SEGMENTAL PRECAST CONCRETE PILES FOR UNDERPINNING

Innovation - Jacked segmental precast concrete piles replace the traditional underpinning method of using jacked segmental welded steel pipe piles. This innovative construction methodology was used to underpin a large historic building in Regina, Canada recently resulting in considerable reduction in cost and construction time. For this project, the general contractor awarded the contract for the lowest tender used the precast concrete pile option for underpinning. His total bid price was approximately $1.8 million (CAD) less than the next low bidder who carried steel pipe piles. The new pile system was implemented after a very rigorous independent design check and a peer review as well as a laboratory testing program of the pile specimens at the University of Manitoba. This project has shown that the use of segmental precast concrete piles will be an economical solution for underpinning structures on future projects.

Project - The 90-year-old Saskatchewan Legislative Building in Regina, Canada (shown in Fig. 1), had undergone damaging differential movements due to a combination of factors: an under-designed original pile system, building modifications over the years, and moisture changes and desiccation in the foundation soils. The resulting structural distress observed inside the building and in the exterior Tyndall stone led to the decision to underpin the building. In 1983 the West Wing of the building was underpinned using jacked segmental welded steel pipe piles. In 1998 the Saskatchewan Property Management Corporation (SPMC), the government body responsible for the building, decided to underpin and stabilize the remainder of the building. The latest underpinning scheme utilized innovative segmental precast concrete piles as the new foundation for the building. The new jacked piles replaced the existing 4.4 m (14.5 ft) long concrete “Raymond” (spirally corrugated steel shell) step-tapered piles that were installed in 1908. The new piles, jacked into the underlying layer of shale, were designed to carry the full load of the building, with the existing overloaded concrete Raymond piles becoming redundant structural elements.

The structural underpinning work of the Saskatchewan Legislative Building required approximately 1800 new piles (versus 2700 existing concrete Raymond piles), with a design service load of 300 kN (67.4 kips). The specifications required that each pile carry a proof load of 600 kN (135 kips) for one hour following installation to verify that the pile was of sufficient capacity. As a result, the pile segments and connections were designed to carry the installation and proof loads of 600 kN (135 kips), which were imparted to the pile by the jacking system. Several completed piles were tested in compression in accordance with ASTM D1143, *Method of Testing Piles Under Static Axial Compression Load.*

Pile Description - The segmental precast concrete piles consisted of cylindrical segments having a length of 1 m (3.3 ft) and a diameter of 155 mm (6.1 in.). The segments were cast using steel-fiber-reinforced concrete (SFRC) with a 28-day nominal compressive strength of 90 MPa (13 ksi) and a steel fiber content of 40 kg/m^3 (67 lb/yd^3). The weight of each pile segment was 45 kg (100 lb) Each pile segment was reinforced with four 8.6 mm (0.34 in.) steel wires, 990 mm (39 in.) in length, welded to a 20 mm (0.8 in.) diameter steel coil as shown in Fig. 2. Recesses were provided at each end of the segments at the location of the coil as shown in Fig. 2(a) to accommodate protective epoxy. The epoxy was required to provide corrosion protection for the threaded, high-strength stainless steel rod that connected the individual segments and maintained continuity of the pile.

Installation Procedures - First, the soil underneath the pile cap was excavated in a volume sufficient to allow the installation of a new pile. Then, a pair of hydraulic jacks with a combined capacity of 680 kN (153 kips) was mounted to the underside of the pile cap as illustrated in Fig. 3. After positioning the first segment, the hydraulic jacks were extended and the segment pushed into the ground far enough to allow installation of the following segment (also shown in Fig. 3). The connection rod was then threaded into the end of the installed segment, epoxy was placed around the bar and the top surface of the pile segment, and the next segment was threaded onto the connection rod projecting from the installed segment. The pile segments were tightened using a chain wrench to a torque of approximately 125 to 190 N-m (92 to 140 lbf-ft). This process was repeated until the pile achieved the required capacity of 600 kN (135 kips), which was typically achieved at a depth ranging from 11 to 13 m (36 to 43 ft) for this project.

Once the pile had been advanced to a sufficient depth to carry the required proof load, the installed pile was loaded to 600 kN (135 kips) for one hour while the settlement of the pile was monitored. After completion of the proof test, each pile was locked off under a load typically equivalent to 50% of the proof load. This pre-loading of the new piles was accomplished by means of sizing and installing steel transfer members while the pile was still under the applied load from the installation jacks. At this stage, the pressure on the hydraulic jacks was released, and the load was transferred to the permanent steel transfer members.

Contact: Sital Rihal, P. Eng. • Dillon Consulting Ltd. • 6 Donald Street S.
Winnipeg, Manitoba R3L 0K6 • Canada • 204-453-2301 • Fax 204-452-4412

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Fig. 1 - Saskatchewan Legislative Building, Regina, Canada

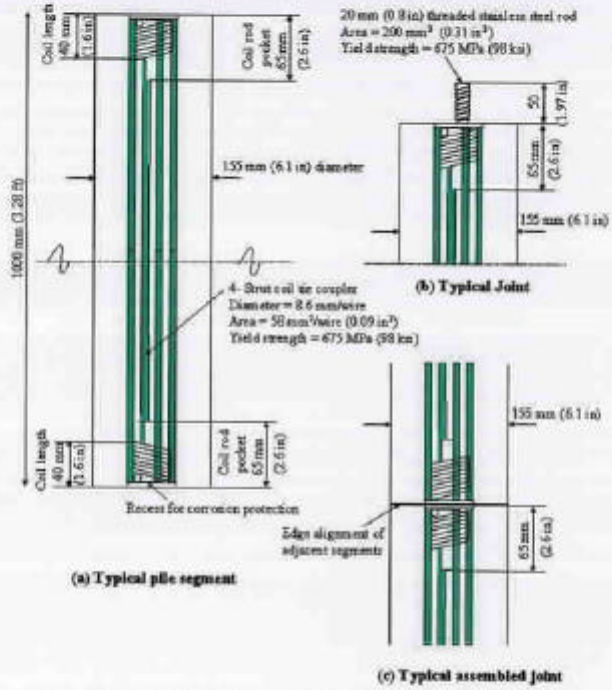

Fig. 2 - Details of Segmental Precast Concrete Piles

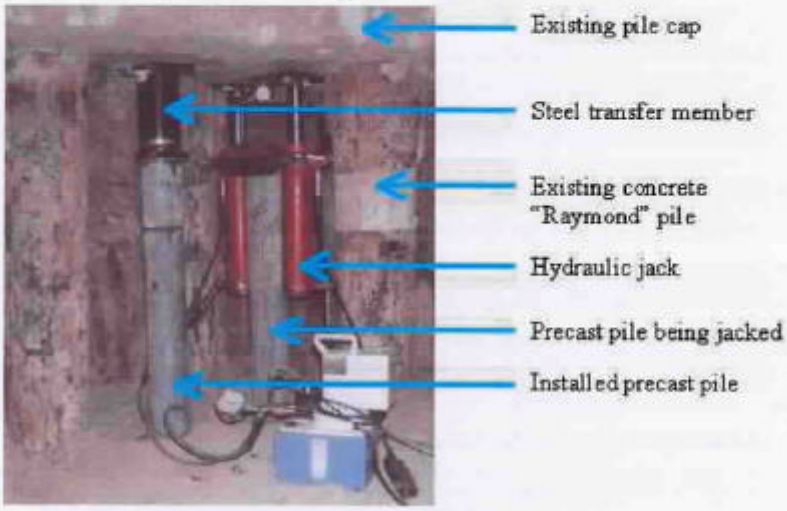

Fig. 3 - Installation of Piles