AWARD OF EXCELLENCE

2016 PROJECT OF THE YEAR FINALIST HIGH-RISE CATEGORY

HARRIS COUNTY ADMINISTRATION BUILDING

HOUSTON, TEXAS

SUBMITTED BY SIKA CORPORATION

Background

The Harris County Administration Building (HCAB) is a 10-story office building located in downtown Houston, TX (Fig. 1). It opened to the public in 1978 as the central facility for local government employees and agencies. It houses public officials, various county offices and hosts the Commissioners Court twice a month. Harris County, which includes Houston as its county seat, has a population of over 4 million people, making it the most populous county in Texas and the third-most populous county in the United States.

Fig. 1: Harris County Administration Building

Project Conditions

The HCAB has suffered from the results of poor construction practices since it opened 38 years ago. The reinforcing steel throughout the building was placed too close to the surface and generally poor workmanship allowed the elements of weather and time to deteriorate the structure overall. Most of the concrete members contained some degree of spalling (Fig. 2), cracking, and honeycombing (Fig. 3).

Fig. 2: Major spall due to rebar corrosion on building façade

Special Challenges

Despite the building having a large footprint of 240 ft x 121 ft (73 m x 37 m) and located in downtown Houston, which is the 4th largest city in the United States, the contractor was given an extremely aggressive schedule of only 12 months to complete all repairs. The building remained open throughout construction and the only time work stopped completely was during elections. Whenever the Commissioners Court was in session, which was twice a month, all noisy construction, including concrete grinding and demolition, came to a stop.

However, the biggest challenge on this project was weather related. In an average year, Houston will

Fig. 3: Honeycombing damage on concrete beams

receive 50 in (1270 mm) of rain. During the 12 months of construction, over 70 in (1780 mm) of rain were recorded, 40% above normal. This worked out to 90 days of significant rain during the project, turning a 12-month construction schedule into 9 months of workable time. To make up for this lost time, work regularly took place on Saturdays and Sundays. A coordinated work plan was essential to stay on schedule as certain tasks could be accomplished indoors or in protected areas during heavy rainstorms. For example, the contractor was able to set up an assembly line in the basement of the building to pre-cut CFRP fabrics, label them and have them ready for days when the weather cooperated.

The entire exposed façade of 180,000 ft^2 (16,725 m^2) was grinded as part of the surface preparation requirements (Fig. 4). Pressure washing was allowed but the City of Houston did not allow any runoff into the storm sewers. Instead, a collection basin was set up on the first floor and water was gathered and vacuumed into a water tanker. The original engineer's estimate called for only 400 ft (120 m) of cracks to be epoxy injected. However, it became apparent early on that this quantity was way off. Ultimately, over 12,000 ft (3660 m) of cracks were identified and epoxy injected, although no additional time was added to the schedule for this extra work.

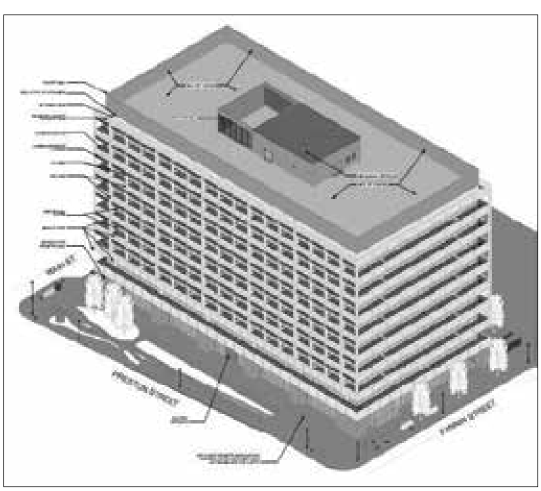

Fig. 4: Southeast isometric view of Harris County Administration Building

Site Access

Because repairs were conducted on the exterior of the building (façade) as well as the air space between the sunshade beams and the window wall perimeter, different methods of access were used for different repairs. The contractor was able to save considerable time, up to 4 months, by using the existing horizontal grating as a working platform that spanned between the sunshade beam and the window wall spandrel beam on every floor. All other bidding contractors had planned to remove the grating, conduct the repairs, and then replace the grate when complete. Not only was it economical to leave the grating in place, but this turned out to be a much safer work environment for the laborers. Rolling scaffolds were utilized on the 3 ft (1 m) inner core and an enclosed netting system was set up with cables to protect the pedestrians from falling debris. Ladders were utilized to allow mobility from floor to floor while working within the confined inner core of the building.

All repairs made on the exterior of the building were accessed from swing stage scaffolds (Fig. 5 and 6). The challenge for the erection of the swing stage was the presence of an oversized parapet wall on the roof which was 12-15 ft (3.7-4.6 m) tall. Scheduling and sequencing of the work was critical to remain on schedule because different repairs were being made off the swing stage. All cracks were filled with epoxy, utilizing pressure injection equipment. The surface bug holes were filled with an epoxy paste and the honeycombed concrete was repaired as well. The deep concrete spalls were repaired with a pre-bagged, cementitious, polymer-modified, self-consolidating concrete mix and the thin repairs were made with a pre-bagged, one-component, cementitious mortar designed for vertical and overhead repair.

Fig. 5: Swing stage equipment used for CFRP repairs

Once the concrete repairs were finished and allowed to cure, the carbon fiber reinforced polymer (CFRP) repairs were conducted. A unidirectional CFRP fabric was installed along the top and bottom flanges of sunshade beams for flexural strengthening. This same fabric (3 layers) was installed on the interior

Fig. 6: CFRP fabric installation at exterior web faces

Fig. 7: CFRP repairs on sunshade beam flange and web

Fig. 8: Shear cracking at post-tensioned cable anchorage

corners between the sunshade and outrigger beams where cracking was prevalent (Fig. 7) A double-bias, +/- 45 degree CFRP fabric was installed on both the interior and exterior faces of the web to provide shear reinforcement (Fig. 5 and Fig. 6). The finished fabric was then leveled off with a silica-fumed-enhanced epoxy resin and painted with a pigmented acrylic coating to complete the repair.

Quality Control Testing and Mockups

As part of the specification, the contractor was required to construct a mockup of the entire system buildup prior to repairs. This was conducted on a lower floor so as to be easily visible from the street level. The purpose of the mockup was to demonstrate the proposed range of aesthetic effects and level of workmanship of the contractor. The architect's and owner's approval were required prior to proceeding. It was during this process that the leveling mortar was selected as well as the color of the façade coating.

Test cubes were made from all cementitious repair mortars to ensure adequate compressive strength and verify proper installation. Core samples were taken of the epoxy crack injection areas to verify proper installation, visually inspect the depth of penetration of the epoxy, and to determine concrete compressive strength. All cored holes were filled with an epoxy mortar.

Pull-off testing was conducted on the CFRP repairs to verify tensile bond. Tests were made to failure with a minimum requirement of 200 psi (1.4 MPa) per ACI 440.2R[1]. Witness panels were made on the different types of carbon fiber fabrics and tested per ASTM D3039[2]. All fabrics were visually inspected for fiber orientation to ensure that alignment was less than 5 degrees off axis. Finally, acoustic sounding was conducted to evaluate the cured CFRP system for delaminations and air voids.

Post-Tensioning Repairs

The structural system for this building is a reinforced concrete frame. The floor framing consists of reinforced concrete slabs supported by post-tensioned concrete beams (Fig. 8), which in turn are supported on two rows of interior concrete columns on concrete piers. The post-tensioned beams cantilever beyond the window wall perimeter and function as outriggers to support the perimeter concrete sunshade system. The ends of the post-tensioned outrigger beams are fitted with precast concrete caps to protect the ends of the post-tensioned system.

Significant corrosion was detected on the ends of the post-tension cables on the north and south elevations and also at the button head anchors located on the east and west elevations. All steel plates and button heads were exhibiting flaking paint and rust, as were the inside of the button head anchors. To repair these anchorage zones, the precast concrete caps were removed and steel rust was cleaned, repaired and painted with an anti-corrosion rust inhibitor. Carbon fiber repairs were made to strengthen the concrete that was overstressed and severely cracked. Finally, the caps were replaced with new concrete using a form and pour technique.

Conclusions

The repairs conducted on the Harris County Administration Building were challenging for many reasons. Working on an occupied office building in downtown Houston was difficult enough. The fact that this was the main government headquarters with lots of public officials scrutinizing every move, while also conducting important business such as public hearings, court sessions, and elections, made the work even more demanding. A very aggressive 12-month construction schedule was met and the project was delivered on time despite encountering record rainfall which effectively shaved 3 months of workable time off the timetable.

The types of repairs were complex and well varied. Access to the architectural elements was difficult, especially working in a narrow 3 ft (1 m) inner core, 152 ft (46 m) above street level. The building required epoxy injection, concrete repairs, carbon fiber strengthening, waterproofing and post-tensioned repairs. All was accomplished due to the coordinated efforts of the contractor, owner, manufacturers, architect and engineer. Without this team effort, the project would not have been as successful as it was.

References

1. ACI Committee 440, "Guide for the Design and Construction of Externally Bonded FRP Systems for Strengthening Concrete Structures (ACI 440.2R-08)," American Concrete Institute, Farmington Hills, MI, 2008, 76 pp.

2. ASTM D3039, "Standard Test Method for Tensile Properties of Polymer Matrix Composite Materials," ASTM International, West Conshohocken, PA, 2014, 13 pp.

Harris County Administration Building

OWNER
Harris County Public Infrastructure Department
Houston, TX

PROJECT ENGINEER/DESIGNER
Norex Engineering, Inc.
League City, TX

REPAIR CONTRACTOR
Structural Concrete Systems, LLC
Magnolia, TX

MATERIALS SUPPLIER/MANUFACTURER
Sika Corporation
Lyndhurst, NJ

ARCHITECT
Johnston, LLC Architects
Houston, TX