonderful platform to share knowledge and encourage research in sustainable practices within the built environment. This symposium serves as an invaluable platform for the exchange of knowledge and the promotion of research dedicated to sustainable practices within the built environment.

I extend my heartfelt congratulations to all the students who have successfully completed their research projects. Your dedication and hard work are commendable, and your findings are crucial to advancing our understanding and implementation of sustainable practices. As you continue your academic and professional journeys, I encourage you to remain steadfast in your commitment to sustainability. Your innovative ideas and solutions will play a pivotal role in shaping a resilient and sustainable world.

In conclusion, I wish you all the very best in your future endeavors. May your research endeavors continue to flourish, and may you achieve great success in your efforts to create a better, more sustainable world.

Dr. Himahansi Galkanda
Sustainability Lead
Arinma Holdings (Pvt) Ltd

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Extended Abstracts

EXPLORING THE APPLICATION OF RAMMED EARTH WALL CONSTRUCTION IN CONTEMPORARY SRI LANKAN ARCHITECTURE

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Introduction

Sri Lanka grapples with a profound economic crisis, affecting diverse sectors, notably the construction industry. Amid economic turmoil, the imperative arises to explore innovative building materials and methods to alleviate challenges. Today, rammed earth construction is experiencing a revival in various parts of the world (R. Rael.2009) This research responds to public interest by investigating the viability of rammed earth as a contemporary construction material in Sri Lanka. The study seeks to discern the current status of rammed earth construction while gauging its potential as a sustainable technique for the nation's future. The investigation delves into key aspects such as aesthetics, cost-effectiveness, construction time, and maintenance. Through a mixed qualitative and quantitative approach, the research aims to provide nuanced insights into the material's applicability in the Sri Lankan context.

.

Methodology

The methodology was selected to answer the research question as to why rammed earth isn't commonly used in Sri Lanka in order to assess the primary research objective whether small scaled contemporary Sri Lankan buildings with rammed earth walls are viable for future construction. With an initial response from an interviewed building contractor, further exploration was done to clarify whether this statement was accurate.

Table 1: Comparison of masonary wall with rammed earth wall

Masonry wall	A 10' x 10' masonry wall can be constructed with two labourers in one days' time.
Rammed earth wall	A 10'x 10' rammed earth wall will require 3 labourers and it will take 5 days' time to complete. With the overall cost being 3 times higher than the masonry wall

International case studies were reviewed and studied on what concerns the selection of rammed earth by architects or home builders. Certain articles, books were referred as well to understand how certain aspects affect this selection. In-depth interviews with local stakeholders, including architects, builders, and individuals associated with

rammed earth construction, enrich the research by providing firsthand experiences and expert opinions. Due to time constraints of this research, the aspects looked into were limited to three, selected from the international case study (D. Marwa, 2014), and one more aspect added through the common and repeated response by the interviewed subjects.

1. Cost
2. Time
3. Maintenance
4. Aesthetic (The aspect below was added through the common importance and repeated response by the interviewed subjects.)

Results and Discussion

Table 2: Summary and comparative analysis of case studies

	COST PER SQFT	TIME PER SQFT	MAINTENANCE	AESHETICS
Masonary brick wall	1500	15 minutes	No maintenance issue in general	Not the main reason for the selection of material
Case study 1 – Community Library in Ambepussa **Architect A**	800 Reason for reduction of cost is the direct sourcing of the soil from site and less cement added in mix (1:15)	22 minutes Reduction of time is due to the available labourforce at site. More time is spent on formwork and compaction	Water damage occurred. The soil is being washed due to the elements.	No. main reason for selection was fot community training for soilders
Case study 3 – M D A Office in Baddegana **Architect B, Interior Designer A, Contractor A**	1900 Increase in cost is due to more labour needed. Soil sourced away from site. More cement added in mix. (1:7)	2.5 hours more of time is spent of formwork, Layering and compaction.	Soil particles falling off the wall. Sealent needed every 3 years for protection.	Main reason for selection
Case study 4 – 188 House in Panadura **Architect C**	2100 increase in cost is due to more labour needed. Soil sourced away from site. More cement added in mix. (1:10)	3 hours more time is spent of formwork. Experimenting with the mix causes delay	Water damage occurred near water body (moss growth)	Main reason for selection

In most cases, rammed earth construction tends to be higher in cost compared to a masonry brick wall, although the difference may not be significant. Factors contributing to the higher cost includes specialized skills, labor intensity, and material and equipment requirements associated with rammed earth construction. Rammed earth construction typically requires significantly more time compared to building a masonry brick wall. This is especially pronounced in scenarios where skilled labor is limited, except for cases where a sufficient labor force is available to expedite the process. Rammed earth walls generally require more maintenance compared to masonry brick walls. This could be attributed to factors such as susceptibility to water damage and erosion, which necessitate regular upkeep and potentially higher maintenance costs. The decision to choose rammed earth over a masonry brick wall is often based on aesthetic considerations. Despite the potential higher costs and maintenance.

Conclusion

Rammed earth technology holds substantial importance in the current scenario where traditional building materials are facing shortages and escalating costs. As highlighted in the case studies, rammed earth presents a complex set of challenges ranging from time and cost considerations to maintenance issues. In Sri Lanka, where unskilled labor is affordable, and voluntary or family labor is abundant. In this context, the extended time required for rammed earth construction is considered manageable because the cost savings from using less expensive labor compensate for the additional time. It can be suggested that, particularly in community and self-help projects, where resource optimization is crucial, rammed earth technology becomes a valuable and viable construction option.

It can also be stated that rammed earth practitioners use the material in several projects instead of using it once and moving back to the usual materials. Therefore, repeated usage of rammed earth could be beneficial in terms of construction industry professionals due to the knowledge and experience gathered from the initial construction process. Maintenance issues seem to be mostly related to water damage and surface deterioration. Considering the exposure to elements in a tropical climate like Sri Lanka this can be an issue which needs resolving if future construction is to be viable. Taking note from a vernacular rammed earth case study, Lime plastering could be done on the wall to avoid maintenance issues, but the aesthetics of the rammed earth wall, which seems to be an important factor for use of rammed earth by Sri Lankan architects despite the higher costs, would be lost. Despite certain challenges, the study also underscores the potential of rammed earth construction within the context of contemporary Sri Lankan architecture.

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SPATIAL MODELLING OF GROUND SUBSIDENCE SUSCEPTIBILITY: A CASE STUDY IN BANDARAWELA AND ELLA AREA OF SRI LANKA

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Introduction

This study focuses on understanding and addressing land subsidence in the Bandarawela and Ella areas of Sri Lanka, highlighting the various factors contributing to this phenomenon (Xu et al., 2016; Hasanuddin et al., 2015). Land subsidence, the sinking or settling of the earth's surface, can result from natural and human-induced factors such as soil compaction, tectonic movements, and human activities like construction and urbanization (Bagheri et al., 2021; Kangana, 2018). Climate change and policies related to land and water management also play a role (Xu et al., 2016). The study emphasizes the importance of identifying causative factors, utilizing GIS and Remote Sensing for mapping subsidence susceptibility, and validating models for accurate predictions. The significance of the research lies in its potential to guide urban planning, environmental monitoring, infrastructure management, and public safety in the face of land subsidence risks (Kangana, 2018). The study's objectives include generating a suitable susceptibility analysis, identifying specific causative factors, and selecting the optimum method for analysing land subsidence in the region. The findings aim to contribute to sustainable development and risk mitigation strategies tailored to the geological characteristics of Sri Lanka's upland regions (Kangana, 2018; Xu et al., 2016). Overall, the study holds significance for both current understanding and future planning in areas susceptible to land subsidence.

Methodology

The study was conducted in the Bandarawela and Ella DS divisions of the Badulla district, Sri Lanka, areas known for their natural beauty and extensive tea plantations. The research involved selecting these regions due to their history of land subsidence and gathering comprehensive data from various sources, including field surveys and digital data layers from the Survey Department and Meteorological Department. Factors influencing subsidence, such as slope, aspect, rainfall, proximity to roads and buildings, faults, and land use, were analyzed. The Analytical Hierarchy Process (AHP) and Frequency Ratio (FR) methods were used to assess subsidence susceptibility. The AHP method involved pairwise comparisons to weigh the importance of each factor, while the FR method calculated likelihood ratios to quantify the correlation between each factor and subsidence incidents. These methods were integrated using Geographic Information System (GIS) technology to develop a spatial model, resulting in detailed maps that visualize subsidence susceptibility

across the study area. The AHP method involved pairwise comparisons to weigh the importance of each factor, while the FR method calculated likelihood ratios to quantify the correlation between each factor and subsidence incidents. These methods were integrated using Geographic Information System (GIS) technology to develop a spatial model, resulting in detailed maps that visualize subsidence susceptibility across the study area.

Results and Discussion

This research aims to create a quantitative and graphical model for land subsidence susceptibility, focusing on highly affected areas in Bandarawela and Ella using GIS and Remote Sensing, particularly ArcGIS. The model generates a susceptibility map categorizing areas into low to high-risk zones, with final outputs including seven maps of identified influencing factors and two susceptibility maps produced through the Frequency Ratio (FR) and Analytical Hierarchy Process (AHP) methods. The goal is to visually represent the potential risk of subsidence in the Bandarawela and Ella region. The causative factors, such as land use, slope, aspect, rainfall, proximity to roads and buildings, and faults, are analyzed to understand their contributions to subsidence. The FR method produces a susceptibility map by weighting each factor's influence, while the AHP method assigns relative importance to factors, creating a hierarchical structure for a detailed susceptibility assessment. The FR is an effective instrument for analyses that carefully examines several parameters to identify patterns and linkages that influence an area of land's vulnerability to subsidence. The widely used AHP is essential to this mapping process because it assigns weights based on relative importance to several selected factors, including land use, slope, aspect, rainfall, distance from roads, distance from buildings, and distance from faults. A significant outcome obtained by using the FR method is the land subsidence susceptibility map, which is shown in full in Figure 1. Figure 2 shows the land subsidence susceptibility map using the AHP method.

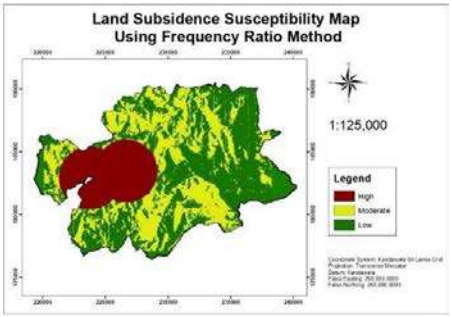

Figure 1: Land Subsidence Map Using Frequency Ratio Method

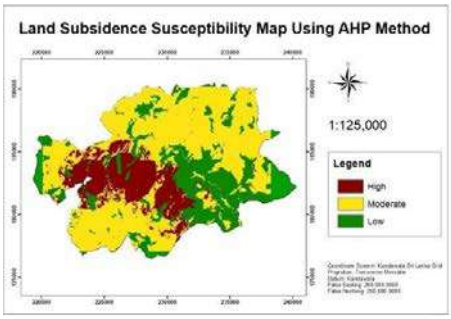

Figure 2: Land Subsidence Map Using AHP Method

The resulting maps were compared for accuracy and reliability by overlaying them with actual land subsidence activity, categorizing areas into high, moderate, and low susceptibility zones. This comprehensive approach aids in informed decision-making for land use planning and risk mitigation in the Bandarawela and Ella regions.

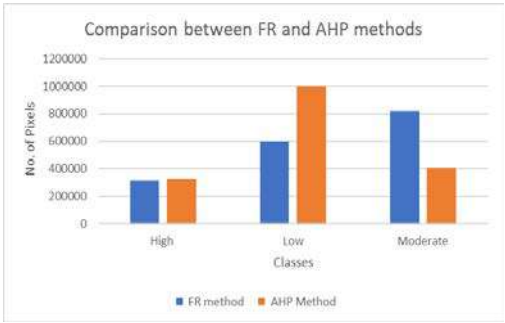

Figure 3: Comparison of Area in Frequency Ratio and AHP method maps using the number of pixels

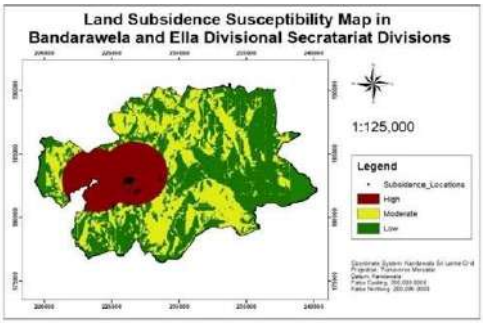

Figure 4: Land Subsidence Susceptibility Map in Bandarawela and Ella Divisional Secretariat Division

Conclusion

This study successfully achieved its objectives in generating a validated spatial model for identifying land subsidence in the Bandarawela and Ella area of Sri Lanka. By comparing the Frequency Ratio (FR) technique with the Analytical Hierarchy Process (AHP), it was found that the FR technique is more accurate in identifying areas of significant subsidence risk. The study identified seven key factors influencing land subsidence and created susceptibility maps using both FR and AHP methods. The use of GIS and Remote Sensing, particularly ArcGIS, proved crucial for visualizing and understanding the spatial distribution of subsidence. The study provides valuable insights for planners, engineers, and policymakers to develop mitigation plans and reduce the risk of subsidence. However, challenges such as accurate data gathering and the predictive nature of risk mapping were acknowledged. Future research opportunities include expanding the list of influencing variables, incorporating advanced technologies like Differential Synthetic Aperture Radar Interferometry (DInSAR), and exploring creative mitigation techniques. The choice of GIS software, such as ArcGIS, ArcGIS Pro, or QGIS, depends on the project's complexity and user preferences. This research contributes to informed decision-making and risk reduction in the context of land subsidence, with implications for broader disaster management efforts.

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IDENTIFYING THE ROLE OF PROJECT MANAGER IN ACHIEVING WORK LIFE BALANCE (WLB) OF CONSTRUCTION SITE LABOURERS FOR A SUSTAINABLE COMPLETION OF CONSTRUCTION PROJECTS

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Introduction

The construction industry involves designing, manufacturing, maintaining, and managing building and civil engineering works (Fox et al., 2008). Sri Lanka's construction sector grew by 12% in Q1 2016, boosting economic growth through building projects and infrastructure (Marambage & Maduwansha, 2021). Private sector construction emphasizes innovation, competitive bidding, and rapid project completion, while public sector services focus on health, education, and engineering (Francis et al., 2013). Successful projects depend on private sector delivery methods and collaborative techniques (Moradi et al., 2020). However, there is a lack of expertise in stakeholder relationship management (Meng & Boyd, 2017). A long hours culture and internal rivalry negatively impact productivity (Moore, 2007).

People have diverse social needs requiring various relationships and activities (Steverink & Lindenberg, 2006). In construction, on-time attendance is vital for project success, as absenteeism disrupts workflow and decreases productivity (Ahn et al., 2014). Meeting social needs is crucial for worker well-being, with universal needs, practical objectives, and resources being emphasized (Steverink & Lindenberg, 2006). Factors like discrimination, personal attributes, job features, self-actualization, self-esteem, and professional respect affect job satisfaction (Ni et al., 2022). Improving migrant workers' health is essential to prevent long-term disease and skill loss (Onarheim et al., 2021). Ensuring a safe working environment and stable social relationships is vital in high-risk construction settings (Kaluarachchi et al., 2022). A centric approach to change in the construction industry involves implementing new strategies, technologies, or policies to respect and balance employees' personal lives with professional responsibilities. High turnover rates due to poor working conditions can hinder project progress and increase costs, making work-life balance crucial for retaining skilled workers. Improving these practices fosters social sustainability, including social justice and equity. In a rapidly changing world, resilience and adaptability are vital. Project managers prioritizing employees' health contribute to sector resilience. The study highlights the importance of creative, human-centered, and socially responsible workforce management in Sri Lanka's construction industry.

Methodology & Experimental Design

The research methodology outlines study objectives, findings, and human behavior trends, using semi-structured interviews and structured surveys for qualitative and quantitative data collection.

I. Research Approach

The purpose of this study is to investigate the relationship between project management techniques and worker's attainment of WLB on construction sites. By combining both qualitative and quantitative information collection techniques, the objective is to significantly contribute to the effective implementation of the construction industry in Sri Lanka.

II. Conceptual Framework

The dependent variable of this study is WLB for the successful completion of the project, and the independent variable is PM role in achieving the WLB of construction site labourers.

III. Data Collection

The primary data for this research was gathered using simple random sampling, purposive sampling, and selective sampling methods, with PMs and construction site labourers in the Sri Lankan construction industry as respondents. The secondary data for this research was gathered using a comprehensive literature survey to identify the factors affecting the WLB of the construction industry.

IV. Data Analysis

Data was obtained through two questionnaires and one semi-structured interview response to achieve the objectives. A total of 118 of the target population were collected for data collection, and 90 responses were obtained from both, for a response rate of 76.27%.

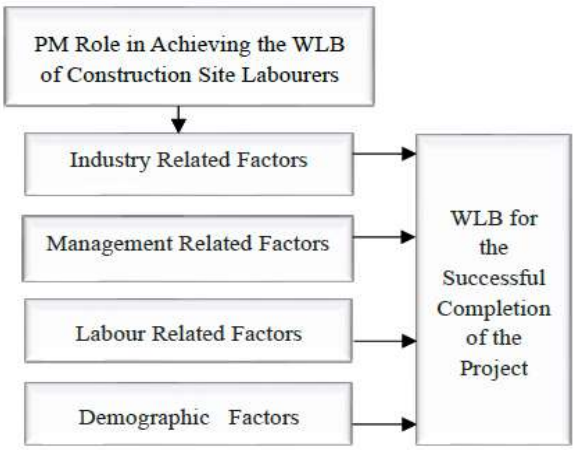

Figure 1: Conceptual Framework

Results and Discussion

I. To identify the relationship of the Project Manager's role on the Work Life Balance of construction site labourers for a sustainable project completion

The study aimed to explore the relationship between the PM's role and the WLB of construction site laborers for successful project completion. Quantitative data was gathered through correlation and regression analysis, with a significance level of less than 0.005. Results indicated a strong correlation between the PM's influence on industry-related factors and the WLB of laborers, and similarly, a significant correlation was found between management-related factors and WLB. This underscores the PM's pivotal role in achieving project success and managing laborer's WLB. Additionally, demographic factors were significantly linked to both WLB and project success, highlighting the importance of project management in addressing these factors. Successful project compliance led to a 32.7% increase in the PM's responsibility for laborer's WLB, particularly influenced by industry-related factors. Conversely, it resulted in a 7.7% decrease in the PM's contribution to WLB influenced by management-related factors. The study concluded that the PM's role in managing demographic factors related to laborer's WLB should reduce by 5.1% for successful project compliance. Factors affecting WLB were identified through secondary data analysis, and semi-structured interviews were conducted to evaluate current industry practices and their effectiveness in maintaining construction worker's WLB.

II. To recommend Project Manager's practices to improve the Work Life Balance of construction site labourers for a sustainable project completion

In the construction industry, PMs are essential in managing time, cost, and quality, though only 20% see HRM as a primary responsibility, illustrating the complexity of their roles. The concept of WLB was scarcely acknowledged in interviews, with few PMs recognizing its importance. The primary factor identified for maintaining WLB is workload management, with PMs emphasizing work schedules, holiday schedules, and a stress-free work environment. Functional activities are organized quarterly, and effective communication is crucial for WLB. PMs encourage laborers to discuss issues, often related to salary and loans, and strive to create a good physical work environment. PMs face challenges in maintaining WLB, such as bridging gaps with laborers and addressing specific requests. Laborer leave is a significant issue, and PMs should guide laborers accordingly. Language barriers, especially for Tamil laborers in Colombo, are another concern. The study found limited WLB awareness among PMs, with only 10% having a good understanding. However, 80% used WLB strategies to resolve labor issues, and PMs recommended organizational policies for WLB, with over 50% taking personal responsibility for it. Training and skill development programs for both PMs and laborers were suggested. To improve WLB, recommended PM practices include effective scheduling, workload distribution, on-

site amenities, safety measures, open communication, protective gear, weather-responsive schedules, and consideration of Sri Lankan religious and cultural holidays. Data from a detailed questionnaire distributed among construction PMs was analyzed using SPSS software, revealing two positive relationships: labor-related and industry-related factors, and two negative relationships: management-related and demographic factors in the context of the PM's role in maintaining WLB for construction site laborers.

Conclusion

The study on WLB practices in Sri Lanka's Colombo construction industry has limitations, such as its focus on government and private projects, potential subjectivity, response bias, and lack of longitudinal perspective. These limitations may affect the understanding of organizational policies' impact on WLB over time. Future research should compare government and private projects, examine various sectors, and expand geographically. A mixed-methods approach can provide comprehensive insights, and further research should explore intervention techniques and ethical issues.To support construction worker's WLB, sustainability practices are crucial PMs play a key role by prioritizing health and safety, creating a positive work environment, managing workloads, supporting training and development, engaging with the community, and promoting flexible work schedules. Strict adherence to safety procedures reduces accidents, while open communication and teamwork enhance morale and job satisfaction. Effective workload management prevents burnout and promotes a healthy WLB. Sustainable practices also include training, skill development, and community involvement through events and local hiring. Flexible work arrangements cater to laborer's varied needs. PMs are essential in implementing these sustainability practices to achieve WLB for construction site workers.

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ASSESSING THE BIOPHILIC DESIGN IN LOCAL PEDIATRIC HEALTHCARE FACILITIES IN RELATION TO PROCESS OF HEALING

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Introduction

Good health is the most valuable gift a person can have, making the pursuit of health is a significant challenge. Health encompasses both physical and psychological well-being. The process of "healing" is crucial in maintaining good health in both these aspects. The concept of healing is ancient, and the environment plays a vital role in this process. This dissertation explores the role of biophilic design in local pediatric healthcare facilities and its impact on the healing process. Biophilic design integrates natural elements into built environments, acknowledging the connection between humans and nature. This study employs a multifaceted methodology to investigate the hypothesis that nature positively influences health. It begins with an in-depth literature review to establish a theoretical framework and identify key concepts related to the impact of nature on health. A questionnaire-based survey gathers qualitative and quantitative data, analyzing participants' experiences with biophilic architecture in Sri Lankan pediatric healthcare. Additionally, a photographic study assesses the implementation of nature-inspired design elements in these environments. By combining these methods, the study triangulates findings for increased validity and reliability.

The literature review provides theoretical foundations, the questionnaire captures real-life perspectives, and the photographic study visually documents the prevalence of biophilic architecture in selected pediatric healthcare facilities in Sri Lanka. In the final analysis of three selected hospitals, a comprehensive examination of biophilic attributes within specific space typologies was conducted. Each hospital's incorporation of these attributes was assessed to identify areas for improvement. While each hospital demonstrates strengths in biophilic design, specific areas within the selected spaces need enhancement. These suggestions aim to contribute to a more comprehensive and impactful implementation of biophilic attributes, ultimately fostering healing environments in pediatric healthcare settings.

Methodology

This study employs a multifaceted approach to examine how Biophilic Design impacts pediatric hospital patients' recovery processes. It begins with a thorough literature review summarizing knowledge about biophilic design in healthcare, focusing on pediatric hospitals. The research uses both quantitative and qualitative

methods, including surveys and interviews, to assess pediatric patients' physiological, psychological, and emotional responses to biophilic design elements. Key design elements effective in pediatric healthcare environments will be identified through this analysis. Additionally, case studies of pediatric hospitals using biophilic design provide practical insights and lessons learned. By triangulating data from literature, surveys, interviews, and case studies, the study aims to offer a comprehensive understanding of the benefits and challenges of integrating biophilic design in pediatric hospitals, providing valuable insights for architects, healthcare professionals, and policymakers.

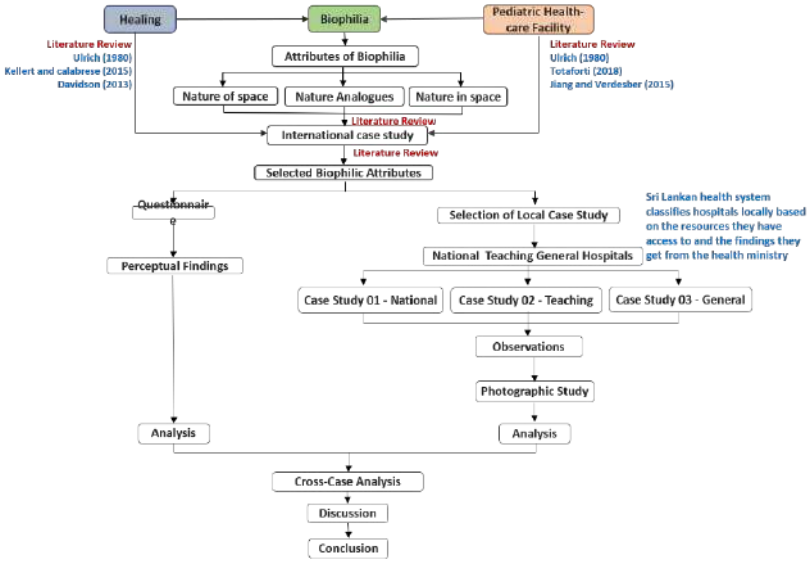

Figure 1: Theoretical Framework (Author,2024)

Results and Discussion

Based on the comparison analysis of the waiting areas at all three hospitals, LRH stands out as an excellent example of a design that integrates a significant number of biophilic features. While specifics about particular characteristics are not given, it is clear that biophilic components are prioritized overall. However, SJGH is unique in that it makes unique use of the water that is present in waiting areas; at the other two hospitals, this aspect is either conspicuously absent or severely restricted. Comparing LRH with SJGH highlights how much more of a focus the latter has on biophilic design, especially when it comes to water components. By comparison, out of the three hospitals, CSTH uses biophilic features the least. All eight characteristics are noticeably low in CSTH, with the exception of biomorphic forms and patterns and diffuse and dynamic light. In the cross-case analysis of space typology 02, it becomes evident that SJGH stands out for its extensive incorporation of biophilic attributes, surpassing both LRH and CSTH. However, upon closer inspection within SJGH's children wards, it is noteworthy that certain biophilic attributes such as the presence of water, biomorphic forms and patterns, and complexity and order are less prominently integrated compared to other attributes. Conversely, LRH and CSTH exhibit a similar spectrum of features when compared inside their respective domains.

In spite of these similarities, the overall research shows that CSTH uses the fewest biophilic features in its spaces. This research indicates that CSTH may be able to improve the biophilic design of its space typology 02 and produce more stimulating surroundings.

Conclusion

The study focuses on the necessity of incorporating biophilic attributes in pediatric healthcare design to enhance the healing process. The concept of healing, popular for over 2000 years, is essential to good health. Most contemporary environments are manmade, and those built with love and care can become healing places. This research examines how biophilic attributes in pediatric-care facilities contribute to creating such healing environments. The study analyses three pediatric-care facilities: LRH, CSTH, and SJGH. Facilities prioritizing biophilic elements—natural light, greenery, views of nature, and outdoor spaces—enhanced well-being and promoted overall health among patients. These elements were linked to reducing stress and anxiety, common challenges for children in pediatric-care settings. Biophilic design also created a familiar and comforting environment, evoking a sense of home and reducing feelings of stress, anxiety, and pain. Natural materials, colors, forms, and patterns contributed to a warm and comfortable ambiance, promoting a sense of belonging and well-being. The study's findings suggest a strong need to incorporate biophilic design in all areas of pediatric healthcare settings. This approach is especially relevant in Sri Lanka, where the tropical climate and abundant natural materials make biophilic design economically feasible and sustainable. This research emphasizes the importance of designing pediatric hospital wards with biophilic elements without compromising hygiene and functionality, ensuring universal exposure to these benefits for all patients.

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ASSESSING COASTAL CHANGES THROUGH SPATIAL ANALYSIS: SHORELINE VARIATIONS FROM 2019 TO 2024 - A CASE STUDY AT OLUVIL, AMPARA

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Introduction

Coastal zones, the transitional areas between land and ocean, are vital yet vulnerable regions. In Sri Lanka, coastal areas are crucial for the economy, ecology, and local communities, functioning as commercial hubs, marine ecosystems, and sources of income. Effective management and understanding of these ecosystems are essential for sustainable development and conservation (Ramkishan et al., 2021). Climate change has exacerbated natural processes like sea level rise and storms, while industrial activities, urbanization, and tourism have increased pressure on coastal areas over the past three decades (Zoysa et al., 2023). Shorelines, which demarcate the ocean-land boundary, are dynamic and characterized by features such as dune crests, cliffs, and vegetation lines that indicate their position (Zahir et al., 2021). Shoreline changes are primarily due to coastal erosion, categorized as natural or human induced. Natural erosion results from events like monsoons and tsunamis, while human-induced erosion stems from unplanned construction. Understanding shoreline changes is critical for developing effective coastal management strategies (Nijamir et al., 2021; Adikaram et al., 2017).

The detection and monitoring of coastline changes are effectively achieved through historical satellite imagery datasets such as Landsat, Sentinel, and Google Earth archival snapshots. Remote Sensing techniques are complemented by UAV surveys and ground truth assessments using GNSS, with RTK data enhancing precision and timeliness in coastal monitoring (Kms & Basc, 2020). LiDAR technology, providing horizontal accuracy up to 2 centimeters and vertical accuracy within 5 centimeters, is pivotal in contemporary coastal management. It offers superior precision for topographic measurements, aiding in assessing coastal dynamics, erosion patterns, and formulating adaptive strategies for sustainable coastal development and risk mitigation (Lin et al., 2019). Although LiDAR technology is costly in Sri Lanka, satellite imagery with spatial analysis software offers cost-effective insights for shoreline monitoring and informed coastal management decisions. This case study investigates shoreline dynamics in the Oluvil area, impacted by natural events like the 2004 tsunami and anthropogenic factors such as the Oluvil harbour construction. Erosion severity increased notably between 2015-2016 and escalated further by 2019, with substantial geomorphic shifts observed up to May 2024. Initial preventive measures by Department of Coast Conservation and Coastal Resource Management

were insufficient due to ongoing geomorphological alterations. Sand accretion occurred along the southern periphery of Oluvil harbour, while adjacent shorelines experienced pronounced erosion, highlighting localized sediment transport variations (Nijamir & Kaleel, 2018).

In response, the Department installed groynes at 120-meter intervals along the coastal stretch to mitigate erosion and stabilize the shoreline. The cost of groyne installation in the Ninavatur area is 55 million, while breakwaters, though more effective, are twice as expensive at 110 million (Department of Coast Conservation and Coastal Resource Management, 2024). This study evaluates the effectiveness of groyne installation and shoreline change patterns using GIS technology and the Digital Shoreline Analysis System, analyzing satellite images from 2019 to 2024.

Methodology

This study employs a thorough methodology to evaluate shoreline dynamics in Oluvil, Ampara. The study area is situated at the centroid coordinates of 7°17'24.88"N and 81°51'34.71"E, encompassing a total area of 21.23 square kilometers. The shoreline extends for 11.9 kilometers within this region.

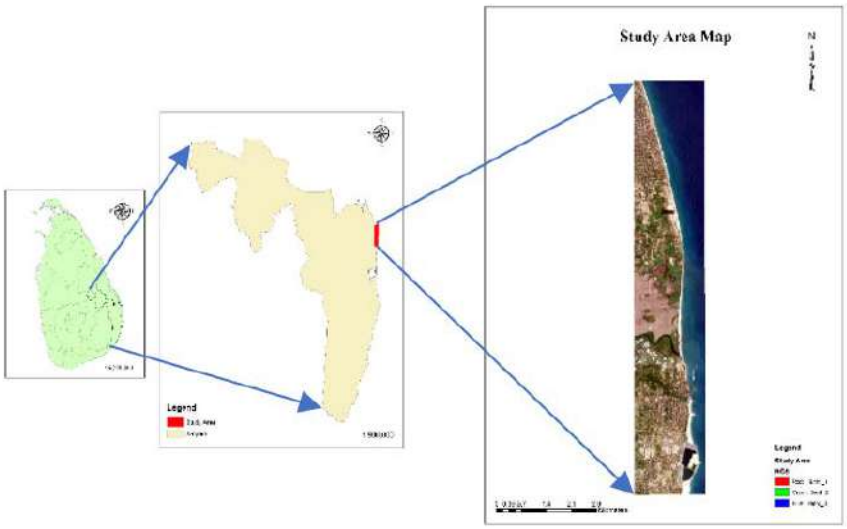

Figure 1: Study area map

From 2019 to 2024, Sentinel-2 satellite images from the Copernicus Open Hub were processed using ArcGIS (version 10.8) with the DSAS (version 5.1) plug-in for detailed shoreline analysis. The Normalized Difference Water Index (NDWI) was applied to distinguish between land and water features, enhancing water bodies while suppressing land cover features. This method facilitated precise coastline delineation (Faloomy NMA et al., 2023; Liu et al., 2017). Raster data was converted to vector format to extract changing coastal morphology, allowing for the digitization of shorelines and baselines. Shorelines from 2019 to 2024 were manually traced, and a baseline was digitized with a 100-meter buffer for consistent reference. The DSAS

Access tool computed rate-of-change statistics from historical shoreline positions. The analysis compared digitized shorelines and change rates to evaluate the impact of groynes introduced in late 2023, highlighting spatial and temporal shoreline variations. This methodological approach ensures a detailed assessment of shoreline changes, informing effective coastal management practices.

Results and Discussion

From 2019 to early 2023, the coastal area exhibited notable erosion, primarily attributed to natural processes and unmitigated wave action. The shoreline analysis showed progressive retreat in several segments of the coast.

Table 1: Analysis of shoreline from 2019 to 2024

Mean Shoreline Change	-1.690497738 m
Max Shoreline Change	14.21m
Min Shoreline Change	-35.31 m
Mean Erosion	-3.443348416 km
SD Erosion	5.115644508
Mean Accretion	1.752850679 km
SD Accretion	3.629503036

By digitizing the shorelines and establishing a baseline 100 meters from the shoreline, we observed that the erosion rate was consistent, leading to a significant loss of coastal land. However, after the installation of groynes in late 2023, there was a marked reduction in erosion. The Digital Shoreline Analysis System (DSAS) tool confirmed a substantial decrease in shoreline retreat. Specifically, the implementation of groynes reduced the erosion by approximately 0.57 hectares. This intervention effectively stabilized the shoreline, illustrating the groynes' role in mitigating coastal erosion by disrupting longshore sediment transport and promoting sediment deposition.

The spatial analysis underscores the profound impact of human interventions on coastal dynamics. Prior to the installation of groynes, the shoreline changes from 2019 to early 2023 were characterized by significant erosion, affecting nearly 68 percent of the seashore areas northwards from the harbor mouth. This erosion can be attributed to wave action exacerbated by the lack of coastal protection structures. The analysis was undertaken to evaluate shoreline variations spanning the period from 2019 to 2024 within the designated study area. The ensuing chart and accompanying graphs illustrate pertinent factors concerning shoreline dynamics, including erosion and accretion levels.

Conclusion

This study assessed shoreline dynamics in Oluvil from 2019 to 2024 using geospatial techniques. Before groynes were installed in late 2023, significant erosion affected 68% of the coastline north of the harbor. Post-installation, the Digital Shoreline

Analysis System (DSAS) tool showed a 0.57-hectare reduction in erosion, stabilizing the shoreline. Sentinel-2 imagery and the DSAS tool were crucial for monitoring changes. The groynes effectively disrupted longshore sediment transport, promoting deposition. This highlights the need for advanced geospatial tools and strategic interventions for sustainable coastal management, offering valuable insights for future initiatives.

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PEDAL-TO-POWER: INNOVATIVE ENERGY HARVESTING FROM GYM BICYCLE PEDALS WITH A PAY-PER-USE INCENTIVE MODEL

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Introduction

The quest for sustainable energy solutions has led to the exploration of novel and unconventional energy sources. This project introduces the "Pedal-to-Power System", a cutting-edge energy harvesting mechanism designed to convert the kinetic energy generated by gymnasium exercise bicycles into valuable electricity. By integrating a meticulously engineered gear and generator assembly with a Pay-Per-Use (PPU) compensation platform, this system not only enhances the sustainability of gym environments but also incentivizes users through monetary rewards for their energy contributions. This innovative approach aligns fitness goals with renewable energy production, fostering an eco-conscious and health-oriented community.

Methodology

Phase 1: System Design

The energy conversion process was defined using electromagnetic principles, selecting a 12V/100A three-phase alternator for efficient energy conversion. The alternator was mechanically coupled to bicycle pedals using a belt system, and the AC output was converted to DC with a rectifier, storing energy in a 12V battery. Sensors were implemented to track energy output and provide real-time feedback to users through a display and an app. Metrics for energy contribution were defined, and a reward calculation formula was developed to create a transparent system for tracking and disbursing rewards.

Figure 1: System Development

Phase 2: Implementation

A high-efficiency prototype was assembled with selected components, followed by bench testing and iterative refinements. The prototype was then installed in a gym for pilot testing to ensure seamless integration. Software was developed to track energy generation and user metrics, with an intuitive interface designed for user engagement and feedback.

Phase 3: Testing & Evaluation

Initial bench testing was performed to evaluate functionality and performance, followed by iterative testing and modifications based on feedback. The prototype was installed and tested in a real-world gym environment, where data on energy output, system reliability, and user interaction were collected and analyzed. The system's effectiveness was assessed and refined for potential large-scale deployment.

Results

The project successfully developed a functional BPEHS prototype that utilizes a 12V/100A three-phase alternator to convert kinetic energy from bicycle pedaling into electrical energy, demonstrating the technical feasibility of the core concept. A Pay-Per-Use (PPU) compensation model was established to incentivize user participation through financial rewards based on their energy contributions, potentially encouraging engagement and promoting a sense of ownership in the energy generation process. Although real-world gym testing wasn't possible, extensive bench testing of the prototype was conducted to assess the system's functionality, safety, and performance under controlled conditions. Additionally, software development focused on creating user-friendly interfaces for both system operation and user interaction.

Figure 2: Evaluation of developed system

Discussion

The "Pedal-to-Power System" advances sustainable energy by harnessing human kinetic energy in gyms. Key achievements include the innovative use of resources, where adapting standard bicycles for the prototype provided a cost-effective approach and valuable insights into repurposing existing technology. Rigorous testing and

iteration addressed challenges like coding errors and adapting non-specialized gym equipment, highlighting the need for comprehensive testing and iterative design to enhance reliability and user engagement. The Pay-Per-Use model effectively used gamification and financial incentives to motivate sustainable practices by converting physical effort into monetary value. Although initially designed for gyms, the project's principles can be scaled to workplaces, schools, and public spaces, transforming human kinetic activity into energy generation.

Conclusion

The "Pedal-to-Power System" faced challenges such as coding errors, high gym equipment costs, and the need to adapt non-specialized equipment. Despite these obstacles, the project achieved valuable insights and successes. It utilized innovative resource strategies by repurposing a standard bicycle for the prototype, keeping costs low and showcasing the potential of existing technology. Rigorous testing and iterative design processes enhanced system reliability and user engagement. The Pay-Per-Use model effectively employed gamification and financial incentives to motivate sustainable practices. Although initially designed for gyms, the project's principles can be scaled to workplaces, schools, and public spaces, creating opportunities to harness human kinetic energy for energy generation.

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ANALYSIS OF THE IMPACT OF BUILDING-STREET INTERFACE ON PERCEIVED SAFETY IN CITIES: AN ANALYTICAL STUDY WITH REFERENCE TO SELECTED STREETS IN COLOMBO

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Introduction

With Cities are complex urban systems that are more than a collection of spaces but a system of flows and networks. (Batty, 2017) Public spaces are the heart of every city, serving as platforms for community and social engagement as well as creative and cultural articulation. Streets are one of the largest and most prominent factors of the physical environment in urbanized areas, becoming more than just a passage for transit, and instead affecting society at large (Gehl, 2012.) In fact, the built environment has a profound impact even on its resident's health, physical activity and behaviour. (Carlson et al., 2012). Today, cities are grappling with increasingly rapid evolution spurred by globalization, changing infrastructure, technological developments and population density. It is estimated that by 2050 the population of major cities, especially cities of developing countries like Sri Lanka will have doubled (Goi, 2017). With this comes inevitable complications and obstacles, foremost among them being safety concerns.

To address these safety concerns and create resilient urban environments, cities need to adopt comprehensive and proactive strategies as creating resilient cities is not only about managing current growth but also about preparing for future transformations in a sustainable and inclusive manner. A decrease in ease and comfort together with fear of crime can affect the sense of perceived safety within urban landscapes, communities and natural environments. (Jansson, 2013). Perceived safety encompasses physical security, anxiety over potential danger and general discomfort. This negative perception of safety can affect an individual's behaviour, by decreasing their social activities and affecting in their usage of public spaces (Sayin et al., 2015). Environmental factors can have a drastic impact on perceptions of safety. Jacobs (1961) and Newman (1972) contend that environmental design, including building typology and public street layouts can play a pivotal role in preventing social inactivity and incoherence by reducing perceived safety. This means it is important to not just focus on preventive and corrective action against criminal activity but to also place significance on how design can affect perceived safety in a community. The dissertation aims to understand the characteristics of the building-street interface that influence the perception of safety in urban environments, in the local context.

Methodology

The study employs a methodology primarily focused on gathering and analysing qualitative data, utilizing observation techniques, mapping and questionnaires where appropriate to gather primary data. 6 case studies in Colombo were identified to examine and comprehend the impacts of building-street interface on perceptions of safety. Semi-structured interviews with the relevant Police Authorities serve as supplementary sources for data validation.

A theoretical framework that explores the complex relationship between the building-street interface and perceived safety was developed and applied to selected case studies. To analyse the impact of the building-street interface, selection of case studies of streets that house a variety of functions and attract diverse pedestrians was paramount. One of the most important and busiest nodes in the city – the De Silva Circus was chosen as the focal point and the first 500m of the six streets that radiate from it- Ward Place, E W Perera Mawatha, Deans Road, Union Place, Srimath Anagarika Dharmapala Mawatha and Dr CWW Kannangara Mawatha- were thoroughly analysed in terms of the building-street interface and the perceptions of safety it generates. The streets are home to an eclectic mix of architecture which cater to the residential, educational, healthcare and commercial needs of the community.

Figure 1: Case Study Map
Source: Google Maps (2024)

The study ascertains the relationship between the building-street interface and the perceptions of safety of its users. In order to study this the characteristics of the interface and the perceptions of the users needed to be ascertained. These aspects of the selected case studies were studied through direct observations, mapping, photographic survey and questionnaires.

Results and Discussion

The findings from the six case studies were compared and analysed. These observations revealed three major themes by the author: the intensity of the activities on the street, connectivity between the interface and the street and the overall liveability of the city.

Intensity

While diversity of use is important to generate perceptions of safety, certain activities can have an adverse impact. According to the survey, people generally find walking near spaces such as bus stops to be relatively unsafe as large crowds gather, making people become more susceptible to crimes such as pickpocketing. Respondents also feel uncertain when walking near residences as they are generally isolated. In contrast users find walking near shops to be safer as they attract modest crowds, are lit up and typically have transparent facades. These observations highlight that apart from having diverse activities the intensity of the activity patterns it generates is important. Generally, streets that generate a moderate intensity of activity are preferred.

Connectivity

Roads that featured permeable facades were generally perceived as safe, highlighting the fact that opportunities for visual connectivity to the streets also have a tremendous impact on feelings of safety. Even in areas where formal surveillance was prevalent, the absence of natural surveillance resulted in the safety of the road to be rated relatively poorly by respondents. However, it must be noted that instances where pedestrian setbacks could be observed, more people were encouraged onto the street increasing physical connectivity to the streetscape and improving the sense of safety.

Liveability

A mixture of many attributes of the building-street interface, as well as greater social implications cause the presence of incivilities in a city. On a micro scale, land uses that attracted large crowds such as hospitals and bus stop generally attracted social incivilities like the presence of beggars. Parks were also commonly used by the homeless for shelter. Physical incivilities like graffiti were typically found on the opaque blind walls of properties with restricted access. On a macro scale, improving the city's liveability, providing shelter for the urban poor, increasing social activity in a city and reducing the need to construct parapet walls around properties should increase liveability thereby raising feelings of safety for all inhabitants of a city.

Conclusion

The cross-case analysis established which roads were perceived to be the safest to walk down and which were considered relatively unsafe. Roads such as Union Place and C.W.W. Kannangara Mawatha scored the highest in terms of providing a strong sense of safety, both in the morning and at night. In contrast roads that were considered less safe, such as Ward Place and E. W. Perera Mawatha had many negative attributes such as a lack of permeability in the facades of the built fabric, limited functions that involve the general public and the presence of incivilities.

The analysis supports previous research done that environmental design has a great impact on perceptions of safety. Characteristics such as permeability, accessibility and the presence of incivilities are relevant, even in the local context, in altering and affecting pedestrians' sense of safety.

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COMPARATIVE ANALYSIS OF FREQUENCY MODULATION AND CONTINUOUS WAVE MODES OF SUB-BOTTOM PROFILER IN BOTTOM LAYER INVESTIGATION

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Introduction

Sub-bottom profilers (SBP) are effective tools used to identify the sediment layers beneath the bottom of any water body. These devices operate by emitting sound pulses that penetrate the seabed and reflect back, enabling the measurement of sediment depth by capturing the two-way travel time and energy differences of the sound waves.

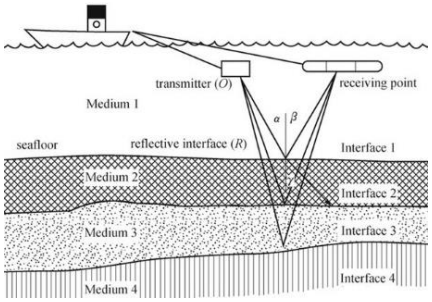

Figure 1: Working Principle of Sub-Bottom Profiler Detection
Source: Saleh, 2016

SBPs operate in two primary modes: Continuous Wave (CW) and Frequency Modulation (FM). When utilizing Sub-Bottom Profilers, choosing the appropriate Sub-Bottom Profiler mode (FM or CW) and understanding their performance is essential in delivering better results for the end user. This research employs the StrataBox HD, a pinger-type Sub-Bottom Profiler, to conduct a thorough comparative analysis of FM and CW modes. The study aims to evaluate the performance of each mode in an underwater environment and to determine the most appropriate mode for conducting geophysical layer investigations with specific requirements. This involves considering key factors such as layer resolution, penetration depth, and data quality.

Methodology

First, ground control points and borehole drilling sample data were obtained from Colombo Port, and five survey lines were planned at the Jaya Container Terminal basin using HYPACK and Google Earth. The survey commenced with the transducer

properly attached and the system mounted to the vessel, following the planned survey lines. Sub-bottom profiling data for sediment analysis were collected across all five lines using both modes. After the survey, the data was processed using HYPACK software. The classified sediment layers were then graphically represented in MATLAB for a detailed comparison, focusing on:

- Depth comparison of the seabed in FM and CW modes
- Analysis of maximum penetration depth in FM versus CW modes
- Assessment of layer variation in FM and CW modes

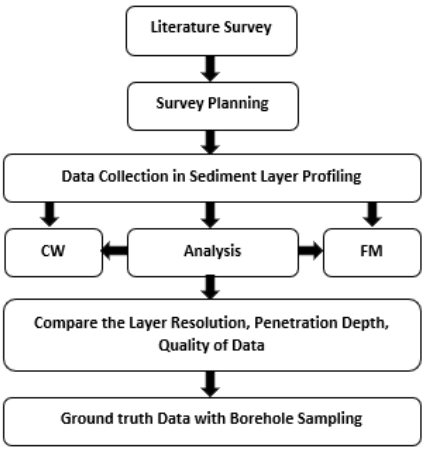

Figure 2: Experimental Design
Source: Undergraduate Research Colloquium, Faculty of Geomatics, SUSL 2024

Finally, the sediment layer data from sub-bottom profiling was validated through comparison with grab samples from survey lines and borehole drilling samples.

Results & Discussion

The survey involved comparing sediment profiles using Frequency Modulation (FM) and Continuous Wave (CW) modes across five designated lines, from Line 01-CW to Line 05-FM. The analysis of Line 05 from the five survey lines conducted is outlined below:

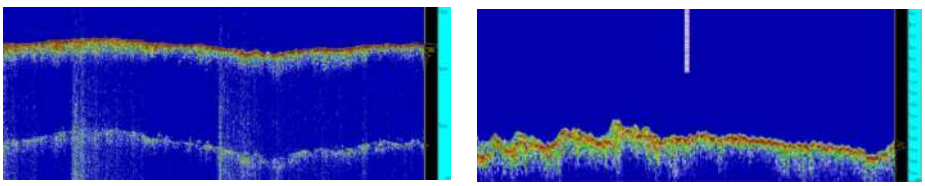

Figure 3: Appearance of Data Samples in StrataBox HD in CW mode vs FM mode
Source: Undergraduate Research Colloquium, Faculty of Geomatics, SUSL 2024

In real-time data collection and visualization of Sub-Bottom Profiling (SBP) at StrataBox HD software, Continuous Wave (CW) mode displays a Range Markers

scale numbered up to 30 meters. In Frequency Modulation (FM) mode, the scale extends up to 19 meters. Additionally, the occurrence of a double echo is notable in CW mode within the real-time data collection visualization dataset. After noting the distinct differences between these two modes in the visualized data, the sub-bottom profiling data was digitized using HYPACK software.

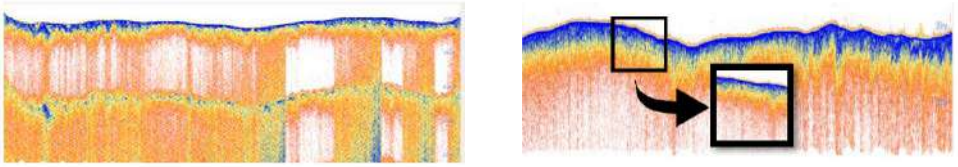

Figure 4: Imported Sediment Layers into HYPACK (CW mode vs FM mode)
Source: Undergraduate Research Colloquium, Faculty of Geomatics, SUSL 2024

During the digitization process, Figure 2 shows that the FM mode identified five distinct sediment layers, whereas the CW mode detected four. Although the CW mode provided greater penetration depth from the seabed, the FM mode offered higher resolution images, enabling a more detailed analysis of smaller features within the outer sediment layers. Finally, the processed sediment profiling data were exported as .xyz and .csv files from HYPACK to MATLAB for a comprehensive comparison.

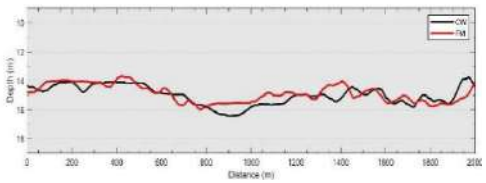

Figure 5: Depth Comparison of Seabed
Source: Undergraduate Research Colloquium, Faculty of Geomatics, SUSL 2024

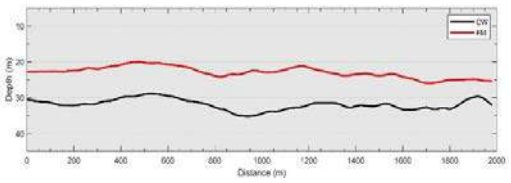

Figure 6: Maximum Penetration Depth Analysis
Source: Undergraduate Research Colloquium, Faculty of Geomatics, SUSL 2024

The CW mode, represented by the black line, and the FM mode, indicated by the red line in the figures above, both exhibit similar fluctuations across the surveyed distance, as shown in Figure 4. This indicates that both methods consistently track the same seabed undulations. However, in Figure 5, the CW mode typically achieves greater depths than the FM mode, showcasing the CW mode's superior capability for deeper seabed penetration.

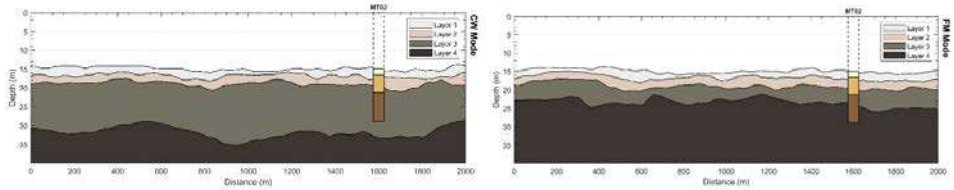

Figure 7: Layer Variation Assessment with Borehole MT 02
Source: Undergraduate Research Colloquium, Faculty of Geomatics, SUSL 2024

Figure 6 demonstrates that the sediment profiling results obtained from both FM and CW align with the borehole drilling sample data from the Jaya Container Terminal basin. The comparison of all survey lines confirmed that the FM mode consistently identified five distinct layers, highlighting its superior resolution for detailed analysis of smaller features. Conversely, the CW mode consistently achieved greater maximum penetration depths, demonstrating its enhanced ability to penetrate deeper into the sediment layers.

Conclusion

The comparison of all survey lines confirmed that the FM mode consistently identified five distinct layers, highlighting its superior resolution for detailed analysis of smaller features. Conversely, the CW mode consistently achieved greater maximum penetration depths, demonstrating its enhanced ability to penetrate deeper into the sediment layers.

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BARRIERS FOR IMPLEMENTING VALUE ENGINEERING TO SUSTAINABLE BUILDING CONSTRUCTION IN SRI LANKA

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Introduction

The construction sector has emerged as one of the world's most important businesses in recent years. Sustainable construction is a process that tries to minimize energy consumption, reduce emissions of harmful chemicals and gases into the atmosphere, encourage material reuse and recycling, and essentially provide customers with pertinent information so they can make better decisions for the environment. In accordance with past studies, a building's life cycle costs can be lowered by 30% to 40% with the use of sustainable building practices. This indicates that the importance of sustainable building practices is growing globally. Value engineering, is a methodical approach to project improvement that reduces lifetime costs. It is a process for determining and cutting out wasteful spending while making sure that reliability and effectiveness are in accordance with the goal of raising net value during the project's design and construction phases. In the construction industry, project managers deal with a variety of challenges when managing their projects. Challenges with the materials utilized, including poor quality, costly expenses, waste material, and loss, are among these challenges, but they are not the only ones. Poor planning, Controlling, management and communication are all issues, as are overspending, delayed transport, unforeseen weather changes, and shortages in a variety of areas (Zaki et al., 2021). VE is one method used to reduce project management issues while achieving sustainability that is used in different countries. Value Engineering applications result in higher quality work that is completed more quickly, with less waste produced in the process.

Furthermore, Value Engineering can be used in building construction to reduce construction costs by 5% to 10% (Ramani & Pitroda, 2017). The VE concept can be applied at any stage of the construction project theoretically. In foreign nations, value engineering is used in the post-contract phase to increase the project's value and achieve sustainable outcomes. To apply value engineering principles to the project in the post-contract phase, it can primarily employ the contractor's change proposals. However, according to the past researches, although value engineering concept methodologies have become common in the construction industry today, their applicability is limited (Ariyawansha & Francis, 2022). Then, at the beginning of the research, it held a pilot survey to identify the applicability of value engineering in the post-contract stage in the Sri Lankan construction industry.

According to the survey's results, 82% of professionals in the construction sector concurred that value engineering is improperly used in the post-contract phase of construction projects utilizing traditional procurement methods in Sri Lanka. Value Engineering is not just about cutting costs. It's also about raising design standards, simplifying the construction process, and saving both time and money (Ramani & Pitroda, 2017). Even though there is a big difference, people occasionally confuse value engineering with cost reduction. Cost-reduction studies are conducted only to reduce costs. Therefore, in the process, quality as well as functionality may be compromised (Abdelghany et al., 2015). There are instances where a higher initial cost will result in a higher-quality project and lower life cycle costs. Hence, it's crucial to take long-term cost savings into account rather than cost-cutting measures that negatively impact the quality of building. This study mainly focused to identify barriers to apply VE concepts in the post-contract stage to achieve sustainable outcomes in building construction projects in Sri Lanka, according to the contractor's perspective. And to identify strategies to overcome those barriers.

Methodology

To accomplish the research objectives, this chapter has essentially addressed the design tools and methodologies utilized in the study and research strategy in an acceptable manner. This chapter examines population and sample, data collecting techniques, data analysis, and presentation. Here, it used qualitative data. Responses from building professionals who work in the sector were the target groups for this study. The respondents personally involved in construction projects and green building projects all around Sri Lanka. eight individuals with a minimum of 10 years of experience in the industry were chosen to participate in semi-structured interviews. The interviewer could come up with open-ended questions on the research topic that should be asked of the interviewee in semi-structured interviews. The interview is organized mostly into two pieces. Information gathered from section one, including name, career, and work experience in that specific field. Open-ended questions about productivity enhancement strategies and their recommendations for improving production in construction projects were included in section two. To collect data, interviews were conducted with occupants and professionals (QS, ENG, and Project Managers). In here, purposive sampling technique has been used.

Results and Discussion

Data analysis is the process of modifying data to address the research problem (Ahuja et al., 2010). Various graphical methods, such as bar charts and pie charts, can be used to present the data. Semi-structured interviews were conducted to gather qualitative data, which was then evaluated using content analysis. The study's content analysis was created using semi-structured interview transcripts and open-ended questions. In accordance with the professional viewpoint in the Sri Lankan building sector, this specific analytical approach may be used to determine the factors that

have the greatest and least amount of influence on one another. Content analysis made it possible to organize the qualitative data that had been gathered in a way that satisfied completed study objectives. In accordance with interviewee IW 4, there could be chances to utilize VE to suggest changes, modifications, or variations that might increase the project's value after the contract has been issued and work has started. These adjustments might be made to the materials, building techniques, or designs to save costs or enhance the outcome of the project to achieve sustainability as well. Value engineering faces several obstacles, which the interviews reveal. According to interviewees, there are several barriers to using VE practices to achieve sustainability in current project management practices in the construction industry. For example, lack of awareness, resistance to change, risk aversion, time-consuming, resource-consuming, organizational culture, and the dissatisfaction of the contractor. Even though there are several barriers, according to interviewees, lack of awareness and the dissatisfaction of contractors are the most impacted barriers. IW2, IW5, IW6, and IW8 all agreed that "most of the time, when applying value engineering change proposals, the client is considering the initial cost of the variation rather than the long-term cost savings due to a lack of knowledge. And it is a huge barrier to achieving sustainability and saving costs in the long term."

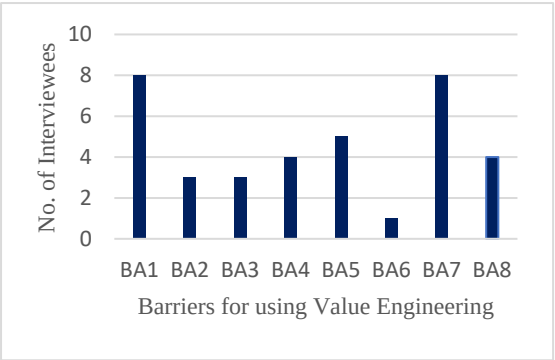

Figure 1: Barriers of using Value Engineering

Interviewees IW4 and IW5 said that “when unanticipated changes occur, VE can be used to effectively manage variances. Project managers can come up with creative ways to lessen the effects of changes without having to incur large additional costs by reevaluating project aspects considering evolving conditions as well as taking long term cost saving in the project”. Interviewees IW7, IW5 and IW 3 said that “in order to keep the project on schedule and within budget, VE can assist in detecting possible risks at the post-contract phase and in developing practical ways to minimize these risks”. Interviewees IW1, IW3, IW5 and IW8 said that “examine the project's demands and functions, concentrating more on the goals than on techniques or supplies. Recognize the main goals and purposes of the project”. Interviewees IW5, IW8 and IW2 said that “motivate the VE team to come up with innovative concepts and substitutes that can fulfill the project's goals and purposes more effectively or economically. Creative thinking should be encouraged during brainstorming sessions. Then, according to the study, the mainly identified strategies to enhance sustainability by applying value engineering change proposals were functional

analysis, idea generation, cost analysis, communication, monitoring and feedback, training and education, and including terms and conditions in client-consultant agreements to enhance value engineering applications.

Conclusion

This study examined whether the Sri Lankan construction industry's present project management practices effectively increase the value of the project by saving cost in short term as well as in long term, when resolving issues occurred in post-contract stage by utilizing the VE ideas. According to the study, value engineering applied to post-contract project management procedures contributes to completing the project on schedule, with the appropriate level of quality by achieving long term cost savings. In the end, it developed strategies for improving VE applications in construction project management in the post-contract stage by identifying the current project management practices and the obstacles to utilizing VE in current project management practices to achieve sustainable outcomes through this study. The VE concept can be applied at any stage of the construction project theoretically. The results show that in foreign nations, value engineering is used in the post-contract phase to increase the project's value and achieve sustainability. However, value engineering is not properly applied in the post-contract stage of the Sri Lankan building industry. The above were highly advised in consideration of the problem's nature and the knowledge that specialists had provided.

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INVESTIGATION ON NEURODIVERGENT SPATIAL EXPERIENCES TO SPECIFY UNIVERSAL DESIGN POLICY

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Introduction

Neurodiversity recognizes a wide range of neuro-cognitive differences, emphasizing unique nervous system characteristics. While Neurotypical individuals are the majority, Neurodivergent individuals have different cognitive functions (Skelling, 2019). Unfortunately, built environments often overlook their needs, hindering their independence and potential. In Sri Lanka, Universal Design mainly considers physical diversity but often neglects neurological diversity, highlighting the need for inclusive design. Exploring neurodiversity in architecture means viewing these conditions as differences, not disabilities. Current designs often create specialized buildings for Neurodivergent individuals, isolating them from mainstream society. Integrating their needs into all buildings ensures equitable access, reduces stigma, and fosters supportive environments. The study highlights the importance of incorporating Neurodivergence into environmental design, focusing on how existing spaces impact productivity, comfort, and safety. It aims to understand these experiences and identify strategies to enhance spaces for Neurodivergent users. Additionally, it examines integrating neurodiversity into universal design principles and assesses potential trade-offs, proposing comprehensive guidelines within these principles to create inclusive environments.

Designed environments significantly influence experiences and well-being, with architects playing a crucial role. By understanding how Neurodivergent individuals respond to their surroundings, architects can create designs catering to diverse needs, fostering inclusive environments. Neurodivergent individuals bring valuable talents, and accommodating their needs benefits society. The research focuses on Clinical Neurodiversity, particularly ADHD, Autism Spectrum Condition (ASC), Intellectual Disability, and Tourette's syndrome. Due to time constraints, ethical challenges, and confidentiality concerns, direct data collection from Neurodivergent individuals was not feasible. Insights were gathered through anonymous surveys and expert interviews, examining foreign precedents alongside local data. Enhancing universal design principles to address Neurodivergent needs will improve experiences and benefit all neurological profiles. By fine-tuning these principles, inclusive design strategies can create universally accessible environments. The study explores the relationship between Neurodivergent individuals and built environments, aiming to create guidelines harmonizing with Universal Design Principles. Current practices predominantly cater to Neurotypical individuals, unintentionally sidelining Neurodivergent needs. Expanding focus to a wider range of building types avoids segregating Neurodivergent individuals.

Navigating current public spaces poses challenges for these individuals. To foster inclusivity and leverage their skills, architects must adopt an inclusive design approach considering their needs across various building types. This study hypothesizes that providing specifications tailored to Neurodivergent needs will enhance their quality of life and benefit the broader population. Universal Design principles often lack the necessary specifications to accommodate Neurodivergent needs, highlighting the need for comprehensive guidelines harmonizing with Universal Design Principles.

Methodology /Experimental Design

After collecting secondary data through literature review and precedence studies, a design framework with the necessary attributes was derived.

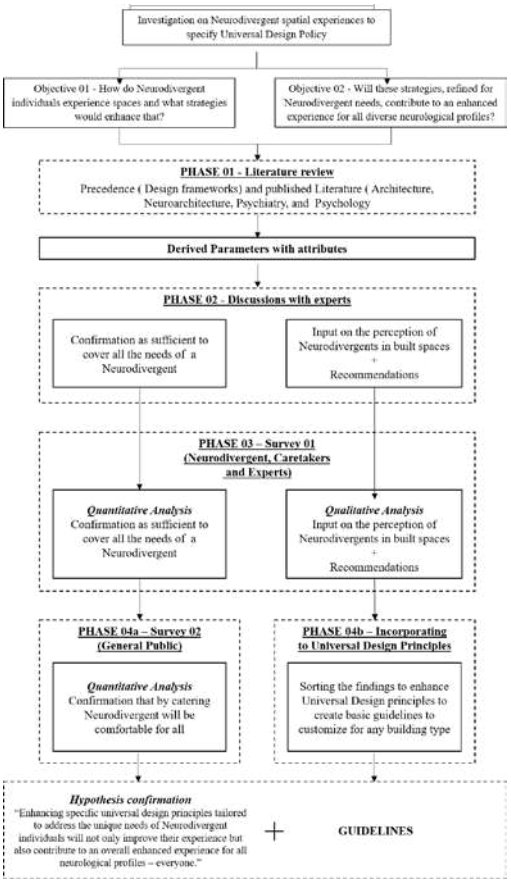

Figure 1: Phases of data collection and analysis
Source: Author, 2024

This framework was then validated through interviews with two psychologists to ensure comprehensive coverage. Subsequently, a survey was conducted targeting individuals with Autism Spectrum Condition, attention deficit hyperactivity disorder, or Intellectual disability, as well as caretakers or family members of these individuals,

and experts. This survey gathered both quantitative and qualitative data to refine and confirm the framework attributes. Architectural strategies were then derived from this information, and another survey was conducted for the general public to confirm the comfort and benefits of these attributes for the majority and validate the research hypothesis. Once survey results were obtained, Universal design principles were further analyzed to create a set of guidelines applicable to any building, ensuring comfort for Neurodiverse individuals.

Results and Discussion

Through a thorough literature review and analysis of precedents, numerous advantageous attributes were identified. Expert interviews further enriched these attributes by shedding light on the cognitive behaviors associated with them. Moreover, spatial qualities conducive to Neurodivergent individuals were delineated. Subsequently, a survey involving 40 participants, including Neurodivergent individuals, their caretakers, and Neurodivergent professional experts, provided additional perspectives and confirmed that these spatial attributes adequately cater to the comfort needs of Neurodivergent individuals. Considering that the majority of the general public is Neurotypical (non-neurodivergent), these attributes underwent scrutiny by this group (comprising 40 participants) to assess whether they would positively or negatively impact their comfort levels. The survey findings indicated that not only did these attributes not impede the comfort levels of Neurotypical, but they also enhanced their overall spatial experience. Subsequently, these attributes were evaluated through the lens of Universal Design principles to determine which principle could best accommodate each attribute. Upon grasping the attributes in coherence with Universal Design principles, these insights can be transformed into a comprehensive set of guidelines adaptable to any building typology, fostering inclusivity for Neurodivergent individuals without segregation and thereby embodying the essence of Universal Design Policy. By integrating these strategies within the seven Principles of Universal Design, alongside a profound comprehension of their purpose, architects and designers can craft built environments prioritizing the comfort and safety of Neurodivergent individuals. This approach resonates with the core of Universal Design principles, promoting inclusivity across diverse neurological profiles and ensuring fair access for all.

Conclusion

In conclusion, this study underscores the importance of embedding Neurodivergent needs within architectural design paradigms by offering comprehensive guidelines that serve as a blueprint for fostering inclusivity and accessibility. By integrating these guidelines into architectural practices, stakeholders can effectively create environments that cater to the diverse needs of all individuals, promoting a more equitable and inclusive society. Enhancing specific universal design principles tailored to address the unique needs of Neurodivergent individuals will not only improve their experience but also enhance the overall experience for all neurological profiles. The survey conducted in this study analysed aspects of spatial comfort

through the perspective of Neurodivergent individuals. Addressing these aspects will enable Neurodivergent individuals to thrive in their endeavours with greater ease, comfort, and safety, thus allowing society to benefit from their unique talents and perspectives. This was further explored in Survey 02, which revealed that the issues faced by Neurodivergent individuals in built environments are also experienced by the majority, albeit to a lesser extent. While Neurodivergent individuals find it nearly impossible to function without addressing these issues, Neurotypical individuals experience only discomfort. Meeting these needs can enhance comfort levels and performance for everyone. Universal design principles were developed to ensure social justice by allowing each individual to reach their full potential and promoting equity. A built environment that provides comfort for each individual to thrive and contribute their best to society truly captures the essence of universal design principles. As proven by this study, it is essential to consider the often-overlooked minority of Neurodivergent individuals. Expanding universal design principles, which currently focus mostly on physical diversity, to include specifications for the needs of Neurodivergent individuals will enhance the quality of life for all. Designing for the most sensitive individual in a room will ultimately improve comfort levels for everyone.

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UTILIZING BIM INTEGRATED SOFTWARE APPLICATION IN THE PRE-CONTRACT STAGE TO ENHANCE ACCURACY AND EFFICIENCY IN MEP WORK QUANTIFICATION

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Introduction

A process called Quantity Take-off involves measuring and calculating the amount of construction materials or perform tasks (Khosakitchalert et al., 2020). Takeoff is critical in determining the materials needed for the procurement, the number of team members needed, the duration of the project, and the cost of the resources. Contractors and owners run the risk of losing money if they overestimate or underestimate the number of essential materials (Sherafat et al., 2022). Technologies for estimating up until the early 1980s included Quantity Take-off and handwriting. Since the 1990s, Quantity Take-off and estimate have Shifted from using 2D-based automated systems to 3D-based automated systems (Choi et al., 2015).

BIM-based quantity takeoff is a novel method of quantity takeoff made possible by the modern technology of building information modeling (BIM) (Khosakitchalert et al., 2020). BIM suggested a symbol recognition system that can recognize different types of symbols in MEP drawings automatically. (Xie et al., 2022). To support this study, a pilot survey (Appendices - Pilot Survey Questionnaire) was carried out to gather information about the MEP sector in Sri Lankan construction projects. Through the pilot survey, the main focus was to get an idea about the quantification process and methods, how MEP scope is managed during the pre-contract stage, errors that can happen in measurements, difficulties faced by MEP professionals, at what stage MEP quantification is performed, and software usage for MEP. When considering the UAE (United Arab Emirates) construction industry, Employers use provisional sums in BOQ for main components, such as MEP works. (K. Seneviratne, A.F Arar and H Hakim, 2016). However, according to the literature survey, most of the large-scale international projects' MEP work is covered as a provisional sum by a specialized contractor. According to pilot survey findings most of the Sri Lankan large-scale projects' MEP work is covered by main contractor's scope of work.

Methodology

The data was collected from industry professionals, including MEP professionals, BIM professionals, and academia. The primary data was collected through the pilot survey and questionnaire survey. The secondary data was collected through the literature review.

Firstly, the current nature and practices of the Sri Lankan MEP sector were studied through the pilot survey. According to the pilot survey findings, there are 10 number of difficulties and challenges were identified. Then after studying their challengeable nature through the questionnaire survey and the Likert scale system were used for that. Both closed-ended and open-ended questions were included in the questionnaire. The questionnaire was distributed among the construction professionals with MEP related experience through email, LinkedIn, and WhatsApp messages. Semi structured interviews were conducted to gather information associated to the final two objectives (To identifying the barriers to applying those BIM applications to MEP works in the construction industry in Sri Lanka and to find out the recommendations to implement those BIM tools for the effectiveness of MEP works in the industry).

The collected data were analyzed using the content analysis and frequency index analysis methods. The frequency index analysis method contributed to identify the challenges or difficulties that the majority of respondents and the minority of respondents faced. Content analysis was used to analyze the data collected through the semi-structured interviews.

$$FI = \frac{\sum W}{A \times N}$$

Equation 1:Frequency index (FI)
Ref: (Kawmudi et al., 2021)

Results and Discussion

According to the pilot survey & questionnaire survey findings, 10 number of difficulties and challenges were identified. Those things were ranked (Table 1) according to their challengeable nature through the questionnaire survey. The frequency index was calculated based on the responses of the respondents. The weighted values are as follows, 1=No Challenge 2= Low Challenge 3=Neutral 4=Challenge 5= Significant Challenge. The result is shown in table 01. According to the table 01, (C01) time required for *quantification* is the most significant challenge that the quantity surveyors have faced during the MEP work quantification using traditional practices. Difficulty in incorporating changes or revisions (C03) ranks as the second most frequent challenge. The third obstacle that quantity surveyors face during MEP quantification is lack of coordination with other disciplines (C04). The fourth and fifth top rankers were identified regarding human errors and re-checking the measurements (C05).

According to responses received from semi-structured interviews, following challenges were identified for implement BIM technology to Sri Lankan MEP sector.

Most of interviewers mentioned that the lack of knowledge about the BIM application is the main barrier of implementing the BIM tools. Since MEP works are specialized work items, special knowledge is expected to quantify them; the same knowledge is to be practiced on the BIM software. High initial investment in BIM software and lack of MEP designers to create the MEP design or model in the BIM environment are the other barriers to implement the BIM.

Table 1: Challenges faced by Quantity Surveyors during MEP

Code	Challengers in MEP Quantification	Responses					Frequency index	Rank
		1	2	3	4	5		
C01	Time required for quantity takeoff	0	2	5	25	20	0.8423	**1**
C02	Low accuracy of measurements	2	4	8	26	12	0.7615	**7**
C03	Difficulty in incorporating changes or revisions	0	3	7	23	19	0.8231	**2**
C04	Coordination with other disciplines (Architectural, Mechanical)	0	0	11	27	14	0.8115	**3**
C05	Difficulties regarding the re-checking measurements	1	1	10	27	13	0.7923	**5**
C06	Miss or double count items during take-off (Human errors)	0	2	13	20	17	0.8000	**4**
C07	Understanding drawings, diagrams, or layout	3	8	19	18	4	0.6462	**10**
C08	Issues related to entering the quantities to the BOQ or Measurement sheet	2	4	13	26	7	0.7231	**9**
C09	Take-off quantities of irregular shape items (Plumbing system, HVAC duct system and drainage system etc.)	1	2	9	29	11	0.7808	**6**
C10	Work with different types of drawing format (CAD, PDF, DWG and JPG and IFC formats etc.)	2	4	11	25	10	0.7423	**8**

Conclusion

The constant state beach can be seen in many transect places in Mirissa depending on the general beach condition. For the beach state, values (loss or gain) less than 10 m are defined as steady-state values. The steady-state beach in Mirissa is due to fluctuations in monsoon seasonality, the orientation of the shoreline and the local wind pattern. Based on the seasonality of the monsoon, the general beach condition in Mirissa exhibits more than 10m of sand accretion and erosion. As a result, Mirissa Beach is ideal for leisure activities and the tourism sector. All monsoon seasons result in sand erosion and accumulation (southwest, northeast, 1st inter-monsoon, and 2nd inter-monsoon).

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SECURE PATHS: ADVANCING ROAD SAFETY THROUGH INTELLIGENT SIGNALING

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Introduction

The Secure Paths research project aims to revolutionize road safety by introducing an innovative approach to intelligent signaling. Traditional road signs play a crucial role in conveying essential information to drivers, but their effectiveness is often limited by factors such as visibility, environmental conditions, and timely updates (Agarwal, 2024). The research addresses these challenges by proposing the implementation of an automated system designed to enhance the range and effectiveness of road signs. This system integrates advanced technologies to establish secure paths for vehicles, ensuring a safer and more informed driving experience. Utilizing cutting-edge sensors and communication modules, the system detects and relays real-time information about road signs and potential obstacles to the on-board intelligence of vehicles. This extended communication range provides drivers with timely warnings and instructions, significantly reducing the likelihood of accidents and enhancing overall road safety (Sadaf, et al., 2023). Additionally, the project introduces an automatic fuel station system that utilizes state-of-the-art sensors to detect the required fuel type, streamlining the refueling process and minimizing the risk of misfiling, thus contributing to both efficiency and safety in the transportation sector (Khan, 2024).

Methodology

The Secure Paths project employs a comprehensive experimental design to validate the effectiveness of its intelligent signaling and automatic fuel station systems. Central to this design is the Arduino Mega 2560, which serves as the central processing unit for both the vehicle and road systems. This microcontroller, chosen for its ample GPIO pins and robust performance capabilities, facilitates seamless integration with various sensors, communication modules, and display units, enabling real-time data processing and decision-making.

Two Arduino Mega 2560 units are utilized: one dedicated to the vehicle system and the other integrated within the road infrastructure. This configuration ensures synchronized functionality and data exchange between the vehicle and the road systems. The vehicle system is equipped with sensors to detect road signs and potential obstacles, relaying this information to the driver through an onboard display. Concurrently, the road system communicates with the vehicle to provide real-time updates and warnings.

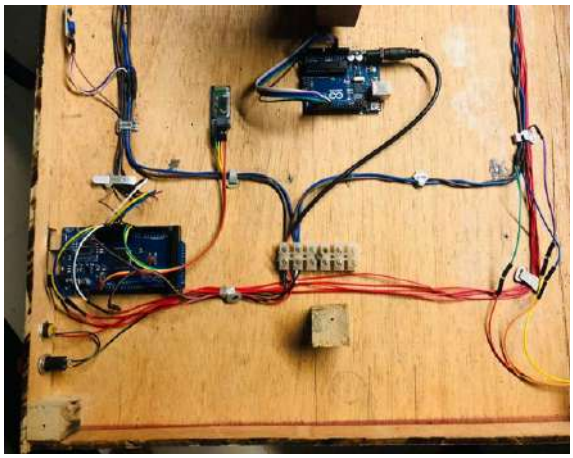

Figure 1: Final wiring of the system

To evaluate the system's performance, a series of controlled experiments were conducted. These experiments involved various scenarios, including different environmental conditions and road configurations, to assess the reliability and accuracy of the intelligent signaling system. Additionally, the automatic fuel station system was tested for its ability to correctly identify fuel types and automate the refueling process without human intervention.

Results and Discussion

The results of the Secure Paths project indicate significant advancements in road safety through intelligent signaling and automated solutions. The intelligent signaling system demonstrated a high level of accuracy in detecting road signs and obstacles, even under adverse environmental conditions such as fog and heavy rain. The real-time communication between the vehicle and road systems provided timely warnings to drivers, resulting in a marked reduction in simulated accident scenarios.

Figure 2: Finalized design

Figure 3: Alerting the driver due to oncoming road signal

Figure 4: The fuel station displaying the price for the remaining fuel

Despite these positive outcomes, several challenges were identified. The implementation of these technologies raised concerns about reliability, compatibility with existing infrastructure, and cost-effectiveness. Addressing these challenges will require ongoing efforts to refine the technologies and promote public awareness and acceptance.

Conclusion

The Secure Paths project aims to improve road safety through intelligent signaling and automated solutions, addressing current infrastructure deficiencies and safety risks. It integrates advanced signaling technologies, automated safety systems, and fuel station automation to enhance transportation efficiency and safety. Future developments will shift from infrared to radio frequency sensors for better accuracy and explore scalability with connected and autonomous vehicles. Continuous research will focus on refining algorithms, system robustness, and resource optimization. Overall, the project sets a strong foundation for future road safety and transportation infrastructure improvements.

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