MECE 4340 Capstone Design – FALL 2023

**Specific frequency band soundproof wall**

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Abstract

This progress report provides a detailed introduction to the work project for the design of specific frequency band soundproof wall installations from September 1 to October 21, 2024. As part of the ME2024-2025 academic year design requirements, the team consists of three members: Zhou Yuming, Wu Tong, and Wang Xiaoqi. The supervising teacher is Professor Li Qi.

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1. Introduction and problem statement

1.1 Motivation

With the acceleration of urbanization, the problem of noise pollution is becoming more and more serious, especially in areas with heavy traffic and industrial areas. Noise not only affects the quality of life of residents, but may also have a negative impact on health. Therefore, it is of great practical significance to design an efficient sound insulation wall to reduce the impact of noise on the surrounding environment.

1.2 Problem statement

To achieve project goals, it is usually necessary to analyze from two aspects. Firstly, in terms of materials, materials that can effectively absorb or block noise should be selected, such as mechanical metamaterials, artificial composite materials/structures with periodicity, constructed through artificial microstructural units. On the other hand, the project also needs to find structures that can reduce noise, such as thin film acoustic metamaterial structures, honeycomb structures, lattice structures, and ultra lightweight porous structures.

2. The installation of soundproof walls should not only consider the sound insulation effect, but also the load-bearing capacity of the wall. This requires us to conduct force analysis on different structures, use drawing software to construct models, and find the structure with the strongest load-bearing capacity and the smallest self-weight.

1.3 Context

Indeed, in the past century of industrial development, people have invented many solutions to reduce industrial noise. However, the existing solutions still have their own shortcomings. It has been the dream of Chinese people since modern times to realize national industrialization and build a world industrial power. But industrial production will have an impact on the human environment. Environmental noise pollution, like other industrial pollution, is a public hazard that harms the human environment. So it is meaningful to study how to reduce noise and design soundproof wall devices. Our group has decided to design a more versatile soundproof wall by combining multiple structures and materials. Our team will submit a 3D model and theoretical derivation process at the end to demonstrate that the designed soundproof wall can better block noise.

1.4 Background status

No progress has been made.

1. Statement of work, deliverables, and validation

2.1 Statement of work

Search relevant literature, conceive several wall structures and wall materials. The wall structure was made by SolidWorks software, and the physical object (sample) was made by 3D printing technology. If the test performance is good, we will consider looking for a foundry to manufacture a solid wall. This form of design process is carried out for products in all three frequency bands.

2.2 Deliverables

Physical working prototypes: Create physical samples of soundproof, sound-absorbing walls, demonstrate the actual effects of different materials and structures, and provide relevant 3D modeling files to facilitate further design and modification. Conceptual design and simulation verification: Write a conceptual design report, describe the design concept of different structures and materials in detail, and use simulation software to verify the sound absorption effect of the design. Provide simulation results and analysis reports showing the performance of different structures and materials on sound absorption and reflection effects.

Feasibility study and multi-scenario assessment:

Feasibility study report: Evaluate the feasibility of the project in practical application, including cost analysis, construction difficulty and maintenance requirements.

Multi-scene evaluation: Evaluate different application scenarios (such as residential, office, concert hall, etc.), analyze noise source characteristics of different frequency bands, and design corresponding sound insulation and absorption schemes.

Independently manufactured frequency band samples: According to the noise characteristics of different frequency bands, soundproof and sound-absorbing wall samples suitable for low frequency, medium frequency and high frequency are independently manufactured and tested and evaluated.

2.3 Validation

Step 1: measurements

Before the installation of the soundproof wall, the sound level meter is used to measure the noise level of the target area, record the noise data of different time periods and different frequencies, and carry out laboratory tests on the selected soundproof material to measure its sound absorption coefficient and sound insulation effect at different frequencies, and record the environmental conditions of the soundproof wall installation area, such as temperature, humidity, wind speed, etc. To assess its impact on sound insulation.

Step 2: analysis

The measured noise data are analyzed to determine the main noise source and frequency range. According to the laboratory test results, the sound insulation effects of different materials at different frequencies are analyzed, the optimal material combination is selected, and the impact of environmental conditions on the performance of the sound insulation wall is evaluated, and the design is adjusted to adapt to the actual environment.

Step 3: validation

Acoustic simulation software is used to establish the calculation model of the sound insulation wall, simulate its sound insulation effect in the actual environment, and compare it with the measurement data for verification. After the installation of the sound insulation wall, field noise measurement is carried out to evaluate its actual sound insulation effect, and comparison is made with the design target. Finally, the overall performance of the sound insulation wall is evaluated according to the field test results. Determine whether the expected goals were achieved and record all data and analysis results.[2]

1. Specifications

|  |  |
| --- | --- |
| object | specifications |
| Noise frequency range | Low frequency range of 20~800HZ ; Intermediate frequency range of 800~2500Hz; High frequency range of 5000-8000Hz |
| Noise partition wall model | 20cm \* 20cm |
| Material | fiberboard, wood board, polyurethane foam board[1] (Not yet determined) |
| Distance between sound source and soundproof wall | 15cm |

Table1. specifications

1. Progress Description

Milestone #1

Build the model and design the parameters

The initial preparation work for the project has been completed.

1）Confirm project objectives and assign tasks accordingly.

2）Collect relevant information and integrate it.

3）Develop a plan.

4）Theoretical verification of the plan.

5）If the plan is not feasible, modify and adjust it accordingly.

Milestone #2

Complete the theoretical work of the project.

1）The plan is feasible, start making a detailed work plan.

2）Draw the blueprint and complete the initial draft.

3）Consult with the supervisor's opinion and make secondary revisions to the initial draft.

4）Complete the final draft.

5）Prepare interim report work (PPT, speech script, etc.).

Milestone #3

Start making models and complete the initial stage of preparation work.

1) List the list of models to be made and calculate the amount. If the budget is exceeded, modifications or replacements must be made.

2) Purchase the necessary materials. And inspect the quality of the materials, and if they are not qualified, carry out return and exchange work.

3) Make a model according to the blueprint.

4) Conduct relevant experiments using the just made model and record the experimental results.

5) Analyze the experimental results and determine whether the model has achieved its goals.

Milestone #4

Summer end Delivery of finished products.

1) Make secondary modifications to the model based on experimental analysis results.

2) The documents required for preparing the results presentation report.

3) Consult the mentor's opinion and modify the model according to the mentor's guidance.

4) Deliver the outcome.

5) Deliver the necessary textual and visual materials for the final presentation and complete the final presentation.

1. Schedule

Figure1. assignment of project

1. Budget

|  |  |  |
| --- | --- | --- |
|  | **Current Budget** | **Resources** |
| decibel meter | 100￥ | Tool shop |
| material plate | 500￥ | Material shop |
| materials processing | 600￥ | Outsourced processing or 3D printing |
| Performance test | 0$ | / |

Table1. project budget

1. Conclusion

We have completed the formulation of the overall plan, and collected online information for sorting and integration. Next, we will design and innovate according to the data collected.

1. Reference

[1] XIE Dong, XIE Xiaoli, YANG Yang, et al. Influence factors of sound insulation performance of common wall and improvement measures[J]. Technical Acoustics, 2023, 42(4): 515-523.Chacón J M, Caminero M A, García-Plaza E, et al. Additive manufacturing of PLA structures using fused deposition modelling: Effect of process parameters on mechanical properties and their optimal selection[J]. Materials & Design, 2017, 124: 143-157.

[2] Yin J F, Cai L, Fang X, Xiao Y, Yang H B, Zhang H J, Zhong J, Zhao H G, Yu D L, Wen J H. Review on research progress of mechanical metamaterials and their applications in vibration and noise control. Advances in Mechanics, 2022, 52(3): 508-586. doi: 10.6052/1000-0992-22-005