Executive Summary

This report is a description, analysis and comparison of the existing floor system and four alternatives. The proposed floor system for the Kenneth Langone Athletic and Recreation Center is a composite steel system. Through the use of manufacturer dsign tables, the CRSI handbook, the AISC Manual of Steel Construction 13th Edition, RAM Structural system, Enercalc Structural Library, ADOSS Concrete design, and other design aids I have analyzed and obtained preliminary sizes for the following floor systems:

- Non-Composite Steel system
- 2- Way Flat Concrete Slab
- Wood Beam with Form Deck
- Pre-Cast Hollow Core Plank

Each system was compared against one another using overall depth, weight and constructability while also taking into consideration the affects each floor system would have on the existing foundation. From the initial analysis I found that the existing floor system is the most economical for the typical bay spans. Other viable options requiring further study are the 2-way slab and the wood beam with form deck. The 2-way slab could greatly reduce the depth of the floor system and the wood beam system could greatly reduce the seismic base shear.

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Introduction

The Kenneth Langone Athletic and Recreation Center – Sojka Pavilion and Kinney Natatorium is located on the Bucknell University Campus in Lewisburg, Pa. It houses a 4000 seat basketball arena and NCAA regulation size pool. The floor system is a composite steel system with a total slab depth of 6 ½”. The foundation is a series of continuous footings.

Gravity Loads

To be consistent with the original design a 100 psf Live Load will be used as most bays are considered Public space. A consistent dead load of 10 psf will be used for Misc. such as MEP, finishes, etc as estimated using AISC Manual of Steel construction. All other dead loads are determined based on floor system.

Existing System

The existing floor system for the Kenneth Langone Athletic and Recreation Center is a composite steel system. The system is comprised of beams spanning in the long direction and girders spanning in the short direction. The composite deck used is a 2” – 20 gage composite deck with 4 ½” normal weight concrete, having a total slab depth of 6 ½”. The beams are cambered ¾” at center to counteract deflection. The system uses ¾” diameter by 5” long steel shear studs welded on the center line of the top flange of the beams.

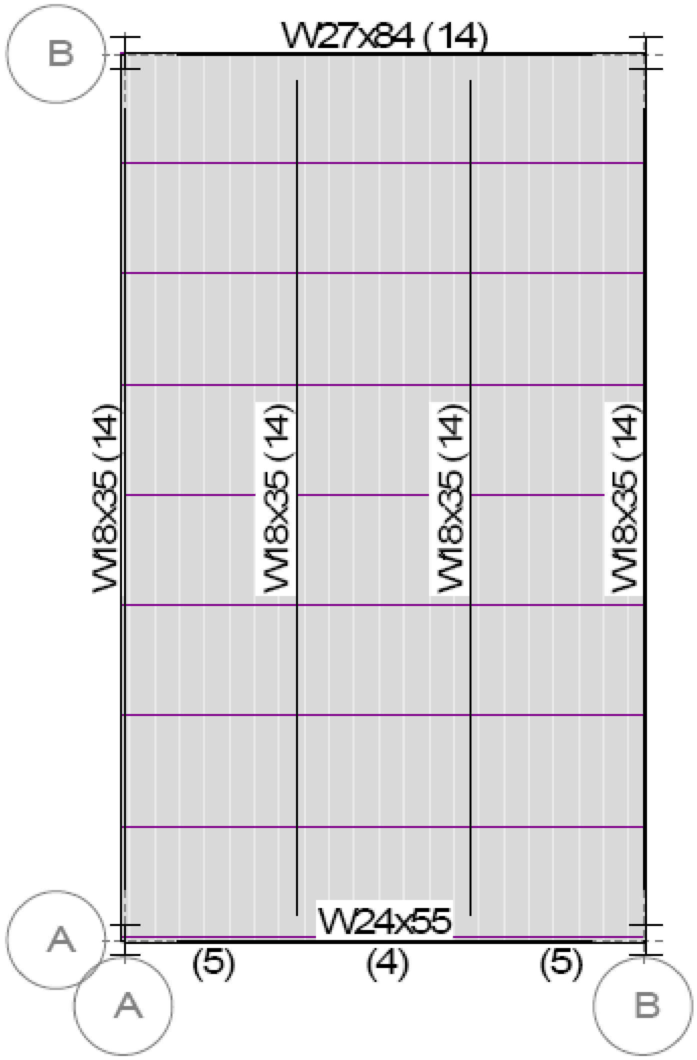

Figure 2.1 Typical Composite Bay

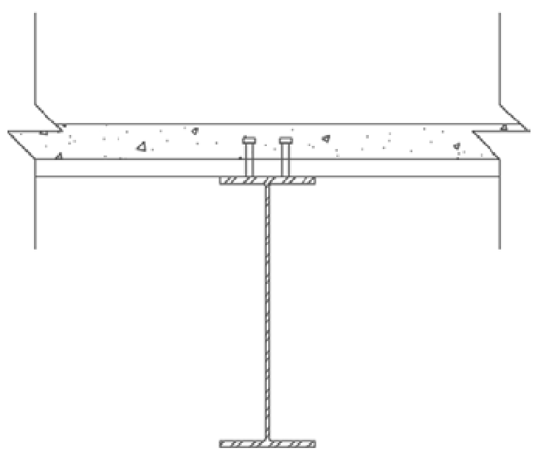

Figure 2.2 Section of Composite Bay

The use of a composite system allows for the longer spans used to keep the corridors and lobby spaces open and free flowing. The system also provides ample space for MEP systems to be distributed easily in the allotted ceiling space. There is a potential for a slight increase in price using a composite system depending on the amount of shear studs needed.

Alternative Framing Systems

The proposed alternative floor systems that will be investigated in this report are:

- Non-Composite Steel system
- 2- Way Flat Concrete Slab
- Wood Beam with Form Deck
- Pre-Cast Hollow Core Plank

These alternative systems will be checked using the typical bay illustrated in Figure 2.1.

Alternative System 1: Non-Composite Steel

The first system selected was a non-composite steel system was selected as the first alternative flooring system for this report. This system was analyzed using RAM structural system. Both the beams and girders were limited to L/240 for total and L/360 for live load deflections. A 2” 20- gage steel deck was selected and the beam and girder spacing was kept the same. To achieve the required fire rating a 2 ½” concrete slab was used.

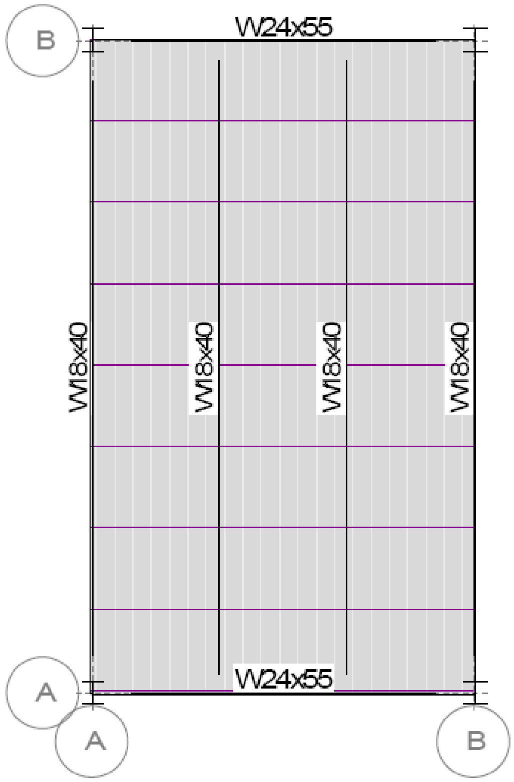

Figure 2.3 Non-Composite Steel System

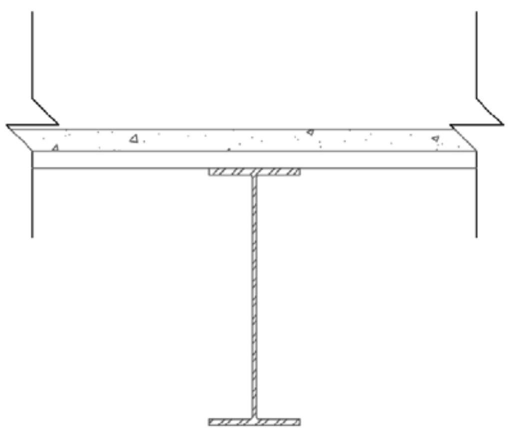

Figure 2.4 Section of Non-Composite Steel System

The non-composite system has the advantage of a thinner slab while keeping the original bay dimensions. This system also eliminates the need for camber in the beams and girders, removing any problems or extra costs that could be incurred. The overall depth of the system is deeper then the original composite system and the increase in the member size would slightly increase weight and cost. This slight increase in weight would have a minimal impact on the foundation system.

Alternative System 2: 2-way Flat Concrete Slab

The second system chosen for analysis was a 2-way Flat Concrete Slab. For this system I first found a preliminary column size using the axial load from technical assignment 1. Using the determined column size and table 9.5(a) in ACI-318 a minimum slab thickness was determined. The slab thickness was determined to be 8”. The system was then analyzed using ADOSS.

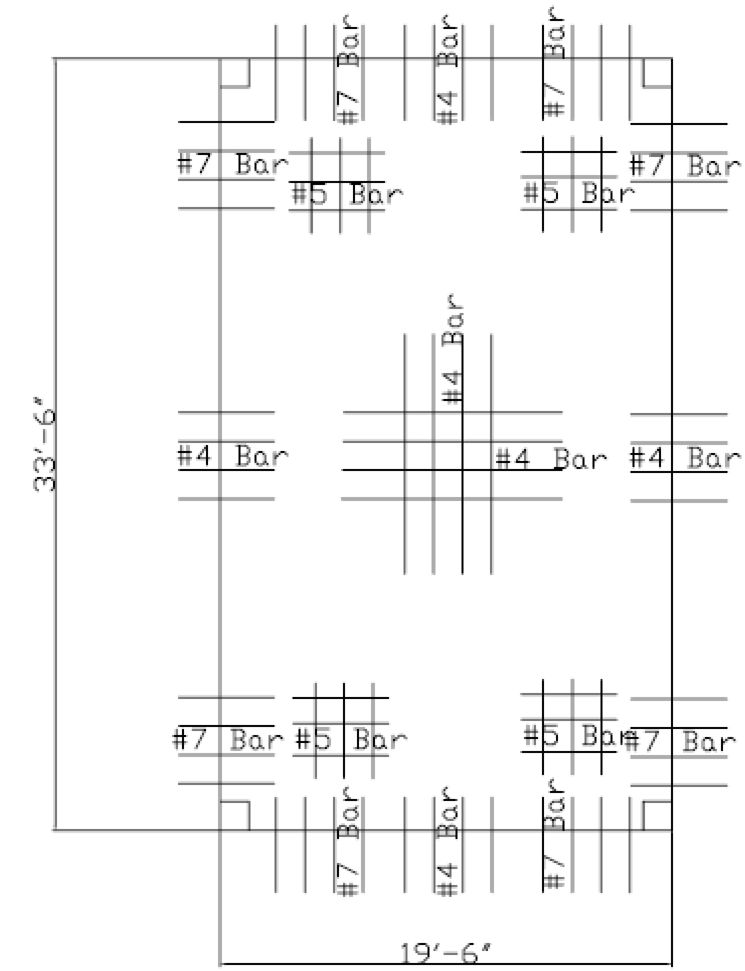

Figure 2.5 2-way Slab Layout

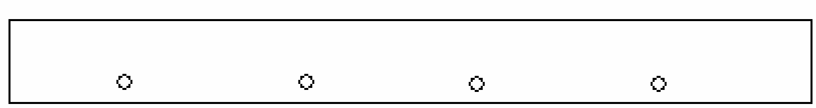

Figure 2.6 Section of 2-way Slab

Although the use of a 2-way floor slab significantly reduces the floor depth, it also increases the weight of the system there by requiring changes in the foundation and increasing the seismic base shear for the building. The need for form work and the large amount of reinforcement also raise the cost and construction time.

Alternative System 3: Wood Beam with Form Deck

The third system that was chosen was a wood beam system with form deck. The form deck was chosen for two reasons, the controlling reason being fire rating. A 2 ½" deep concrete slap was used on top of a 2" 20 gage steel deck to meet the required fire rating. A typical wood floor construction of ply wood and purlins would not meet this requirement. The form deck and concrete also allows for a longer span and therefore the elimination of purlins, keeping the area open to run MEP and other utilities.

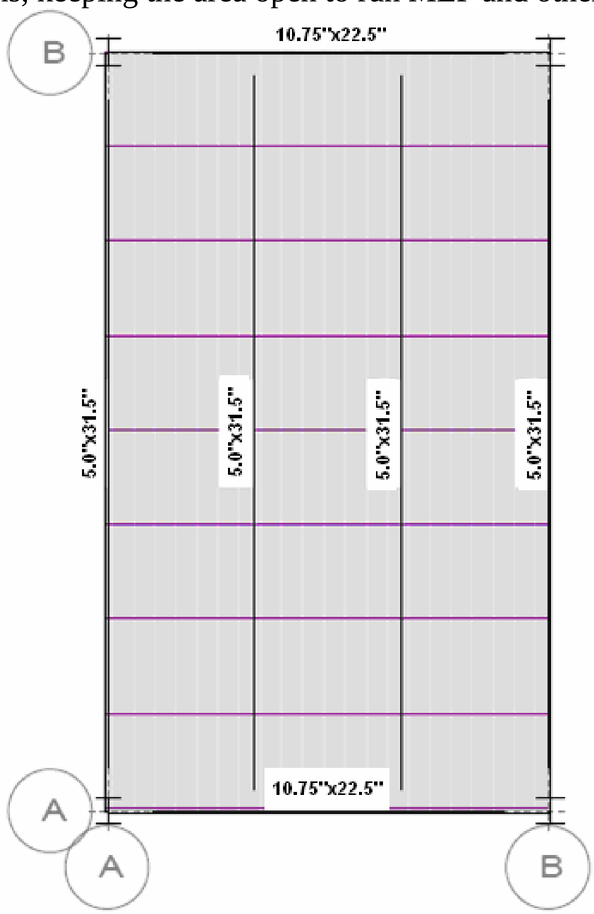

Figure 2.7 Wood Beam with Form Deck

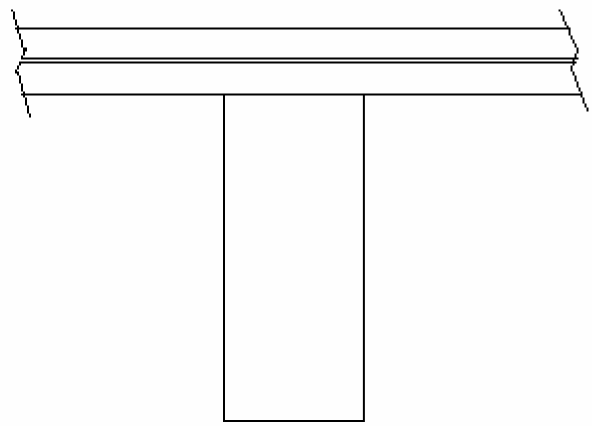

Figure 2.8 Section of Wood Beam with Form Deck

The wood beam system is the lightest overall system out of the 5 studied. The saving in weight would decrease the seismic base shear which would positively impact the lateral system. Also the decrease in weight would put less stress on the foundation system. A draw back to this system is that its reduced weight and rigidity of the materials would increase possible vibrations. This system could also has a potential for high cost and longer production time due to the custom nature of glulam members.

Alternative System 4: Pre-cast Hollow Core Plank

The fourth and final system that was chosen was a pre-cast hollow core plank on steel beam system. The hollow core plank was selected based on fire rating and the Nitterhouse Concrete Products design tables. To provide a level floor surface for the Kenneth Langone Athletic and Recreation Center it was decided that the planks should be sized with a 2” C.I.P. topping. This system also required the typical bay to be resized. The new bay is sized at 33’ 6” x 20’. This bay size was selected to minimize the number of custom planks needed. An 8” x 4’ was selected to accommodate the required loading and to minimize the floor depth. The controlling factor in the design of the steel support girders was deflection. Using Enercalc Structural library, which is based on AISC Manual of Steel Construction 9th Edition, to analyze the steel member, it was found that a W 18x 283.

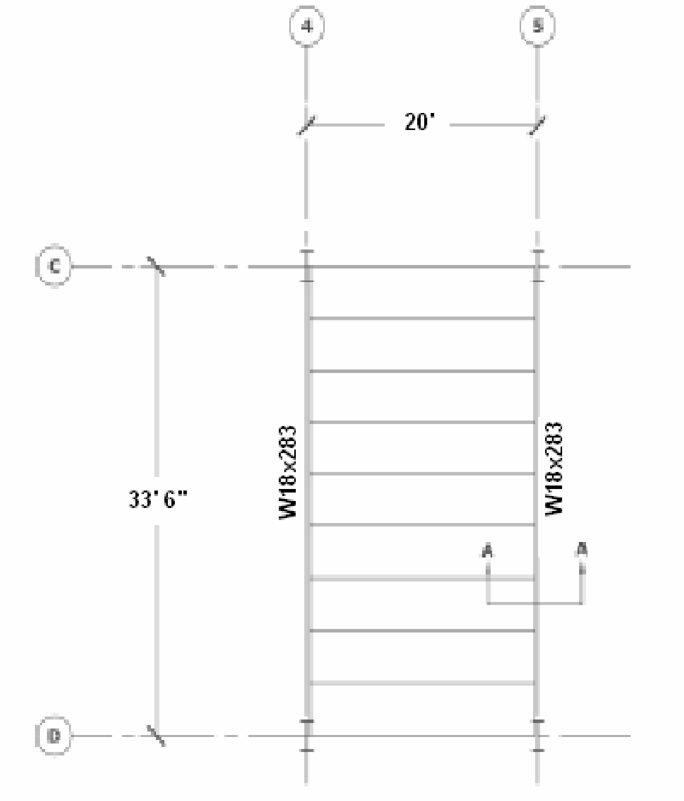

Figure 2.9 Hollow Core Plank

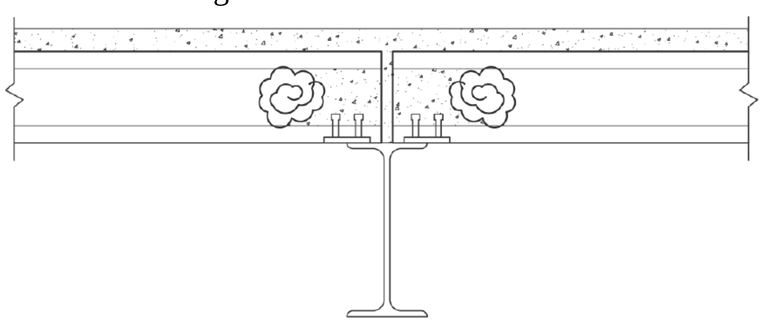

Figure 2.10 Section of Hollow Core Plank

The hollow core plank system is one of the simplest and most rapid to construct. The system cost is also a minimum, but the negatives of the system that may eliminate it from being looked into further. The additional weight of the system would have a negative impact on the foundation system and causes an increase in the seismic base shear. The change bay size and geometry would also require many custom designed planks which would greatly increase the cost of this system.

Conclusions

Of the four systems analyzed in this report I feel that only the Wood beam with form deck system and 2-way slab warrant any further exploration. A more in-depth analysis of the wood beam system could minimize the depth of each beam by changing the spacing. And further analysis of the 2-way slab could reduce slab depth more by changing bay sizes to and therefore further reduce the weight and seismic base shear.

Floor System	Overall Depth	Span	Seismic	Foundation	Cost	Construction
Composite Steel	-	-	-	-	-	-
Non Composite Steel	Minimal Change	No Change	Minimal Increase	Minimal Change	Minimal Decrease	Fast
2-way Slab	Smaller	No Change	Increase	Increase	Increase	Staged
Wood Beam with Form Deck	Slightly Deeper	No Change	Decrease	Decrease	Possible Increase	Fast
Hollow Core Plank	Deeper	1 way Increase	Increase	Increase	Possible Increase	Fast