Senior Thesis 2005-2006

Final Proposal

For Fall Semester

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Executive Summary

The proposed senior thesis study of the Food Science Building in University Park, PA will concentrate its' focus on the Production Area contained within the building. There will be three different analyses performed on the Production Area along with a critical industry issues research topic pertaining to the area. These will be as follows:

- **Analysis 1:** Structural Slab and Concrete Encasement of the Steel Beams
  - Alternative 1: The use of precast double tees.
    - Proposed Benefit: Will provide a better finish while expediting schedule.
  - Alternative 2: Redesign using all c-i-p concrete in this area.
    - Proposed Benefit: Vital schedule savings while aiding in constructability.
- **Analysis 2:** Incorporating a Mechanical Chase Surrounding the Production Area. & Relocating the Basement Mechanical Room
  - Alternative 1: Build a mechanical corridor around entire Production Area.
    - Proposed Benefit: Increased mechanical efficiency and schedule savings.
  - Alternative 2: Relocate basement mechanical room under Production Area.
    - Proposed Benefit: Reduce mechanical sizing and complex job coordination.
- **Analysis 3:** Stainless Steel Bollard Detail.
  - Alternative 1: Redesign a less complex structural installation detail.
    - Proposed benefit: Ease of installation will result in VE and schedule savings.
  - Alternative 2: Replace with precast concrete curbs.
    - Proposed Benefit: A more finished product that would match the equipment.
- **Research Issue:** LEED/Sustainability Review for the Production Area.
  - To develop a set of LEED requirements for a food processing area or laboratory.

The above issues will consider value engineering analysis, constructability review, schedule reduction and acceleration, along with issues research.

Breadth Topic 1 – <u>Structural Slab and the Concrete Encasement of the Steel Beams</u>

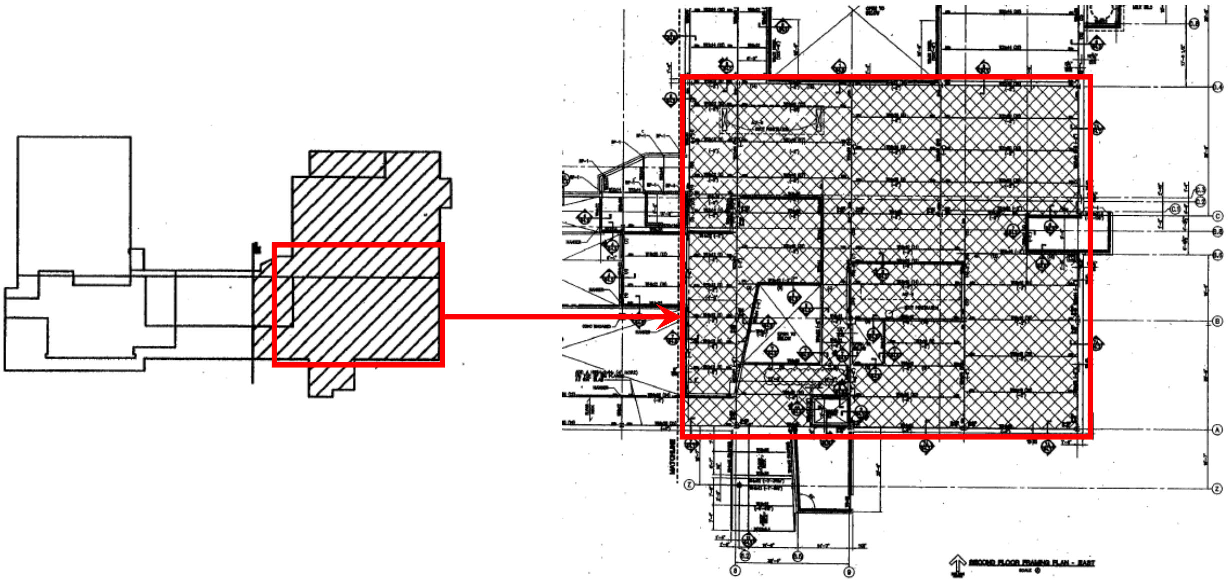
<u>Background</u>

The main Production Area is located in the east part of the Food Science Building on the first floor level. The ceiling of this area (the second floor) is currently designed and installed as an 8” thick structural slab vs. the rest of the buildings’ typical 6” concrete slab-on-deck. Additionally, each structural steel beam, girder, and column in this area had to be encased with concrete which held no structural integrity; it was done simply for sanitation and cleaning purposes. This was the solution that was decided upon by the architect, engineer, and owner to solve the issues of sanitation requirements for a food processing facility. The other requirement that this solution maintained was that there was no exposed carbon steel in the area. The chemicals used weekly to clean and sanitize the area are so powerful that they would eventually corrode and eat through carbon-based structural steel.

<u>Problem</u>

The problem with this design was the difficult constructability and immense schedule impact that it has had to the project. The start-up and useable operation of the Production facility in the Food Science Building is by far the driving task on the schedule. The sequence of the trades that has to take place and the continuous irregular and complex details of the area made management and coordination almost infeasible at times. The extensive amount of mechanical and electrical rough-in that had to take place in the slab-on-grade below before it could be poured was key. This had to be done before the shoring and scaffolding in the area could begin for the structural slab above, which was also waiting on structural steel completion in this area before it could begin. Add in that once they got to this point, no two beam encasements were the same and that after all shoring, forming, and decking was complete another sizeable amount of mechanical and electrical rough-in had to be installed before the structural slab could be poured. These delays and problems continuously pushed back the schedule as well as creating daily headaches for everyone involved.

Refer to the figures below for structural layout showing the location of the structural slab in the building.



Proposed solutions

The proposed solution to the structural slab and steel beam encasement problem is a redesign to another structural system to be used in the area. There are two systems I feel could be utilized in its' place.

Alternative #1: The elimination of the structural slab and steel beams and the utilization of structural precast double tee's bearing on steel girders.

Proposed Benefit: The precast double tees will give a more finished, professional look to the area while maintaining all of the owners' requirements. They will provide a factory "steel plated" finish on the concrete ceiling which will be much more smooth and aesthetically pleasing than you can get with cast-in-place concrete. If able to coordinate around the erection of the building's structural steel I feel that the installation of the double tees will be significantly quicker than the original design and expedite the schedule and progress of the project in this area. On the other hand, another study must be done reviewing all the relocating of the mechanical and electrical rough-ins that are to be installed in the structural slab.

Alternative #2: The elimination of the use of structural steel in this area and the redesign using structural cast-in-place concrete columns, beams, and slab.
Benefit: This would enable a more efficient schedule letting the concrete contractor begin work in this area with out the steel erector having his steel in place. Thus, the steel erector could begin at the west end of the building while simultaneously the concrete contractor can begin with his work in the Production Area on the east end. By the time the steel erector works his way around to the building's east side the concrete contractor should be done with this work. Hence, steel erection can continue and further trades can begin work in the Production Area. Consequently, this will allow the work in the Production Area to begin separately, without depending upon the rest of the building's progress.

These alternative value-engineering solutions will aid constructability and schedule. They will improve the overall quality of the Production Area while saving money and significant time in the schedule. Additionally, during the construction process the flow of job-site coordination, staging, and sequencing amongst trades will be notably improved.

<u>Solution Method – Tasks and Tools</u>

The design of these alternative systems will be based upon the necessary structural loads and requirements above and below the Production Area with regards to the remainder of the building. Below the Production Area is merely a slab-on-grade, but above is a small mechanical room with an air handling unit and an additional 3 stories of building.

I will utilize the project engineers and professionals in the field of concrete and precast design to aid my analysis. Also, I will recall my skills learned in concrete design class with some help from qualified AE faculty if necessary. A preliminary list of tasks necessary to redesign these alternative systems is as follows:

Alternative #1 – Precast Double Tee's:

a) Determine required live and dead load requirements for the floor.
b) Determine span distances for the precast double tees in between steel girders.
c) Size steel girders.
d) Size steel columns.
e) Determine how to make all necessary connections.

Alternative #2 – Complete Cast-in-Place Structural Floor System and Columns

a) Determine required live and dead load requirements for the floor.
b) Choose structural c-i-p floor system that would be best to use: 2-way slab, waffle slab, etc.
c) Design structural slab floor system chosen: thickness, reinforcing, etc.
d) Design c-i-p concrete beams and girders: size, reinforcing, and connections.
e) Design c-i-p concrete columns: size, reinforcing, and connections.
f) Determine how to connect c-i-p structural concrete portion of the building back to the remainder of the structural steel building.

Breadth Topic 2 - Incorporating a Mechanical Chase Surrounding the Production Area & Relocating the Basement Mechanical Room.

Background & Problem

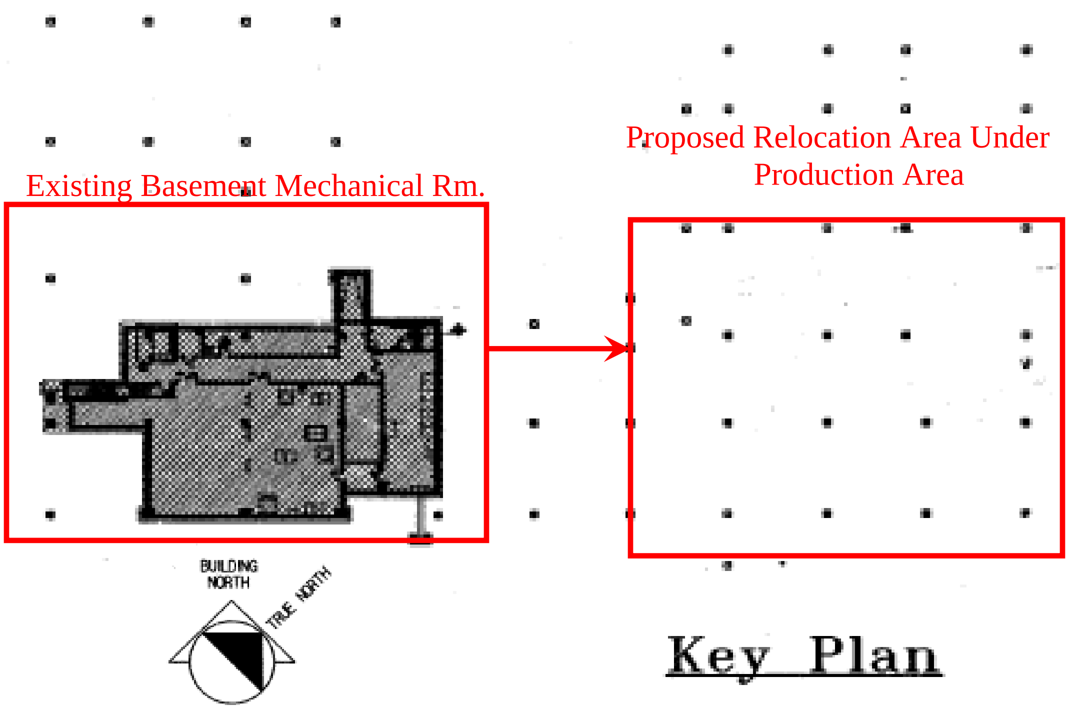
Incorporating a Mechanical Chase Surrounding the Production Area

The Production Area is a highly mechanically driven area of the building. A huge part of the sequencing and schedule delays was due to all of the rough-ins that had to occur in the slab-on-grade before pouring. This held up shoring, which held up structural slab that intern kept continuously pushing the schedule back for the Production Area. Additionally, the same situation occurred in the above structural slab area, although the rough-ins in this area contained an added factor. Due to the vast amount of conduit, pipes, and penetrations a close watch had to constantly be kept on the coverage and structural integrity of the concrete structural slab. All of this work was performed with the idea to keep the least amount of piping exposed in the Production Area itself. Thus, keeping the least amount of exposed piping hanging in the ceiling, the less of a chance there is for bacteria, etc. to grow up there. In spite of their efforts of the design to achieve this there still ended up being a significant amount of piping exposed in the Production Area's ceiling. Also, all of the mechanical and electrical piping running in the Production Area ceiling meant that there needed to be time allowed in the schedule for this work to be done before flooring could begin. Intern, equipment installation, connections, and start-up can't begin until flooring is complete. Refer to the picture below showing a portion of the ceiling in the Production Area while current installation and construction in the area is not even complete.

Relocating the Basement Mechanical Room

The Food Science Building contains a partial basement level; meaning that only the west side of the building has a basement level below the first floor level. This basement area serves solely as the buildings mechanical and electrical rooms. A majority of the services coming from this mechanical and electrical room serve the Production Area which is located at the opposite end of the building on the east side. Therefore, a lot of mechanical and electrical coordination was necessary to route all of the piping through the building to get it to where it was needed. As well, a good deal of extra piping was necessary to make these runs.

Refer to the figures below of the building layout to show the locations of the basement level mechanical room and the location of the Production Area.



Proposed Solution

The following studies of the mechanical systems of the building along with the redesign and relocation will add value to the building while reducing and accelerating the schedule.

<u>Incorporating a Mechanical Chase Surrounding the Production Area</u>

Alternative: To build a 3' or 4' corridor around the entire Production Area that will be used only as a mechanical chase to run all of the main mechanical, electrical, and refrigeration lines through.

Proposed Benefit: From this chase you could stub through the wall where necessary to make your connection, thus eliminating multiple runs across the Production Area ceiling. Additionally, this would provide easier operation and maintenance in the future. All of the piping will be run orderly around the chase supported from the walls making locating lines and repairs easier and quicker. Also, the maintenance workers would not have to enter the clean Production Area when performing ordinary maintenance. Along with the above benefits the largest benefit would be the schedule savings during construction. By placing all of the main pipe runs in an area other than the Production Area you will save a huge amount of time in the schedule. You can have your mechanical, electrical, and refrigeration trades working in the chase while at the same time having the flooring trade working in the Production Area an entire trade earlier.

<u>Relocating the Basement Mechanical Room</u>

Alternative: Relocating the basement of the building, which contains the mechanical and electrical rooms, from the west side of the building where it currently stands to the east side of the building under the Production Area.

*Proposed Benefi*t: By relocating the basement mechanical and electrical rooms from the existing west side of the building to the east side under the Production Area it will improve constructability, coordination, and maintenance. It will shorten a majority of your pipe runs while also reducing the conflicts that may occur along the way. Though, the most noteworthy benefit that will arise from relocating the basement will be that all of the rough in that had to go in the slab-on-grade below the Production Area could now be run overhead in the basement and stub-upped through the first floor

slab. This will greatly ease constructability and future maintenance along with a huge schedule savings. The huge schedule savings will come because now the progress of the structural slab above is no longer in conflict with anything below! Additionally, the layout for all of the stub-ups for equipment that won't even be on-site for months to come is insignificant because you can now stub-up through the basement ceiling anytime, anywhere creating perfect layout the first time!

Solution Method – Tasks and Tools

The redesign and relocation of these lines and rooms will require input from experienced professionals. There are many contacts I have developed through the project that I will utilize to aid myself in this manner. The main contact I will use is Tom Burger whom is the engineer/project manager in charge of the equipment in the Production Area. Tom has built production facilities for twenty years therefore I will hope to gain as much insight as possible from him.

In addition, I will involve the architect to get their professional opinion along with the owner so that I may still adhere to their requirements. A preliminary list of tasks necessary to redesign these alternative systems is as follows:

Alternative – Incorporation of a Mechanical Chase

a) Calculate square footages for all of the rooms in the Production Area, so that I make sure I keep the same size rooms as necessary in my layout redesign.
b) Determine how to relocate and reorganize the rooms keeping this to a minimal while adding in the space for the mechanical chase.
c) Figure the piping lengths and routing that should be in the chase.
d) Determine where what pipes will need stubbed through the wall and where.
e) Determine the additions or savings to the piping lengths and associated costs.
f) Determine whether or not any added turns in the piping affect sizing, flow, etc.

Alternative – Relocating the Basement Mechanical Room

a) Determine if new layout relocation will meet necessary size requirements.
b) Determine a general layout of how to reroute all mechanicals and electricals.

c) Determine if the general lengths of piping have changed.

d) Determine if any resizing of piping is necessary due to run lengths, turns, etc.

Analysis 3 – Stainless Steel Bollard Detail

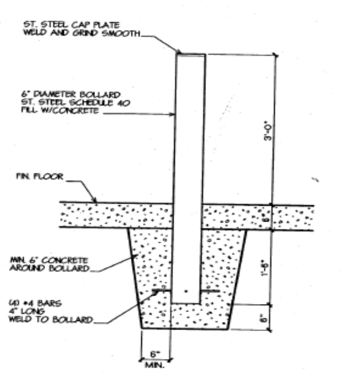
Background

The Production Area contains fifty-six 6" stainless steel bollards that are set in 2' of concrete below a 6" slab-on-grade with #4 bars welded to the bottom of the bollard. These bollards are located sporadically throughout the first floor level of the Production Area for protection of equipment, doors, and entrances for when a forklift is moving around the area.

Problem

In order to place these bollards per the detail, below the 6" slab-on-grade in 2' of concrete with #4 bars welded to the bottom of them, they need to be installed before the slab-on-grade is poured. Therefore, you are trying to layout the exact location of these bollards before the equipment, doors, and entrances are located or placed. Additionally, you don't even have a concrete slab to place marks on and chalk lines down. Hence, you are left trying to layout these bollards in the gravel base of the slab while working around the underground rough-in: conduit, pipes, drains, etc. Even then, if you are able to locate and place them correctly the first time, once the slab-on-grade is poured and all of the walls, equipment and doors are being installed hopefully there was not a change that relocated any of them because the amount of work necessary to remove one of these bollards and place it even a couple inches to the side is tremendous. It is my initial hypothesis that the bollards were structurally over designed to meet the requirements of withstanding a "fork-lift carrying milk cartons at 1mph" *(a logical guess)*.

Refer to the figure below to view the bollard design detail:



11 AB.6 **Typical Bollard**
1 1/2"=1'-0"

Proposed Solutions

The proposed solutions will offer value engineering to the project by providing the same quality with a simpler installation that may result in a cost savings on labor to the project. Also, this would help to expedite the schedule during this phase of the project.

Alternative #1: Redesign a bollard detail that is less complex and more easily installed while maintaining the necessary structural requirements.

Proposed Benefit: A more feasible installation detail would provide easier installation during construction while maintaining the necessary structural requirements.

Alternative #2: Replace the stainless steel bollards with either cast-in-place concrete curbs or precast concrete curbs that can be installed once everything is in place. These curbs would act as guide-rails thus blocking and detouring the forklifts when they get too close to the equipment.

Proposed Benefit: An installation process that could take place after the equipment and everything is set. Thus, they will match the layout of the equipment and doors perfectly. In addition, a continuous guide-rail would be more protective than a bollard at each corner.

Solution Methods – Task and Tools

The solution for this will have to begin with talking to the PSU Creamery personnel determining their uses and needs. As well, industry professionals such as Tom might have seen simpler solutions for the same idea. Additionally, talking with precast curb suppliers and the concrete contractor may be able to provide some insight. Subsequently, I can then perform a quick structural analysis and design. A preliminary list of tasks necessary to redesign these alternative systems is as follows:

Alternative #1: Redesign a less complex installation detail.

a) Determine the necessary load requirements the bollard will have to withstand.
b) Determine the moment that the bollard will resist and calculate accordingly.

c) Determine the most efficient installation design.

d) Calculate costs accordingly.

Alternative #2: Redesign bollards to curbs.

a) Determine the needs for the bollards as far as protection of what and how much.

b) Make sure that the continuous curbs will not inhibit anything else.

c) Determine the necessary load requirements the curbs will have to withstand.

d) Determine the moment that the curbs will resist and calculate accordingly.

e) Determine cost and compare.

f) Figure scheduling of this task when and how long.

Issue Research – <u>Sustainability Review for the Production Area</u>

Through research and investigation of current sustainable designs and requirements I will develop a set of LEED requirements for a food processing area or a laboratory. These results can then be applied to the Food Science Building in either the Production Area or the laboratories. While trying to incorporate a sustainable design into the building I hope to keep costs the same or lower. At a minimum I wish to be able to project a future savings cost for the operation and maintenance of the basic systems of the area: electrical, lighting, HVAC, etc.

This research will require much professional input and direction. I will utilize the AE faculty, most notably Dr. Riley, to aid me in this investigation. Additionally, I plan to utilize last year's senior thesis research from Rob Leight's which developed a set of LEED requirements for museums. In talking with Rob I hope to figure out his approach to this type of research and to be able to expand on it. Lastly, I will meet with the owner to review my findings and discuss the feasibility of whether or not they are ideas they would have wanted to incorporate.