Introduction

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Boyds Bear Country
Pigeon Forge, TN

Introduction:

Boyds Bear Country, located in Pigeon Forge, Tennessee, is designed as a multi-functional space and tourist attraction for Boyds Collections Ltd. The town of Pigeon Forge is said to be "Your All-American Getaway" with attractions such as Dollywood and Smokey Mountain WildWater Rafting. This setting creates an atmosphere where Boyds Bear Country is right at home, taking the place of an oversized barn, invoking ideas of traditional Americana while still holding its scale amongst other strong attractions.

The 112,620 square foot building houses three floors of retail space with multiple cashier and information desks. Warehouse storage, a loading dock, a full sized restaurant, food court, ice cream parlor, and special events areas are scattered through the building, and offices occupy the fourth and top floor.

In studying the existing structure of Boyds Bear Country, it became apparent that the building, as constructed, implemented a wide variety of materials and methods of construction. Not only does this create added difficulties in the design and analysis of the structure, but the coordination of trades and site work became more difficult than originally intended. In order to minimize the complexity involved in all areas of construction, this report analyzes two alternative structural systems and their impact on the cost, coordination of trades, scheduling, and architecture of the building.

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Background of Existing Systems

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Background of the Existing Structural System:

Framing Layout

The structural framing as originally designed at Boyds Bear Country is primarily a composite steel grid with wooden roof trusses. The main structural grid is made of standard steel shapes, listed below. A typical floor plan of the original framing system can be seen as Figure 1. It should be noted that all typical floor plans included in this report are from the second floor, as each floor is slightly different. A full set of all structural plans may be found in the appendix.

Structural Steel Shapes	Type	[ksi]
Wide Flanges and WTs	ASTM A992	50
Pipe – Type S, Grade B	ASTM A53	35
Tube – Grade B	ASTM A500	46
Plates	ASTM A36	36
Other Shapes	ASTM A36	36
¾" Diameter High Strength Bolts	ASTM A325	n/a

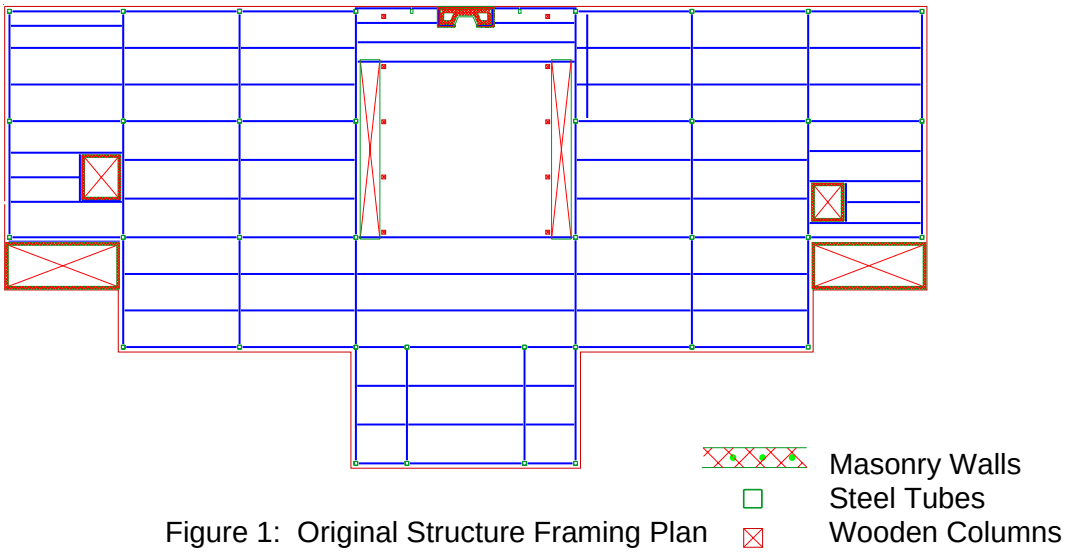

Figure 1: Original Structure Framing Plan

Typical bays measure ~30'x30' square with W16 beams, framing to W24 girders, which connect to steel tube columns. This framing grid varies around stairwells, elevators, and the front façade projection of the building.

Deeper members are located within the center bay, which features spans up to 60'. On the central floors, this center bay becomes and atrium flanked on either side by large escalators with decorative wooden timbers.

Structural wooden framing is located in other areas of the building, primarily in exterior seating areas. Structural joists, girders, and posts are typically specified as No. 2 Southern Pine. All roof framing consists of wooden trusses spaced 2' on center and were manufactured off site of primarily 2x4 No. 2 Southern Pine. These can be during construction in Figure 2.

Exterior walls on the ground floor are primarily concrete block, ranging from 8" to 16" thick; both common concrete blocks (1500 psi) and high strength Ivany blocks (2800 psi) are used. These blocks are also used in the construction of walls surrounding stairwells, mechanical rooms, and elevator shafts. It is important to note that a portion of these walls envelope the frames used for lateral resistance, and thus also contribute to the lateral stability of the structure. Interior walls throughout the building, and exterior walls on the upper floors, are constructed of cold-formed steel framing sheathed in plywood and gypsum board, as shown in Figure 3.

Figure 2: Roof trusses of 2x4 No.2 Southern Pine spaced at 2' OC.[1]

Figure 3: Light gauge steel framing with plywood sheathing[1]

Structural Slabs

Elevated slabs in the building are composite construction. All elevated slabs are supported on 3" x 20 gauge Type VL galvanized steel decking, and the slabs of the main structure are composed of 6½" thick, monofilament synthetic polypropylene fiber reinforced, 3,000 psi lightweight concrete. The slab of the Northeast pavilion / mechanical area is composed of 5½" of normal weight concrete. Secondary reinforcing consists of 6x6-W2.0xW2.0 welded wire mesh in both types of concrete. A cross-section of the typical interior slab can be seen in Figure 4 and a photo of the slab as placed in construction can be seen in Figure 5.

Interior floor slabs on grade are 4" thick, monofilament synthetic polypropylene fiber reinforced, 3,000 psi non-air-entrained concrete; with 6x6 W2.0x2.0 WWF on 4" of dense

gravel aggregate. Exterior slabs on grade are typically 5" thick, 4,000 psi air-entrained concrete; with 6x6 W2.0x2.0 WWF on 6" of dense graded aggregate.

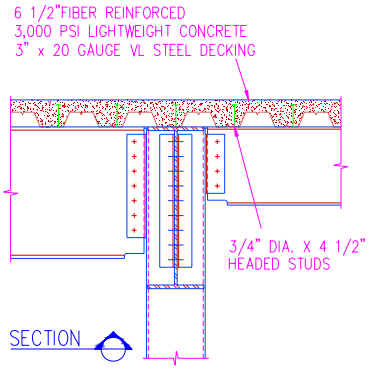

Figure 4:
Cross-section of typical slab

Figure 5: Composite slab as placed during construction[1]

Lateral Resisting System

Original drawings for Boyds Bear Country in Pigeon Forge, Tennessee call out two lateral systems, that of masonry shear walls and steel braced frames. In specific study of the design documents, it can be found that the primary lateral resistance system is concentric steel braced frames. A secondary masonry lateral resistance system can be found in 5 of the 8 braced frames in the building. These frames sit on either one or two masonry piers which are incorporated within reinforced block walls. In more detailed study of the building and its performance, it has been shown that lateral forces are collected and resisted by solely the braced frames; the masonry portions incorporated into the bases of the frames is merely a continuation of surrounding block walls. The two types of frames, chevron and crosses, can be seen in Figures 6 and 7. All eight of the concentric steel braced frames can be seen, highlighted in red, in Figures 8 and 9.

Figure 6: Frame with
Double Angle Cross-Bracing[1]

Figure 7: Frame with
Tube Chevron Bracing[1]

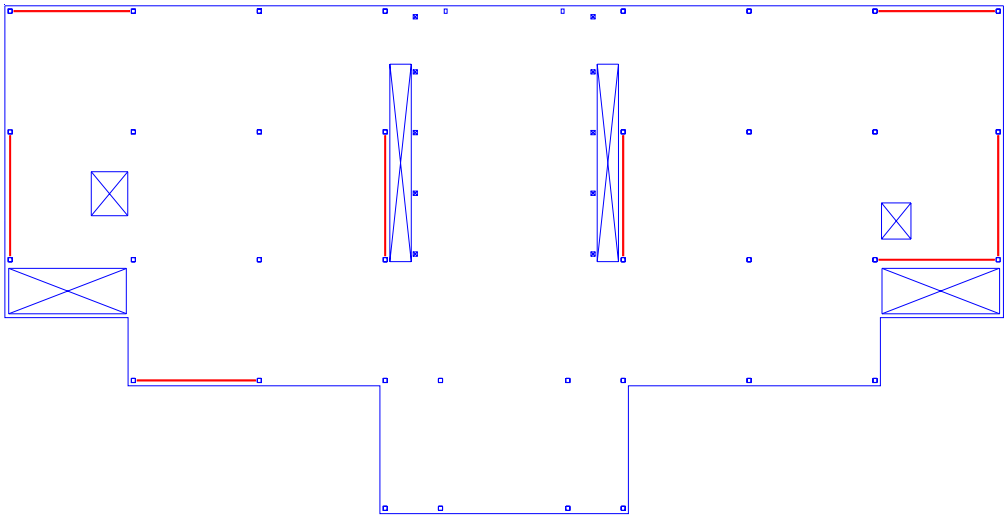

Figure 8: Original Lateral Resistance System Plan

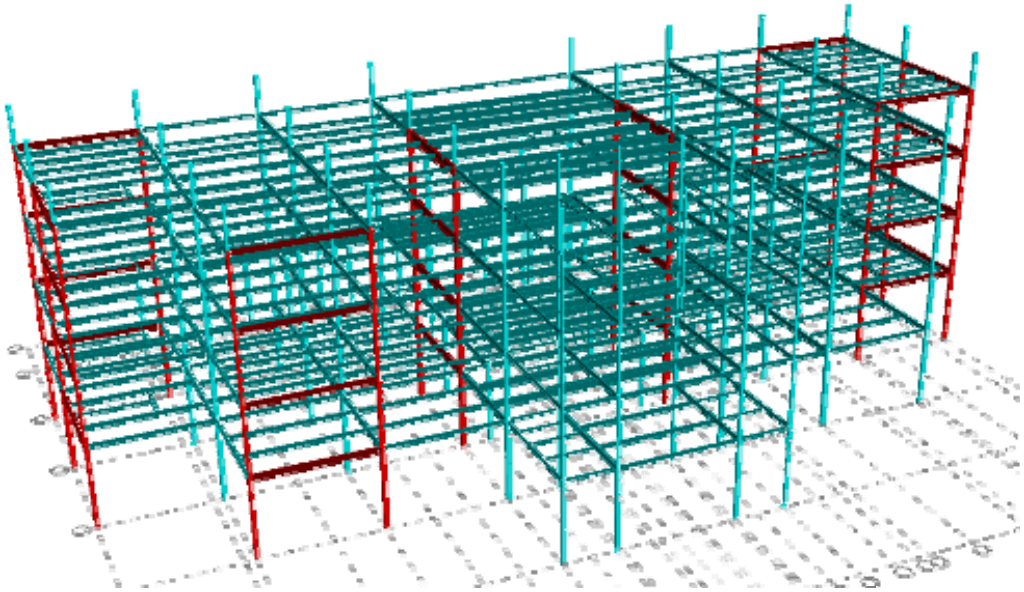

Figure 9: Original Lateral Resistance RAM Model

The floor system of composite steel beams, girders, and concrete deck acts as a diaphragm, transferring lateral forces to the frames at each of four elevated floor levels. Both wind and seismic forces are imparted as lateral loads on the structure, and through design calculations included in this report, it is found that seismic forces control the design of the structure.

Foundation System

Foundations of the building consist of shallow footings. All wall footings are simple thickened slabs measuring 2'-0" wide and 1'-0" thick. Column footings extend to a maximum of 3'-0" thick. Masonry piers are located scattered through the building, above grade. These tie the lateral force resisting braces to the foundation and are mainly located underneath columns adjacent to bathrooms and mechanical areas.

Foundations of the building are designed with a bearing pressure of 3,000 psf based on geotechnical investigations of the site. Typically, exterior footings extend to 3' below finished grade, to account for frost depths.

Footings consist of 3,000 psi cast in place concrete with reinforcing billet steel of ASTM A615, grade 60, with class B splices. Masonry piers in the building are constructed of Ivany block. Footings which have a pier surrounding a column are highlighted in Figure 10. The footings supporting typical columns measure 12.5 feet square and 30 inches deep. Figure 10 shows this typical footing circled.

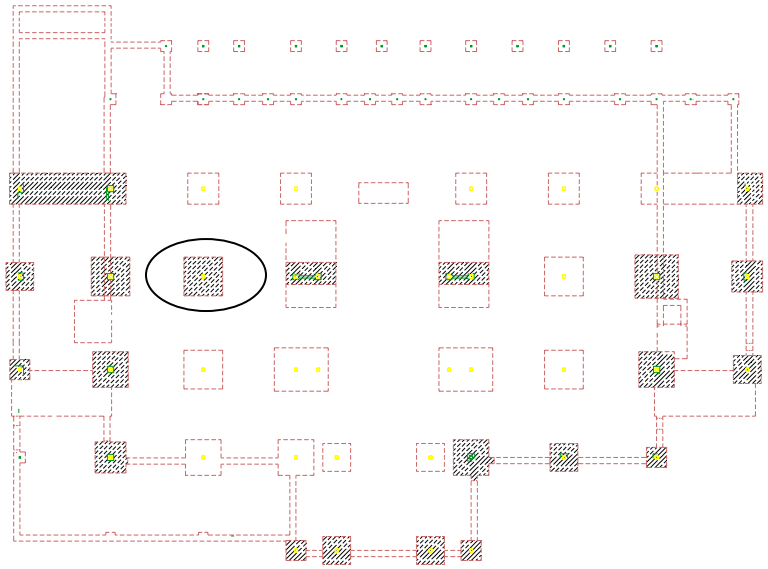

Figure 10: Original Foundation Plan

Expansion and Movement Joints

Vertical control joints are located at intersections of reinforced and un-reinforced CMU walls. Control joints in the floors slabs are required at 15'-0" OC in each direction. Control joints are not readily visible in the finished structure as they are covered with hardwood flooring and wooden column covers.

The main building itself, designed as a steel structure with a maximum length of 240', does not feature an expansion joint.