*Final Opening.*

*Rough Opening.*

# Innovative Reinforcing Gives Old Structure New 'Light'

*By B. Keith Brenner, P.E.*

After the dream of a new building fell through, Maine Health was faced with finding an existing building to house all of its corporate and administrative operations. Multiple offices, scattered about the city of Portland, Maine needed to be consolidated into one facility. A suitable 89,000 square foot building was obtained, and Harriman, architects and engineers located in Auburn, Maine, were challenged with how to adapt the outdated 1946 concrete structure to a modern facility for all its employees.

The building was originally constructed for Sears Roebuck Co. as a retail store in downtown Portland. There were very limited floor-to-floor heights and no windows. Although some small windows were added in the 1980s when it was converted to office space, the building was still a very uninviting place to work.

The three-story structure consisted of reinforced concrete two way slabs, with square concrete columns, capitals and drop panels. The bay spacing was typically 18 by 20 feet. This type of construction is very uncommon in the State of Maine, but it provided a very solid structure to work with.

A design concept was developed which involved cutting large openings at each floor level, including the roof. The size of the openings varied, with the largest being 86 by 17 feet. This would create a three-story atrium allowing natural light into the floors below. The challenge structurally was to develop a way to reinforce the structure to accommodate these large openings. Several options were considered, including the addition of structural steel in key areas. The disadvantage of this option was that it would create a cumbersome matrix of steel beams surrounding the atrium at each floor level. There was also the difficulty of getting longer pieces of steel into the building given the limited size and location of openings. The steel framing would have visually reduced the spaces even more and was not the desired option architecturally. This is when the option of using CFRP (carbon fiber reinforced polymer) was considered. CFRP is used to reinforce/rehabilitate existing structures that are currently deficient, or need alterations such as presented here. CFRP is often used for seismic retrofit of concrete structures in high seismic areas. The product is desirable from an architectural standpoint, as it is not visually detractive and consumes very little space.

The first task was to analyze the existing slabs to verify their capacity and to determine the effects of placing large openings at each level. Ram Concept from Bentley was used to aid in this analysis. Fortunately, existing structural drawings were obtained to provide input such as reinforcing steel placement, concrete design strengths

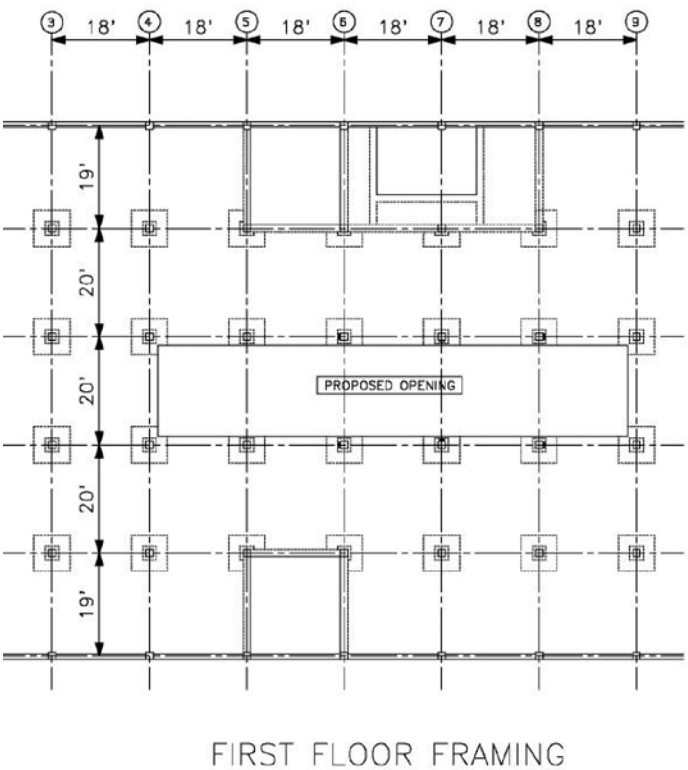
*Carbon Fiber Install.*

*Reinforced Slab.*

and design loads. Since the building was designed as a retail facility, it had greater design live loads than those required for office use. This helped in the end, as it reduced the amount of CFRP reinforcement that was required.

With the openings cut, the computer model revealed that relatively few areas were deficient. Additional reinforcing would be required at the adjacent column line for negative moments above the column capitals. This was welcome news for the contractor, since it meant that the CFRP strips could be applied to the top of the existing slab as opposed to having to work overhead on the bottom of the slab. This good fortune was short lived however, as it was discovered that there was a 3-inch un-bonded topping on the structural slab. This topping was removed in the reinforced areas prior to applying the CFRP strips.

The product used for the reinforcing was Sika Carbodur®, manufactured by Sika Corporation. The CFRP strips were 0.047-inch (1.2mm) thick and approximately 4 inches wide. The material is lightweight, easy to work with and has a design tensile strength of $4.06 \times 10^5$ psi.




*Framing Plan.*

*Existing Construction.*

Software, provided by SIKA Corp. was used to help determine the amount of CFRP strips required at each column location. The contractor, Consigli Construction of Portland, Maine, was trained by SIKA to apply the products. The 15-foot long strips were adhered to the slab using SIKADUR 30 epoxy, after pull tests confirmed that there was adequate bond strength of the concrete surface.

Once all of the CFRP strips were applied and properly cured, cutting of the concrete slabs began at the lowest level. 8- by 5-foot sections were saw cut and lowered to the basement level. Control points, placed on the bottom of the slab, were monitored with surveying equipment during the removal to verify the slabs behavior after the redistribution of stresses. The actual deformations, measured in the adjacent bays, compared well with the predicted amounts. Removal operations continued upward until the last piece of concrete was removed at the roof.

For the first time in the building's history, natural light was provided to all levels of the concrete structure. The openings were staggered at each level to maximize the light penetration and to create interest.

The use of the CFRP strips was the key to making this a very successful project that was completed under a compressed 14-month schedule. It also demonstrates the ability to use contemporary products to revitalize outdated structures.▪

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