

Construction Analysis

Original One-Way Pan & Joist System

Design Results

Total Depth: 25"

Slab: 5" thick

Pan & Joist:

20" pan + 5" slab

Joist width: 8"

Pan width: 53" or 66" typical

Reinforcement:

Top: 3 - #10

Bot: 3 - #9

Stirrups: 16 @ 10"

Beams:

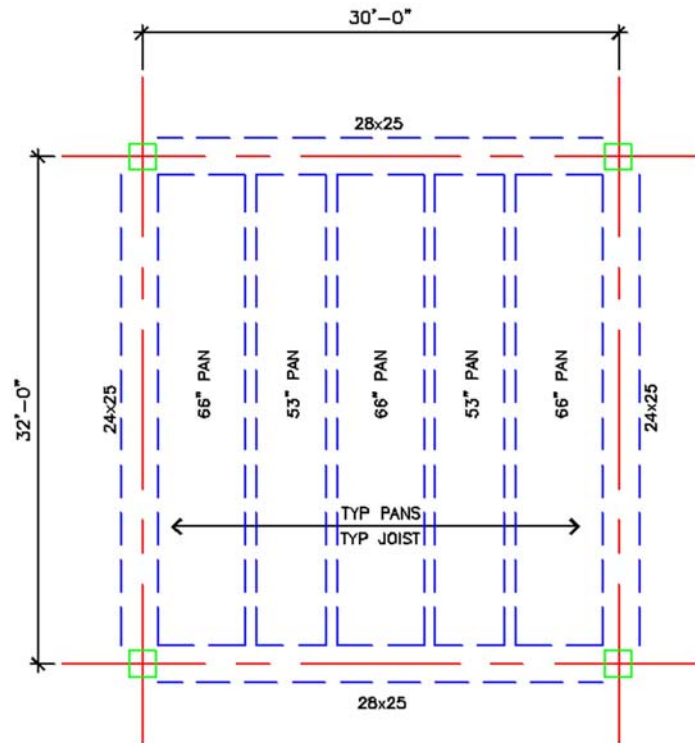
Size: 28" x 25" or 24" x 25"

Reinforcement:

Top: 7 - #11

Bot: 5 - #9

Stirrups: as needed

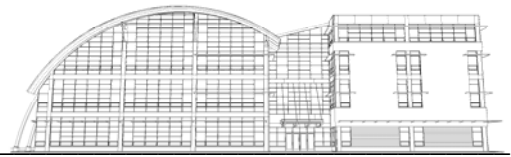


Advantages

- A pan and joist system is more economical than other concrete systems. In this one-way system, the concrete that is in tension (which is usually ignored in design) is eliminated with the use of pan forms thus reducing cost.
- Due to concrete's weight and stiffness, vibrations through the system are severely limited. Through design the deflection was limited to well less than $L/360$.
- The main reason this system was chosen instead of a standard steel system is the advantage concrete has when considering fire resistance. The simple 5" slab supported by the concrete joists does not require additional fireproofing, whereas steel would need to be sprayed with a fireproofing material.
- The ability of this system to adapt by changing spacing, depths, and widths allows the system to be used under changing loads and bay sizes.

Disadvantages

- This system, like most concrete systems is still quite heavy, which could negatively affect the seismic response of the building.
- Constructing this system is more time consuming than a simple steel erection. Pan forms must be used and reinforcement placed correctly, each of which requires additional man hours.



Structural Estimate

A detailed structural takeoff was done to establish values for the concrete estimate. Spreadsheets were created to takeoff foundations, columns, and beams. These spreadsheets included reinforcement calculations and cubic yardage of concrete.

To simplify the many joists spanning each bay a generalization was assumed. Taking a typical bay, the amount of concrete in the slab and joists along with the amount of reinforcement was found in a cy/sf and lbs/sf respectively. These values were then multiplied by the total square footage of each floor to find the estimated amount of concrete and reinforcement used on the floor. The bay was chosen to provide a conservative assumption on the values of the material.

The material takeoff was totaled and then entered into Estimating ICE/ MC² estimating software. The unit prices and labor costs are taken from an established RS Means archive and are held constant for both estimates.

To keep the systems equal only foundation, columns, and framing members (excluding the roof) were accounted for. The roof design was left unchanged and therefore would not make a changing impact on either system.

The following are the estimated costs of the original concrete system:

Description	Cost
Labor Total	\$1,577,704
Material Total	\$1,263,230
Equipment Total	\$37,657
Total Cost	\$2,878,591

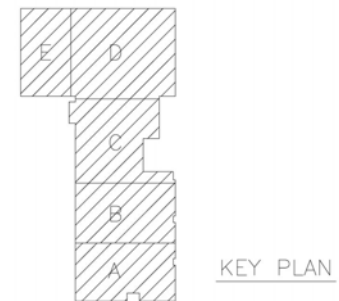
Structural Construction Schedule

The first assumption that was taken when looking at the construction schedule of this system is that the site is large enough to make the cast-in-place concrete forms. Therefore these forms can be construction onsite.

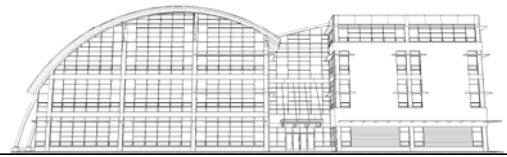
The cast-in-place system will be constructed in levels and in areas. The building is broken down into areas labeled A through E. A figure of this is shown to the right.

Microsoft Scheduler was used to find the total construction time of the specified system.

Construction Time = 186 Days



Detailed takeoffs, the estimate detail, and schedule can be found in Appendix D.



Composite Steel Beams with Composite Slab on Metal Deck System

Design Results

Total Depth: 25"

Slab:

Span: 10'-0"

System:

1.5" metal deck w/ 4.5" slab

3.5" long - 3/4" dia. studs

Reinforcing:

6x6xW2.1xW2.1 wwf

Beams:

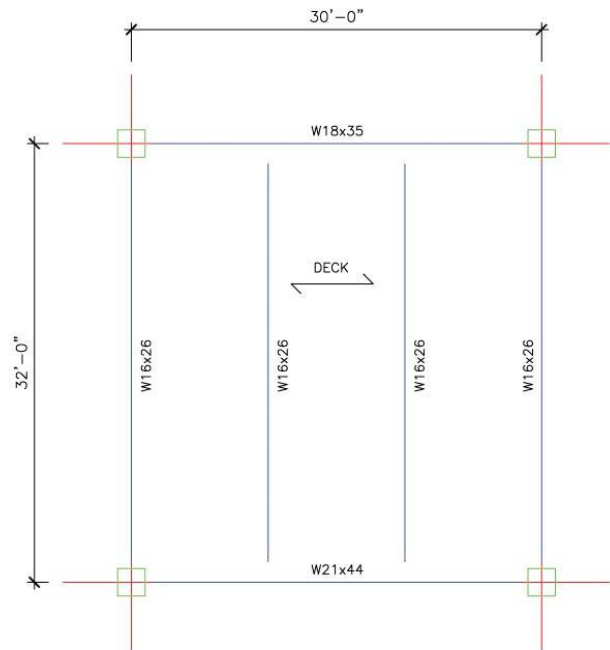
Span: 32'-0"

Size: W16x26

Girders:

Span: 30'-0"

Size: W21x44

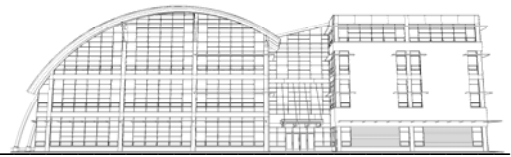


Advantages

- This steel system is comparably lighter than the concrete systems previously used. The composite actions of the slab and deck help to reduce the size of the members.
- Erection of steel is fast and easy. While a crane will be needed to place the steel members, the time-efficiency of placing the steel more than makes up for the extra cost.
- Since this is a typical steel framing system it can be used in most building scenarios. Changing bay sizes or loading patterns only mean a simple change in beam size. Connection details remain standard throughout the building

Disadvantages

- Steel is a high quality design material because of its strength. Steel suffers from vibration effects much more than a concrete system.
- Deflections can become a problem when dealing with heavy loads and large spans, which are present in this building. A simple camber of the beam could rectify the problem; however, in some heavily loaded areas lateral bracing or mid-span reinforcement may be necessary.
- The lateral system for this building is minimal because of the extensive use of concrete columns and floor framing members. If steel were to be used, the lateral system will have to be redone. Moment connections, braced frames, or other lateral supports will be needed to support the wind and seismic loads acting on the building.
- Unlike its concrete counterpart, this steel system requires fire proofing of the steel members only. Since the slab is 4.5" the deck is not required to be fireproofed. The large amount of steel needed only means an even larger amount of spray-on fire proofing, an obvious cost drawback.



Structural Estimate

A similar detailed estimate was done to evaluate the cost of the new steel system for Bradley Tech. The takeoff was not done manually; instead RAM outputs were used to detail quantities.

Unlike the concrete estimate, assumptions and generalizations were not needed and the exact number of steel members could be counted. However, one thing that the steel system required that was not present in the concrete is fireproofing. Abiding by code guidelines, the metal deck did not need to be sprayed due to its thickness, but fireproofing the rest of the exposed steel structure was required. A simple hand calculation was done to find this value and entered into the estimate.

Similar to the original system foundations and all structural members were accounted for excluding the roof system. This helps to provide a constant system comparison and produces the best results.

The following table illustrates the estimated cost of the alternate steel system.

An addition steel surcharge fee is applied to the cost of steel. This was assumed to be \$100/ ton

Description	Cost
Labor Total	\$1,103,434
Material Total	\$1,028,654
Equipment Total	\$26,816
Total Cost	\$2,158,904

Structural Construction Schedule

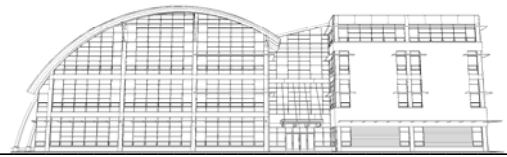
The schedule of steel construction was organized much like that of the original cast-in-place system. Construction will be done by levels and separated into areas of construction as described in the key plan shown earlier.

The assumption was made that the site was large enough to contain a steel staging and storage area during construction of the structure.

Microsoft Scheduler was used to find the total construction time of the specified system.

Construction Time = 148 Days

Detailed takeoffs, the estimate detail, and schedule can be found in Appendix D.



System Comparison

Based on the analysis done above a comparison of the original pan & joist system and the redesigned steel system was constructed. The comparison method is described below and the results follow.

Factors	Structural Systems	
	Existing One-Way Pan & Joist	Composite Steel Beam & Metal Deck
Weight		X
Depth	X	X
System Cost		X
Floor Vibration	X	
Durability	X	
Constructability	X	X
Construction Time		X
Total	4	5

Results and Conclusions

From the comparison above it can be seen that the redesigned steel system is an adequate alternative. It is an overall lighter system while maintaining the same system depth required by the architecture of the building. Concrete, being the heavier system, does in fact limit vibration effects. However, in the design of the new steel system vibrations were checked and did not present a design problem.

The system total costs are very close. With the increasing prices in steel one could argue that the overall cost for both systems is equivalent; however, specific to the area, steel is a cheaper construction material than concrete but is not as readily available.

An all concrete system is a durable design, especially when compared with structural steel. On the other hand, the time of construction of a concrete system is considerably longer due to the increase in labor time due to placing reinforcement and constructing forms. When looking at the construction of steel, lead time for steel orders and fireproofing time come into consideration. With the impact of all these factors the steel system has a shorter construction time and hence presents an advantage.

Looking at the results it is very difficult to choose a better system. Steel may seem to have the advantage but examining what is best for the building the original system seems to fit the needs. In a new steel system the ceiling finishes must be changed, impacting cost and appearance, as well as a slight redesign of the buildings façade which is examined next.