14

AN EARLY EXAMPLE OF TOP-DOWN CONSTRUCTION

by

A.C. Visvalingam

Abstract

The paper describes an early example of "top-down construction", where parts of the permanent structure of the 30-storey Park Lane Hilton Hotel were used as horizontal props for the continuous bored sheet piling which was installed along the boundaries for the site for the purpose of enabling the deep basement excavation to be carried out safely and economically.

1.0 Introduction

One of the most expensive and potentially dangerous items of work in building construction is digging down for basements in such a manner as to prevent the collapse of the vertical faces of the resulting excavations. In this connection, a term which is heard more and more frequently now is "top-down construction". This expression is employed to describe a construction procedure where parts of the permanent structure are built commencing at ground level and are, thereafter, progressively continued downwards in such a manner that the completed parts, in conjunction with previously-installed continuous sheet piling or diaphragm walling, help to retain the sides of the deepening excavation.

Once the substructure work has been carried out economically and safely, superstructure work follows.

The impression given by some recent articles in the technical press is that this technology is new, but the example described below is one which was designed and constructed over thirty years ago. As far as the writer is aware, the term "top-down construction" had not even been coined by then.

In "top-down construction", just as much as parts of the permanent works are utilized as components of the temporary works, parts of the temporary works may also be incorporated into the permanent structure. Moreover, there have also been some recent modifications to this technique, where upward construction, commencing from ground level, is also progressed at the same time as the substructure work is extended downwards. This is certainly an advance on the original concept but the added complexity may be justified only in exceptional cases where commercial considerations call for a particularly intensified speed of construction. It is not proposed to go into these newer developments in this paper, which will be confined solely to describing the one specific example of "top-down construction" which was adopted in the case of a major hotel building in London.

2.0 Park Lane Hilton

In 1961, the structural design of the then tallest reinforced concrete building in the United Kingdom was entrusted to M/s W.V. Zinn & Associates, Consulting Engineers, by whom the writer was employed at the time. The building was to house a 30-storey hotel, the Park Lane Hilton, in London. (Note: At the last moment, after construction had commenced, the height of the building was restricted to 27 storeys by the authorities because there was a line of sight problem involving Buckingham Palace).

The Client for this project was the multi-millionaire Mr. Charles Clore who also owned the contracting firm, M/s Token Construction Co Ltd, which, inter alia, was to carry out the entirety of the civil works.

As the Managing Director of Token Construction had been a reinforced concrete designer himself for over 25 years, this assignment was expected to be all the more challenging in that the structural designs would be subject to careful scrutiny not only by the London County Council's own checking engineer, from the point of view of safety, but also from the Client-Contractor, who would look for low cost and ease of construction.

Dr. A.C. Visvalingam, *MA, PhD, DIC, MICE, MIStructE, MIE(SL), CEng, Engineering Consultant.*

He graduated from the University of Cambridge in 1959. He obtained the DIC from the Imperial College of Science & Technology and the PhD from the University of London.

During the project planning stage, the Client-Contractor, the Architect and the Chief Engineer of W.V. Zinn & Associates had agreed on the broad outlines of the Building's structural systems, both in respect of their permanent functions and in respect of how parts of the permanent structure could be used to provide support for the temporary shoring of the excavation for the 3-4 basements which had been provided. That is, by the time the detailed design of the temporary works and the main elements of the permanent structure were entrusted to the writer, the basics of how the-still-unnamed "top-down construction" concept should be applied in the case of this Building had been broadly formulated. However, the possibility that this concept might previously have been adopted elsewhere by others even before 1961 is not to be discounted.

3.0 Description of Site, Layout, Soil and Foundations

The site is located in one the most prestigious and extremely busy locations in London, facing Park Lane (Fig. 1). Three narrow streets form the boundaries of the site on the two sides, and at the rear, i.e. the half which is further away from Park Lane.

The building was designed architecturally to cover the entirety of the site. It was to consist of 3-4 basements, a 4-storey Podium and a Y-shaped Tower extending 26 storeys above the Podium (Fig. 2).

The basements and the Podium covered the entirety of the site whereas the Tower was located on the front half of the site, closer to Park Lane (Fig. 1).

Entry to and exit from the basements was provided through two spiral ramps which were located over the rear half of the site (Fig. 1).

Both the design and the construction procedures had to take into account the imperative need to keep the surrounding streets clear for public use at all times, and to safeguard the neighbouring buildings against excessive settlements.

The writer cannot remember what the soil strata were in the top few metres but, below them, it was London blue gault clay with a permissible bearing pressure of 10 tons.ft^{-2} or 1100 kN.m^{-2} at a depth of 10-11m. There was no problem of ground-water infiltration.

Based on the geotechnical recommendations, no load-bearing piles were used to take the permanent loads. Instead, the Podium was founded on a raft at the basement 3 level, and the Tower on an independent raft at the basement 4 level (Fig. 2). Consequently, the depth of formation of the Tower raft exceeded that of the Podium raft by the height of one basement plus the difference between the thicknesses of the two rafts,

As the consolidation of the clay layers below the foundations would not be uniform, elaborate studies had been carried out on the settlements to be expected. The geotechnical computations had indicated that the Tower and the Tower basements would settle by about 75mm, whereas the Podium and the Podium basements would rise up by about 25mm during construction, and thereafter (Fig. 3). Therefore, the Tower and Tower basement structural levels were initially made up to about 100mm higher than those of the Podium and Podium basements so that, at the end of construction, the levels of the slabs in the Podium and the Tower would have gone a long way towards becoming equal.

In order to accommodate the relative vertical movements of the Tower and the Podium, hinged slabs and beams were provided in the gaps which were left between the lower floors of the Tower and the Tower basements, on the one hand, and the Podium and the Podium basements, on the other (Figs 3 and 4).

4.0 Construction

Continuous bored sheet piles of 450mm diameter were first constructed right round the perimeter of the site to a depth of some metres below the formation level of the rafts (Fig 5). These were designed to hold back the vertical faces of the excavation at the boundaries of the site, with propping provided by "ring beams" at basement 1 level and at basement 3 level, as described later on.

In addition, a number of temporary load-bearing bored friction cum end-bearing piles (G to R) were constructed about 2.5m inside the boundary at intervals of about 13m along the stretch ABCD (Fig 5). The purpose of these will become clear further along in the text.

Excavation was carried out inside the area ADEF (Fig 5) so that berms inclined at 45 degrees were left intact to support the perimetral bored sheet piles (Fig 5T1). This was necessary because the bored sheet piles were not capable of acting as free vertical cantilevers to support the required full depth of excavation, of up to 11.0 m or so. That is, initially, the excavation went to the full depth only over the area A 'D 'E 'F and was sloped up to basement 1 level at ADEF. The sheetpiling acted as a cantilevered retaining wall from a little below ground level down to basement 1 level (perhaps, effectively, a little lower).

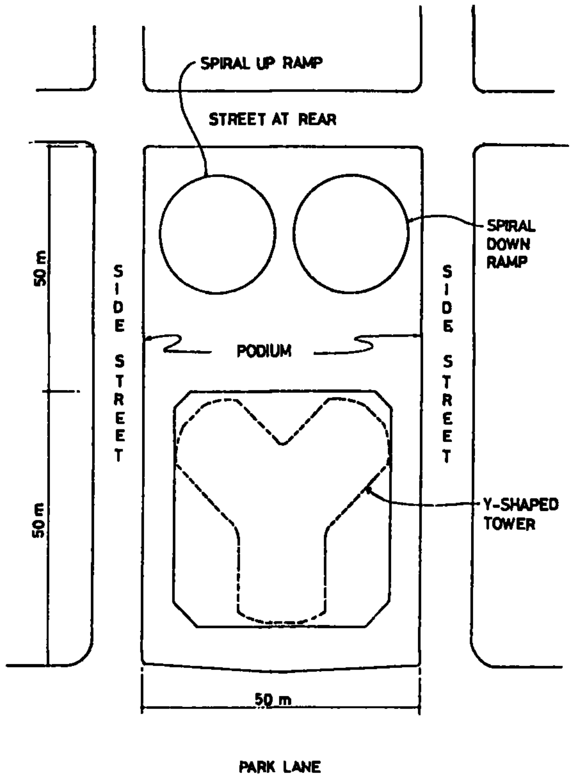

Figure 1 - Schematic Plan

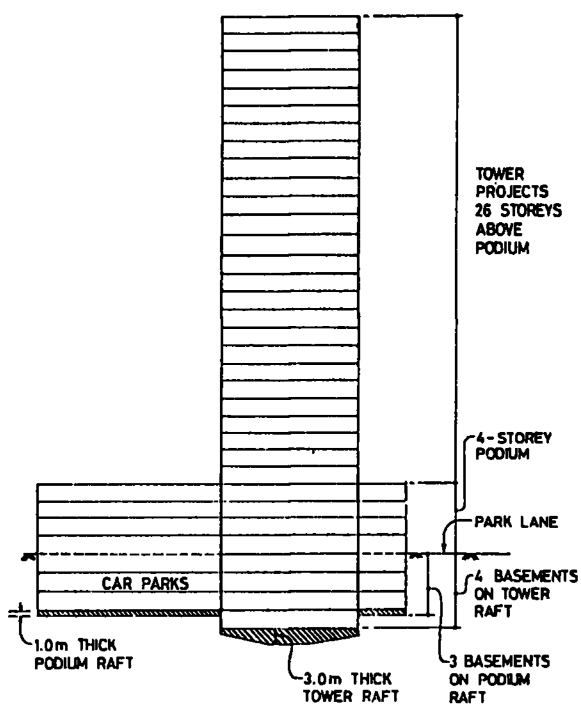

Figure 2 - Park Lane Hilton Schematic Cross-Section

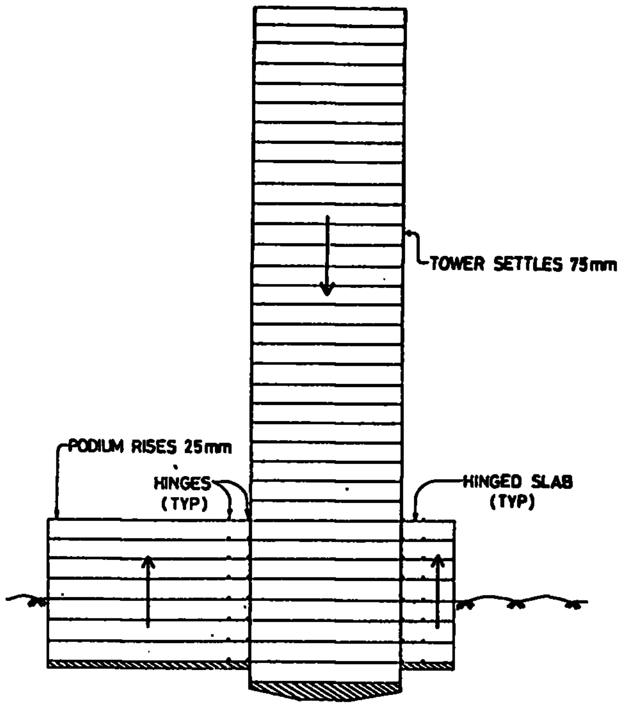

Figure 3 - Park Lane Hilton Schematic Cross-Section

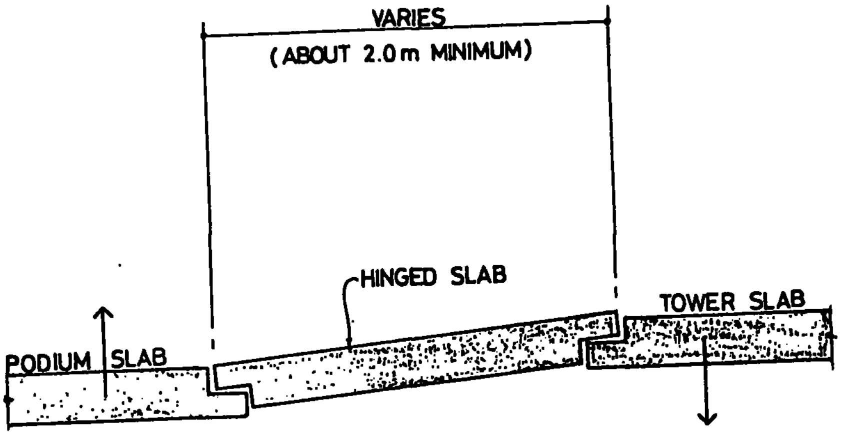

Figure 4 - Schematic Detail of Hinged Slab

The exposed surfaces of the sloped earth berms were gunited so as to prevent deterioration in wet weather (Fig 5T1).

The Podium raft was constructed over the area A' D' E' F', and whatever parts of the structure which could be constructed up to basement 1 level over the area ABCD were completed (Fig 5T2). A U-shaped strip of the slab at basement 1 level was then constructed over the front half of the site so that, in combination with the slab over the rear half, what was called a "ring beam", to the plan shown in Fig 6, was formed.

Whereas the basement 1 slab over the area was treated as a rigid horizontal diaphragm, the U-shaped strip ABCD was reinforced to resist the horizontal reactions, at basement 1 level, from the perimetral bored sheet piling to which the entirety of the "ring beam" acted as a prop. Part of its weight was taken on the temporary load-bearing piles G to R which were referred to above and the rest by notching into the contiguous bored sheet piling. The ring beam was also designed to resist the vertical loads to which it would be subjected at intermediate stages of the construction, and, later, when functioning as part of the permanent structure.

Next, a small excavator was lowered through one of the ramp openings in order to carry out the excavation of the earth from under the basement 1 level slab (Fig 6U1). the excavation was continued down to the basement 3 formation level, and the 1.0m thick raft constructed to a somewhat similar ring beam shape to that shown in Fig 6.

With the propping provided by the basement 1 and basement 3 ring beams (Fig 6U2), it was a simple matter to excavate down to the formation level of the Tower raft, without any further shoring, as the stiff clay at this depth was capable of standing up in a vertical face of over 4m.

The Tower raft was then constructed (Fig 6U3) and work proceeded upwards in the normal manner.

It will be appreciated readily that it was vital to check the structural sufficiency of the sheetpiling under the varying load conditions to which it was subjected at the various stages of construction up to ground level, and this was, of course, done.

5.0 Concluding Remarks

There is a great deal to be said for trying to utilize parts of the permanent works to reduce the cost and complexity of temporary works. Hence, there is no way in which the structural designer of the permanent works can say that his job is confined only to the permanent works and that all temporary works are a matter for the contractor, who would be obliged to take full responsibility for the latter. A good designer must, from the outset, consider the methods, procedures and temporary works which are likely to be adopted for the construction of the permanent works so that any cost-saving, synergistic benefits are not ignored.

"Top-down construction", of which an early example has been described here, is one way of achieving this objective in appropriate conditions.

It is germane to place on record here that some of the data in this paper is based on the highly-compressed Report on Training & Experience submitted by the writer in April 1963 to the UK Institution of Civil Engineers when applying for its Corporate Membership whereas, for the rest, he has had to rely on his memory.

6.0 Acknowledgements

The writer is indebted beyond measure to his superiors at M/s W.V. Zinn & Associates for the excellent training given to him in the field of reinforced concrete structures and for the confidence shown in entrusting to him the design of these foundation works and the entirety of the superstructure of this then very important building. He is also grateful to Professor B.L. Tennakoon, President of the Sri Lankan Geotechnical Society, for providing the necessary stimulus to prepare the parent of this paper for presentation at one of the Society's seminars.

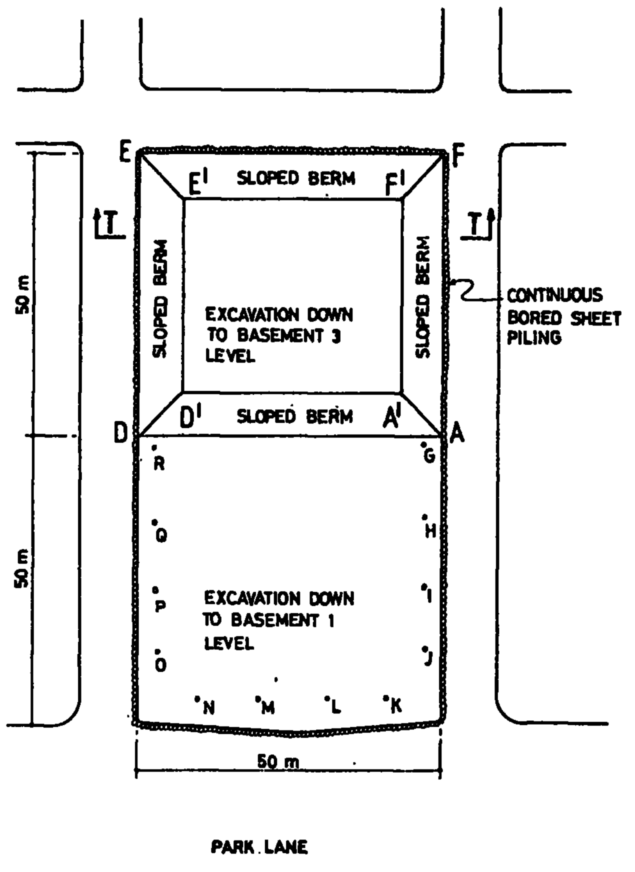

Figure 5 - Initial Excavation for Podium (Schematic)

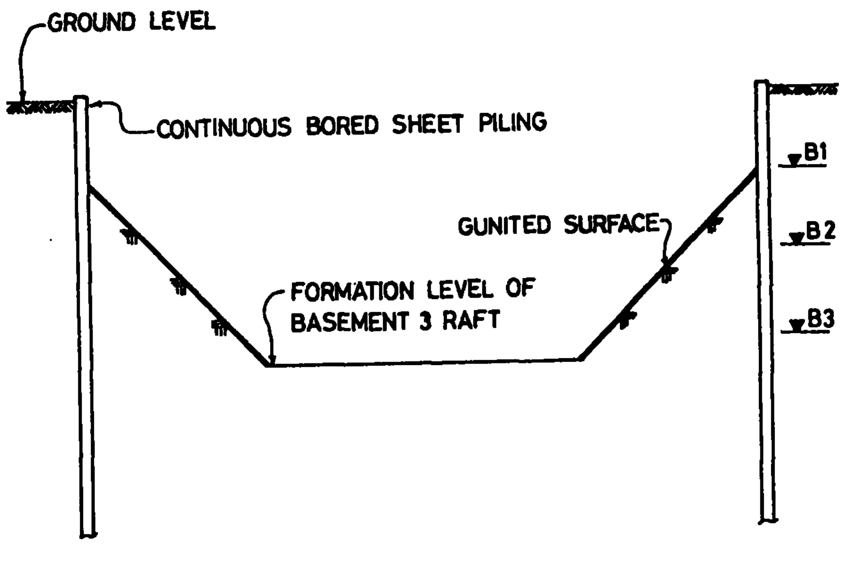

Figure 5T1 - Section T-T (Schematic)

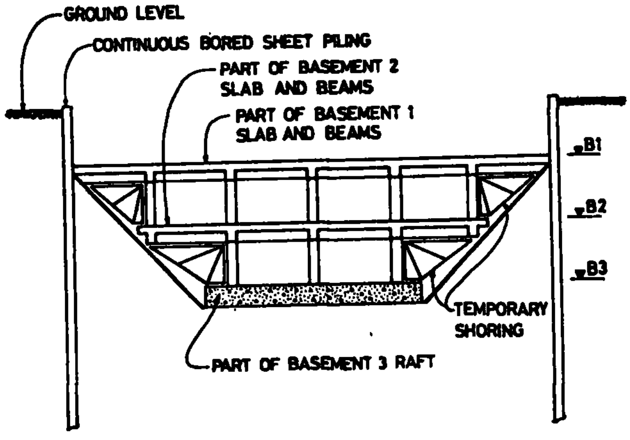

Figure 5T2 - Section T-T (Schematic. Car Ramps not shown)

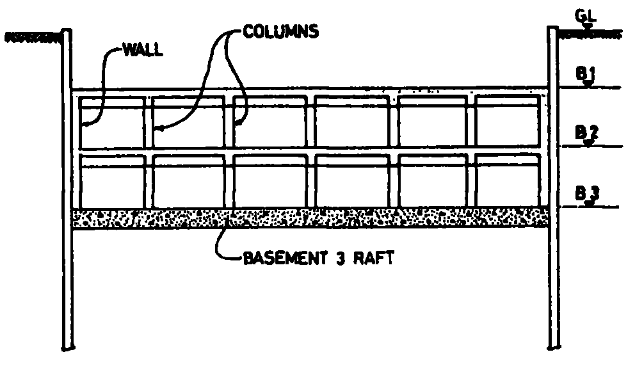

Figure 5T3 - Section T-T Through Podium upto Construction of Basement 1 (Schematic. Car Ramps not shown)

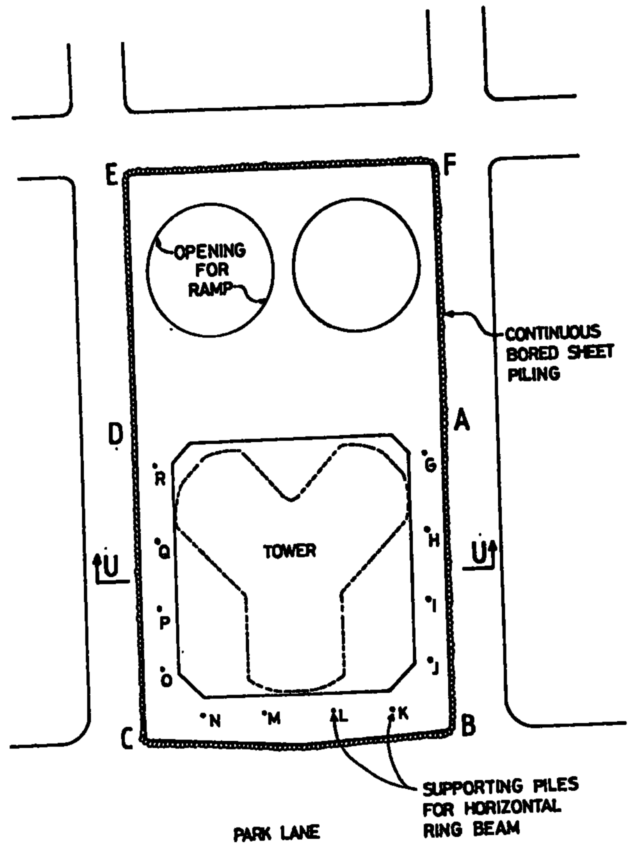

Figure 6 - Schematic Plan

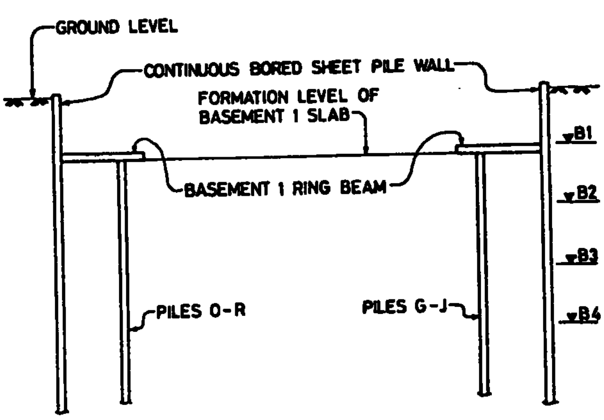

Figure 6U1 - Section U-U

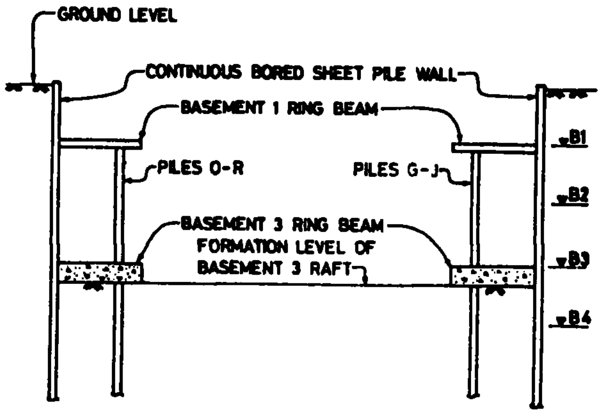

Figure 6U2 - Section U-U

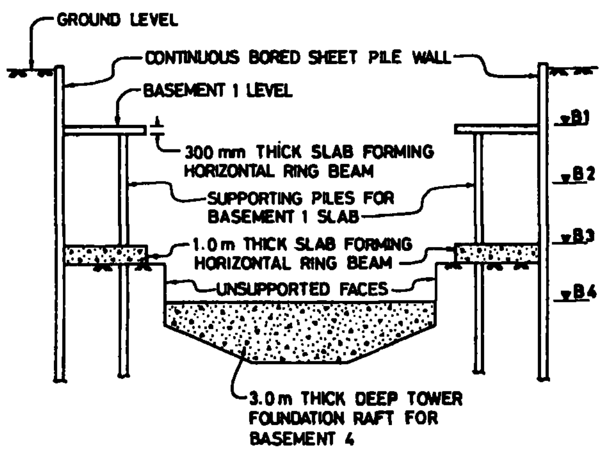

Figure 6U3 - Section U-U (Schematic)