The IBM Greenock Investigations, Remedial Works and Court Case

In 1985, Steve Dawson, who had worked with me on aspects of Tuen Mun Road and Tsuen Wan Bypass in Hong Kong, made contact and asked me to investigate an interesting construction issue unfolding during the construction of very large production modules at the IBM Plant, Spango Valley, Greenock. Steve had been on a Scott Wilson Hong Kong sponsored management course at Imperial College, London, a few years earlier and had decided to join IBM's construction team at Portsmouth rather than return to mainstream consulting with Scott Wilson in Hong Kong.

Having met Steve on site, I was taken to the pile driving operations for Module 3. The site was a hive of activity. Piling and floor construction had been completed for Modules 1 and 2 and steelwork and cladding were well underway and heading towards Module 3! Modules 4 and 5, further down Spango Valley and at a lower level, were being prepared for piling and some work had already started.

Numerous precast concrete piles had been driven to 'refusal' and several had been subjected to load tests. Everyone seemed satisfied that the piles had been constructed and tested properly. However, it had been discovered that the piles and pilecaps [for support of the reinforced concrete suspended floor and the superstructure steelwork] were behaving oddly. Some piles/pilecaps appeared to have remained at the specified levels, some had settled and others appeared to be 'rising' out of the ground!!

Over the next few days, full details of the ground investigation were produced as were details of the pile design, driving records and testing. It quickly became clear that some piles had been driven to a satisfactory end bearing in the underlying rock while others had not reached rock or other suitable founding strata. Further investigation revealed that 'piling platforms', several metres thick, had been constructed from imported granular material, in accordance with the designer's requirements, over the existing strata which, from existing ground level down, included, upper silty clay, peat, gravel, lower silty clay, [each varying in thickness but often several metres thick] overlying weathered volcanic rock. Spango Valley was, in short, a steep 'V' shaped glaciated valley cut into poor volcanic bedrock.

The piles had been driven to 'refusal' [using the Hilley formula as the 'mantra'] and some had been load tested! What everyone had missed was that the large thicknesses of granular fill provided the motive force for large settlements due to consolidation of the underlying upper and lower silty clays and peat!!

All ground layers, including the granular fill, provided very significant skin resistance to driving and, in the short term, to pile load testing. Furthermore, consolidation of the upper and lower silty clays and peat [which was estimated to take years to complete] immediately resulted in negative skin friction, or drag-down, on the driven piles from all the ground layers apart, perhaps, from the till resting on the rock. This resulted in overloaded piles and very large non-uniform pile and ground settlement.

Any pile that had been driven into competent rock appeared to rise above the surrounding ground level as the ground settled! Any pile driven short of competent rock was being dragged slowly downwards!

During the investigations, I was appointed Expert Witness to IBM and was ably assisted by Brian Robertson on all general matters and by Roger Doubal on detailed geotechnical issues.

Henry Boot Scotland Ltd was the Main Contractor and they had sub-contracted the design and construction of piling to West Pile. The Architect and Consulting Engineer was RMJM, Edinburgh.

RMJM created a small dedicated team to handle their side of the investigation and their Expert Witness was Professor Alan McGown of Strathclyde University, a geotechnical specialist. Alan McGown had, in fact, been one of my lecturers at Strathclyde University in the 1960s.

Although Prof McGown and I were providing expert opinion and advice to RMJM and IBM, respectively, we, and our respective teams worked closely together in establishing the facts and specifying the further ground and other investigations required to fully understand the complexities of all that had already been constructed and had yet to be constructed.

In addition, as 'time was of the essence' with regard to completion of the construction contract, we found ourselves working closely together to devise appropriate remedial works and meaningful criteria for the driving of all the remaining piles at modules 3, 4 and 5. It was agreed, for example, that a contour plan of rockhead beneath all 5 modules was urgently required to establish which piles had reached competent rock. This required extensive further ground investigation. Further ground investigation was also required to obtain soil samples to establish reliable soil strength parameters. It was agreed that reliance on the Hilley driving formula was a form of 'voodoo' and that all piles had to be driven into competent rock. This required clear target lengths and founding levels to be established for all piles.

Perhaps the most controversial decision was that, because re-driving piles beneath Modules 1, 2 and part of 3 would be impractical, it would be necessary to excavate most of the gravel infill placed beneath these modules to remove most, if not all, of the motive force causing consolidation, settlement and negative skin friction [or down-drag] on the piles supporting these modules. The floors and superstructure of Modules 1-3 were, therefore, completed and fitting-out was allowed to proceed while arrangements were made for miners to excavate the underlying granular fill leaving a giant void with stable side slopes up to ground level at the perimeter areas of the modules.

As Modules 4 and 5 required less granular infill than at the other three modules, the piles were designed to accommodate the resulting negative skin friction and arrangements were made to ensure that the piles were driven into competent rock.

During the investigations, remedial works and completion of construction, there was excellent cooperation between all involved but, of course, there were several insurance companies acting for the various parties, each with their own expert witnesses and they found it difficult to agree who was responsible for what and to what degree. As a result, there was a court case, IBM v Henry Boot Scotland Ltd, West Pile and RMJM.

The case was heard around 1986 by Judge John Newey at St Dunstan's House, London, The High Court of Justice Queen's Bench Division. Over a period of about a week, the witnesses of fact were examined and cross examined by the QCs for IBM, Boot, West Pile and RMJM. Each QC sought to show their own client in the best light and all the others, including IBM, in the worst! This procedure followed when I gave evidence as the first [and as it turned out, only] expert witness and found myself 'in the box' for just over a week as each QC tried to score points and counterpoints. Following my evidence, the parties decided they had heard enough to see how things were going to turn out, so they decided on a bit of final 'horse trading' concerning the split of liability and costs and the case was settled 'out of court' with no need for a judicial decision.

There is no room here for a detailed explanation of all of the problems that had to be resolved as a result of the general settlement of the site following the placement of the granular fill but the following gives an indication of the issues.

There was large, long-term and variable settlement of the site. This affected drainage, car parking and the piping of the burn that ran through the site.

All service connections between the modules and the adjacent ground had to be made 'flexible' to accommodate settlement.

Stairs and ramps to entrances had to be re-designed to accommodate vertical settlement and the additional horizontal space required for additional steps etc.

Vertical connections between canopies over doors and ground level features had to be re-designed to accommodate vertical movements.

Long term monitoring and prediction of settlements throughout the site was required.

The impact of settlement on the stability of the embankments supporting the adjacent A78 had to be investigated and accommodated.

It is interesting to note that, in addition to the investigation and expert witness work described here, commencing 1985, Scott Wilson Scotland continued to provide a wide range of services to IBM Greenock until around 2002.

JP McCafferty July 2015

IBM Greenock looking west down Spango Valley towards the Inverkip Chimney

Note the A78 Greenock-Inverkip Road to the north and the Greenock-Wemyss Bay railway to the south.

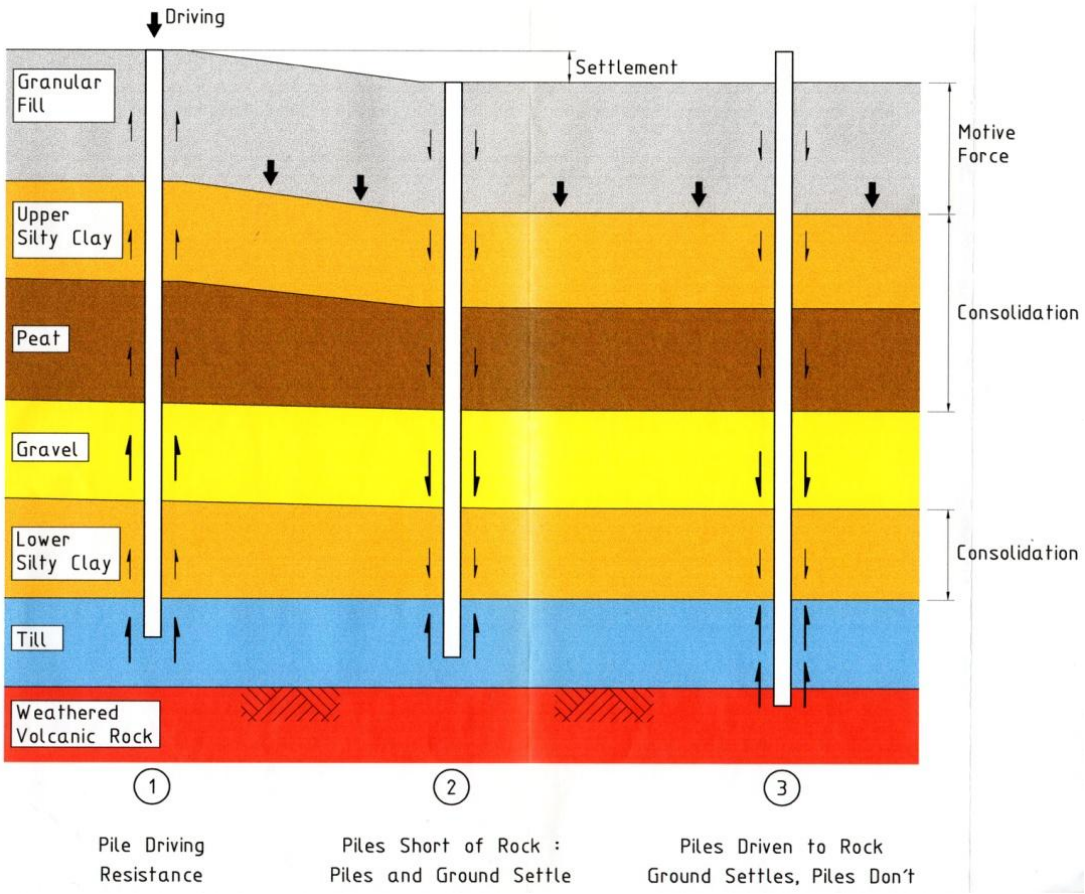
Modules 1-5 are in the distance adjacent to the A78

IBM Greenock looking south west

Modules 1-5 are to the right adjacent to the A78

Modules 1-3 to the left and Modules 4 & 5 to the right and at a lower level

The thickest layers of imported granular fill were beneath Module 3, tapering towards Module 1. The 'motive force' of the granular fill was removed beneath these modules to reduce negative skin friction and the exposed piles cross braced to provide buckling stability.



Piles, resistance to driving, down-drag, consolidation and settlement simply explained!