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Building Design with Soundproofing Attributes

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Abstract: *This research primarily focuses on creating the blueprint for a three-story soundproof building, specifically the Reading Hub planned for the Surigao City Tourism Office. The envisioned structure spans approximately 130 sq. m and caters to the desired interior design of the industry partner. The soundproofing component employs polyurethane, a proven and effective material in various architectural applications. The study adopts a descriptive research approach and furnishes details regarding Structural and Aesthetical Requirements, Reverberation Time, Design Criteria, and Cost Estimates. The outcomes of this design endeavor affirm its structural adequacy, aligning with the stipulations of NSCP 2015 and ACI 318. Reverberation time calculations have yielded results well within the acceptable range for an average control room volume. The estimated costs suggest that constructing a three-story building is justifiable.In summation, the design of the three-story soundproof building utilizing foam bricks and adhesive wallpaper stands as an efficacious venture. This affirmation is rooted in its meticulous evaluation and endorsement by both the industry partner and professional Engineers.*

Keywords: soundproofing, building, attributes, foam system

I. INTRODUCTION

In the midst of the ever-expanding influence of media on information consumption, it remains evident that public libraries persist in their significance for readers and researchers alike. This continued relevance is acknowledged by the Surigao City Tourism Office, recognizing the necessity for Surigaonons to possess a hub of knowledge. A dedicated space is required, where individuals driven by their fascination for books and artistic endeavors can congregate, immersing themselves in the realms of wisdom. Additionally, this space caters to those in pursuit of a tranquil setting for scholarly pursuits and the showcasing of their creative talents. Furthermore, it serves as an oasis for those seeking respite, allowing time to drift by as they relish the tranquility of the surroundings [1, 2].

In contemporary times, individuals are increasingly engrossed in strenuous physical pursuits that drain both their energy and mental capacities. Unfortunately, this often leads to a disregard for nourishing their intellectual faculties. The establishment of a reading hub in Surigao City could serve as a transformative solution. By providing a convenient avenue for knowledge access, this initiative would offer the local populace an opportunity to nurture their mental acumen. Moreover, the envisioned hub would create a tranquil sanctuary, free from the disruptive clamor of the external world, thereby fostering an environment conducive to focused learning and contemplation [2, 3].

Positioned adjacent to a bustling National Highway and a vibrant Children's Playground, the intended project site is susceptible to the infiltration of both vehicular and human-generated noise. The intrusion of such cacophony presents a significant challenge, potentially impeding the occupants' ability to maintain concentration and focus on their endeavors. Addressing this concern, the researchers intend to introduce an innovative measure aimed at minimizing the impact of noise within the premises. This entails the proposition of an engineered material, namely foam brick sticker wallpaper, strategically implemented to mitigate the noise factor and promote a more conducive environment for productive activities [4, 5].

For a comprehensive grasp of soundproofing principles, a fundamental understanding of sound wave dynamics is essential. Whenever an object undergoes vibration, it initiates a corresponding motion in the surrounding air. Consequently, when a sound originates from a stereo, for instance, it propels the air forward, and its audible manifestation occurs upon reaching the eardrum, inducing vibrations therein. The absorption of sound results in its transformation into thermal energy. Within this context, soundproofing materials play a pivotal role in hindering the

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propagation of sound across spaces by obstructing its trajectory. Broadly speaking, their function is to regulate noise by impeding its ingress or egress from a designated area [6, 7].

The ensuing section of the study will delve into a comprehensive exploration of the attributes of the foam brick sticker wallpaper and its efficacy. To provide a concise overview of this material, it is a deliberately engineered substance aimed at adeptly absorbing sound frequencies originating both internally and externally. Notably, the selected soundproof foam brick sticker wallpaper not only excels in mitigating ambient noise but also contributes to maintaining a comfortable room temperature, thereby exhibiting energy-saving characteristics [8, 9, 10].

The researcher's groundwork for this study is primarily built upon existing product reviews and research studies, owing to the absence of any local building implementation of the chosen soundproofing material. The driving force behind this endeavor is to pioneer the adoption of an innovative soundproofing material and design for a three-story reading hub situated in Surigao City. This initiative will predominantly center on ensuring the enduring sustainability of the structural composition of the building [11, 12].

The impending project study carries substantial implications, notably in augmenting Surigao City's tourism appeal. This stems from the profound societal utility of the envisaged reading hub, coupled with its unique distinction as the city's pioneer structure imbued with acoustic design and soundproofing methodologies. While manual testing of the chosen material remains pending, the researcherremains sanguine about achieving positive outcomes, which would also contribute to the aesthetic enhancement of the building. It's worth noting that the selected material is readily accessible within the Philippine market. Beyond its primary function as a reading haven, the proposed reading hub serves as a platform to showcase Surigaonon artistic prowess, as evidenced by the curated gallery section that spotlights top-notch artwork. In addition, the facility will feature a dedicated Multimedia Room, offering an avenue for immersive video presentations that capture the allure of Surigao City [13, 14].

II. METHODS

Figure 1 delineates the sequential progression of this study, commencing from its inception to the culmination of outcomes. It initiates with the pivotal phase of data collection, encompassing the precise measurement of the designated lot area. This preliminary step assumes paramount significance, as it furnishes the fundamental parameters for structuring the architectural blueprint. Simultaneously, survey-driven data acquisition plays an indispensable role in gauging the study's relevance within the Surigao City community. Additionally, it serves to elicit the preferred interior design specifications from the industry partner.

Subsequent to this, the endeavor transitions into the creation of preliminary comprehensive plans. These encompass architectural, structural, electrical, and plumbing blueprints, meticulously crafted to align with the stipulations of the National Building Code of the Philippines (NBCP) and the broader requisites outlined by the Local Government Unit (LGU) of Surigao City. The imperative structural analysis phase aims to discern the structural response to imposed loads, thereby informing the formulation of definitive structural plans. Furthermore, the incorporation of an acoustic design component seeks to establish an environment conducive to quietude within the reading hub, effectively evaluating the efficacy of the foam bricks sticker wallpaper in sound-absorption capabilities. Within this process, a comprehensive cost estimate emerges, assuring prudent budget allocation, while the implementation schedule is guided by PERT/CPM methodologies.

The ultimate output of this comprehensive endeavor is none other than the meticulously devised Design of a Three-Storey Soundproof Building. This edifice is envisioned to be situated within Luneta Park, Rizal St., Surigao City, poised to assume the role of a public reading hub.

Following the requisite approvals from both the Tourism Office and the City Mayor, the researchers embarked on the process of ascertaining the buildable area. Employing a measuring tape, an area spanning 130 square meters was meticulously determined. Subsequent to this initial step, the focus transitioned to executing a comprehensive Structural Analysis. This analytical endeavor aimed to glean critical insights into the requisite dimensions imperative for shaping the structural framework of the envisioned edifice. The ensuing phase involved the meticulous composition of an all-encompassing set of plans. Leverage of drafting software facilitated the creation of architectural, structural, electrical, and plumbing blueprints, seamlessly integrated to conform to established standards.

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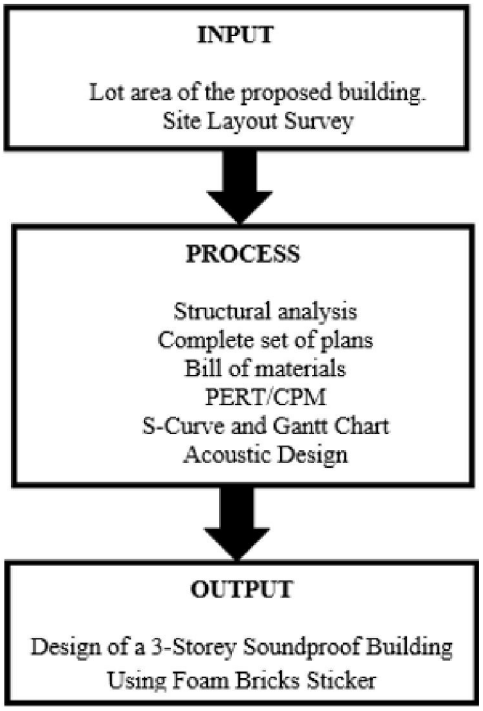

Figure 1. Design Flow

Given the strategic location of the project alongside a national thoroughfare, thereby exposed to potential noise disturbances, the researcher embraced an acoustic design approach. This involved intricate calculations pertaining to the building's reverberation time, effectively mitigating noise concerns within the interior spaces. Moreover, harnessing the capabilities of Microsoft Excel, an exhaustive cost estimation exercise unfolded. This systematic analysis meticulously projected the financial outlay for the envisioned three-storey soundproof building, uniquely enhanced by the integration of foam bricks sticker wallpaper.

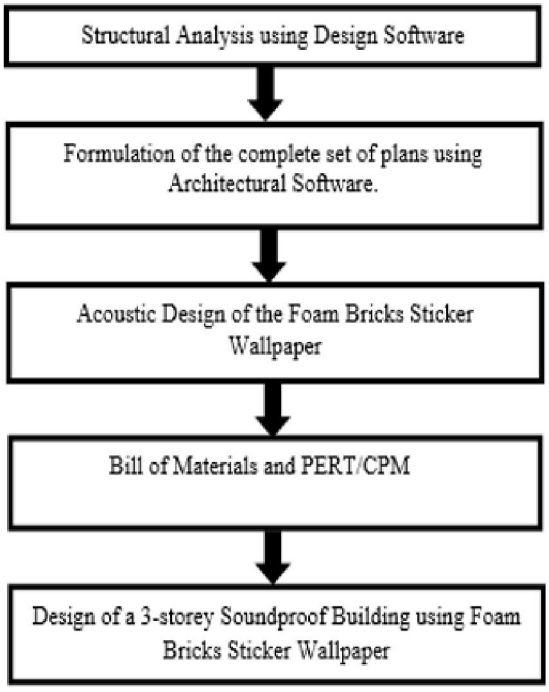

Figure 2. Design Flow

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2.1 Project Setting

The study will be carried out within Brgy. Washington, Surigao City, specifically at the coordinates 9°47'32"N 125°29'42"E, situated within the Luneta Park premises. This chosen site boasts a lot area of 130 square meters, earmarked for development. The prospective reading hub's strategic positioning on Borromeo St. renders it subject to ambient noise emanating from vehicular traffic and human activity. Positioned proximately behind the edifice is the Children's Playground, further contributing to the anticipated noise exposure

Figure 3. Location of the Project

2.2 Instruments

This study embraces the utilization of a diverse array of computer-aided software tools, strategically leveraged to serve as pivotal enablers, expediting the achievement of the research objectives.

Drafting Software emerges as a robust and versatile asset, empowering the creation of floor plans, building permit drawings, landscaping layouts, and building inspection plans. This software transcends conventional methods, allowing for intricate design formulations with heightened precision, negating the reliance on traditional stencils and technical drawing instruments. Its adeptness in 2D drafting facilitates the rapid realization of design concepts.

Conversely, Graphic Software assumes a transformative role, wielding the capability to translate three-dimensional images and videos into captivating visual narratives, enriched with mesmerizing visual effects. Within the context of this study, Graphic Software stands poised to imbue architectural designs with vitality and vibrancy, thereby amplifying their visual impact. This dynamic visualization tool augments the efficacy of design presentations.

Augmenting these capabilities is the utilization of Structural Design Software, an engineering application meticulously crafted to expedite the analytical, modeling, and design phases of structures. This software's proficiency promises an accurate and efficient computation process, substantially streamlining the complexities inherent in structural engineering. Favored by contemporary construction practices, this software offers an efficacious approach to the realm of structural design.

Microsoft Office, a comprehensive suite of tools tailored to contemporary work paradigms, comprises instrumental components such as Microsoft Excel, Microsoft Word, and Microsoft Project. These components seamlessly cater to the multifaceted demands of this study, serving as indispensable aids. Microsoft Office significantly enhances researchers' capacity to generate reports, curate construction estimates, and implement PERT-CPM methodologies to ensure efficient project management. Noteworthy is the role of Microsoft Project, facilitating cost estimations and facilitating the creation of exhaustive construction expense breakdowns. Additionally, it serves as a robust scheduler, enabling the vigilant tracking of project timelines.

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In tandem, these software tools collectively expedite the research process, empowering researchers to operate with heightened efficiency and yield outputs characterized by exceptional quality.

III. RESULTS AND DISCUSSION

Assisted by graphic software, Figure 4 presents the envisioned perspective view meticulously crafted by the researchers for a Reading Hub that embodies modernity and reader-friendliness. The trees adjacent to the structure are slated for preservation, with their inclusion in the construction process contingent upon the guidance of the partnering industry's leadership..

Figure 4: Perspective View of the Project

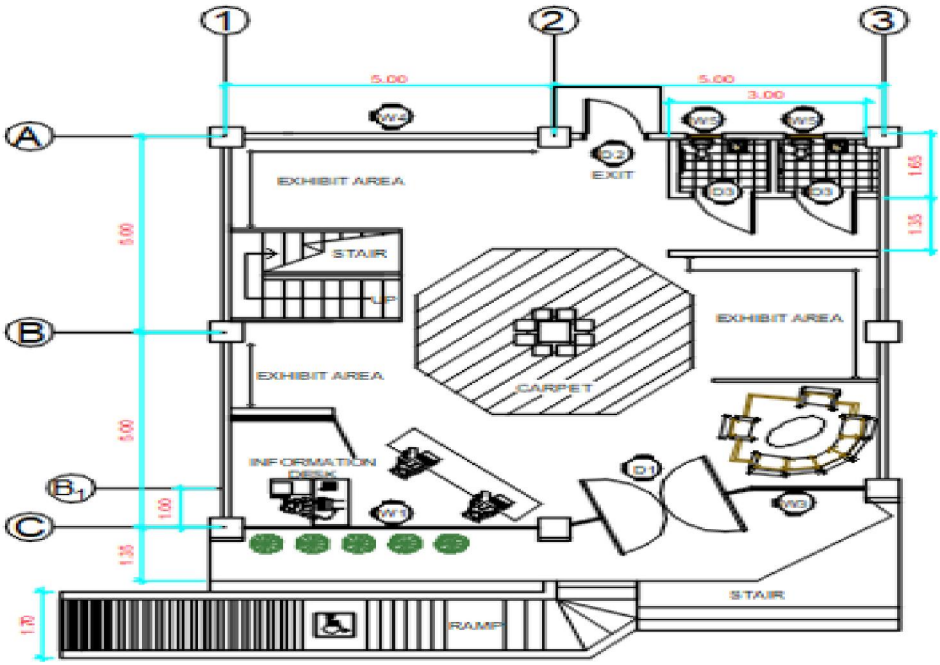

Figure 5. Ground Floor Plan

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The researcher conceptualized a structure in accordance with the dimensions recommended by the Surigao City Tourism Office, encompassing an approximate area of 130 square meters and situated adjacent to a national highway. Leveraging this available space, a 3-storey edifice was ingeniously designed, intended to comfortably accommodate a maximum populace of 80 individuals. The surroundings of the building prompted the researchers to devise a soundproof construction approach, adeptly employing Foam Brick Sticker Wallpaper to mitigate noise intrusion, while concurrently enhancing the structure's visual allure.

In alignment with the preferences of the industry partner's desired interior design, the researchers thoughtfully incorporated several strategic elements. A ramp catering to persons with disabilities (PWDs) was seamlessly integrated, fostering inclusivity. Moreover, the ground floor level was designated for a gallery space, expertly curated to showcase diverse artworks. This level also encompasses gender-segregated restrooms, as depicted in Figure 5, ensuring comprehensive convenience for the building's occupants.

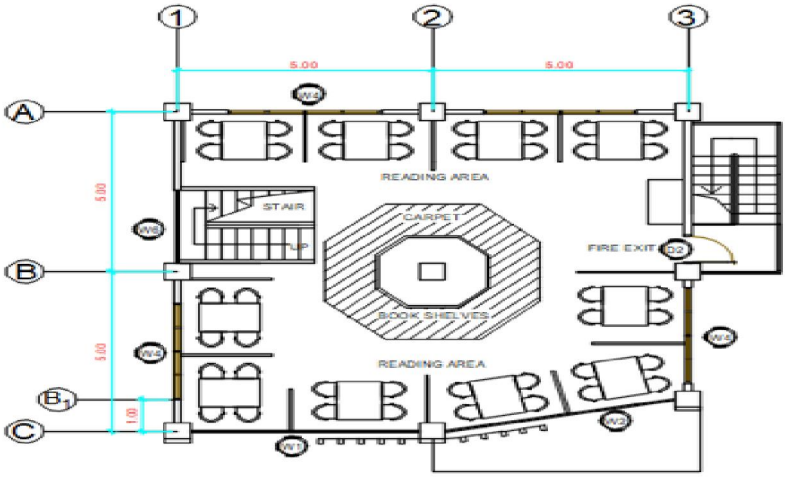

Figure 6. Second Floor Plan

Illustrated in Figure 6, the Second floor serves as the Reading area, characterized by a design featuring cubicles to effectively shield users from distractions such as visual disturbances and ambient noise. This floor boasts a remarkable capacity, accommodating up to 40 individuals, surpassing the capacity of other floor levels. A central octagonal structure prominently stands as the repository of knowledge—a collection of bookshelves teeming with a diverse range of genres, newspapers, and magazines.

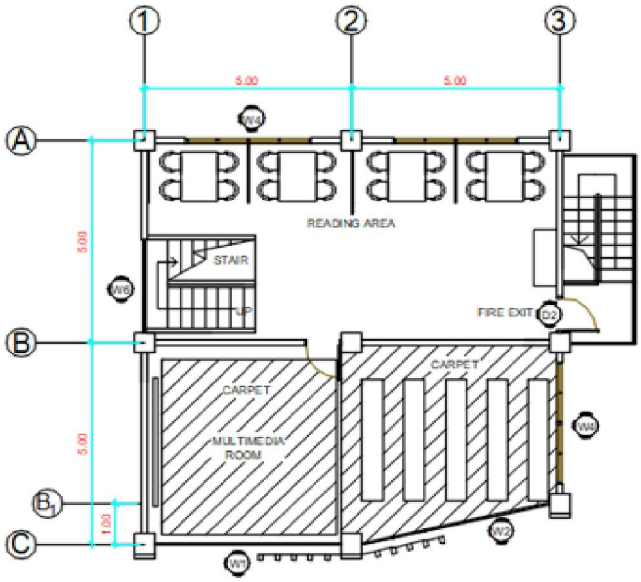

Figure 7. Second Floor Plan

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Depicted in Figure 7 is an intricate depiction of the third floor's layout. This particular floor encompasses a Multimedia Room alongside a designated reading area. Additionally, a comprehensive roof deck plan has been meticulously crafted, complete with a lush garden and thoughtfully arranged seating for moments of relaxation. Notably, the researchers have meticulously incorporated emergency exit points on every floor level, prioritizing the safety of occupants.

Figure 8. Acoustic Material

The researcher has meticulously orchestrated the building's design to foster an atmosphere of tranquility conducive to effective learning. To ascertain the building's potential, an acoustic material shown in Figure 8 are used to create a soundproof environment, the researcher has conducted calculations to determine the reverberation time, a crucial metric in assessing acoustic performance. According to standards for average control room volumes, optimal reverberation times typically fall within the range of 0.3 to 0.4 seconds. The reverberation time, also known as T60 time, signifies the duration it takes for sound to diminish by 60dB.

Results derived from the researchers' calculations reveal that, on the first floor, the Reverberation Time without acoustic materials is 3.316 seconds, surpassing the preferred range. However, the application of acoustic materials drastically reduces it to 0.348 seconds. Similar trends are observed on the second floor, with a reverberation time of 0.318 seconds, and on the third floor, which exhibits the lowest reverberation time of 0.232 seconds. Notably, the third floor, housing the Multimedia Room and Reading Space, necessitates a lower reverberation time for optimal acoustics. The calculation of averages vividly underscores the indispensability of the chosen materials in the building's construction. Thus, the incorporation of these materials is essential for effectively attenuating sound decay, facilitating the achievement of soundproofing objectives within the building.

IV. CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

- The research findings indicate that the structure has successfully met both the structural and aesthetic prerequisites for the building. This achievement has been facilitated by employing graphic software to visualize and refine the desired industry partner's design, along with assembling the various building components.
- The conclusions drawn from the analysis of reverberation times on each floor level of the building affirm the material's effectiveness in soundproofing the structure. Notably, the measured reverberation times align with the established average control room volume, confirming the material's suitability for the intended purpose.
- The study's comprehensive evaluation, incorporating the National Building Code of the Philippines, National Structural Code of the Philippines 2015, and ACI 318-2011 through design software, culminates in the determination that the structural design stands as a robust and stable framework.
- Additionally, based on the results obtained from the project's cost estimates, it is established that the financial feasibility of the endeavor is reasonably sound when gauged against current market prices in the Philippines.

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4.2 Recommendations

- For projects involving large areas and to enhanced soundproofing, a thicker foam brick is advisable.
- For projects involving large areas and to enhanced soundproofing, it is recommended to consider a broader array of acoustic parameters.
- It is advised that future researcher subject the soundproofing material to diverse test methods.

V. ACKNOWLEDGMENT

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