50 CAVILL AVENUE SURFERS PARADISE

TOP-DOWN CONSTRUCTION

Peter Openshaw, General Manager, S.I.F. Bachy Entreprise Pty. Ltd.

INTRODUCTION 50 Cavill Avenue is a major high quality 24 storey office block situated in the heart of Surfers Paradise. The developer, Corporate Equities, was confronted with the choice of paying a large cash premium to the Gold Coast City Council or, alternatively to provide 420 on site parking spaces.

The second option was examined and found to be feasible by constructing 5 levels of basement within a cast-in-situ diaphragm wall using the top down method.

The project proceeded on that basis and was the first known large scale application of the top down technique in Australia. The success of the undertaking was recognised by two awards including the Engineering Excellence Award 1992, Building and Civil Engineer Design Category. Weathered Howe P.L. were the structural consultants. Bachy were the diaphragm wall and foundations contractor. Watpac were awarded the contract for the remaining construction work.
1. Top Down Method

Although, in specific circumstances, this method may be used for 2 or 3 levels of basement, it is more usually found on deeper excavations. The essential elements of the process are the construction of a retaining wall around the future basements and the construction within the wall of the basement slabs in descending order as bulk excavation progresses. These slabs provide the temporary and permanent lateral support to the wall. In all known Australian examples the wall has taken the form of a diaphragm wall.

Unless the site is unusually narrow the basement slabs will not span unsupported from wall to wall and intermediate support is required. Habitually the support is located at the final column positions and frequently are in fact the final columns. They clearly need to be constructed before bulk excavation commences or, in any case, before it proceeds far.

These structural elements are referred to as prefounded columns and their construction raises specific problems. The siting of these columns at the permanent locations allows the top down method to be taken a step further to the "Up and Down" method in which, after the construction of the ground floor or first basement slab, work may commence on the superstructure. In this way basement construction is virtually removed from the critical path removing, equally, one of the major disincentives for underground site development. To construct 5 levels of basement on the Cavill Avenue site using any other method would have taken many months longer.

2. Résumé of Overall Design of Substructure

Economics and the overall stability of the structure determined that full hydraulic pressure could not be allowed to act beneath the completed 5th basement slab. Permanent pressure relief was provided beneath the slab, and to a deeper, confined aquifer with potential to cause base instability. To avoid this pressure relief extending outside the site, with all the possible consequences, the diaphragm wall was taken to essentially impervious rock at a depth of 35m. The wall also supported the relatively small vertical loads from the outside bay of the basement slabs.

In terms of lateral stability, it was designed to cantilever during excavation for pouring of the first basement, thereafter it was supported by the slabs.

The foundations were designed as barrettes (rectangular piers constructed under bentonite) bearing on rock with a stress of 6-7 MPa. Since it is impractical, if not impossible, to construct pile caps at a depth of 5 basements, the barrettes were dimensioned such that only one was required beneath each column.

The columns were 310 UC structural steel section. Certain columns required the application of additional plates to increase the load carry capacity. They penetrated 4-5m below excavation level to allow load transfer into the concrete of the barrettes. For some of the very heavily loaded columns, which bore substantial superstructure load before all basement slabs were poured, buckling as a failure mode requiring consideration. Certain barrettes containing such columns were backfilled with lean-mix concrete above 5th basement level to ensure that the effective length was similar to the length actually exposed. The remaining barrettes were backfilled with aggregate.

3. Construction

For contractual reasons the specialist works were divided into two packages, diaphragm walling and foundations.

Diaphragm walling commenced in July 1989 and was completed 4 months later using 2 rigs. The 600 mm wall incorporated recesses at future basement slab levels formed with expanded polystyrene. Bent-out bars located at the back of the recess provided a pin-joint at the junction with the slab. The reinforcement cages measuring 7m x 22m and weighing approx. 10T were fabricated in one piece on the ground then lifted and placed in one lift. The joints between panels used the Bachy CWS technique in which a PVC waterstop spans the construction joint and ensures watertightness.

It was important to ensure that the wall was down to rock and anchored into it since the material immediately overlying it was very pervious. Around part of the perimeter this layer consisted of very strongly
cemented gravels which substantially reduced production rates. The recovery of rock fragments from the bottom of the excavation was used as evidence that the impervious material had been reached. Prior to concreting the bentonite was recycled to remove soil particles in suspension and to clean the base of the panel.

Upon completion of the diaphragm wall the construction process was interrupted whilst a building contractor was selected to undertake the substructure and superstructure works. Watpac was selected and the barrette foundations were carried out by Bachy as a subcontractor to Watpac.

The first attempt to construct a barrette was met with collapse of the trench. A walk around the site revealed the problem. The diaphragm wall was preventing the escape of rainwater from the site. During the interruption of construction the ground water within the wall had risen to the level of the top of the wall and was overflowing across the pavement. As a consequence the bentonite had insufficient positive head to stabilize the excavation.

This is a phenomenon of which diaphragm walling contractors are aware and should guard against. It is however generally associated with much smaller sites where water loss from the bentonite is a substantial contributor to ground water rise. Fortunately there was a dewatering contractor on site and the problem was quickly resolved. The incident did at least indicate that the diaphragm wall was watertight.

The barrettes all extended to rock and the process of excavation, bentonite treatment and concreting were unremarkable.

The specification required a great degree of accuracy in placing of the steel columns with an out-of-vertical tolerance of 1.200 and out of tolerance in plan at the top of column of 5mm. The configuration of the column and reinforcement cage was such that the column would be no more nor less vertical than the excavation into which it was placed. This aspect of tolerance was therefore addressed during the excavation stage and involved the use of experienced operators and constant attention to verticality. The position in plan was assured by transferring accurate marks to the concrete guide walls prior to the construction of the barrettes and locating the top of the column by reference to these.

In the great majority of cases these tolerances were met. Perversely when there was a problem it was at the top and the error was more than a few millimetres. Setting out errors were suspected, leading to some finger pointing between the subcontractor and builder.

With the exception of a limited number of foundations under the lift core, the remaining columns could just as easily have been placed in circular bored piles. The decision to opt for barrettes was based primarily on the tolerance issue. To sink a bored pile to a tolerance of 1.200 with confidence requires the sinking of a casing. Given the presence of a substantial thickness of very dense sand in the first 12m this process would have been costly and time consuming. Another drawback to the use of bored piles is that, short of boring a shaft very much larger than required, only one tremie pipe can be used. This leads to asymmetrical flow of the concrete during the pour which tends to displace the bottom of the column.

4. Pumping Test

The contract for the diaphragm walling contract included a guarantee on the residual inflow of water into the site. This was to be verified by a pumping test prior to commencement of bulk excavation. The test involved draining water from both above and below the clay aquiclude and, was to be continued until it was assessed that a steady state had been reached. In the event the flow rapidly dropped to below 6litre/sec., well below the 12litre/sec. specified.

5. Construction of the Substructure

The tower occupies approximately the central third of the essentially rectangular site. In this section the slabs were poured without any voids for the removal of excavated material. On either side of the tower only the outside bay of the slabs were poured leaving a large void at either end of the site. The portion of the slab that was poured was sufficient to provide the necessary lateral restraint to the wall.

The first stage of construction was to excavate for, and construct the first basement slab. This provided the platform from which the construction of the superstructure was launched. From this point construction proceeded upwards and downwards simultaneously.

As each basement level was reached a trowelled blinding layer was placed at the slab soffit level. This was treated with bond breaker prior to placing of steel and concrete. After completion of the slab the steel columns were encased in concrete over the height exposed. When excavation commenced on the next stage the blinding layer was stripped from beneath the slab.

When the final excavation level was reached the subsoil drainage system was installed prior to pouring of the slab. The excavation voids in the slabs above were then filled in using conventional bottom-up construction. During construction of the basement adequate dewatering of the whole site was generally achieved with only one well operating.

Whilst construction of 50 Cavill Ave. was progressing up and down a virtually identical exercise was underway 20m away installing diaphragm walls for the 5 level underground carpark for the Surfers Paradise Transit Centre and the wall for a 4 basement carpark near Mascot Airport in Sydney was well advanced. The whole development was completed on schedule. Settlement of the surroundings as a result of the 14m deep excavation was well below the 20mm predicted and residual pumping requirements are minimal.