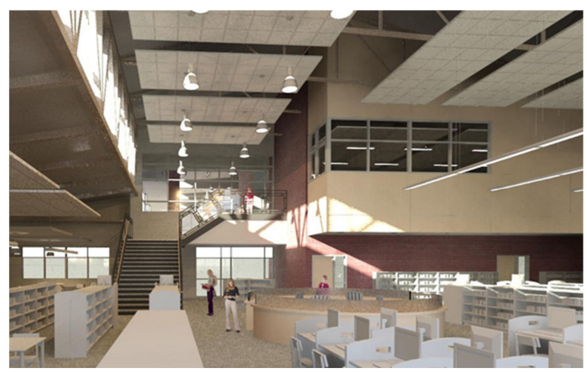
Landis Run Intermediate School

Lancaster, PA

Technical Report Three



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Executive Summary

After a discussion with the Project Manager for the General Contractor it was determined that the three biggest constructability issues on the project were the shear amount of soil that had to be graded coupled with the excess rain experienced this summer, the use of steel angles to help support the perimeter of steel decking as oppose to additional steel joists, and the decision by the electrical contractor to do underground rough-ins. The latter of the two challenges were not ones that could be overcome but rather had to be dealt with in the most efficient manner possible.

It was apparent from the discussion that the areas for possible schedule acceleration were site work, footings, masonry, flooring, and casework. Soon, only flooring and casework will be left to accelerate the schedule since the superstructure is nearly complete. There are no special techniques which need to be utilized in order for these trades to be accelerated. However, significant costs could arise from the additional manpower and overtime that may be required.

The value engineering process on LRI was nearly non-existent mostly because it was a design-bid-build project. Although a few contractors made suggestions on the basis of convenience to the contractor most suggestions were not accepted. In addition, few alternates were accepted. After discussing the topic with the project management team it appears that no significant amount of money was spent or saved as compared with the total project cost for any changes that were approved.

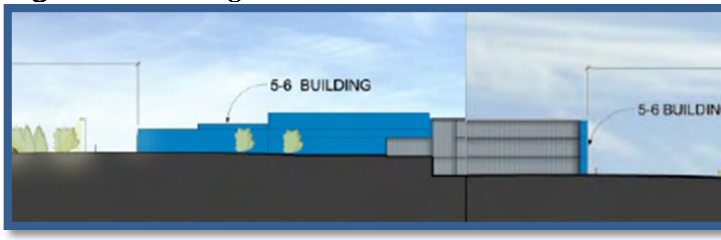
The breakout sessions at the PACE Roundtable provided little if any direct research opportunities for the project. This is mostly due to the fact that much of what was discussed in the first session dealt with occupancy issues which I will not be able to research due to the occupancy date of the project. The second session discussed workforce issues which will be impractical for research due to the significant distance between the project and myself. However, the sessions did provide some indirect research ideas that can be incorporated into other areas of research such as sustainable design.

Due to the common design of the building and the simplicity of the building site there were little research ideas uncovered throughout the first four topics discussed in this paper. Other research ideas, which were thought of originally or through discussion with industry professionals, are renewable energy and sustainability, the feasibility and design of a standardized modular classroom, and the feasibility, cost, and schedule impact of precast panels on the project.

Constructability Challenges

Soil Conditions

Figure 1.1: Designed Grade Differential



As stated in Technical Report One, there was no significant deep excavation due to the use of shallow strip footings for the entire building. However, there was a very significant amount of cut and fill on the project. The design, shown in Figure 1.1, was based off of utilizing an existing grade differential. In order to do so the grade differential had to be made more drastic by cutting at the bottom of the hill and placing the lifts at the top of the hill. This was a challenge on the site because of the shear amount of soil that had to be moved and the significant amount of rain that the project experienced in the summer. The soil needs to be dry enough to be in a specific range of moisture content in order to obtain a compaction level that is specified in the contract documents. The rain caused significant delays during the summer and the project still has not totally recovered to its baseline schedule from the delays.

The project team mostly relied on time and various excavating equipment to aerate the soil by turning it over repeatedly to expose it to the sun and air. This was generally effective but also cost a substantial amount of time. Generally, it would take 2 to 3 days of sunlight for the soil to dry out after a heavy rain.

During the preparation of the building pad for Area C, the project team convinced the owner to bring in stone, with a cost of around $250,000, in order to avoid the time delays that would be associated with waiting for the soil to dry. This was done because it was felt that the project could not afford to lose any more time on waiting for soil to dry.

Use of Steel Angles for Decking Support

Figure 1.2: Steel Angle Deck Supports

As noted in earlier Technical Reports, LRI is a load bearing masonry structure which utilizes steel joists to support a composite metal deck. However, steel angles like the one shown in Figure 1.2, which were bolted into the walls, were used to support the decking at the two walls of the room which were parallel to the joists. The process of installing the steel angles took longer than the time it would take to install two additional joists since it they were installed by two workers utilizing a vertical lift. It would have been much quicker to install additional joists with a crane at the ends of the rooms. This method added significantly to the duration required to install the decking support and therefore the time it took to have all the decking installed. In turn, this prolonged the time it will take to get the building dried in, which is a top priority due to the anticipated inclement weather that is typically experienced in winter.

Since the angles were specified in the design this issue wasn't something that the project team could really overcome but rather one that they just had to deal with. The project team just made sure that the installation of the steel angles was on schedule so that there was no extra time taken up by an already extended activity. Steel angles were specified in the design as oppose to additional joists in order to save the owner money since the cost per linear foot of angle is less than the cost per linear foot of steel joist.

Atypical Underground Rough-Ins

Figure 1.3: UG Electrical Rough-Ins

The decision by the electrical prime to do underground rough-ins earlier in the project versus doing overhead rough-ins later in the project was a challenge for many on the project team. An example of underground rough-ins by the electrical contractor can be seen in Figure 1.3. This required additional coordination between the primes during an already complex part of the schedule. In addition, it this meant that an additional trade could hold up the pouring of slabs and grouting of walls which are critical path items. This activity took up additional time during the superstructure construction phase and therefore delayed the date of dry-in for the project which is an important milestone in the critical path of the schedule and one which the project team is striving for before the onset of inclement winter weather.

Again, this issue was one that the project team couldn't really overcome but rather one that they just had to deal with. This is due to the fact that since the project is multiple prime, the GC cannot dictate which means and methods the other primes have to use on the project. The project team dealt with the issue by making sure that all the primes were aware of when slabs were to be poured and when walls were to be grouted. They placed the responsibility on the other primes by stating that these dates were final and that it was up to the primes to ensure all their rough-ins were completed prior to pouring.

Schedule Acceleration Scenarios

Critical Path Description

The critical path on Landis Run Intermediate, as shown in Figure 2.1, is typical of most load bearing masonry buildings in the Lancaster area. The first part of the critical path is the superstructure which includes footings, load bearing masonry walls, steel joists and angles, steel decking, and concrete slabs. These activities form the most substantial part of the critical path on LRI. As the erection of the superstructure progresses, subsequent critical path activities will trail to make the most efficient use of time on the project.

Dry-In activities, such as the installation of water proofing, insulation, doors, windows, and the brick veneer are the next part of the critical path. Since LRI is of substantial size the dry-in activities trail the superstructure in many areas, especially in the classroom wings, as oppose to waiting for the superstructure to be completely done.

As the dry-in activities are being completed in a given area the overhead rough-in and ceiling grid can start to be installed. The installers have to be sure that the immediate area in which they are installing overhead rough-ins and ceiling grid is substantially dried in because any water that comes in contact with pipes and other overhead equipment will cause rust and other issues which will have to be remedied.

The entire building needs to be dried in before the finishes start to be installed because fluctuations in temperature and humidity can damage many of the finish materials. Once all of the overhead rough-in and ceiling grid activities are completed in a given area the finishes can start to be installed. Finishes on LRI include the installation of flooring, drywall, painting, millwork, casework, classroom equipment and technology, and specialty equipment in the gym, kitchen, and cafeteria.

The complete installation of all the finishes and the successful testing and commissioning of the building systems will make the building substantially complete.

Significant Risks to the Project Completion Date

The most significant risks to the project completion date are inclement weather and coordination with other primes. The weather is a huge risk to the project. All of the interior activities require the building to be dried in for two reasons. The first reason is that contact with water or high levels of moisture can damage many of the finish materials. The second reason is that in order to avoid damage from shrinkage and expansion the building needs to be a consistent temperature and humidity level for a given period of time in order to let the materials adjust to the surroundings before installation. Since the project suffered significant rain delays in the summer, getting the building dried-in so that interior work can begin is a top priority for the project team.

Figure 2.1: Critical Path on LRI

Coordination with other primes on the project is also a significant risk to the project completion date. Warfel is in charge of making and updating the schedule throughout the project which the other Primes must meet. However, besides making the schedule the GC has little if any control over the other primes on the project. This means that the primes must coordinate with each other on a daily basis to ensure that everyone is on the same page and that no mistakes are made or that nothing important gets missed. For example, in the summer the electrical prime didn't order a long lead item, the new switchgear, in time. This made meeting the installation date of the switchgear impossible. This error required multiple weeks of meetings and planning to remediate. The solution that was created was to install the switchgear over three different weekends in order to supply electricity to the site in time for the interior trades to begin work. Errors like this pose a huge risk to the project and show the need for excellent communication and cooperation between the five primes on the project.

Key Schedule Acceleration Areas

According to the project manager for the GC, the key areas in the beginning of the project that could have been used to accelerate the project were the site work, footings, and masonry. In fact, in the summer the project team relied on the masonry contractor to make up delays in the schedule that were caused by adverse weather. The masonry contractor accomplished this by bringing in a larger work force than they originally planned to use. The contractor set up an addition mixing station in order to supply enough mortar to the additional manpower.

With only one more floor to construct in the classroom wings the superstructure is approximately 80% complete. This means that any schedule acceleration areas for the remainder of the project are the interior trades. Almost all of the interior trades can be accelerated by simply working more hours or by bringing in a larger workforce. However, the general contractor only has control of the interior trades with which they hold a contract, which are mostly finishing trades such as drywall and flooring. After speaking with the project manager for the general contractor, he identified flooring and casework as two major interior trades that can be accelerated if needed in order to get back to the baseline project schedule. There are not any special techniques that would need to be utilized to do so. However, the costs associated with accelerating the flooring and casework trades could add up due to the added man power and overtime that would be required.

Value Engineering

There was no significant value engineering process in terms of the primes suggesting value engineering options to the owner or architect. Some suggestions were made by primes or subcontractors to the owner on the basis that they would prefer one option over another (i.e. using a different manufacturer or different product) but typically these suggestions were not based on adding value to the project and did not result in significant cost differences. These suggestions were more so based on convenience to the prime or subcontractor. In addition, there were many alternates listed in the specifications for the project. The owner received figures for "adds" or "credits" from the different primes and made the decision on whether or not to accept the alternates based on the quotes.

Suggestions or alternates that were accepted:

1. A switch from one steel deck manufacturer to another
2. The use of a different type of sink which allowed some walls to be deleted but increased the amount of flooring required.
3. The deletion of some exterior sun shades

Suggestions by contractors that were not accepted are:

1. Changing the façade entirely to split face CMUs in lieu of brick (made by GC).
2. Installing cheaper air handler units with similar operating specifications (made by MC).

The value engineering ideas that were implemented on the project did not detract or further the goals of the owner in any way. Although I was not given access to the costs of any of the alternates it appears that there was no significant savings or additional costs as compared to the overall cost of the project.

Critical Industry Issues

Energy Management Services

The "Energy Management Services" session at the PACE Roundtable discussed:

1. What are energy management services (EMS).
2. How are EMS programs verified.
3. How they are successfully provided and delivered.
4. What are the benefits to the owner.
5. Who is in the best position to provide them
6. Required knowledge of EMS professionals.

The major points that were taken away from the session are:

1. Occupant behavior can have the greatest effect on whether energy management systems are successful.
2. Simpler systems with a low level of user control seem to be successful more often that complex systems with a high level of user control.
3. Energy management programs are more often successful when the program is bought into by the occupants from "the top down"
4. Occupant training can significantly increase the success of the program.

What surprised me about the discussion at the meeting is the fact that often times energy management programs and systems are designed and installed into a building but don't perform on the level they were designed for. In addition, the lack of an industry standard for implementing energy management services and systems was a bit shocking. Since I've been exposed to LEED and energy issues since the very beginning of my education I often times forget that it is relatively new to the industry and its use and implementation is still being figured out by many in the industry.

Topics that industry professionals suggested researching are:

1. The existence of any EMS programs in the U.S. and how they may be improved.
2. The structure of typical performance contracts for EMS.
3. Total life cycle cost analysis of typical EMS.
4. The cost of metric measuring systems versus their savings.
5. LEED certification level versus performance of the building.

Some issues that might be applied on my project are studying the LEED certification level of the project (Silver) and estimating the life cycle cost of the various systems in the building. I could then compare these figures to studies done by the United States Green Building Council to see if the building performs on par with other similar Silver rated buildings.

I could also propose renewable energy systems for the project and calculate their cost throughout the life cycle of the buildings. I could also estimate the energy savings from these systems and study their impact on the LEED rating of the project.

Key contacts from this session who might be able to advise me in my areas of interest are: Daniel Kerr, Mr. Michael Arnold, and Chris Taylor.

Learning Systems for Training a Sustainable Workforce

The "Learning Systems for Training a Sustainable Workforce" session at the PACE Roundtable discussed:

1. What is a sustainable workforce.
2. How can you improve a workforce.
3. How to identify good behaviors.
4. How to focus and emphasize team behaviors over hierarchies.
5. How to change "old school" thinking by industry veterans.
6. What skill sets are needed to be part of a sustainable workforce.

The major points that were taken away from the session are:

1. Integrated teams, not hierarchies, are going to be the standard in the years to come.
2. Changing industry veterans ways of thinking can be challenging.
3. Communication and collaboration are key.
4. More creative tasks require more freedom for teams.
5. Identifying and reinforcing good behaviors is imperative to successful teams.

The opinion held by many of the industry members that the hierarchy structure of many general contractors today is quickly becoming obsolete was very surprising. It was said that teams are more efficient and successful and will be the standard on projects in the years to come. I hadn't heard anything of the like up until this point. I can see how teams would be more effective at managing a project and look forward to seeing this industry issue work itself out in the future.

Topics that industry professionals suggested researching are:

1. Strategies to maintain a team environment throughout projects
2. Looking at different team member's strengths and how they are managed – what conflicts may be created.
3. Who drives the management process when a team is managing the process.

Some topics that might be applied on my project are studying the interactions between the primes and the personality types of project managers for each prime. After studying the personality types I could study who "wins" or comes up with solutions to various problems to understand who is driving the building process.

Also, I could study various methods of maintaining a team in environment through the project by studying the bi-weekly meeting between the primes. I could test various team building methods to see if any methods produce a more cohesive group.

Key contacts from this session who might be able to advise me in my areas of interest are: Mr. Richard S. Fiore and Mr. Michael Arnold.

Problem Identification & Technical Analysis

As described in the previous two technical reports LRI is a fairly simple building. Its building type, load bearing masonry, is the most common type of building in the Lancaster area. Its site is wide open with enough space to accommodate all required equipment and personnel. Its owner is experienced and already owned the land on which the building is being constructed. The construction phase of the project did not utilize BIM which was most likely the right decision since the cost of implementing BIM during the construction phase for a common building type does not make sense. In addition, it is the opinion of the prime contractors that the time frame they were given to construct the building was very sufficient given its size and design. Also, the distance of the site would make research on team interaction impractical since I will not be able to make it to a significant amount of team meetings. Therefore, the areas discussed above, constructability, schedule acceleration, value engineering, and critical industry issues did not provide applicable areas of research for my project. The following pages contain other research areas I've come up with either on my own or through discussions with various industry members.

Cost & Impact of Renewable Energy Systems

The project is currently striving for LEED silver with a total of 52 points. In addition, there are two regional priority credits that the project qualifies for which are not currently being counted. With a total of 54 points the project is only 6 points away from being a LEED Gold building. In addition, the project is on a very large and open campus which has many suitable areas for placement of various renewable energy systems. Furthermore, the long life span that the building was designed for means it can withstand a longer payback period and still see a substantial pay back down the road. Also, since many district buildings sit on the same campus there might be a possibly that a storage shed can store and transfer energy from the renewable energy systems to various buildings through user controls. With this in mind I thought that the project had great potential for sustainability research and design. The following are various sustainability research ideas:

1. Various types of renewable energy and their economic impact on the school from an initial and life cycle standpoint.
2. An estimate of potential energy savings for the life cycle of the building.
3. The impact of said systems on the LEED rating of the building.
4. The energy performance of the building as compared to other similar buildings with the same LEED rating.
5. The cost and schedule impact on the construction of the building with the addition of renewable energy resources and possibly the energy storage shed.

In addition, researching the areas listed above would open up the following breadth areas to study:

1. The structural, electrical, or architectural design of an energy storage shed to store any renewable energy created on site and possibly distribute it to the other district buildings on the campus.
2. The efficiency and cost of various energy storage systems and which would be most suitable for the site.

In order to study these various topics I would need to research:

1. Available types of renewable energy sources and their costs.
2. Structural designs of sheds.
3. Energy storage systems and their electrical design.
4. Typical energy performance of LEED Silver or Gold buildings.

Feasibility and Design of a Modular Classroom

During my discussion with an industry member at the PACE Roundtable the industry member expressed his confusion at why schools which have extremely similar requirements throughout the state are constantly redesigned on an individual basis for each school district. With this in mind I thought it would be interesting to research the feasibility of a standardized modular classroom design with various standardized options including size, finishes, and technology.

The following are various modular standardized classroom research ideas:

1. The feasibility of a modular classroom – I would study this by interviewing superintendents and architects about the requirements of typical classrooms they have experienced. I would then compile all the data to see what the average requirements are and how far apart the all the requirements fall to see if there would be one set of standardized classrooms to satisfy many different school districts.
2. The cost and schedule implications of a modular classroom – I would interview various architects, especially the ones that designed LRI, on how much time the design of the classrooms typically takes them when designing a school. I would then translate that savings in design time into a cost savings. I would also research various prefabrication methods and determine how a standardized classroom could be prefabricated, shipped, and installed. I would then calculate the anticipated time savings of installing prefabricated modular classroom and translate that into a cost savings as well.

The following are various breadth research ideas which could stem from the topics listed above:

1. The structural design of a standardized modular classroom.
2. The lighting design of a standardized modular classroom.
3. The mechanical design of a standardized modular classroom.
4. The architectural design of a standardized modular classroom.

Precast Panels

Although Areas A & B are unique and are not repetitive, Areas C & D are nearly mirror images of each other and are highly repetitive. Therefore, precast panels may be effective in terms of cost and time savings on the project. I would research in depth:

1. How the façade could be split into identical sections to make precast panels most efficient.
2. The cost of precast panels versus the actual cost of the stick built masonry walls.
3. The schedule impact of installing precast versus stick built masonry.
4. The energy performance of precast panels versus stick built masonry.
5. Whether precast panels made a positive or negative impact on the cost and duration of the project.

The following are various breadth research ideas which could stem from the topics listed above:

1. The structural design of the precast panels.
2. The impact of precast panels on the requirements of the mechanical systems.

In order to conduct the studies listed above I would need to research:

1. How to design concrete precast panels.
2. The energy performance of precast panels versus stick built masonry.