

# **SENIOR THESIS, SPRING 2007**

The Pennsylvania State University, Architectural Engineering Department

## **Structural Analysis of the Duquesne University Multipurpose/ Athletic Facility**



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# Executive Summary

Currently under construction in Pittsburgh, PA, the Duquesne University Multipurpose Facility will be a dominating feature of the Forbes Avenue Corridor. The University's newest facility is a 125,000 square foot activity center housing everything from academic to athletic spaces.

The building's lateral resisting system is a configuration of concentrically braced frames located around the perimeter of the structure. For my first investigation, I chose to study whether or not there was a more efficient bracing configuration than the existing tension only scheme. I assessed three alternate designs including concentric frames evaluated for tension and compression, chevron bracing, and alternating diagonals or "K" bracing. Each system was judged on the basis of structural performance, drift control, and overall weight. My second investigation was focused on the gravity system of the structure. As stated above, many of the floors are shared by spaces housing both athletic and sedentary spaces. Since the inactive areas will require a certain level of privacy, floor vibrations from the surrounding active areas should be limited. Using the rhythmic vibration criteria noted in chapter 5 of AISC Design Guide 11, I evaluated and designed several critical areas of this building.

To further investigate spatial relationships, several noise significant wall and floor/ceiling assemblies were studied. These systems were evaluated based on STC and IIC acoustical rating criteria.

In the constant pursuit of a more efficient design, cost is always a consideration. For both the gravity and lateral areas of my depth study, a detailed cost comparison was performed. Material, fabrication, and labor costs were included in each estimate as well as manufacturing location and delivery complications.

I have concluded the following based on the above noted study:

- The alternate chevron bracing scheme results in the lightest weight and most inexpensive lateral system for these particular locations.
- The alternating diagonal scheme is the most expensive lateral system due to the increased size of bracing and frame members.
- Overall building drift was controlled best by the chevron and concentric tension-compression lateral systems.
- When analyzing vibration criteria for the long spanning bays, castellated beams meet the rhythmic criteria outlined in Design Guide 11, and offer a significant weight savings when compared to traditional wide flange shapes.
- Open web steel joists were considered, but found to be inefficient when considered for the long spanning floor areas.

# Multipurpose Athletic Center

## Project Background

Duquesne University, located in the city of Pittsburgh, is in the process of expanding its campus. The land being developed is situated along Forbes Avenue, adjacent to the A.J. Palumbo Center, and “will be used for commercial and educational purposes, improving both the entrance to campus and the Forbes Avenue corridor.” The first phase of the project, a multipurpose athletic facility, is currently under construction, and should be ready for use in January 2008. The building itself will be home to a variety of spaces including retail outlets, fitness and recreation facilities, athletic offices, and a ballroom/conference center.

### Duquesne University Multipurpose Center Project Fact Sheet

Owner:	Duquesne University
Architect:	DRS Architects
Construction:	Jendoco Construction
Structural:	Atlantic Engineering Services
HVAC:	Dodson Engineering
Electrical:	Hornfeck Electrical
Building Size:	125000 square feet
Building Height:	7 stories
Project Cost:	\$24 million
Delivery Method:	Design, Bid, Build
Construction Start:	March, 2006
Anticipated Finish:	January, 2008



The lower floors of the structure will house a Barnes and Noble bookstore as well as other retail outlets (Starbuck’s coffee, etc...). The subsequent floors will house facilities for use by Duquesne University faculty and students. The second and third floors will house some classroom and office space intermixed with aerobic and dance studios. The third floor will also be home to the first of two gymnasium spaces. Lastly, the fourth and fifth floors will be used predominantly for a gymnasium (fourth) and a ballroom/banquet space (fifth).

During the process of researching this structure in previous Technical Assignments, several opportunities emerged for my spring thesis studies, as follows:

- Vibration control
- Material optimization
- Lateral stability/Torsion
- Lateral system design
- Design efficiency



Site Location

When driving to and from the city of Pittsburgh, the “Forbes Avenue corridor” serves as a barrier between Duquesne University campus and the city itself. As shown in the above mapping, the new athletic facility is being built on the outskirts of Duquesne’s campus. This building is the first in a long line of projects that will further enhance the college campus.

As construction draws to a close on this project, more construction in the same area will be beginning. The Pittsburgh Penguins have recently finished a deal guaranteeing their stay in Pittsburgh for the next 30 years. The site of the new arena will be a block away, and clearly visible from the upper ballroom area of the Duquesne facility. Along with the new arena, the city skyline will also provide a spectacular view from the ballroom balconies and pre-function areas.



Under Construction 8/2006



Current Construction 4/2006



## General Architecture

Pittsburgh Pennsylvania, with over 1900 bridges in its surrounding area, is known as the “City of Bridges”. The predominant exterior feature of the Multipurpose Facility branches out from the building in the form of a steel pedestrian bridge, connecting to an adjacent parking garage. The bridge itself provides a lively extension, sprawling over top of the Forbes Avenue landscape.



The architectural layout of the Multipurpose Facility is typically rectangular. Each floor is primarily a rectangular grid system divided into publicly and privately functioning areas. The building will be an extension of the campus, providing auxiliary spaces for students and faculty to further exercise their minds and bodies. While the building is owned by the university, the building will serve the community as well. A lower level coffee shop and bookstore will be located on the ground floor, and be the primary entrance for the public. For students, the primary entrance will be from campus connected pedestrian bridge.



The exterior of the building is clad in red brick, masonry units and glass panels. The lower two stories are clad in an off white color masonry, broken with a strip of rough faced CMU. The brick façade is generally uninterrupted. It is, however, separated from itself at the fifth floor by another strip of rough faced CMU. This relatively plain façade is complimented on every face with areas of expansive glazing.

These large window sections allow the occupants of the building to experience the outdoor environment while working, or working out inside. Other than the extended bridge, no structural elements are exposed to public view.