# Composite Steel Joists – Case Histories

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## KOHL'S DEPARTMENT STORES

Kohl's Department Stores headquartered in Menomonee Falls, Wisconsin, has operated 929 department stores nationwide since 1962. Since 1994, over 650 new stores, including thirty-five two-story stores and four structural slabs, one distribution center, and three phases of their corporate headquarters were constructed utilizing composite steel joists.

### Steel Composite Joist Selection and Advantages

There are three basic prototypical sized stores, an 88,000 square foot one-story store plus an 8,000 square foot storage mezzanine, a 101,475 square foot two-story store, and a 68,000 square foot one-story store without a mezzanine. The exterior walls are prototypically load-bearing masonry or tilt-up concrete walls.

Prior to 1994, the storage mezzanines were constructed of precast concrete planks and steel beams, pre-engineered steel, 3" concrete slab and form deck over 12" **K**-Series joists spaced at 2'-6" on-center and spanning 15'-0" typically. The second floor construction was 3" concrete slab and form deck over 28" **K**-Series joists also spaced at 2'-6" on-center and spanning 40'-0" typically. The precast concrete plank mezzanines were costly and provided time delays in the construction, the pre-engineered steel mezzanines had column interferences with operations and office layout flexibility and the **K**-Series joist mezzanine also had column interferences in order to provide the required clearance. The second floor concrete slab and form deck over **K**-Series joists was very susceptible to vibration perceptibility.

In 1994 the mezzanine construction was revised to a 4" concrete slab and 1-1/2" composite deck over 12" composite steel joists spaced at 6'-0" on-center, spanning 30'-0" and supported by exterior masonry or tilt-up concrete load-bearing walls and interior steel beams and columns. The composite steel joist construction provided the following advantages:

- Reduced joist depth
- Over 50% fewer joists and bearing plates
- Utilities located within and through the structure
- Joist compatibility with the load bearing wall
- Reduced in-place cost

Also in 1994 the second floor construction was revised to a 5" concrete slab and 1-1/2" composite deck over 28" composite joists spaced at 6'-8" on-center, spanning 40'-0" and

supported by either load bearing exterior precast or tilt-up concrete walls or exterior Joist Girders and columns and interior Joist Girders and columns. The composite steel joist construction provided the following advantages:

- Reduced vibration perceptibility
- Over 50% fewer joists
- Utilities located within and through the composite joists and Joist Girders
- Reduced in-place cost

**Steel Composite Joists Lessons Learned**

The composite steel joist depth, layout and details that were originally specified were based on recommendations from the "Nucor-Vulcraft Steel Composite and Non-Composite Floor Joists" catalog. Initially, the steel sub-contractors and steel erectors were unfamiliar with composite steel joists and the following conditions were occurring:

- Steel erectors unfamiliarity with stud size and quantity to bid
- Steel erectors unfamiliarity with welding studs to joists
- Insufficient camber in joists

The steel sub-contractors and steel erectors were able to resolve these conditions with the following revisions to the project documents:

1. Structural drawings and specifications require the joist supplier to provide estimated stud size and quantities to the steel erector prior to bidding.
2. Structural drawings and specifications require the joist supplier to design and specify on composite joist shop drawings appropriate stud size and layout compatible with joist top chord.
3. Structural drawings and specifications require the joist supplier to specify the design camber on the final composite joist shop drawing and the joist camber is specified to be field inspected prior to pouring the slab.

**Kohl's Department Store, Rapid City, South Dakota**

The $3.15 million Kohl's Department Store structure and site completed in October 2004 has 80,000 square feet of retail space, 8,000 square feet of office and receiving dock and 8,000 square feet of mezzanine storage. The building was located on a site that had grades at one end 12'-8" below finished floor and also had highly expansive fills.

The project architect was Korsunsky, Krank and Erickson from Minneapolis, Minnesota and Ambrose Engineering from Cedarburg, Wisconsin was the structural engineer. Because the site would have required over 170,000 cubic yards of fill to support a slab on grade and the underlying soils were highly expansive fills, the first floor was designed as a structural slab.

The first floor was constructed of a 5" concrete slab and 1-1/2" composite deck over 28" composite steel joists spaced at 6'-8" on-center, spanning 38'-0" to 40'-0" and designed for a live load of 75 psf for retail stores and a live load of 125 psf at the receiving dock. The first floor composite joists were supported by exterior concrete grade beams and interior Joist Girders and columns. The mezzanine was constructed of 4" concrete slab and 1-1/2" composite deck over 12" composite joists spaced at 6'-0" on-center, spanning 30'-0" and designed for a live load of

125 psf storage load. The mezzanine joists were supported by exterior masonry load-bearing walls and interior steel beams and columns.

The first floor composite steel joists and Joist Girders were exposed to a crawl space overlying the expansive soils and were specified to be painted to protect the steel from exposure to moisture. The horizontal leg of the joist top chord was not painted to allow the studs to be welded through the deck to the top chord. Figure 1 shows some of the design details for the composite steel joists.

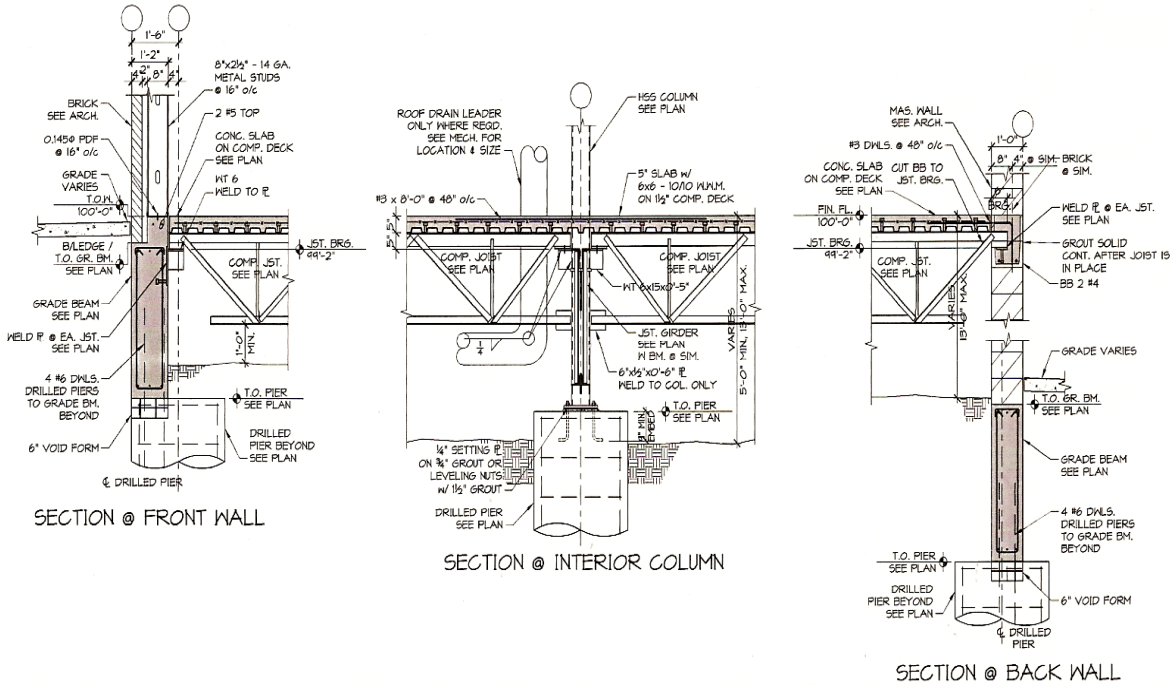


FIGURE 1 DESIGN DETAILS OF THE COMPOSITE STEEL JOISTS

A composite structural steel beam and structural steel girder was considered as the first floor's structural slab and the cost savings of using the composite steel joists and steel Joist Girders was estimated to be $134,000. The overall cost savings of utilizing a structural floor with a crawl space compared to over-excavating the highly expansive fill, replacing and filling the site to the finished floor elevation was estimated to be over $2.5 million.

The general contractor for this project was Witcher Construction, Eden Prarie, Minnesota, the steel fabricator was American Structural Metals, Somerset, Wisconsin and the composite joists, joists, Joist Girders and metal deck manufacturer was Nucor Vulcraft, Norfolk, Nebraska.

## CONDOMINIUM /RESORT CONSTRUCTION USING COMPOSITE STEEL JOISTS

### Kalahari Indoor Water Park Resort, Sandusky, OH

The Kalahari Indoor Water Park Resort constructed an addition to the existing condominium wing to provide additional support of their indoor and outdoor water park operations. The new addition is a $22 million, six-story, 288 unit, steel framed facility utilizing composite steel joists with concrete topping on steel deck for the floor framing system. Construction reached substantial completion in December, 2007.

PLANNING Design Build, Inc. from Madison, Wisconsin provided the architectural and engineering services for the project and Rudolph Libbe from Toledo, Ohio served as general contractor. The six-story facility utilizes 20 inch deep composite steel joists spaced at 8'-6" to 9'-3" on center with spans of 27 feet. A floor-to-floor height of 11'-0" was required to match existing conditions, which created floor-to-ceiling heights of 8'-8" within the individual units. The composite joists are designed for a total uniform load of 100 psf consisting of a 60 psf dead load and a 40 psf live load. Bridging was provided per SJI requirements and manufacturer's recommendations. A total slab thickness of 5 inches consisted of 2 inch composite steel deck with a 3 inch concrete topping. The composite steel deck had a specified design thickness of 0.0348 inches (20 gage). Type-B headed studs with a 1/2" diameter and 3 1/2 inches long were specified for the composite connectors to the joists. Normal weight concrete with a specified compressive strength of 4,000 psi was utilized for the concrete topping. Synthetic fiber reinforcing was provided in the concrete topping slab for crack control.

The existing condominium wing utilized hollow core pre-cast plank and steel beam construction, which was designed and constructed by PLANNING Design Build, Inc. The composite steel joist system offered multiple benefits over the original pre-cast plank and steel beam system of the existing facility. Some of those benefits were:

- Utilization of one erector during construction instead of separate pre-cast and steel erectors.
- Reduced erection time due to fewer pieces to erect.
- Crane's capacity requirements are reduced due to weight savings between plank and joists.
- Reduced foundation sizes due to reduction in building dead load.
- Elimination of water infiltration issues resulting from core-drilling in hollow core plank.
- Steel framing allowed for tighter construction tolerances over pre-cast concrete.
- Interior build-out issues experienced as a result of plank camber and gypsum topping installation were eliminated.

Overall, the composite steel joist system allowed for a faster, less expensive, and smoother construction process to be realized over the existing pre-cast plank option. Construction tolerances were tighter, product quality issues were eliminated, and the final product performed at a level equal to or better than the original system utilizing pre-cast plank.

**Key Lime Cove Resort, Gurnee, IL**

Key Lime Cove Resort located in Gurnee, Illinois consists of a 60,000 square foot indoor water park with retail and restaurant amenities connected to a 422 unit hotel facility. The hotel facility consists of two steel framed four-story hotel wings utilizing composite steel joist framing. Construction cost of the hotel wings is a combined $34 million. Construction will reach substantial completion in March, 2008.

PLANNING Design Build, Inc. from Madison, Wisconsin provided full single source services consisting of architectural, engineering, and construction services for the project. The four-story hotel wings utilize 24 inch deep composite steel joists spaced 9'-5" on center with spans of 27 feet. A floor to floor height of 11'-4" is utilized to match masonry coursing used to construct the elevator and stair shafts. A floor to ceiling height of 8'-7" is provided in the individual hotel room units. The composite joists are designed for a total uniform load of 100

psf consisting of a 60 psf dead load and a 40 psf live load. Bridging was provided per SJI requirements and manufacturer's recommendations. A total slab thickness of 4 1/2 inches consisted of a 2 inch composite steel deck with 2 1/2-inch concrete topping. The composite steel deck had a specified design thickness of 0.0348 inches (20 gage). Type-B headed studs with a 1/2" diameter and 4 inches long were specified for the composite connectors to the joists. Normal weight concrete with a specified compressive strength of 4,000 psi was utilized for the concrete topping. Synthetic fiber reinforcing was provided in the concrete topping slab for crack control.

Based on the lessons learned from the Kalahari Resort condominium project and the pre-cast system used for the original facility, the composite steel joist system utilized was compared to conventional steel joist systems and conventional wide-flange composite beam systems, and the pre-cast system was discarded as a competitive option. The primary benefits of the composite joist system over the other systems were varied, and some of these benefits are:

- The composite joist system offers significant weight savings over the other two options.
- The composite joist system utilizes approximately 50% fewer joists than the conventional joist system.
- Unit costs of composite steel joists are approximately 30% lower than wide-flange framing per ton.

The composite joist system is a faster and less expensive system than conventional steel framing systems. Weight savings can range anywhere from 30 to 50 percent and fewer pieces allows for faster erection time. The reduction in erection time also allows the contractor to realize savings in crane usage over conventional systems.