Proceedings of Meetings on Acoustics

Volume 25 http://acousticalsociety.org/

170th Meeting of the Acoustical Society of America

Jacksonville, Florida
2-6 November 2015

Architectural Acoustics and Noise: Paper 2aAA9

Challenges facing fitness center designers in multifamily buildings

Kody N. Snow and Scott B. Harvey
Phoenix Noise & Vibration, Frederick, MD; ksnow@phoenixnv.com, sharvey@phoenixnv.com

Amenity spaces in multifamily and mixed use developments have become extremely popular and possibly mandatory to the economic success of the project. Of these amenity spaces fitness centers are extremely common and pose significant design challenges to the noise control engineer. This paper will compare several mitigation techniques used to control fitness center noise from today' prominent sources including treadmills, group exercise, weight machines, free weights and cross fit weight drops. Mitigation in both wood and concrete structures will be addressed.

1. INTRODUCTION

With the push for transit centered living in major cities there has been a significant increase in demand for the construction of multifamily and mixed use developments. To appeal to the future resident and their urban centered lifestyle, architects are incorporating more amenities into building designs. These amenities may have been offered in an architect's previous building designs, but they were not considered a significant factor in generating building occupancy.

One amenity space that has gained a lot of popularity is the fitness center. With the growing trend of incorporating fitness centers into the design of multifamily buildings, the square footage that a fitness center once occupied within a building has increased. This leads to more fitness equipment offered within a fitness center and an increase in the number of residents using the fitness center at one time. Where the fitness center of old building design was a 500 ft2 room with two or three treadmills and a stationary weight machine, the newer fitness centers are five to eight times in size and offer the benefits of a complete gym with membership. In addition to the size increase, residents expect to be able to access the gym at all hours.

As the size of fitness centers increase, there is an increase in the number of sources capable of generating noise and vibration impact upon the surrounding occupied spaces. Treadmills, weight machines, free weights, group exercise, loud speakers, entertainment features, etc. are all sources of noise and vibration impact if proper mitigation techniques are not incorporated into the fitness center's design. Designing a fitness center that minimally disturbs the surrounding occupied spaces requires coordination with the building's owner and architect, as well as incorporating recommendations early in the design phase.

2. FITNESS CENTER NOISE AND VIBRATION SOURCES

Generally the exercise equipment within a fitness center does not transmit noise and/or vibration on its own, it is the exercise activity that involves the equipment that generates the noise and vibration. Most exercise equipment requires some form of human interaction to be considered a source. For example, a treadmill operating on its own will generate some noise from the belt of the treadmill rolling over the treadmill's running surface, as well as some noise from the treadmill's motor. Once a human is introduced into the activity the situation becomes more complex, as vibration generated by the impact of the person running on the treadmill will transfer through the treadmill's supports and into the building's structure. Therefore, when designing mitigation for fitness center noise and vibration sources, the multiple activities in which they will be used should be considered.

A. Cardiovascular Equipment

Cardio equipment usually consists of treadmills, ellipticals, and stationary bicycles. This type of equipment is usually located in rows of three or more machines and near exterior walls or walls with televisions. Typically ellipticals and stationary bicycles are not significant sources of noise and vibration. The smooth up and down movement of an elliptical can generate some vibration, but not as much as the footfall impact of a runner on a treadmill. Treadmills become a more prominent source when more than one treadmill is being used at a time.

B. Group Exercise

An activity that was once considered too large to be held within the small fitness center of a multifamily building and was limited to full gyms with memberships is now being offered as a

fitness activity in newly designed multifamily buildings. The sequential movements of the exercises that sometimes involve running in place, jumping, and dancing can generate discernable levels of low-frequency vibration, plus the combination of amplified music and synchronized shouting makes noise an issue. Vibration is usually only an issue if the exercise group is large.

Group exercise classes may also include amplified music with an instructor's voice over the music at relatively high volumes. The music is often rhythmic with significant low frequency content, increasing the difficulty of mitigation.

C. Weight Machines

Noise and vibration generated from a weight machine is usually user dependent and can be attributed to the impact of the weights upon one another. Another source is the moving pieces of the machine forcefully impacting with the safety stops.

D. Free Weights

Free weights include dumbbells, barbells, and kettle bells. Weight lifting activities that incorporate free weights usually generate noise and vibration through the dropping or impact with the fitness floor. The levels of noise and vibration can vary depending upon the exercise and the amount of weight being used. CrossFit, a weightlifting sport that is growing in popularity, can involve the dropping of free weights from various heights rather than using a controlled movement to place weight upon the supporting surface. This type of activity can generate significantly high levels of noise and vibration.

E. Electronic Entertainment Features

Outside of the exercise equipment, fitness centers also feature electronics, such as large televisions suspended from the ceiling or mounted on the walls. Sometimes the speakers to the televisions are disabled and the televisions are limited to being displays with audio jacks at the exercise equipment or exterior speakers mounted elsewhere. If televisions or exterior mounted speakers are used to play audio within the fitness center, their rigid attachments to the walls or ceiling above can transmit noise and vibration into the surrounding spaces.

3. FITNESS CENTER DESIGN CONSIDERATIONS

A. Location

Like most noise and vibration sources, the simplest method of mitigation is locating the source in an area of the building away from living units. Due to accessibility and the popularity of an amenity space like a fitness center, architects prefer to locate fitness centers in an elevated area of the building with a nice exterior view and in close proximity to living units. This typically results in the fitness center having a living unit on at least one of the adjoining walls and a public area located below (main lobby, lounge, internet café, etc.). There is also the possibility that living spaces will be located above the fitness center. Therefore, when approaching fitness center design, noise and vibration transmission in all directions should be considered.

Locating the fitness center on the lower floors of the building and away from living units will help reduce the need for mitigation solutions. Usually the first floor of a building has a lower number of living units with most of the floor dedicated to other building amenities and service areas. Placing the fitness center next to the building's service areas (trash rooms, mechanical rooms, stairwells, etc.), as well as above the parking garage minimizes the number of occupied spaces that may be impacted. Also, depending on the type of building, i.e. high-rise with

underground parking, Texas wrap building (u-shaped building with elevated parking garage on interior.), or a podium style building, the first floor is typically constructed on a concrete slab, which is a preferred structural system over wood or steel assemblies.

B. Hours of Operation

Though it may seem obvious that a building's fitness center should be limited to certain hours of the day, it is not always the case. Not all residents within a building operate on the same schedule, resulting in a building's occupants using the fitness center at non-typical hours of the day. Limiting the hours in which a resident can use the fitness center is a simple method to help prevent noise and vibration impact upon other residents during the more sensitive hours of the day (late evening, nighttime, and early morning hours). Scheduling can be a useful method of noise control, though controversial as many users prefer early morning workouts.

C. Equipment Placement

As previously mentioned, the noise and vibration generated within a fitness center can vary depending on the exercise activity being performed. Activities that are known to generate more noise and vibration than others should be located further away from noise sensitive spaces. Treadmills should be located along exterior walls or column lines, where the rigidity of the supporting floor is greater and less likely to deflect from forces generated by footfall. Treadmills should also be located away from wall partitions providing separation from adjoining living units, as noise from the treadmills can impact living units when located directly next to them.

Placing weight machines against or near a partition providing separation from an adjoining living unit should be strongly avoided. Vibration entering the structure from operation of weight machines will transfer directly into adjacent spaces. Therefore, weight machines should be placed away from the walls of adjoining units to increase the distance by which vibration has to travel to cause impact. Direct contact between a weight machine and living unit partition will allow for vibration to transfer directly through the partition and into the living unit.

Free weights are only a noise and vibration source when they are dropped. When dropped, they generally generate significant noise and vibration levels that can be heard or felt throughout the fitness center and surrounding spaces (side to side, above, and below), even at long distances depending upon the structure. Locating free weights as far away from living units as possible, as well as not directly above sensitive spaces, will help reduce impact generated by their use. Designated areas of use are recommended to prevent residents from using free weights in areas of the fitness center that are closer to the sensitive spaces.

Similarly, electronics capable of transmitting noise are recommended to not be rigidly attached to wall partitions of adjoining living units. Locating speakers and televisions along exterior walls and non-living unit walls or resiliently suspending them from the ceiling will help prevent them from causing noise impact.

4. MITIGATION SOLUTIONS

When developing the most appropriate approach for mitigation of a fitness center, both airborne and structure-borne noise should be considered. The location of the fitness center in relation to the surrounding spaces will have a strong influence on the decision, as noise and vibration have the ability to impact spaces in all directions. Structure-borne noise will be addressed primarily through the use of a resilient flooring material or floating slab and airborne noise will be addressed through partition and floor/ceiling design.

A. Isolation at the Source

When available, the best method of isolation is directly at the source. This philosophy applies to all exercise equipment that is offered within a fitness center. Isolating equipment at their point of contact with the supporting floor will help minimize the amount of vibration transferring into the floor. Isolation pads specifically designed for the exercise equipment are preferred, such as treadmill isolation pads. Sufficient mitigation of vibration generated from exercise equipment should not rely solely on the rubber supports provided with the exercise equipment, additional mitigation provided by a resilient floor surface is also required.

Everyone is familiar with the standard circular steel weight plates that are commonly found in fitness centers. Steel plates are known for the loud noise they make when impacting with one another, as well as generating high levels of structure-borne noise when impacting the floor. Most fitness centers are phasing out the old standard steel plate for a rubber/urethane coated steel weight. These weights make much less noise when impacting each other, but are still capable of generating excessive structure-borne noise levels when dropped. This is because the rubber/urethane coating is minimal and offers little to no absorption of force generated from impact with the floor. The best alternative for free weights are bumper plates, which are made from recycled rubber and designed to be dropped on the floor. Though bumper plates are much more resilient than a standard steel plate or rubber/urethane coated steel plate, they are still capable of generating uncomfortable levels of structure-borne noise.

B. Floor Design

Choosing a fitness flooring product that will meet the needs of the fitness center in which it is implemented should be determined by the types of exercise equipment and activities that will be promoted within that space. As it is known by acoustical consultants and engineers, the impact insulation class (IIC) rating (ASTM E492) is not the most representative parameter to use for determining the effectiveness of a flooring product for fitness application. Fitness activity excites low frequency structure-borne vibration below the limits of the ASTM E492 standard and can be difficult to mitigate. Therefore, field testing and design by experience are currently the best tools available for determining an applicable solution.

A fitness center with only cardiovascular equipment can be controlled through the use of a standard thickness acoustical underlayment (1/4” thickness) and thicker isolation pads located under the supports of treadmills, whereas for the same center with added weight machines, a resilient floor of 1” thickness or greater is more appropriate. Based upon experience, fitness centers featuring free weights and group exercise classes require the use of an isolated concrete slab or a rubber fitness flooring product of 2.5” or greater. Furthermore, activities such as Olympic lifting or CrossFit strongly benefit from specially constructed platforms or isolated concrete slabs on spring type isolators.

In addition to acoustical performance, there are two other important deciding factors that an architect or building owner considers prior to considering how well a flooring product or assembly will solve their noise and vibration issues. The first deciding factor is cost, which includes the product and installation cost. If the building owner determines that the cost of the solution is more than the inconvenience of an unhappy resident, they will choose to have an unhappy resident or eliminate the fitness center. This is especially true for buildings of existing construction.

The second factor is the Americans with Disabilities Act (ADA) Standards for Accessible Design. The architect has to ensure that changes in flooring materials from corridors into the fitness center will comply with the ADA requirement of a ¼” without edge treatment and ½” with proper edge treatment for changes in flooring level. Due to the ADA requirement, the ability to use a

flooring product of considerable thickness is limited. Some of the newer fitness flooring products incorporate ADA requirements into their design. Incorporating a fitness flooring material into a building early in the design phase will allow for the architect and structural engineers to account for the materials' added thickness and weight. This can be done by recessing the concrete slab as needed within the fitness center, removing the limitations of the ADA requirement.

C. Ceiling Design

The minimalistic or industrial design trend is becoming more popular among architects, which eliminates finished ceilings in occupied spaces in preference to the industrial look of an exposed concrete deck, mechanical ducts, and plumbing elements. This trend removes any acoustical performance benefits that would have been gained from or incorporated into a finished ceiling. Due to the greater than average noise and vibration levels that can be generated from within a fitness center and the limitations of an exposed concrete slab ceiling, the requirement for a finished ceiling within and below fitness centers is still needed to control noise and vibration.

Unlike the floor within the fitness center, which will help mitigate noise and vibration beneath and on the same level as the fitness center, improving the performance of the fitness center's ceiling or of the space beneath the fitness center will only help with impact upon those spaces located above or below. Again, the extent of recommendations for improving the floor/ceiling system for spaces located above and below the fitness center should be determined by space use. An exposed concrete deck ceiling is acceptable within a fitness center when no other spaces are located above; however a finished ceiling may still be found beneficial.

Fitness centers located above lobbies and other noise sensitive areas will benefit from the use of a resiliently supported ceiling. A resiliently supported ceiling, such as a spring isolated ceiling will help improve airborne and structure-borne noise mitigation. The use of a spring isolated ceiling is strongly encouraged when a flooring product of 1" thickness or less is being used throughout the fitness center. Most importantly, resiliently supported ceilings will help mitigate residual structure-borne noise that is present after transferring through the fitness floor.

Finished ceilings within fitness centers are primarily required when living units are located directly above and the proposed concrete slab will not provide sufficient reduction of noise. Weight drops, the impact noise of weight machines, loudspeakers, etc. can all generate airborne and structure-borne noise levels louder than other typical sources (speech, televisions, walking, etc.). It is often found that the International Building Code (IBC) requirement of 50 STC and 50 IIC is insufficient at providing a comfortable noise level for living units located adjacent, above, or below a fitness center. Remember this standard was designed around control of normal footfall noise and vibration, not that of running or weight drops impacting the floor. Installing a spring isolated ceiling within a fitness center is recommended when loud activities, such as group exercise classes, are planned to be offered.

5. CASE STUDIES

A. Multifamily Building in Reston, VA

The building is comprised of two fourteen story residential towers with a three-story building connecting the two towers. The building owner was very concerned with noise impact upon the main lobby located directly beneath the second floor fitness center. Noise generated by fitness activities could impact the main lobby, giving prospective residents a bad initial impression of the building. The 3,350 ft2 fitness center was designed to feature free weights, treadmills, weight machines, and also included spin and yoga studios (see Figure 1 below).

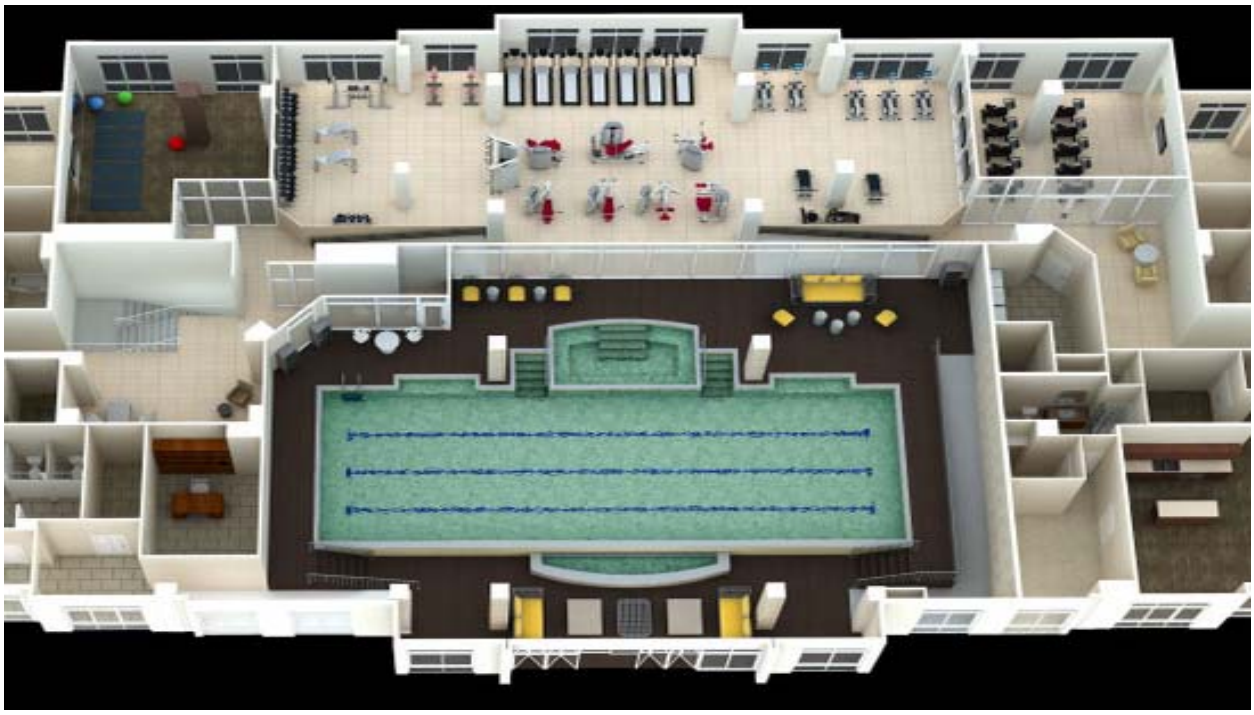

Figure 1: Second floor fitness amenities offered within the building.

Phoenix Noise & Vibration proposed many solutions to help mitigate the noise from the fitness center upon the lobby, which included a floating concrete slab or a rubber fitness floor greater than 1" thickness. Due to the costs associated with a floating slab and the changes to the structural design to account for the slab depression, the owner decided not to proceed with a floating slab. The proposed rubber fitness floor greater than 1" thickness was also decided against due to ADA accessibility and interior design complications.

Through compromise, our solution was to install a ¾" fitness floor within the fitness center and to isolate the gypsum board ceiling within the lobby using spring isolators. Spring isolated ceilings were also installed within the yoga and spin rooms because of the possibility of converting the spaces for group exercise classes.

Installation of the spring isolated ceiling became a much more complicated task than originally designed. The lobby's ceiling featured many coffered areas and had a large amount of mechanical ducts. A majority of the mechanical ducts were also fit to field installation, meaning that the mechanical plans were not a true representation of the actual condition. This made the spring isolator layout much more difficult than typical, involving multiple field visits for location verification.

Thanks to patience and diligence from the building owner and a strong appreciation for a quiet building, the ceiling was installed properly (see Figure 2). This required several field visits by Phoenix Noise & Vibration to educate the installers and insure proper ceiling isolation. Based upon feedback from the owner and occupants of the building, they are happy with the

Figure 2: Coffered ceilings within the main lobby.

B. Two Floor Health Club in Rockville, MD

Though this project did not have residential spaces surrounding its location, it did present many of the noise and vibration problems that can occur when locating a fitness center in a multifamily residential building. The health club is located on the third and fourth floors of a multistory commercial building and offers all of the exercise activities of a typical health club (treadmills, elipticals, free weights, group exercise classes, etc.). This project was unique because the health clubs' interior western wall adjoins with three movie theaters and future commercial office space will also be located on the same floors as the health club.

From the owner's prior experience with noise and vibration issues at other facility locations, we were requested to be involved in the project from the early design and development. One major concern was noise and perceivable floor vibrations generated from group exercise classes upon the adjoining theater and commercial spaces. Our proposed solution was to construct an isolated concrete slab.

Developing the specifications for the isolated slab required us to conduct pre-buildout testing on the concrete structure of the building to determine the concrete floor's resonant frequency. This involved recording simultaneous vibration measurements in multiple locations throughout the third and second floors of the building. With heel drops as our input source and single axis low noise accelerometers coupled with a multi-channel analyzer, we were able to determine the resonant frequency of the structure. Thanks to the help from Kinetics Noise Control, the specifications for an isolated concrete slab were implemented into the design of the health club. A 4" thick concrete slab isolated from the structural slab with Kinetics Roll-out Isolation Material (RIM), specifically designed for this project, was installed in the group exercise room.

Based upon feedback from the client, the isolated concrete slab is performing as required, as there have been no complaints of vibration from group exercise in the surrounding occupied spaces. See Figure 3 for the finished group exercise space.

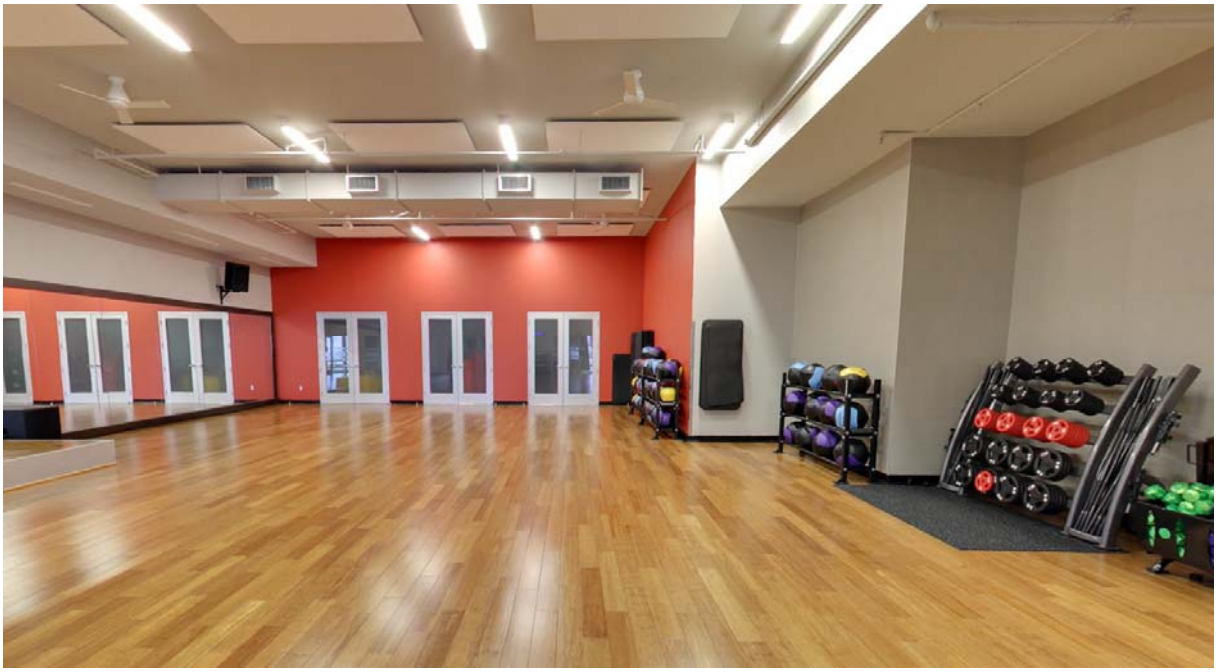

Figure 3: Health club group exercise classroom.

6. CONCLUSION

Unfortunately there is no one specific remedy to creating a fitness center that does not generate noise and vibration issues. There are many design factors that need to be considered when locating a fitness center in a mixed-use residential building. Due to the variety in building owners' and architects' willingness to provide a low noise and vibration impact fitness center, the approach to designing mitigation solutions can be very project specific. When implementing recommendations for fitness center design it is best to be involved in the early design stages. This allows for more design factors (slab depressions, flooring thickness, ADA compliance, ceiling heights, etc.) to be accounted for and does not limit the mitigation solutions available for application.