



Proposal Problem and Potential Solutions

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Boyds Bear Country
Pigeon Forge, TN



Proposal Problem and Potential Solutions:

Statement

Boyds Bear Country in Pigeon Forge, Tennessee was built as a combination of several materials, creating difficulties in both construction and design. The materials present in the building can be categorized as follows:

Steel

- Hot rolled structural members
- Metal decking
- Shear studs
- Bolted / welded connections
- Light gauge steel framing

Concrete

- Cast-in-place elevated slabs
- Lightweight cast-in-place elevated slabs
- Cast-in-place slab on grade
- Shallow foundations

Masonry

- Normal CMU block
- Ivany (high strength) CMU block
- Structural Piers

Wood

- Manufactured trusses
- Timbers

Variety of Finish Materials

- Gypsum board
- Plywood, etc....

The design is complicated by the number of materials used in the building. These require additional analyses of material properties and interactions which can impact nearly all aspects of design. Structurally, one result of the use of numerous materials can be seen in the lateral resisting system. Here, the use of concentric steel braced frames is further complicated by the introduction of masonry piers and masonry walls, creating a large amount of additional considerations to successfully analyze system's behavior. Other services required, such as mechanical duct work, electrical wiring and lighting, all must be altered to adapt to these materials. Mechanical systems must account for variations in thermal properties, electrical systems must account for variations in conductivity, and lighting layouts must account for variations in the quality of finish materials. Overall, the inclusion of multiple materials in the building creates additional difficulties and considerations within the design process.

Completing the construction of a building also becomes more complicated with the use of numerous materials. This requires the attainment and coordination of many contractors. In the case of Boyds Bear Country, separate suppliers were used for each

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trade including structural steel members, masonry block, cast-in-place concrete, wooden trusses, wooden timbers, mechanical equipment, electrical equipment, elevators, and sprinklers. A separate contractor was used for site work, general contracting (which included aspects such as roof trusses, exterior stone work, and light gauge steel), structural steel, mechanical systems, electrical systems, elevator systems, and sprinklers. With the addition of each contractor and each supplier, the required amount of coordination and the potential for error increases.

Specific difficulties in the construction of this building occurred with the coordination of masonry walls and structural steel. Masonry portions of the structure are designed as both non-retaining and retaining walls, and surround structural steel framing. During construction steel was erected and block placed around the basement level areas during the process of installing the first floor steel. After the masonry had set, the basement and first floor steel was plumbed, ripping apart the completed masonry walls. Difficulties such as this are less likely to occur as more construction is completed off-site and few trades are required.

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Proposed Solutions

In order to lessen the downfalls created by the application of multiple structural materials, involving a number of different trades, two options are further considered in this report to transform the building into primarily a single material. Both of these materials lessen the amount of construction completed on site to be decreased. In doing so, the complications of contractor and site coordination can be further minimized.

Pre-Cast Concrete Alternative

The first option to be studied in depth is be the application of structural pre-cast concrete system. This pre-cast system focuses on double-tees supported by pre-cast beams, girders, and columns. The application of double-tees adapts well to the grid system currently developed for the building, and utilizes columns spaced at 30' and 60' on center. The individual member strength of this system adapts well to areas of varied loading, found supporting storage areas of the building. Stability and lateral force resistance is provided by pre-cast shear walls located near areas of vertical transportation. Specialized attention is required for the connections associated with the shear walls in order to ensure proper stability. Additional changes are made to the structural system in changing the retaining and foundation walls to cast-in-place concrete from the original masonry block. This eliminates a highly labor intensive material from the construction site, while utilizing a material already present in other phases of construction. Wooden trusses frame the roof, as currently applied in the structure. This allows for the completion of a roof with several complicated gables, as originally designed. Foundations will be concrete poured on site.

The breakdown of included materials can be listed as follows:

Steel
Welded member connections
Light gauge steel framing
Concrete
Pre-cast concrete members
Member toppings
Cast-in-place retaining / foundation walls
Cast-in-place slab on grade
Shallow foundations
Wood
Manufactured trusses
Timbers
Variety of Finish Materials
Gypsum board
Plywood, etc....

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Engineered Wood Products Alternative

The second option to simplify the use of materials in the structure comes in the use of wooden framing. Primary members of the structure are engineered wood products as opposed to large scale timbers; ensuring members free of large defects, with known properties, with higher strengths, and supporting sustainable design. Typical bays measure 22.5' by 30' and vary in size as required in lobby areas. Pre-cast concrete shear walls are utilized as the lateral force resisting system. Additional changes are made to the structural system in changing the retaining and foundation walls to cast-in-place concrete from the original masonry block. This eliminates a highly labor intensive material from the construction site, while utilizing a material already present in other phases of construction. Wooden trusses frame the roof, as currently applied in the structure. This allows for the completion of a roof with several complicated gables, as originally designed. Foundations will be concrete poured on site.

The breakdown of included materials can be listed as follows:

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| <p>Steel
Member connections</p> <p>Concrete
Pre-cast concrete shear walls
Cast-in-place retaining / foundation walls
Cast-in-place slab on grade
Shallow foundations</p> <p>Wood
Manufactured floor trusses
Laminated structural members
Floor planks
Manufactured roof trusses
Stud wall framing</p> <p>Variety of Finish Materials
Gypsum board
Plywood, etc....</p> |
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Solution Methods

A combination of manufacturer supplied load tables, hand calculations, and computer programs are used to determine the proper structural members implemented in the structure. These are often material specific, and are detailed below.

Pre-Cast Concrete Solution Methods

The pre-cast concrete redesign option is completed using 15' wide double-tees, selected using load tables provided by the supplier, in this instance, by High Concrete Structures in Denver, Pennsylvania. Supporting members are designed to meet PCI and ACI 318-05 standards with finite element analysis using RISA-3D, PCA-Column, and PCI load tables. Shear walls are designed using RISA-3D, allowing for an accurate calculation of member drift. Additional considerations such as floor diaphragms are designed in MathCAD. The retaining and foundation walls are designed using hand calculations in MathCAD.

As a more massive system, the application of pre-cast concrete results in changes to the lateral force resisting and foundation systems. Lateral loads increase under seismic conditions, thus requiring a stronger system than currently applied to the building. This is accounted for in the design of pre-cast concrete shear walls, replacing the existing steel braced frames. The foundation system is required to carry larger loads than the existing system. Shallow foundations satisfy the loading created by this new system and are designed using MathCAD.

Engineered Wood Products Solution Methods

The wooden redesign option is completed using engineered wood products and thus designed using supplier load tables and backed by hand calculations, MathCAD calculations, and WoodWorks designs. All members are designed to meet NDS requirements. Additional requirements in the areas of vibration, deflection, fireproofing and other member protection issues, are completed by matching IBC and NDS requirements with available materials and suppliers.

Pre-cast concrete shear walls are designed to meet ACI 318-05 requirements with finite element analysis, using RISA-3D, MathCAD and hand calculations. The retaining and foundation walls are designed using hand calculations in MathCAD.

As a lighter system, the application of a wooden structure results in changes to the lateral force resisting and foundation systems. Lateral loads are decreased under seismic conditions, thus causing wind loading to control the design of the structure. Calculations are included determining the controlling lateral forces on the structure, and thus determine proper members to resist the selected forces. The foundation system also is required to carry lighter loads than in the existing system. Shallow foundations are adjusted to satisfy the loading created, including a design with special attention paid to areas supporting the masonry shear wall and its connections.