ENGR10
Professor Parikh
December 7th, 2023

Enhancement of PSEC Lab Wing at Foothill College: A Leap Towards Efficiency and Technical Excellence

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Executive Summary:

This project aims to improve the quality of learning at Foothill College, targeting the 4700/4800 PSEC Lab Building. Our student-conducted survey has shown the most significant issue that affects learning in this building is the excess noise generated by the ventilation system. We plan to solve this issue through the creation of a device that absorbs the sound generated by the ventilation system while still allowing proper airflow and ventilation. Our design is a sound-absorbent yet air-permeable cover. The material made to cover the vent is made of a thin and porous sound-absorbing foam. The foam that we use in our design process will greatly contribute to the outgoing sound wave's decreased amplitude. The foam is framed in a durable, lightweight, and nonconductive metal frame, with magnetic corners capable of retaining the device's position relative to the air vent. This cost-effective and easily implemented device will enhance the learning environment of the PSEC 4700/4800 Lab Building, sparking greater success in students and teachers alike. Our solution is by adding this sound absorbing technology we can greatly change the amount of noise caused by the ventilation system.

Introduction to Building 4700/4800:

Our group looked into the 4700/800 building for our project because we wanted to see if there were any problems the building had or if the teachers had any concerns for this building. We sent a survey out to the teachers so we could have a better understanding of this building and from the survey we found that almost half of the staff expressed feelings on the HVAC system. The teachers also expressed some technical and mechanical issues but seeing that more than half talked about the HVAC we decided to put our focus on that. The HVAC was causing lots of noise in classrooms and would work awkwardly sometimes making the classes cold or blowing air

really loud. We were able to get a blueprint of the building allowing us to thoroughly look at was causing the loud noise

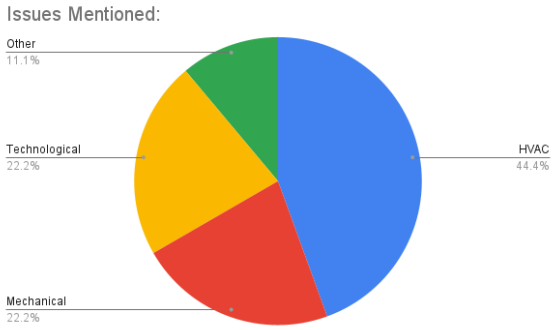
Our recent internal assessments and surveys distributed to staff and faculty members who work in this building have revealed key insights into the overall sentiment and concerns for the building, indicating a trend that these issues are disruptive to a learning and teaching environment. The issues that were brought up by the staff were in the following categories: Technological, which pertains to any issue that will have to do with presentation, teaching, or learning technology, Mechanical, which has to do with the mechanics of some building areas like automatic doors, HVAC, has to do with all venting, heating, or temperature controlling, and the final category of problems that didn't fall into any larger categories, other.

In Figure *S.1* we can see that HVAC makes up almost half of all the interviewed staff's grievances, with Mechanical and Technological together making up almost 45%. In our anonymous survey, Teacher A said, "The ventilation system- it's loud and unpredictable. Often the building is far too cold…" and similarly Teacher B said, "The air is blowing constantly and is very loud". The ventilation system does get quite noisy as one of my other associates and I investigated. We learned this by examining other classrooms to see exactly how bad the noise was getting. Some rooms in the building had much greater airflow than others which made it even noisier. This seems to be the overall sentiment where these classrooms have equipment that has become disruptive and requires additional work to reduce the bothersome noise.

Regarding the other concerns, faculty members have reported frequent malfunctions with the technology essential for conducting classes. In reference to the effect that this malfunctioning technology has on the classes, another teacher said "As far as the window screens go, many of my labs require darkness."; letting these issues persist seems to be a common issue as well with

another teacher mentioning “Unfortunately I think the biggest source of the problem is an overworked facilities department. If they had more time or resources I don’t think we’d have these particular issues.” These dissatisfactions entrusted to us by our teachers and staff are what lead us to why we are pursuing the resolution of this issue and our ultimate goal.

Figure S.1:



Project Goals:

Our aim with this project is to improve the space that several professors and students share to better Foothill College’s learning conditions through a device with simple implementation and cheap cost that reduces the noise generated by vents in the building. For students and professors to perform their best daily, the surrounding environment must also reflect top-notch quality. As students of Foothill College, we empathize with other students and teachers over the struggles of technical difficulties that impede our learning. By crafting a solution for the noise generated by the vents in Foothill College Building 4700/4800, we aim to enhance the learning environment, allowing professors and students alike to succeed.

Background Information on HVAC Noise:

Noise or sound is the result of vibrations in an object causing pressure waves to travel through a medium and to our ears (What Is Sound?). In the scope of an HVAC system, there are several vibrating components from various parts of the system that can produce some sort of noise. Any interaction between moving air molecules and a physical component can create noise. One possible source of noise is the powerful fan in the central air conditioning unit which pushes all the air necessary to sustain the building. Additionally, the fast-moving air molecules colliding with fittings and the duct itself could be another source of noise. This is more so the case when the air that collides with the elbows or sharp bends in the ductwork. Furthermore, interactions with objects inside the ducts like filters or even dampers (motorized fins that control air flow) can also create noise. Then, as the air exits the ducts, it is redirected by the vent, also known as a diffuser, which would also create noise. When all these noises from different sources travel with the air that is expelled from the diffuser, they result in overlapping and further amplified noise (“Ductwork - Noise Transmission”).

Research on Noise Reduction:

Because sound is typically created through vibrations in an interacting object, one strategy for reducing noise in an HVAC system could be to reduce the vibration throughout the system. This can be done by surrounding the central AC unit and the ductwork with vibration-dampening material. The product shown in figure R.1 is vibration-dampening material with adhesive that can be directly applied to metal to reduce vibration (“HVAC Noise Reduction: Soundproofing Ductwork and Vents”).

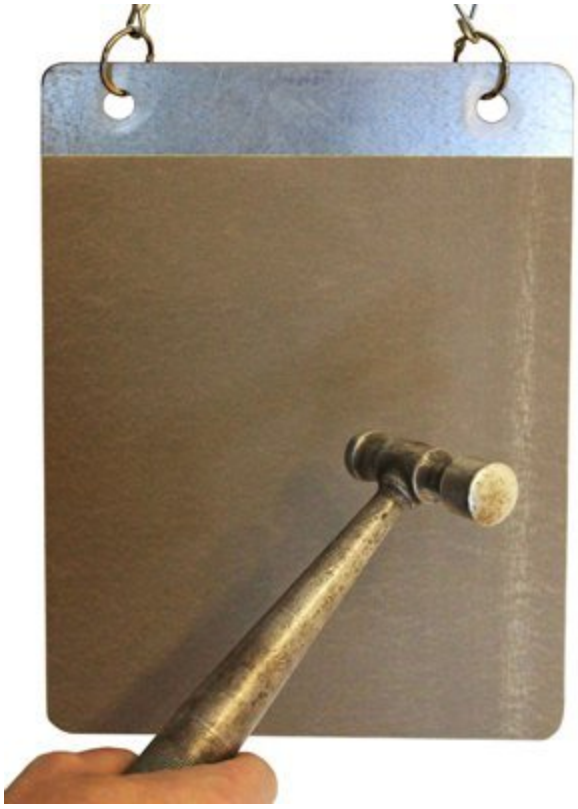


Figure R.1: *Vibra Block® Sound Deadening Material (Pad)*

Another strategy is to reduce the noise as the air passes through the ducts. This can be done by lining the *inside* of the ducts with a sound absorbent material, typically sound absorbent foam as shown in Figure R.2 (“HVAC Noise Reduction: Soundproofing Ductwork and Vents”). But from what we have observed, all of the “exhaust” ducts already have those installed with the system, and therefore, this would not be the solution to our problem.

Figure R.2: *Thermaflex® M-KE Flexible Duct*

To reduce the noise caused by interaction between pressurized air and the air vent/diffuser, the plate itself can be changed out for a design with less disruptive fins or even the material that the diffusers made out of. Current diffuser design throughout the “Science & Engineering” building is similar to that shown in Figure R.3, with multidirectional fins that work to deflect the air. The diffuser shape that generates the least noise, often used in auditoriums, is a grid-shaped plate as shown in figure R.4. However, by removing the deflecting fins the diffuser’s function of redirecting air is vastly reduced (“How to Fix a Loud Air Vent Noise HVAC DIY”).

Figure R.3: *Curved Vane Directional Diffusers*

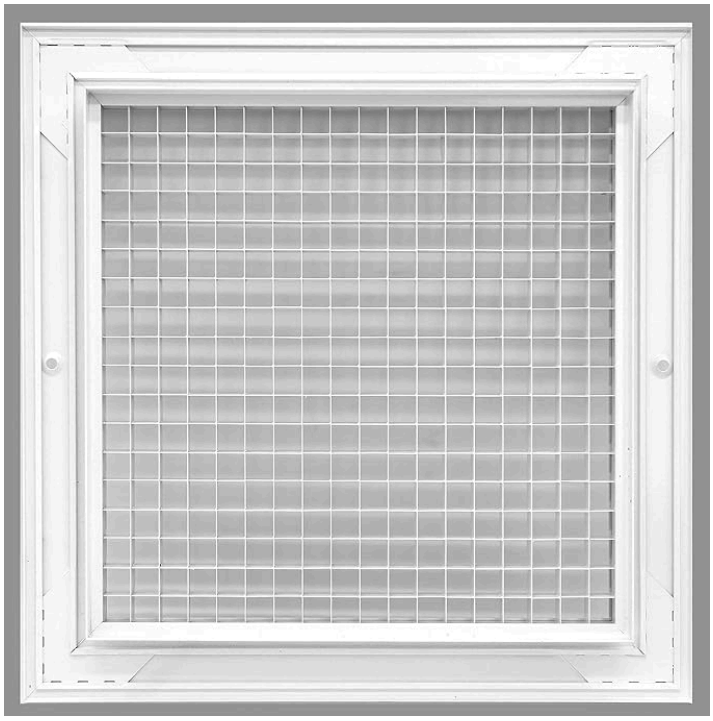


Figure R.4: *12" x 12" Cube Core Eggcrate Return Air Grille*

Another strategy is to employ systems that better control airflow. By restricting airflow, we can reduce the pressure and velocity of the air and thus reduce the sound it creates ("HVAC Noise Reduction: Soundproofing Ductwork and Vents"). These systems already exist in Foothill College Building 4700/4800, as shown in Figure R.5 showing the ceiling diffuser designs in the Record Set of the PSEC HVAC system. However, the systems in our classroom (room 4716) are the direct duct-to-vent systems without air volume dampening labeled as "Diffuser In Lay-in Ceiling" in Figure R.5.

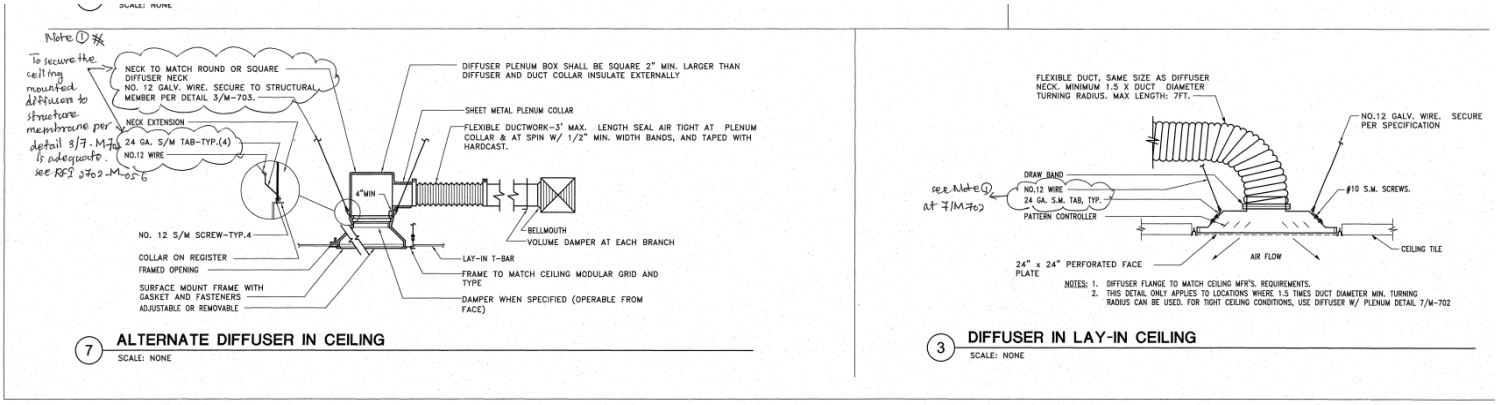


Figure R.5: “PSEC Record Set Mechanical HVAC Only”

This dampening is typically done through motorized fins in the ducts that can remotely open or close. Dampening, however, has drawbacks. It allows for the individually controlled airflow out of specific vents, but can cause a pressure buildup when, for instance, one classroom needs to be extremely cold while another does not require as much air conditioning. The room that does not require air conditioning will close the dampeners while there is a high air pressure created by the needs of the other room. That highly pressurized air passing through closed dampeners will push against the dampener fins creating more noise. To reduce that kind of pressure buildup, a bypass dampener can be installed, which essentially creates a one-way valve between where the pressure would usually build up return it back to the intake of the air conditioner as shown in Figure R.6 (“How to Quiet a Noisy Forced-Air System”).

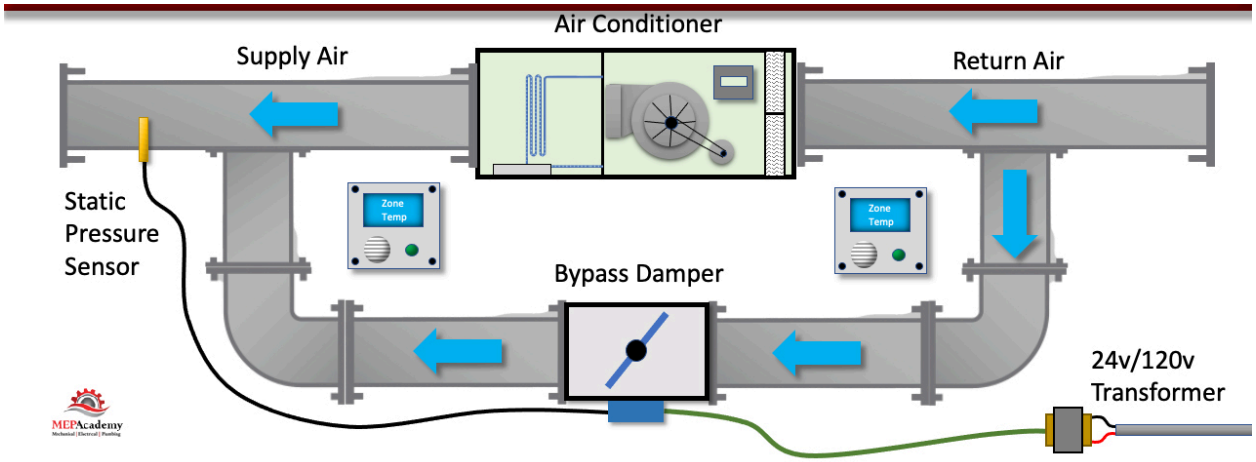


Figure R.6: *Bypass Damper in HVAC VVT System*

Feasible Solutions for Sound Reduction:

We decided to avoid invasive solutions that would require drastic alterations to the buildings ductwork because solving the issue in this way would directly contradict the mission of our project. If we were to install the bypass damper or modify the ductwork that is currently installed it could take multiple days to repair with classes being affected by the work being done. We want to reduce the noise currently causing disturbances in the classroom so making too many changes to the current layout may adversely affect our mission. When it came to investigating the issues that may be present in our classroom of 4716 we used a camera to inspect if the ducts above our room may have any obstructions or disturbances. However, after checking the physical unit and systems in the room, we learned that the unit itself was not our main concern for the noise. It is possible that the amount of pressure being sent into the room may be too high for the vents to contain the noise that is made. We concluded this with our direct observations that we had made from going into different classrooms in the building.

Fortunately we have other solutions that will not be invasive like installing new ductwork. Sound mazes are an option that we discovered in our research of how to dampen sound or reduce the amount of extraneous noise made. Sound mazes are pieces of foam or sound

absorbing materials backed with wood or other hard material stacked in a way that the foams will block the sound while the gaps in between the slots allow the air to continue to pass through. This can be an easy installation where we would only need to measure the internal diameter of the vents, build a box that fits the inside of that vent and get the correct dampening material for the interior of the box.

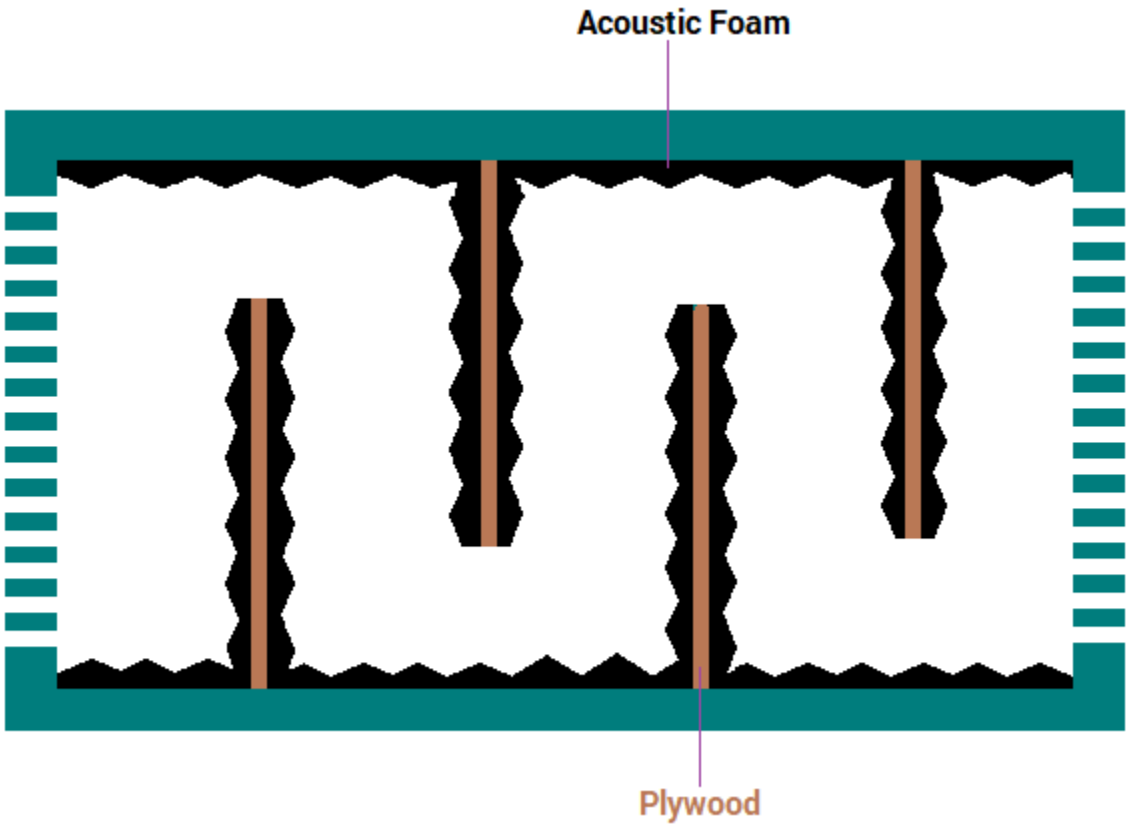


Figure F.1: *Sound Maze Diagram*

Another option that may produce a similar result is installing an outside cover that is a slab of sound dampening material framed upon a lightweight metal frame with magnetic corners to stick to the exit vent. This sound dampening material could also allow air to pass through it but still absorb the sound; the air would move both through the foamy dampening material and around the cover so that air is not heavily obstructed. The SonoLayr nanofiber by NanoLayr, a

New Zealand based acoustics company, would be the perfect candidate for both the sound maze and the sound cover we designed. Their proprietary sound cloth is breathable and thin enough to dampen and absorb those mid to high frequencies that we are trying to eliminate.

Solution Comparison:

Both the sound maze and our custom designed product are the most cost effective and least invasive of all possible solutions but both products also have their advantages and disadvantages. The sound maze is a tried and true and well known solution to a noisy ventilation system but opening the vents to install the maze and taking the extra effort to build the box specifically for each room may be time consuming. The cover we designed would be the easiest to install, most universal for all rooms in the building, and also would not be in the vents in case any obstructions would occur. Our sound cover would allow air to flow cleanly throughout the entire system even while it exits and would still give us the benefits of keeping excess noise to a minimum.

Conclusion:

Overall, we wanted to help improve all of our learning by getting rid of some distractions and we think that addressing the issue of noisy ventilation will do just that; teachers in our survey overwhelmingly expressed their concerns over the disturbances that these vents caused, thus leading us to focus on this issue. We investigated all kinds of methods to eliminate this issue and wanted to go with the simplest and most cost effective. It was a challenge for us to find out exactly where our issue was coming from and how to approach coming up with solutions so researching different ways that noise can be caused in ventilation systems and the different

sounds that certain issues make ultimately started to lead us towards the right path. Our research led us to look into different methods of dampening sound and different materials that can give us the best results so we came up with both a well known solution and something of our own design that took the knowledge we learned and applied it to our classroom setting. We found our design to be the best suited solution for this issue with its lower cost and faster time for installation while still retaining the ability to achieve our sound dampening goals.

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