DUQUESNE UNIVERSITY BROTTIER HALL GARAGE REPAIRS—PHASES I AND II

BY PHILLIP ELGIN

Duquesne University, located on a bluff overlooking downtown Pittsburgh, PA, is a private university originally founded in 1878 as a Catholic college. The success of the university has led to a student population of over 10,000 and a need to provide additional student housing. Accordingly, the University purchased Brottier Hall in 2004, which added housing for a capacity of approximately 750 students. The lowest three levels of the 24 story high-rise building accommodate parking for 112 cars.

The building was originally constructed in 1967 as a condominium tower featuring spectacular views of the Pittsburgh skyline and the Duquesne campus. The parking areas of the building are accessed through a single 16 ft (4.9 m) wide garage door at the highest parking level and the three levels of the garage are connected by a single-lane circular ramp. The structure has a rectangular footprint with a central girder line along the full length of the building. Parking areas on the west half of the building are framed with 14 in. (360 mm) deep precast concrete double tees that span between the exterior wall and the central girder line. Areas east of the central girder line include parking, storage, and circulation spaces framed with structural steel and 8 in. (200 mm) deep concrete hollow-core planks.

Original construction also had a 2 in. (50 mm) concrete topping slab over the double tees and some of the hollow core planks and a 1/2 in. (13 mm) layer of asphalt over the remaining hollow-core planks. The structure slopes from the exterior walls toward the central girder line where floor drains are located. Each floor level is approximately 16,000 ft^2 (1485 m^2) with approximately 3000 ft^2 (280 m^2) occupied by maintenance rooms, stairs, and elevators.

Fig. 1: Double-tee stem deterioration

STRUCTURAL CONDITION ASSESSMENT

Visible deterioration within the garage (Fig. 1) led the university to contact a structural engineer to perform a structural condition assessment of the three parking levels. Observations indicated that limited maintenance and/or renovations were conducted to the parking levels since its construction. Considering those conditions and factoring the exhibited distress, the university retained the structural engineer to perform a full structural assessment of the parking levels, including opinions of probable cost to perform the repairs.

The assessment determined that the observed deterioration along the central girder line was rather extensive. Evaluation of over 210 precast double-tee stems revealed that approximately 40% of the stems were cracked at the support. In addition, 24 stems indicated signs of bearing failure and a large number of top flanges were also deteriorated. Some locations of steel beam corrosion were found with laminations exceeding 2 in. (50 mm), and large portions of the steel angle used for precast member bearing were deteriorated.

Additionally, chain dragging and sounding indicated approximately half of the concrete topping slab over the precast double tees was delaminated, and approximately 1/4 of the concrete topping slab over the precast hollow-core planks was delaminated. Nearly 1/3 of the nonstructural concrete column encasements were deteriorated as well.

REPAIR RECOMMENDATIONS

Due to the extent of deterioration, the immediate recommendations from the structural engineer included identifying and blocking specific areas for parking. Repair recommendations made in the assessment were separated into "emergency/structural repairs" and "maintenance repairs" and included:

1. Sandblasting, reinforcing, and coating existing steel members along central girder line;

2. Demolition and repair of deteriorated double-tee flanges and stems;
3. Replacement of severely corroded structural steel angle and WT-members;
4. Reinforcement and repair of hollow-core plank;
5. Removal of concrete and asphalt topping materials;
6. Installation of new topping slab with sealed control joints; and
7. Installation of new traffic-bearing coating.

The assessment report also included an opinion of probable cost, which was developed with the assistance of a local concrete restoration contractor. Costs for a multi-year phased repair project were included as well. "Emergency repairs" were budgeted for nearly $350,000, and "maintenance repairs" averaged $350,000 for the upper and middle level and $110,000 for the lower level. Contingency and escalation costs were also considered. The university proceeded with repair documents and renovation of the garage levels based on a three-phase renovation plan.

CONSTRUCTION

Construction repair details incorporated double-tee, hollow-core, and topping concrete repairs as well as steel reinforcing details. Phase I of the project included the removal and replacement of deteriorated construction along the central girder line (Fig. 2 and 3). Two full levels of temporary shoring were required at both sides of the central girder for the entire length of the garage. In addition, a permanent steel shoring beam was needed to facilitate repairs made within a congested mechanical room. Phase II of the project included concrete topping slab removal and replacement, precast double-tee flange repairs, repairs to the ramp areas, and replacement of concrete encasements around structural steel building columns.

Original repair details showed a concrete "shoe" to strengthen the deteriorated precast double-tee bearing ends. During the bidding process, it was suggested to include an alternate detail using carbon fiber mesh to reinforce the bearing ends instead of the concrete "shoe". The repairs were completed using the carbon fiber mesh approach (Fig. 4), as carbon fiber mesh proved to be a cost-effective and less cumbersome repair alternative.

Another repair challenge was reinforcing the deteriorated double-tee flanges at locations of complete loss of material. The deterioration of the flanges was unknown until demolition; thus, additional design and construction adjustments were required. Demolition of deteriorated topping and precast elements resulted in total removal of portions of precast double-tee flanges. The thin profile of the flanges made reinforcing dowels unworkable, and the structural engineer had to develop a system of hooked reinforcing bars to be included with the topping slab placement to adequately reinforce the deteriorated flanges. The contractor was able to expedite the purchase and installation of the epoxy-coated reinforcement and also maintain tight bar clearances required within the thin concrete placement.

Fig. 2: Double-tee end demolition (from below)

Fig. 3: Double-tee end demolition (from above)

During the repairs for the single-lane ramp topping slab, additional unforeseen conditions were discovered, which included extensive deterioration of structural steel members (Fig. 5). Corrective repairs included partial steel beam replacement and steel beam reinforcing prior to repairing the ends of the precast planks and placement of the concrete topping (Fig. 6).

PROJECT CHALLENGES

One of the major challenges of this project was to minimize the construction schedule. Phase I repairs were completed during one school semester and one summer. Phase II repairs were performed only during the following summer months. This time included 28 days to allow for new concrete to cure prior to installation of the new traffic-bearing coating. This time frame, combined with unforeseen field conditions, required close coordination among the university, the engineer, and the contractor. Constant communication was maintained to ensure successful completion of each phase.

Fig. 4: Carbon fiber mesh installation

Fig. 5: Steel beam deterioration at ramp

Fig. 6: Steel beam replacement/repair

The completed project (all three phases to be completed by August 2010) will include approximately 40,000 ft^2 (3716 m^2) of concrete repair area over three parking levels/ramps. Over 100 precast concrete double-tee stems were strengthened using carbon fiber mesh during the first phase of the project and over 150 linear feet (46 m) of structural steel beam reinforcing was installed. The overall project cost will total approximately $1.5 million. While this project was not particularly large based on repair quantities, the complexities of severe deterioration, a compressed schedule, and existing unknown conditions presented numerous challenges for the entire team to meet. Meeting these difficulties required the team to implement experience, cooperation, and commitment to a quality restoration project.

Duquesne University Brottier Hall Garage Repairs—Phases I and II

OWNER
Duquesne University
Pittsburgh, PA

STRUCTURAL ENGINEER
Barber & Hoffman, Inc.
Cranberry Township, PA

PRICING & RESTORATION CONTRACTOR
CPS Construction Group
Pittsburgh, PA

MATERIAL SUPPLIER
BASF Chemical Company
Florham Park, NJ

***Phillip Elgin**, PE, is a Design Engineer with Barber & Hoffman, Inc., in Cranberry Township, PA. He received his Bachelor of Architectural Engineering degree from Pennsylvania State University, University Park, PA, and currently serves as an ICRI Pittsburgh Chapter Director. His experience includes new design for commercial projects, as well as investigation, repair, and renovation of existing parking garage and façade projects.*