THE DEMOLITION OF
BERNARD HOUSE OFFICE BLOCK
PICCADILLY PLAZA,
MANCHESTER.

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by
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Synopsis.

The paper describes the demolition of Bernard House in Manchester, a necessary enabling operation for the redevelopment of Piccadilly Plaza. The Plaza is a 1960's development of two multi-storey office buildings alongside a multi-storey hotel, all sitting on a plinth of car parking, shops and basement storage.

At ten storeys high, Bernard House was the smaller of the two office buildings. Its floors were supported by a central core and perimeter reinforced concrete window mullions, all base supported off a pre stressed concrete slab. Demolition of the slab is this paper's main subject.

The main technical difficulty was linked to the slab's post tensioning. But the contract was generally made harder by the city centre location next to a busy bus / metro station.

Background and history.

Allott & Lomax became involved with the Piccadilly Plaza redevelopment in December 1997 when asked to assist with its assessment for possible purchase by Portfolio Holdings Ltd. The complex had been in receivership for some years and the potential developer secured exclusive rights on an assessment to purchase for a three month period. During this time, the team of construction professionals were to appraise its development potential and devise options for regeneration.

The Plaza was built during the early 1960's and comprises two multi-storey office buildings, Sunley Tower and Bernard House, of 30 and 10 storeys respectively. Alongside these towers there is a multi-storey hotel. These three tall structures sit on top of two-storeys of retail space with roof top car parking (approximately 80,000 sq ft at each Level). (See Figure 1). The original developer/contractor was Bernard Sunley and the towers were named accordingly, Bernard House being the smaller building lay literally "in the shadow" of Sunley Tower.

When first built, the Plaza was at the heart of Manchester's main shopping area. But the main focus of shoppers had moved during its lifetime and Piccadilly had become a less fashionable part of the city centre. Events such as the closure of the Woolworth's store after the tragic fire in 1979 and the construction nearby of an Arndale Shopping Centre added to the trend of shopping activity moving away. Moreover after 35 years life, the Plaza had begun to look tired and needed a serious condition appraisal.

The Plaza had gone into receivership in 1991 and as some six years had passed without a buyer, the mortgage holder was understandably keen to encourage potential purchasers. Lettings in the offices were at a low level and the ground floor shops were not high quality. The roof of Sunley Tower, however, provided a good source of income with its plethora of aerials and telecommunications dishes.

The review period for possible purchase started in early January 1998 with a site briefing meeting between the client and other design team members. During this initial meeting what turned out to be the main source of information for the subsequent project was discovered when the Plaza manager advised that some original construction drawings remained in the old Clerk of Works office

Going into this office was like going back 35 years! It was almost as if the Clerk of Works had slipped out for a site inspection. The 1950's desk, chair, cupboard, drawing board, plan chests, old fashioned telephone and adding machine they were all there, time warped in place. There were five plan chests in the room each having 30 drawers, one chest being full of drawings, bar bending schedules and an array of notes and sketches made by the Clerk of Works, a Mr W P Waller. Altogether there were over 3,500 drawings and other documents from the original construction phases still stored.

The quality of these drawings was variable, they had of course been a working set. Pieces had been ripped off and lost, others were damaged, some stuck together but with sections missing. More importantly, as we were to find out later, the drawing set was far from a complete. Many of the cross-referenced drawings were missing along with other parts of the information trail.

Nevertheless, by reviewing the drawings it was determined that complex development had occurred over three phases. The phasing took the construction from Mosley Street in the West towards Portland Street in the East. Phase 1 was therefore the area which included Bernard House and construction of this phase had progressed during 1960 - 62, possibly into early 1963.

Phases II: Sunley Tower, and III: the Piccadilly Hotel and shops beneath followed on. From the dates on the drawings we deduced that design of the Phases II and III had been carried out during the construction period of Bernard House

After the review period, it was decided that a viable scheme for redevelopment was possible and Portfolio Holdings went ahead with the purchase. Work then started in earnest to prepare a scheme for planning permission and construction.

Developing the scheme

The preparation of a planning scheme for redevelopment took some time, approximately 9 months, but it became clear early on that Bernard House was unlikely to be retained. At the time of complex purchase, Bernard House had only a single tenant on its lowest accommodation level (Level 3) and even part of that floor had been sublet. Despite extensive marketing and offers of favourable deals, all upper six floors were vacant and had been so for several years. The floors were perceived as offering a poor layout since the core required circulation space around it. Moreover the size of the central core for lifts, stairs and toilets, removed a relatively large proportion of the total floor plate from use. The roof was a timber structure of a '60's fashion hyperbolic paraboloid shape and a prominent feature of the city skyline. However, it leaked and was clearly reaching the end of its useful life. The decking leak was also starting to degrade the main support beams and would have lead to their eventual failure.

Collectively the office building was impossible to let. Despite this reality, it was essential for redevelopment planning submission to demonstrate that retention of Bernard House had been seriously considered. This was soon proved a wise course of action because during the approval stage, the main objectors wanted nothing changed and in particular Bernard House to be retained. The objectors wanted the complex "returned" to its original format, suggesting that removal would be "an act of vandalism". Nonetheless the scheme including the demolition of Bernard House did receive planning consent on 8th July 1999.

The Technical Aspects

To devise a safe scheme for taking the tall building while retaining other structure around its base, an understanding of exactly how the structure worked was imperative. Fortunately construction drawings were available, though unfortunately neither calculations nor technical descriptions could be found. Initially, looking at the building "cold" we were unaware that it was a post-tensioned, pre stressed, reinforced concrete structure although it had to be something different just looking at its shape and disposition.

During demolition, as during life, the central core was to provide the structure's overall stability so the core was not too difficult to maintain albeit temporarily. However, it was the response of the pre stressed

Level 3 slab to load removal which proved of greatest concern as this slab clearly supported the entire perimeter superstructure. With the limited amount of knowledge available, and in the absence of calculations, it was vital to maximise understanding about the pre stressing system used. At the time of floor construction quite a number of different systems had been in use, but no identifying descriptions could be found on the drawings.

It was decided to solicit information through the Verulam column of "The Structural Engineer". Bearing in mind that more than 35 years on, the majority of qualified structural engineers from the 1960's would be retired or no longer with us (!) this was a long shot. Amazingly, there were a number of responses from readers which helped, including one response from New Zealand. These helped identify the system as the PSC system designed by Pre stressed Concrete Ltd who had been based in London and subsequently became part of the Costain Group. Unfortunately, although we were able to speak to Costain, and elsewhere, they were unable to obtain any project specific information.

Additional information was received via the inaugural lecture of Professor John Gibson of City University in 1989, which included references to the design of Sunley Tower and its wind loading as being assessed by model and wind tunnel testing. The lecture also described how Professor Gibson had been involved in load testing Bernard House because some of the cable ducts had become accidentally grouted up during concreting. It was significant that none of the drawings found in the Plaza office were annotated or made reference to this problem. At this point, no more documentation could be procured and any further information had to come from the building itself.

Prior to this stage in the project, the client had been reluctant to permit any intrusive investigation. However, as part of the soft strip operations in late 2000, before the main demolition works got underway, we were able to remove some external cladding and initiate partial removal of the concrete encasement to reveal the end block anchorages of the pre stressing cables.

The Overall Structural System

To determine how to take the building down safely, both the construction and construction sequence had to be understood.

The post-tensioned, pre stressed concrete slab at Level 3 lying above the car deck, was the first level of lettable office accommodation. Columns springing from its perimeter propped all the edges of the higher structure while the core acted as a common support to the centre. Each floor's plan dimension was approximately 81 ft (24.70 m) square overall. This was made up of a 32 ft (9.75 m) square core with the floor projecting out 24 ft (7.32 m) on each side from the core face. Figure 2.

The key elements of Bernard House, its core and Level 3 cantilever slab, were cast from normal density reinforced concrete. Level 3 was heavily reinforced conventionally but also incorporated 100 cables ducts Figure 3. Each duct enclosed 72 individual pre stressing wires arranged in four levels of 18 wires.
The timber roof was supported by twin glulam beams on each of its four axes. These beams in turn supported four layers of cross laid tongue and grooved boarding covered with a waterproof membrane. Below the roof, and above Level 3, there were six concrete floors shown on the drawings to made from normally reinforced concrete but using "aglite" lightweight aggregate.

Sequence

Having identified the design as SCD, what was found on site lead to some confusion. The SCD design system information did not match with the drawings nor with the site exposed end blocks. After some further research, it became apparent that the early system used by SCD was similar to the Magnol-Blaton system and it was that system revealed in situ and not the later SCD system

Identifying the system used was essential but equally wire diameter sizing was needed for our own check calculations, yet no sizes were indicated on any of the drawings. It was known that at the time of construction two strand diameters were in common use for pre cast concrete floor units, 0.216 or 0.276 inches. By site measurement the use of 0.276 inch strand was confirmed

For the safe, taking down of the structure, cable loads had to be released under controlled conditions. Hence the demolition sequence, had essentially to be the reverse of the construction balancing the release of cable load against reductions in applied load. To ensure correct release of pre stress, a detailed retrospective design was needed. An initial design had been carried out develop the tender documents, but a complete design was required before actual demolition could commence.

The final demolition sequence was developed in close co-ordination with the contractor, Connell Brothers Ltd with whom we had worked on the contract to demolish the bomb damaged Marks & Spencer store in Manchester. This building also contained post-tensioned, prestressed, concrete elements, although on that occasion the units were beams spanning between columns. The demolition design had to account for the methods of approach favoured by the contractor, bearing in mind the type of plant and equipment available and what could be used in this location.

Information from the drawings suggested that during construction of the upper floors, cables were tensioned and grouted up at three specific stages to allow early removal of temporary supports. Our own "retrospective" design, based on the drawings, but supplemented by information obtained in situ, was intended to confirm the soundness of that understanding.

Initially it was thought that the structure was probably a cantilever projecting off a very substantial core. At 9.75m square, the core with walls 610 mm thick, was undoubtedly substantial and the drawings did refer to the Level 3 slab as the "cantilever" deck. Yet, check calculations failed to prove the slab could act as a cantilever.

Consequently some review of the options was required for a more probable design approach. Part of the evidence lay in the pattern of cable duct arrangement. For all these ducts had been laid in a longitudinal and latitudinal pattern producing a strong annulus around the core, (likened to a square doughnut). It was thus concluded that the intention had been to produce a rigid plate with the core just providing vertical support and global moment support via the twist of the floor as a whole.

By studying the design in detail and assuming the structural system, sufficient confidence was gained to decide that taking the building down sequentially and de-stressing the cables in reverse order to that indicated on the construction drawings was a safe way to proceed. In effect this meant sequentially de stressing the cables and compensating for the slab strength reduction by sequentially removing dead load from the upper floors.

To safeguard against mishaps, continuous monitoring of the Level 3 slab movements was arranged. This monitoring had to provide information on slab displacements linked to construction weight being taken off by demolition and subsequent debris removal. Theoretical estimates of slab displacement were produced, but these had to be confirmed by measurement In this way, by balancing the demolition work, the slab position could be maintained roughly constant and so its safety assured.

A similar monitoring approach had been used with success on the Marks & Spencer demolition. So again the services of the Department of Civil and Structural Engineering at UMIST were called upon to provide equipment and carry out the slab movement monitoring. The information about movement facilitated tuning of the de-stressing stages by cutting more or fewer cables if the slab rose too much. Conversely, if the slab were deflecting too much, the contractors could be instructed to remove more superimposed debris.

The theory behind this approach was always to return the slab to a level at or slightly above the original starting position. The difficulty was in predicting how the slab would react as load was progressively removed as first the roof and then each floor were taken away. The dead load of the roof was estimated to be in the order of 15 tonnes and each upper floor approximately 240 tonnes, making a total of approximately 1,450 tonnes.

For maximum control, as well as displacement monitoring, strain gauges were added to monitor cable load changes during cutting. The aim was to assure strand release from bond with the enveloping grout. This would provide confidence in force release, for if the cables retained their bond and all the pre stress force were not released, cable response and behaviour as concrete was broken out around could be unpredictable and dangerous. To guard against such unpredictability, the contractor installed precautionary energy absorbing buffers at the end anchorage's of all cables being cut.

Strain gauge readings were carried out during the first stage of de-stressing but only on a limited number of the cables. It was originally intended to measure strain by attaching gauges to individual wires but this proved impractical because of the number and tightness/ compactness of strand groups within the ducts. As a compromise, gauges were attached to the concrete slab between the cable cut locations (just above the cable), and measurements taken there. On site, the gauges did register release of pre stress force as the cables were cut so indicating that bond had been broken.

The available drawings showed that there were three stages of cable stressing; which of the 100 cables were stressed at each stage, and the exact order of stressing. For the original building work, the construction progressed in a traditional manner until the core walls had been built up to Level 4. At this point, the post-tensioning of the Level 3 slab cables commenced and continued as follows: -

Stage 1. 48 of the 100 cables were stressed after the Level 3 slab had been cast on propped shuttering and the walls had been taken up to Level 4.

These cables were then grouted, and after the grout had gained the strength, the supporting props and formwork were removed and construction proceeded thereafter off the pre stressed concrete slab. This also enabled the contractor to proceed with other construction works at lower levels.

Stage 2. 32 further cables were stressed (80% in total) after the slabs for Level 4, 5 and 6 had been cast plus the walls up to Level 7.

Stage 3. The remaining 20 cables were stressed after the slab at Level 7 had been cast.

The taking down of Bernard House could be a reversal of the construction process and was therefore sequenced overall as follows:

* Removal of the timber roof.

* Breaking out the slab at Levels 10, 9 and 8 plus the core walls, stairs, edge beam and mullions above Level 8. This action was predicted to result in the slab moving upwards.

* On completion of the first demolition stage and removal of debris, de-stressing was started by cutting 20 of the 100 cables. This was intended to allow the slab to sag back downwards towards its original position.

* Demolition of the upper floors (Level 7) was then completed to remove more slab. Core walls, stairs, edge beam and mullions above Level 7 were also demolished.

* On completion of the second demolition stage and removal of debris, the cable de-stressing procedure continued by cutting a further 32 of the 100 cables bringing the total number of cables cut to 52%. This reintroduced the cycle of balancing upwards and downwards deflection,

* Work on Levels 4,5 and 6 followed in the same pattern

* At this point, temporary support to the Level 3 slab was to be introduced to permit final de-stressing and demolition. Once supported with all residual debris removed, the last strands could be cut and then the slab itself could be demolished. (By the time work had progressed to-

wards Level 3, so many pockets had been cut that the ability of the slab to support itself had been significantly degraded)

The detail of cable cutting was as follows. First the contractor set out the cable positions on the slab surface, pockets were then cut to locate and expose the cables required to be cut in the first de-stressing stage and strain gauges were attached to the concrete and wires.

For the final stages of Level 3 slab removal (in its weakened but propped state), the cutting sequence was reviewed using experience gained from work on the upper floors. This lead to the decision to cut all remaining 48 stressed cables before starting to remove any of the slab. The cables were de-stressed by releasing them gradually working inwards from the slab edge, cutting and de-stressing the outer cables as the work progressed. The target was to maintain the maximum possible pre stressed annulus until the projecting slab had been reduced to a smaller size than existed during the full load condition. Cutting sequences maintained the corner areas evenly balanced to be followed by a series of cuts in the side perimeter cables to eliminate their stressing. Throughout this stage reliance was placed on the bond of the wires inside the ducts retaining sufficient pre stress force to remain supported by the reducing annulus. This was assisted by the action of the reinforcement that had been incorporated into the slab during its original construction to act prior to pre stressing.

The Quality Plan required that cables were cut in the correct sequence and that they were completely cut through (bearing in mind there were 72 individual wires in each cable). Only the cables for the relevant stage were marked to eliminate the potential for cutting the wrong ones, (some cables were close together and in confusion the wrong one might easily be cut). Correct workmanship was also assured via monitoring and supervision. Deformation monitoring was continuous as strands were cut and strain gauges were checked to assure that grout bond had been released. Observed slab deformations were much in line with expectations.

What had been a negative aspect of the building layout: the central core with stairs and lift shafts, now proved most useful when it came to demolition. After stripping out the core lifts, their shafts served as a chute for dropping debris down to ground level. The debris was then removed and taken off site through the loading bay. This procedure did require that reinforcement and other metal items be separated from the concrete rubble at upper slab level to prevent shaft blockage, but the materials had to be separated in any event for final disposal.

Demolition started on 8th January 2001 with the cutting up of the roof. Thereafter, the first stage of the de-stressing started with the first cable being cut at on 12th March 2001 and the work was completed by the 24th March 2001.

REFERENCES : JMR M&S ISE Jn