San Diego, CA
NOISE-CON 2019
2019 August 26-28

Experiences with Gym Noise and Vibration in Mixed-Use Buildings

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ABSTRACT
In the past few years, we have been involved in the design of gymnasiums in mixed-use buildings. These include gyms that are an amenity for the building users and those that are separate retail tenants. Gymnasiums generate both continuous and transient noise that can be difficult to reduce. Continuous noises include amplified music and instructor voices during a class. Transient noises are generated by activity such as weight drops and "running on" treadmills. In our experience, modern gyms can generate noise levels comparable to nightclubs, so some leases have provisions establishing allowable noise and vibration levels in adjacent spaces. When leases do not have such criteria, a more subjective approach is often necessary. This paper discusses the trials and tribulations of several case studies involving various obstacles encountered during both design and construction of mixed-use buildings and the fitness facilities within them. These cases demonstrate the challenges of trying to make a gym acoustically compatible with adjacent spaces in a building.

1 INTRODUCTION
The advent of high-intensity-interval-training (HIIT) gyms in mixed-use buildings poses substantial acoustical problems. These gyms are no longer restricted to cardio equipment and weight machines. New gym owners seek out to provide their clientele with an effective "experience" that produces "maximum" results. The subsequent workouts often generate significant impacts in both airborne and structure-borne noise and vibration, which can be a nuisance to adjacent noise-sensitive spaces. In these environments, clients can drop or throw weights on the floor or against the walls; and jump, kick, and/or hit heavy implements against various objects (e.g., tires). We have encountered several difficulties when mitigating the conflicts inherent in these mixed-use projects.

2 TRENDS
As inhabitants in the U.S. continue to concentrate in cities, mixed-use developments combining residential and commercial uses in one building or complex are becoming more frequent. As acoustical consultants, we have seen a significant increase in projects where fitness facilities lease spaces in mixed-use buildings and need to reduce noise transfer into noise-sensitive spaces.

2.1 Fitness and Health "Boutiques"

Fitness is akin to fashion, with workout tendencies fluctuation from "hot" to "not" very rapidly. The demand for instant results is affecting many aspects of our lives. The contemporary urban dweller is constantly "on the go" with a full schedule trying to balance work and a personal life, which results in thinking that they have "better things to do than to count calories".[1] Thus, gyms have adapted to meet this demand in fitness trends with specialized fitness facilities. These boutique gyms allow the participant to take full advantage of their time spent with the intention of burning more calories and building muscle, in contrast to more conventional workouts.

2.2 Types of fitness activities

HIIT is a form of cardiovascular exercise strategy alternating short periods of intense aerobic exercise with less-intense recovery periods. Although there is no universal HIIT session duration, these intense workouts typically last under 30 minutes, depending on a participant's fitness level. The duration of HIIT also depends on the intensity of the session. These workouts rapidly burn calories and often offer a music-filled atmosphere where every session feels innovative, entertaining, and stimulating. With the combination of amplified music and impact-generating activities that HIIT adds to the traditional fitness practices, many acoustical conflicts can arise.

Figure 1: *A typical workout at a modern gym (Flickr). Dropped weights create high impact noise in the building.*

3 ACOUSTICAL SOURCES

Fitness activities can generate complaints from nearby residents who are disturbed by several sources, including structure-borne noise due to weights being dropped on the floor, people jumping, and high sound levels from amplified music. The resulting intrusions are not exclusive to residents; other adjacent commercial spaces can be affected as well.

3.1 Conflicts

While no construction assembly is entirely "soundproof", noise mitigation can play a critical part in design of a new gym facility. Lawsuits have risen due to gym facilities that have not adequately reduced their acoustical impacts on adjacent spaces. In 2013, the owner of a gym in New York had to pay $250,000 to settle complaints from neighbors in the mixed-use building they were leasing.[2] As consultants, our goal is to facilitate cohabitation between gym owners and other occupants by providing recommendations on how to address these matters.

3.2 Criteria

City and State governments have established noise/zoning ordinances that limit allowable noise levels at various times of day for several zones. These limits provide allowable limits to noise impacts but provide minimal direction in how to foresee potential problems or how to achieve the acceptable levels. Some noise ordinances can be vague and open to interpretation, while others are very specific, so not every criterion is the same.

Tenant improvement guidelines can be incorporated into mixed-use building leases to address noise and vibration intrusion from gym facilities. This can range from limits on the hours of operation to the type of workout equipment allowed. However, if the requirements are too stringent, there can be push back from gym operators who want to maximize their investment.

We have worked with various corporate gym facilities to develop standards to address noise and vibration in adjacent spaces, which we have applied to most of our gym facility-related projects.

4 APPROCHES TO MITIGATION

As mentioned above, we have developed standard practices for our gym facility projects to reduce impacts on adjacent noise-sensitive spaces. We use "virtual inaudibility" as a criterion to try to avoid complaints. Virtual inaudibility occurs when the noise levels are reduced to at least 10 dB below the ambient noise level in adjacent spaces. This has been successful in helping to reduce the occurrence of complaints in most of our gym-related projects and allows us to quantify the impact into adjacent noise-sensitive spaces. We can typically meet this goal with a combination of architectural modifications and by establishing maximum allowable sound pressure levels for the music.

To determine what type of constructions will be needed, mock-ups can be built and tested in the field to determine the acoustical performance of the current assemblies. This establishes a better understanding of the building and the impact of the proposed activities (e.g., simulating gym noise, weight drops, treadmills use) at noise-sensitive spaces can be quantified.

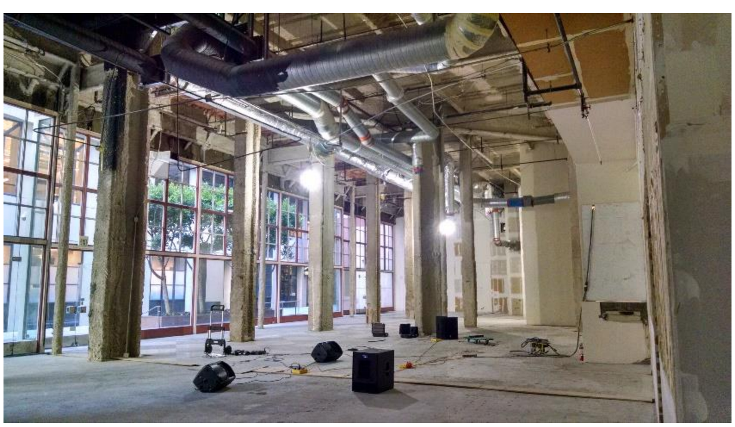

Figure 2: *Mock-up of airborne noise transmission in a proposed gym facility under offices.*

4 CASE STUDIES

The following sections discuss several case studies involving methods and some obstacles encountered during both design and construction.

4.1 Gym Facility, San Mateo, CA

We provided acoustical recommendations for a gym in San Mateo that was already operational and had office tenants located above who were complaining of noise and vibration transfer into their space due to treadmill use. We visited the project site during typical business hours and conducted simultaneous vibration measurements in the corridor adjacent to the treadmills (fifteen treadmills in total) and on the office floor above.

Figure 3: *Vibration measurement location at the gym adjacent to rows of treadmills.*

While the gym was located on the first floor, the floor assembly consisted of wood framing with a crawl space located under the area of the gym.

Figure 4: *Floor assembly of the gym.*

Due to the floor assembly, the treadmills imparted significant energy into the building structure. The rhythmic impact on the treadmill generated significant vibration and structure-bone noise in the conference space above. Noise and vibration also increased as the speed and intensity of the activity increased (i.e., from walking to running pace).

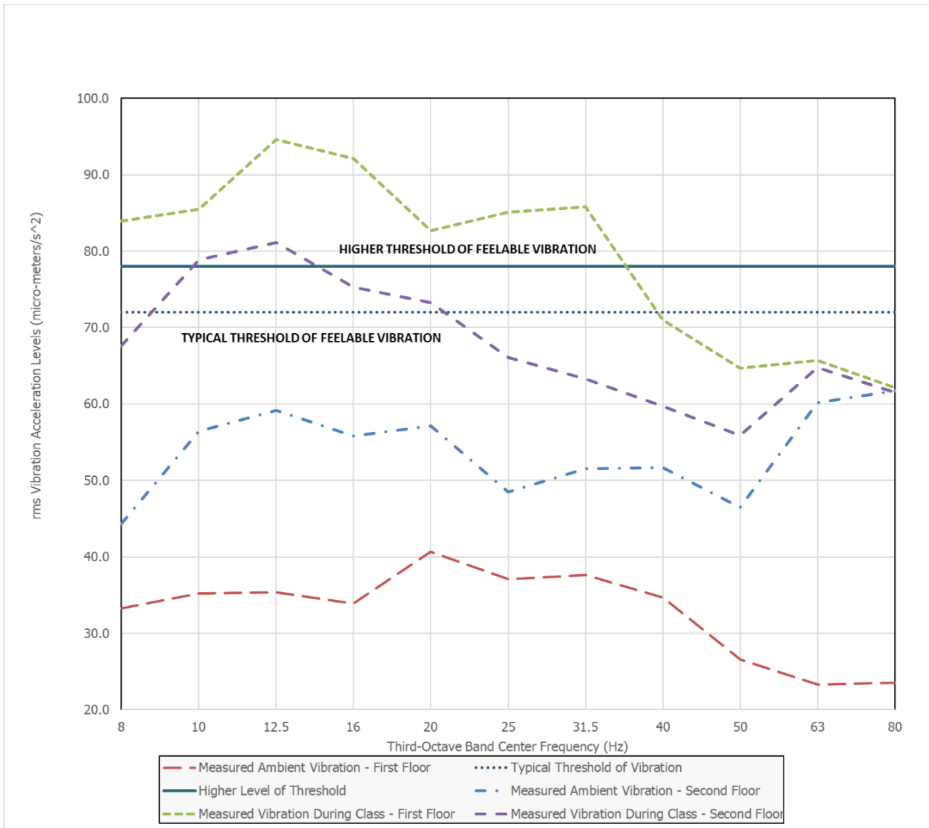

Figure 5: *Measured vibration levels.*

In order to reduce the vibration and structure-borne noise of the treadmills in the office spaces above, we recommended increasing the structural stiffness of the floor. We also recommended increasing the damping by adding significant mass to the floor structure. Once the structure was stiffened, a resilient fitness flooring was recommended for use under the treadmill area.

The gym owner hired a structural engineer and contractor to stiffen the floor assembly by adding beams that ran the span of the floor to the structure underneath the treadmills.

Figure 6: *Structural improvements done at the gym.*

After the floor was stiffened, the gym owner still felt high levels of vibration as did the office tenants upstairs. When we returned to test the assembly, we did not find any change to the previous vibration levels, which was inconsistent with our previous experiences. We set up a meeting with the structural engineer on-site to review the assembly and found that the new structural supports were not installed properly. The new beams had a gap below the structure which did not provide any additional support.

This incident established why it is important to conduct post-construction measurements to quantify the performance of the new assemblies.

4.2 Gym Facility, San Francisco, CA

We provided acoustical recommendations for a gym in San Francisco that offers a high-intensity group workout regimen using treadmills, free weights, and other exercises, all led by an instructor shouting into an amplified sound system. We conducted a mock-up study for this project and determined that an isolated floating floor assembly would be required to reduce free-weight impact noise transmission to adjacent noise-sensitive receivers. During design of the project, we worked with the architect to design an assembly that would meet the project goals.

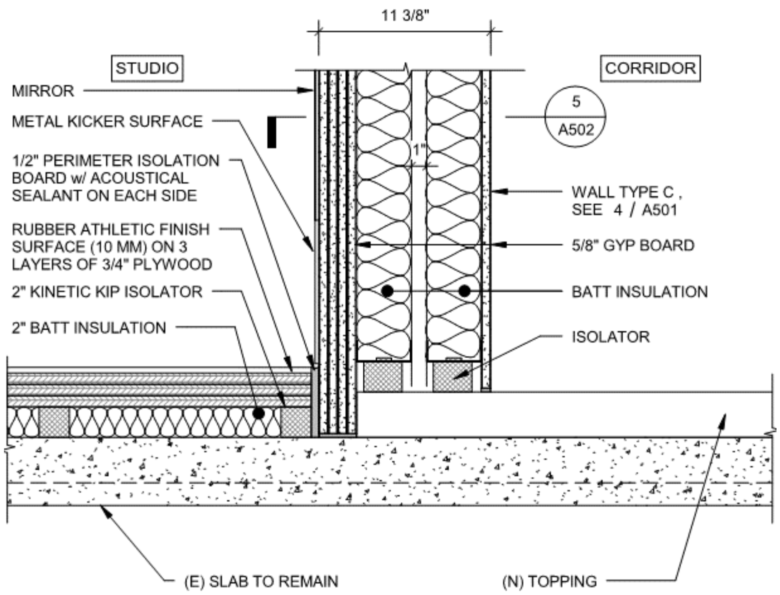

Figure 7: *The designed assembly as shown in the project drawings.*

During the construction phase, we received a call from the subcontractor to observe the installation of the floor. No submittals for the floor assembly had been received prior to the call. When we arrived, we noticed inconsistencies between the installation and the project design.

Figure 8: *The installed floor (left) compared to specified product (right).*

While the isolators were the same, the product specified (i.e., Kinetics RIM system) comes with the insulation incorporated between the glass fiber isolators. The isolators were not installed in the direction where they are effective (in compression). Additionally, the installed assembly did not incorporate the required 1/2-inch thick perimeter isolation board. The installed floor was not acceptable for numerous of reasons:

1. Without any shop drawings, no calculations had been conducted to address static load, and the isolators could have been incorrectly selected to account for the needed deflection.
2. The isolators are tested under compression for their performance. With the specified Kinetics RIM system, the mat system rolls out so that each isolator is facing the correct direction for compression. The individual isolators were installed in different directions, which could result in acoustical and structural defects of the floor.

3. The insulation installed was the wrong thickness and was preventing contact between the plywood and the isolator. Additionally, the insulation was to have been unfaced. The contractor was cutting custom holes in standard, faced building insulation.
4. Without the perimeter insulation board, the floor would have had a rigid connection with the rest of the structure, which would have "short-circuited" the isolators.

After much deliberation with the subcontractor, we learned that the installed product had been ordered from a different vendor representative of the manufacturer without a submittal review or engineered shop drawings. The installed floor was not acceptable and had to be removed, which led to a delay in schedule and additional cost for materials and labor.

This experience emphasizes why diligent construction administration is vital to all projects. Due to this happening, we specifically have called out that future details label the Kinetics RIM system, in lieu of describing the assembly. We were fortunate to have caught this mistake and had the ability to rectify it to prevent a potentially worse situation later.

4.3 Gym Facility, San Francisco, CA

We provided acoustical recommendations for a new gym in San Francisco that also offers a high intensity group workout regimen using treadmills, free weights, and other exercises, led by an instructor. From our understanding, the ceiling assembly separating the studio from an upstairs real estate office was composed of a six-inch thick concrete slab. However, after we conducted a mockup study for this project, we found the assembly lacking in performance, only achieving an NIC (Noise Insulation Class) rating of 30. Based on the lower performance of the assembly, we provided recommendations for a ceiling assembly with a "tunnel" ceiling construction and stricter maximum allowable sound pressure levels in the studio.

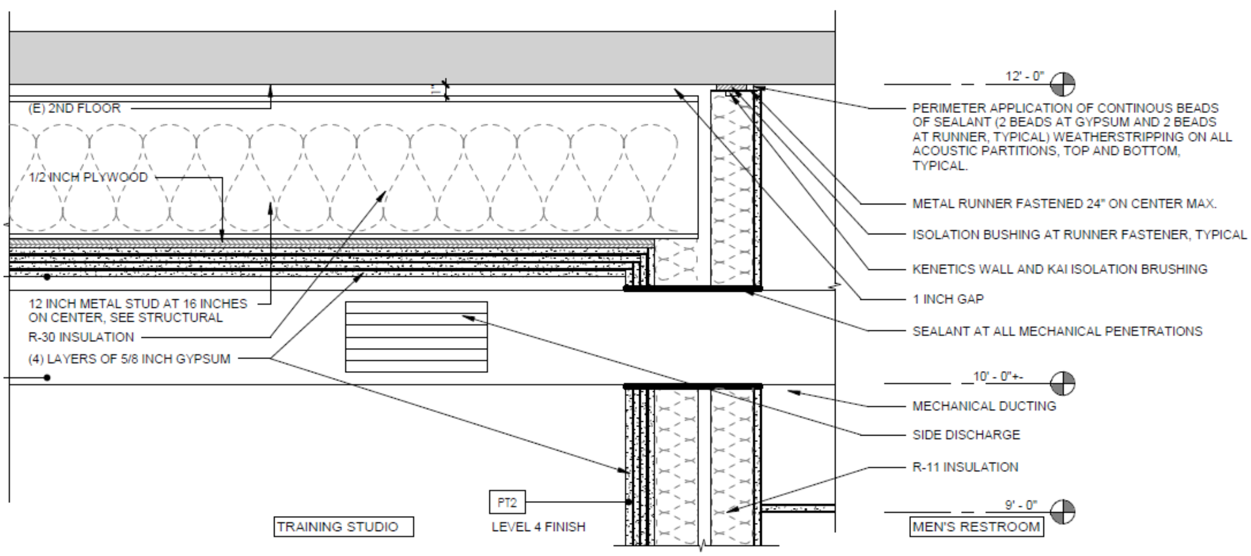

Figure 9: *The designed ceiling assembly as shown in the project drawings.*

When construction began and the contractor removed the existing gypsum board in the studio, the crew found an existing infill of the slab the was just plywood (approximately five feet by seven feet) with no concrete above.

Figure 10: *The "framed" infill in the slab of the studio.*

We had recommended that the hole be filled with concrete from the top, but that was not possible due to constructability limitations and there being a tenant above. Therefore, the hole had to be filled from below with an assembly comprising eleven layers of one-inch-thick cement board, which had an equivalent surface density as the concrete slab. This assembly was sealed airtight at its perimeter.

After the studio was completed, we conducted post-construction testing for noise intrusion between the studio and the office above. The results showed that the background noise levels in the office were not impacted by the studio noise and the "virtual inaudibility" goal had been met.

This case study was quite challenging since leaving the hole untreated would have required lowering the maximum music sound levels in the fitness facility to a point less than desired by the operator, perceived to be inconsistent with brand standards for a "high energy" workout.

5 CONCLUDING COMMENTS

Corporate gyms have adapted in realizing how vital of a role acoustical consultants play in the design of their new or existing fitness studios. We understand that cost is often a primary factor in the decision-making process, and we try to be flexible and work with gym owners and adjacent tenants to create exciting urban mixed-use projects that function successfully. Developers and designers need to work together with acoustical consultants so that noise and vibration isolation can be addressed early in the design process and implemented properly during construction.

6 ACKNOWLEDGEMENTS

This report was supported by members from Charles M. Salter Associates Inc., and we would like to thank them for their assistance.

7 REFERENCES

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