

# STRUCTURAL STEEL ACCOMODATES LOW FLOOR- TO-FLOOR HEIGHT

Creative framing configuration allows for an 8'8" floor-to-floor height on this five-story addition

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**T**O SATISFY THE INCREASING DEMAND FOR APARTMENT-STYLE CARE FACILITIES, THE Brookridge Retirement Community recently completed a five-story addition. The new addition to the successful upscale Continuing Care Retirement Community features a mix of independent living units and apartments, with a five-story full service Health Center and Commons Facility nestled in a densely wooded site. The addition to the five-story building was located in a heavily wooded area, which could only be accessed by providing a new road to the building.

Ray Troxell Associates, Winston-Salem, NC, provided full design services for the addition. Lead architect Kyle Troxell, AIA contracted with Structural Solutions, P.A. of Greensboro, NC, to provide structural engineering services. General Contractor Hugh G. Strickland, Inc., also of Winston-Salem, was soon brought on board to complete the team.

Brookridge Retirement Community is a mix of independent living units and apartments. The existing structure consisted of load bearing masonry walls, with cast-in-place concrete flat slabs for the floors and attic. The floor to floor height was a low 8'-8". The pitched roof structure was constructed of light gage metal framing, corru-



*The addition to the Brookridge Retirement Community was designed to look as though it was built at the same time as the original building*

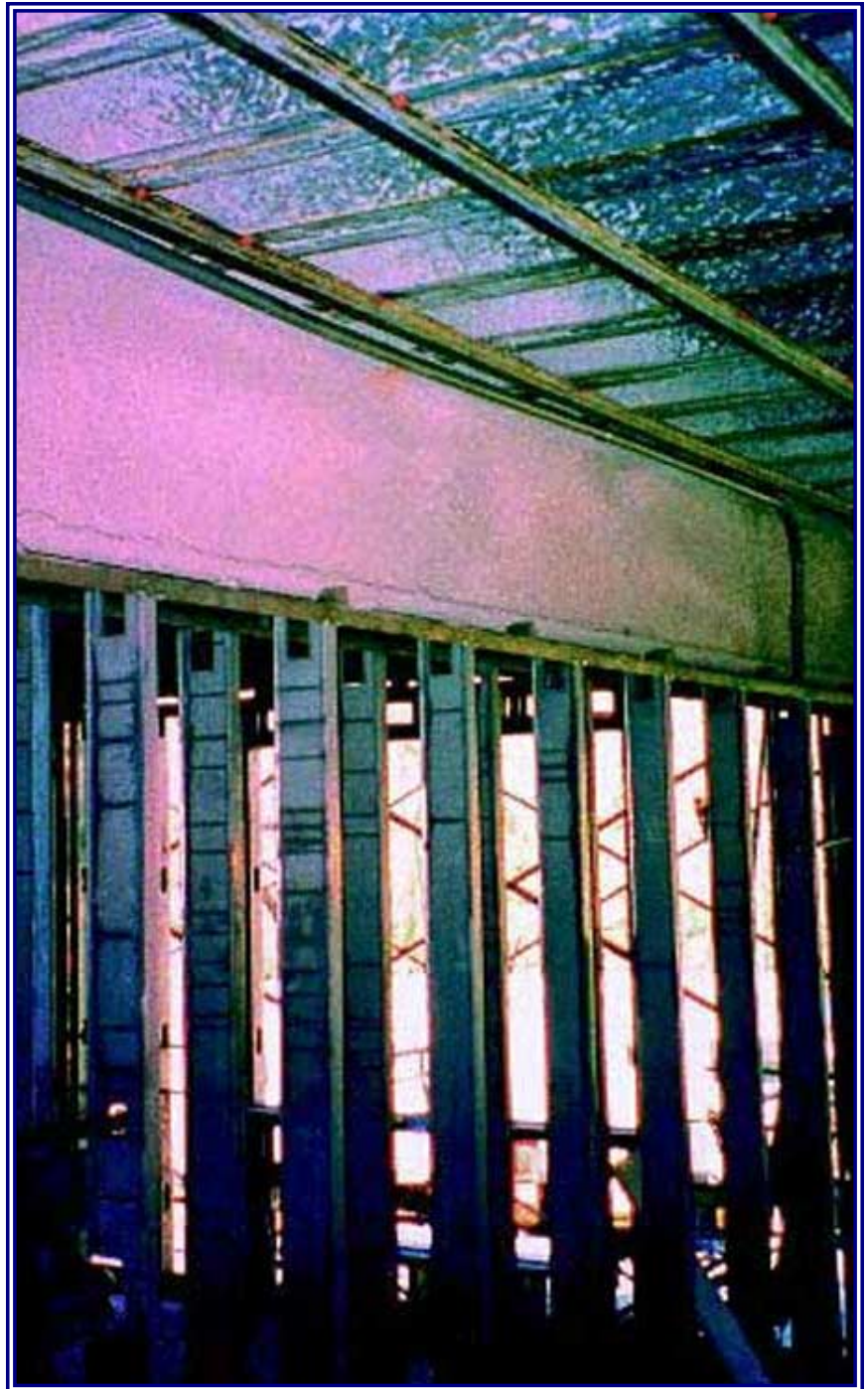
gated steel decking, wood sheathing and asphalt shingles. The exterior walls were split-faced CMU and brick.

The footprint of the addition is only 1,300 sq. ft. The Owner's program was to add five new two-bedroom apartments, one unit per floor. The exterior had to blend in with the existing structure "as if it had always been there". Following the design process, construction of the facility had to be completed in ten months when the new tenants would arrive.

### **STEEL FRAMING ALTERNATIVE**

Due to the relatively fast schedule, the design team wanted to find an alternative structural system. Constructing a load-bearing masonry and cast-in-place concrete structure would be too time consuming, especially since construction was to begin in September and continue through the winter. Structural steel was the obvious choice for speed and ease of construction, but the low 8'-8" floor-to-floor height had to be matched, with allowance for an 8'-0" ceiling height.

Several years ago, Modern Steel Construction had a story about a hotel in Boston that utilized structural steel framing with a very low floor to floor height. I dug through the 8-year stack of MSC's in my office and found the September, 1993 issue. The structural engineers used 3" deep 18 gage composite steel deck to span the entire 13'-4" room width. Steel beams were located only at the walls between each room. I contacted Kyle to see if the Brookridge room layout would allow this type of framing system to be used. The bedrooms were 11'-2" and 12'-0" wide, and the kitchen and dining areas were 12'-6" wide. With the required live load being only 40 psf, this could be spanned with 3" - 18 gage composite steel deck with 3-1/4" of lightweight concrete, without the need for shoring. However, the corner of the building stepped out to cre-



*Shown is a fireproofed interior steel beam. Note the double metal stud wall that will enable the beam to be hidden.*





*Web openings were utilized to accommodate many of the building's utilities.*



*The underside of the composite floor deck is seen with furring channels applied for the gypsum wallboard ceiling. Beyond are the diagonal braces spread apart to accommodate the window opening.*

ate a 17'-2" wide living room. Shoring would have to be provided in this area.

#### **DESIGN CONSIDERATIONS**

The framing was modeled and designed using the RamSteel computer program. Interior steel beams were centered on the wall between the two bedrooms, and the wall between the bedroom and living room. Two wythes of metal studs were used to make 9" thick interior walls, which had two distinct advantages. First, it allowed the beam with spray fireproofing to be completely hidden within the wall, eliminating the need for bulkheads on one or both sides of the wall. Secondly, it provided greater resistance to sound transmission. The perimeter steel beams were similarly hidden within a double stud wall. The columns were W8x24s, and fit within the stud wall when the web was oriented parallel to the wall. However, when the web was perpendicular to the wall, the 8" column with spray fireproofing was too deep to be hidden within the 9" wall. For this reason, these columns were offset 2" towards the interior of the building, still hidden within the 9" interior stud walls that were parallel to the web. Single angle connections were used to connect the beams to the columns at these offset conditions.

The ceilings in the bathrooms were dropped to 7'-0" to provide space for utilities. Close coordination was required with Consultant Engineering Service, Inc., the mechanical consultant, during the structural design process. The layout of all plumbing and exhaust lines had to be determined and coordinated with the beam locations. Holes were provided in the beam webs to allow for penetration of the mechanical and plumbing components. One opening was required through each floor to allow waste lines, vent lines, and exhaust ducts to be distributed vertically.

The existing lateral force resisting system was masonry shear walls. Since the addition was steel-framed with metal stud walls, a different lateral system would be required. Nearly every exterior wall required windows, making it difficult to locate diagonal bracing. One alternative was to utilize steel moment resisting frames. However, moment frames would be inherently more flexible than masonry shear walls. While there was an expansion joint between the old and new structures, I still wanted to minimize differential deflections. Diagonally braced frames would provide a much stiffer system.

The two interior walls between the bedrooms and living room would accommodate the braces, however there were no walls in the other direction. The braces would have to be located in the exterior walls of the building. The architect established the size and location of each window to compliment the existing design. The configuration of each brace was controlled by the window dimensions. A "K" brace configuration was used, with the braces spread apart at the top as required to avoid interference with the window openings. The braced frames were designed using RISA 2D.

#### **DESIGNING FOR CONSTRUCTABILITY**

The layout of the steel framing resulted in the interior columns being braced in only one direction, since there were no beams framing into the column webs. Once the deck and concrete was installed, the slab would brace the column against weak axis buckling. Until that time, temporary struts were designed and installed between the columns to brace them laterally. This was especially important since the columns were fabricated in one piece for the full height, and all steel would be erected before any concrete was placed. The struts used bolted connections and were located 4"

below the deck to facilitate removal.

One area of each floor required shoring of the metal deck due to the excessive span. Typically, this would involve erecting shores beneath the deck, bearing on the level below, with reshoring below that level. Bill Allen, project manager for the general contractor, contacted me to request an alternate shoring system. Due to the small footprint of the building, Bill wanted to place concrete on more than one level at a time. This would not be possible with conventional shoring. Bill wanted to erect temporary steel beams to shore the deck, that were connected to the permanent framing. Using this scheme, the shoring did not have to bear on the level below, and concrete could be placed on all five suspended floors at one time. The beams were then removed after the concrete cured.

#### **FABRICATION AND ERECTION**

AISC-member Carolina Steel Corporation of Winston-Salem fabricated the structural steel. With short spans and light loads, the steel beams and columns were relatively light, and did not involve difficult fabrication. The 3" - 18 gage composite steel deck was supplied by Consolidated Systems, Inc. , of Columbia, SC.

Steel erection began in November, 1997. The winter of 1997 was especially wet, which slowed construction considerably for several weeks. Still, the main structural steel was erected in 5 days. Installation of the metal deck, screed angle, shear studs, etc. took another 3 weeks. Placement of the concrete slabs on metal deck took an additional two weeks. This six-week duration was a vast improvement over the time that load-bearing masonry and cast-in-place flat slabs would have taken.

#### **CONCLUSION**

Structural steel proved to be the material of choice for this project. By using a creative

approach to framing layout and slab design, the low 8'-8" floor-to-floor height was achieved, and still allowed for an 8'-0" ceiling in most of the rooms. Using structural steel allowed the structure to be constructed quickly and easily, even in less than ideal weather conditions, which allowed the contractor to proceed with construction through the winter.

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