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THE SUPPORTWORKS NEWSLETTER FOR DESIGN PROFESSIONALS

The Evolution of the Push Pier System

Today's push pier systems have earned acceptance throughout the engineering community, with designers and manufacturers continuing to provide systems capable of ever-increasing load capacities and improved performance. But this wasn't always the case. So where did it all begin, and how did we arrive where we are today?

Push pier systems (also known as jacked piles, resistance piers, or hydraulically driven piers) have undergone many changes since their inception in the late 1800s. Push piers were first used in the populated areas of the northeast with several inventors from New York being the pioneers of these early systems. Throughout the development of these systems, a common methodology of pushing hollow tubular column sections to a suitable load-bearing stratum was employed. Push pier systems have always been considered as retrofit since they require an existing structure to provide the reaction (to the drive force) necessary to advance structural elements to competent soil or bedrock.

The first patented system was by Jules Breuchard (Patent No. 563,130) in 1896; a concentric system which required removal of portions of the brick foundation walls to allow for placement of structural header beams (stone or steel) and a hydraulic ram. The first application of this system was to support a four-story building during construction of the basement portion of the Commercial Cable Building in New York City in 1896. Some settlement issues resulted from the Breuchard system, since a factor of safety was not specified.

A 1917 patent by Lazarus White (Patent No. 1,217,128) addressed the long-term stability issues experienced with previous methods by recommending a factor of safety of 1.5 applied to the calculated service load. In a later patent, registered in 1931 (Patent No. 1,827,921), White recommended simultaneous loading of each pier after application of the final drive force to evenly distribute the pier loading during lock-off procedures.

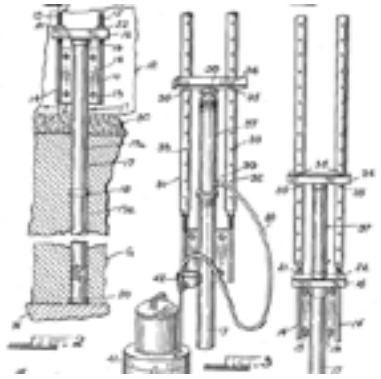
An eccentrically loaded flush-mount bracket system was presented in the 1961 Revesz and Steinsberger patent (Patent No. 2,982,103). This system had many similarities to current flush-mount pier systems, including attachment of a flush-mount bracket to a foundation wall and using a drive stand and hydraulic jack to provide the final drive and lock-off force. This patent also recommended applying a factor of safety of 1.5 to the service load to determine the required final drive load. The components and setup of this system are shown in Figure 1.

The first patent for a side-load, under-footing bracket with vertical and horizontal bearing plates positioned against and below a footing was issued in 1975 to George Langenbach (US Patent No. 3,902,326). The system was further refined in subsequent patents to resemble the push pier systems common today (See Figure 2).

For more information related to Supportworks' current push pier design and installation procedures, refer to Chapter 2 of the 2017 Supportworks Technical Manual. An electronic copy of the manual can be viewed at OnStableGround.com.

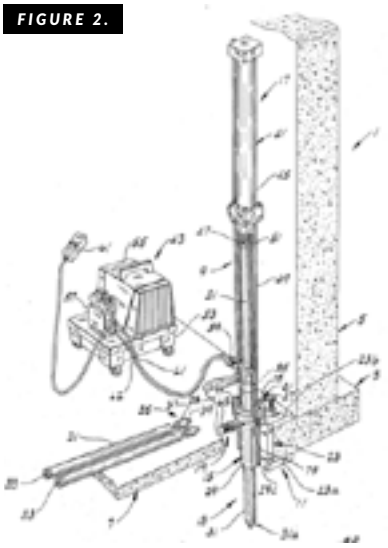
DONALD A. DEARDORFF, P.E.,
SENIOR APPLICATION ENGINEER

FIGURE 1.

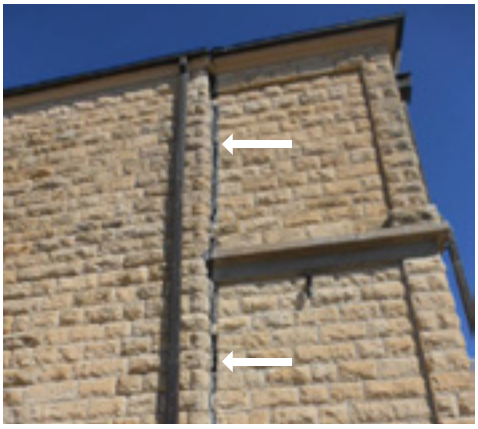


Revesz and Steinsberger Push Pier System (1961)

FIGURE 2.



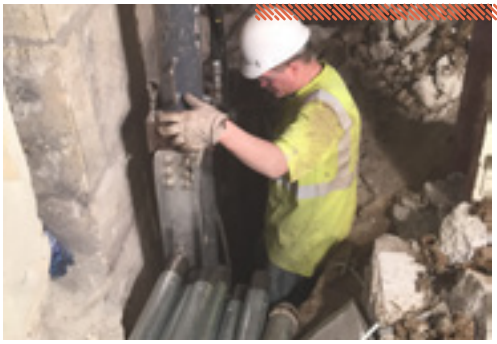
Langenbach Patented System (1975)



Vertical crack observed on south face of corner

Southeast corner of wing experiencing settlement

Trimming footing for retrofit bracket placement



Installing interior push piers

Installed piers at exterior corner

Project: **Wainwright Hall**
Location: **Fort Riley, Kansas**
Pile Installer: **Foundation Recovery Systems**

Challenge: Wainwright Hall at the Fort Riley Military Reservation in north central Kansas was constructed in 1889. A 50-foot-long by 10-foot-wide porch in the southeast corner of the south wing was later enclosed using the same native cut limestone block as the original structure with the exterior walls and columns supported by a continuous concrete footing. This remodeled area settled away from the main structure.

A geotechnical investigation identified a general soil profile of up to seven feet of fat clay fill over variable alluvium consisting of lean clay, silt, and sand. The native soil was underlain by hard, weathered limestone bedrock, observed at 30 to 40 feet below grade.

Solution: Design engineers determined that the poor condition of the existing footing would limit spanning capability of the foundation and the spacing of a retrofit pier system. Retrofit helical piers were originally considered, but later determined to be a less desirable option due to installation difficulties and the potential for group effects. A system of hydraulically - driven push piers was ultimately selected to permanently stabilize the settled portion of the building. Push piers can be installed at a relatively tight spacing, in difficult access conditions, and with smaller equipment.

Thirty-six (36) Model 288 (2.875-inch OD by 0.165-inch wall) push piers were staggered along the inside and outside of the exterior walls at a two-foot, center-to-center spacing. The piers were installed opposite each other at the existing column locations. The footings were notched back to the face of the walls and the vertical and horizontal concrete surfaces trimmed smooth for uniform bearing against the retrofit bracket. The push piers were advanced to depths from 37 to 40 feet below grade to bear on the competent bedrock and achieve hydraulic fluid pressures of at least 4,000 psi, corresponding to 56.7 kips or more of drive force. The piers were then connected in series to be simultaneously reloaded and locked off at 25.5 kips. The lock-off load greatly exceeded the design working load of 8.7 kips; however, care was taken during this process so as not to mobilize the structure (stabilize only). A factor of safety of at least 2.2 was achieved (FOS = drive load/lock-off load).

Upcoming Webinar Opportunities

- **An Introduction to Helical Foundation Systems**

  1st Wednesday of every month 11:30 am (CT) and 1:30 pm (CT)

- **An Introduction to Polyurethane Foam Injection**

  2nd Wednesday of every month 11:30 am (CT) and 1:30 pm (CT)

- **An Introduction to Hydraulically Driven Push Pier Systems**

  3rd Wednesday of every month 11:30 am (CT) and 1:30 pm (CT)

Project: Washington University Parking Garage
Location: St. Louis, MO
Pier Installer: Foundation Supportworks® by Woods

Challenge: The parking garage was supported on drilled shaft foundations. The stonework façade was supported independently from the parking structure on shallow spread footings. A column footing supporting the façade settled approximately four inches, causing the first level facing to vertically separate from the façade above. Plastic shims were continually added at the separation, but a more permanent solution was required to stabilize the footing and prevent further settlement.

The general contractor anticipated relatively shallow, competent bedrock based on previous projects in the area. Retrofit helical piers were originally planned to underpin the footing, stabilize the lower façade, and attempt to lift this section back toward its original elevation. A service load of 40 kips was estimated for the column.

Solution: With shallow bedrock expected, a system of hydraulically driven push piers was selected over retrofit helical piers as the more economical solution. Push piers can also be installed at tighter spacing than retrofit helical piers and installation equipment would allow for easier access within the limited work area. Four (4) Model 288 (2.875-inch O.D. by 0.165-inch wall) push piers, two at each end of the rectangular footing, were installed to balance the column load and support the estimated design working load of 10 kips per pier.

A two-foot-deep concrete wall was encountered while excavating for two of the pier locations. The structural engineer determined that the wall was a turned-down slab left from an old parking lot. The concrete wall was removed, the excavation made, and the push piers installed at their planned locations.

The piers were driven to refusal (drive force of at least 53 kips) and an average depth of 15 feet below the bottom of the footing. Hydraulic lift cylinders were fitted to the installed pier assemblies and connected in series to apply uniform load and lift the footing. The plastic shims were removed and the settled façade was successfully lifted to make contact with the upper section. The joint was resealed by the general contractor. Both the pier installation and structural lift were completed in just one day.

Settled façade; separation

Plastic shims at separation

Advancing push piers to bedrock

Connecting hydraulic lift cylinders

Completed Project

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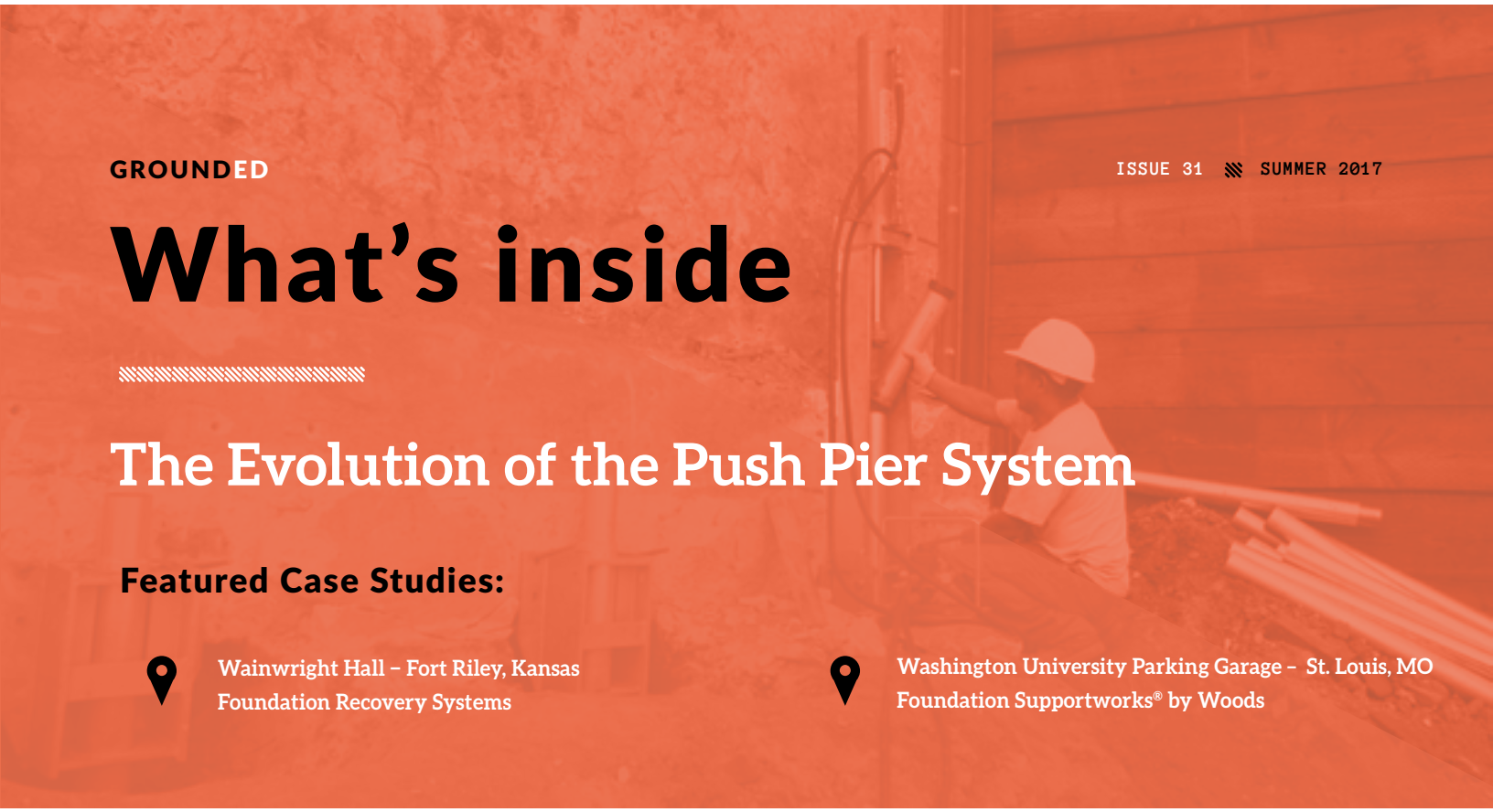

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