THE PENNSYLVANIA STATE UNIVERSITY

Applied Research Laboratory

Building V

STATE COLLEGE, PA

Senior Thesis Proposal
(Executive Summary)

Eric M. Foster
Architectural Engineering
Structural Option

Advisor:
Dr. Linda M. Hanagan

-- EXECUTIVE SUMMARY --

The Applied Research Laboratory's Building V (Bldg. Five) is an $18 million, 3-story office building and research facility being constructed in State College, Pa. The 121,000 square foot structure will function as a specialized research facility for a branch of the U.S. Department of Defense. This high-security infrastructure will include lab and office area on all but the third floor level, which was designated mainly for office space. Building V will be constructed using different precast systems, including the twenty-eight shear walls that make up the main lateral force resisting system. Building V is also being designed to achieve a LEED certified Gold rating.

Upon request of the tenant, necessary actions were taken to allow for the addition of several floors needed for office space. The new structure will be designed with 4 additional levels of office space, totaling 7 stories overall. With the addition of these levels, the structure shall be redesigned using steel framing as the main lateral and gravity systems. Research and advice taken from a co-working engineer suggests braced frames be used to maximize the strength of the lateral system. Additionally, a concrete core shall also be considered to aide with torsion and drift criteria. Other structural issues, like the green roofs introduced, will be addressed during design phase to avoid any unnecessary strength calculations.

Converting the precast structure to a taller, steel framed structure will also stimulate changes to the envelope and overall perspective of the new edifice. An architectural breadth will be conducted to facilitate changes with overall architectural layout and aesthetics. The aesthetics portion of the architectural breadth is directly related to design criteria set forth by the second breadth topic: blast resistance. This breadth study will include research concerning blast resistant systems and progressive failure in the event of an attack. Due to the increased level of security required by the occupant, advanced research on blast resistant systems could prove efficient and thus will be investigated.

This proposal details the tasks to be completed during the second part of the senior thesis project along with a schedule of those tasks broken down over a weekly course of the semester.

--BREADTH STUDIES --

ARCHITECTURE:

Introducing a completely different steel framing method for ARL's Building V will have ramifications to the existing floor plan and overall design. Great effort will be taken in order to maintain a majority of the existing layout spaces and areas, relocating areas as deemed necessary. In an attempt to minimize deflection and vibration concerns, the 35'x35' typical bays will be considered and likely reduced to incorporate shallow floor plenums and stiffer diaphragms. Special interest will be devoted to floors 1 & 2 based on the amount of open lab space desired and the introduction of blast protection. Furthermore, removing the precast panel envelope around the perimeter lends itself to a variety of different façade and glazing finishes. The change induced on the exterior of the edifice due to the redesigned steel framing and glass curtain façade will be analyzed and incorporated in the appearance overhaul.

In addition, with the existing structure striving for a LEED Gold rating, it only seems fit to incorporate green roofs throughout the plan. Depending on the layout of the proposed structure, green roofs will try to be developed on lower floors. Placing the green roofs lower to the ground will be less critical during lateral loading, compared to being placed on upper levels where the weight of the roof could cause significant drift issues.

BLAST PROTECTION:

As stated in the building introduction, Building V will function as a highly classified research facility for development testing of underwater weapons. Such top secret information related to the government makes the site prone to foreign attacks. A depth study concerning blast resistant systems and progressive failure will be examined to gain a better understanding of this information, as well as its practicality. The exact detail of research and testing is being withheld due to security purposes; hence the study shall include blast resistant designs for both interior and exterior spaces. Interior explosions resulting from unknown testing conducted within working lab areas shall be considered and designed for mainly catastrophic failure of the entire structure. Similar to interior blast designs, the exterior perimeter of the structure will be developed to withstand a blast impact while minimizing the amount of damage to the structure. Special glazing designed for this reason shall be researched and analyzed in order to determine permissible designs.

-- TASKS & PROPOSED SCHEDULE --

TASKS & TOOLS:

Task 1. Blast Resistance Breadth (Part 1):

Research all necessary information pertaining to blast resistance. Includes researching blast loads, blast capacities & properties of various materials, as well as study the effects an explosion will introduce to the façade and lateral system under special conditions. Examine progressive collapse and element failure throughout the redesigned structure and investigate possible solutions.

Task 2. Architectural Breadth (Part 1):

Sketch a schematic redesign of the existing structure, including: altered floor plans with new steel framing and grid pattern, elevations of the proposed structure detailed with story heights and overall building height, and potential wall sections displaying feasible building components (i.e. – glazing, column covers, etc.) required of the new structure.

Task 3: Preliminary Design:

Verify the buildings existing/new gravity loads. Determine trial sizes for structural members using a combination of hand calculations and computer modeling, along with an experienced, working engineer's guidance. Similar to Tech II, this requires typical bay floor systems be analyzed and designed via hand calculations & computer modeling for the various gravity loads to obtain relative member sizes.

Task 4: Preliminary Analyses:

Use the schematic design information & estimated member sizes acquired in Tasks 2 and 3 to perform a lateral load analysis. Analyses will consist of wind and seismic forces estimated from existing information (gravity loads, superimposed loads) and assumptions taken from the schematic design (seismic weight of the structure, overall height due to plenum depth variance).

Task 5: Model System:

Construct 3-D model of proposed structure using ETABS, RAM, or any other program capable of performing the task. Determine practical locations to introduce braced frame(s) and determine whether or not a concrete core should be incorporated to oppose the effects of torsion and drift.

(TASKS & TOOLS cont.)

Task 6: Lateral System Design:

Perform any necessary adjustments to the structure found through computer based modeling and hand calculations to come up with a finalized lateral force resisting system design for the new structure; making sure all required braced frames are in their respective positions.

Task 7: Lateral Analysis:

The preliminary analysis performed in Task 4 should yield the controlling lateral load combination(s). The governing load combination(s) shall be reanalyzed similar to Tech III with the finalized system of Task 6 in order to determine how the lateral loads will be distributed throughout the building, and the amount of load each member is required to resist. Also, determine if the new structure will require the foundation system to be redesigned.

Task 8: Architectural Breadth (Part 2):

Research the essential LEED credits to establish Gold and Platinum ratings and determine whether or not feasible to press for a Platinum rating. Incorporate green roofs considered during structural design phase. Use research found in Task 1 to select blast resistant glazing and required column covers that will unify architectural redesign.

Task 9: Blast Resistance Breadth (Part 2):

Performing all necessary calculations for strength and sustainability prove the selected blast resistant components are practical.

Task 10: Final Presentation:

Conclude any results and final design problems which may have arose, organizing these results into a written final thesis report. A 10 minute presentation summarizing this report will be composed and presented to the faculty and jury of the Architectural Engineering Department.

PROPOSED SCHEDULE: