St. Pancras, Euston Rd, London: A Case Study in Matching Historic Brickwork

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The Station and the former Midland Grand Hotel at St. Pancras in London have been at the centre of a major construction and infrastructure programme. This included the insertion of a new Western Ticket Hall for London Underground underneath the raised forecourt of the grade I listed building. The author was appointed as specialist advisor to London Underground's project team on the historic brickwork associated with the new ticket hall. Detailed investigation and analysis were undertaken of the bricks, mortar and pointing as used by George Gilbert Scott in the original Victorian work. This guided the development of specific manufacturing techniques to achieve the required appearance of new brickwork with very fine brickwork joints. The new methodology was used on the repair work to the raised forecourt in front of the former Hotel, in particular the reconstruction work on the elevation facing King's Cross Station.

INTRODUCTION – THE LONDON UNDERGROUND PROJECT

The requirements for brickwork repair, reconstruction and extension at King's Cross St. Pancras, associated with the insertion of the new Western Ticket Hall for London Underground underneath the raised forecourt of the grade I listed building (St Pancras), presented some unexpected and extraordinary challenges. Meticulous detective work was necessary to identify the original detail, skills were stretched to match the manufacturing precision of the Victorian brick maker, and some important lessons were learnt concerning modern conservation practice.

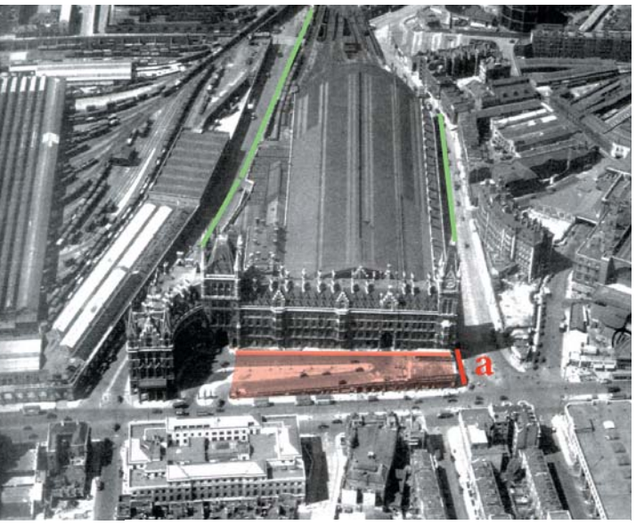

Fig.1.An aerial view of St Pancras showing the areas in which brickwork is affected: green – the CTRL project; red – the London Underground Limited project; (a) the London Underground demolition. *(image but not annotations reproduced from Jack Simmons)*

The brick elevations of St. Pancras Station and the former Midland Grand Hotel, with its elevated forecourt onto Euston Road, were designed by George Gilbert Scott in 1865–7 and built in 1868–74. The Hotel and W.H. Barlow and R.M. Ordish's Station of 1864–68 behind it were listed Grade I in 1967. Together they form one of the greatest Victorian landmarks in London and Britain, combining fine engineering and spectacular neo–Gothic architecture on a monumental scale.

A lavish establishment when built, by 1935 the Hotel was considered outdated and so it was closed down and converted to railway offices, to become known ever since as St. Pancras Chambers. It was finally completely abandoned in 1980 after being refused a fire certificate and has stood empty ever since, yet remaining a treasured set for filming and fashion photography.

The condition of the listed envelope had gradually reached such an advanced state of deterioration that extensive emergency repairs were undertaken in 1991–95 funded by British Rail and English Heritage at a cost of £10m. This was followed shortly afterwards by a programme of extension, refurbishment and conservation works, which will eventually see the Station reopening as the London Eurostar Train Terminus with a new Western Ticket Hall inserted underneath its forecourt to extend London Underground's King's Cross Station and St. Pancras Chambers fully repaired and converted into a luxury hotel and residential apartments.

Fig.2.Part of the Pancras Road façade of the elevated forecourt shortly after its completion, c1880. *(Reproduced by the permission of English Heritage, NMR)*

Fig.3.Alterations to the Pancras Road façade of the elevated forecourt at the beginning of the twentieth century. *(Reproduced by the permission of English Heritage, NMR)*

Two main projects were undertaken which affected the historic brickwork and these are both shown in the annotated aerial view of St Pancras (Fig.1): London Underground Limited's (LUL) project to insert the new Western Ticket Hall of King's Cross under the raised forecourt of St Pancras, and the Channel Tunnel Rail Link (CTRL) project. Both projects were undertaken using the powers provided by the CTRL Act 1996. The author's professional involvement as a historic buildings specialist and this paper are exclusively on the London Underground project to conserve the forecourt façade.

Early photographs show St Pancras shortly after its completion in c.1880. The two middle arches of the brickwork associated with the elevated front onto Pancras Road (Fig.2) were replaced in the early twentieth century with a single flight of stairs (Figs.3–4). These stairs were taken down as part of the London Underground construction of the Western Ticket Hall, as was one of the remaining original arches of the forecourt wall onto Pancras Road where it adjoins the clock tower (Fig.5). The intention had been for the arch and stairs to be rebuilt once the extension was complete.

The reconstruction was planned to be carried out using materials salvaged from the demolition, which had been stored for re-use, supplemented with new matching materials as necessary. This however could not apply to the brickwork. The hard mortar used in the original construction made it impossible to salvage enough original bricks and therefore a new matching brick had to be procured – and as it turned out, a method had to be devised for matching George Gilbert Scott's original brickwork.

Fig.4.The Pancras Road façade prior to the London Underground Limited demolition. *(Reproduced by the permission of English Heritage, NMR)*

Fig.5.Pancras Road façade of the elevated forecourt following the London Underground Limited demolition – *Areas 1* and *4* of original brickwork.

Analysis

Matching brickwork requires a full understanding of both the visual qualities and the technical attributes of the original construction and of its constituent elements, namely the mortar mix, the joint finish, the coursing and the brick itself. In situ observations identified three distinct forms of surviving original brickwork finishes:

Area 1 (Figs.5–7): the single–storey elevated front terrace (forecourt) of St Pancras retains undisturbed areas of original brickwork, with *Area 1* onto Euston Rd being one of these. Characteristic here are the fine joints, 4mm wide or less in the horizontal with the vertical joints being overall even finer than the horizontal. Their sizes were confirmed and recorded by measured survey. The mortar mix is off-white with pronounced aggregates and an incised line to the horizontal. The brickwork is laid in English bond, as is the case throughout the building. Bricks manufactured by Gripper[1] were recovered from the adjoining demolished area and this is consistent with the records of both the preference of the architect and the earlier construction date (Stage 1) of this part of the building.

Area 2 (Figs.8–9): the façade of the Clock Tower onto Pancras Road adjoining the elevated terrace displays similarly sized joints and mortar mix which however here appear to have been coated with a blackish material. When first seen, this coating may be mistaken for dirt from atmospheric pollution. Interestingly, further observations of brickwork elsewhere on the main façade of the building provide strong evidence to suggest that this is a remnant of the original joint finish.

Area 3 (Figs.10–11): the curved façade of the west wing, onto Euston Road, displays areas of original red mortar joints which are 'tuck-pointed' black. Importantly, the red joints here are wider than those described earlier and of the same colour as the bricks. Finished flat, they provide a homogenous red background of bricks and red joints, which is then broken down to regular English bond coursing by

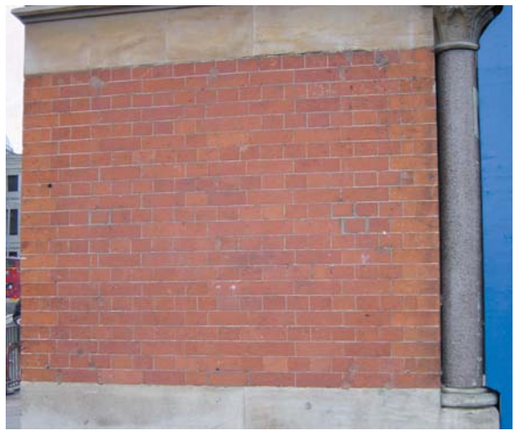

Fig.6–7.*Area 1*: overview and detail of original brickwork with fine joints and original Gripper bricks on the elevated forecourt of Pancras Road; the joints now show and off-white mortar.

Fig.8–9.*Area 2*: overview and detail of original brickwork with fine joints to the Clock Tower, Pancras Road. The blackish coating to the white mortar is now believed to have been the original joint finish.

means of (thin) tuck-pointing in black. This confirms that the dark coating on the façade to Pancras Road is the original joint finish, rather than the result of atmospheric pollution.

Consequently, the conclusion may now be drawn that the joints of the brickwork in *Areas 1* and *2* onto Pancras Road were thin joints (4mm or less), originally finished in black mortar and that the off-white joints seen today were not originally visible. In addition, and indeed very importantly, the existing physical evidence suggests that the black mortar finish (black thin joints) would have been applied throughout the facing brickwork of the Grade I listed building including main and secondary facades, although other aspects of the specification of the construction varied. The loss of the black mortar and black tuck-pointing finishes has revealed the various brickwork and joint details underlying this original finish.

It is not clear whether the exposure of the off-white mortar (*Area 1*) is the natural result of age and weathering or of the cleaning techniques used on the facades in the past – or perhaps a combination of the two.[2] In addition, the original bricks have lost their fired faces, exposing the brick core and leaving the textured surfaces seen today. This was particularly obvious when the protected side of a reclaimed Gripper brick was compared with the one exposed and may indicate the use of abrasive cleaning methods in the past.

Fig.10–11.*Area 3*: overview and detail of the curved elevation onto Euston Road. Original brickwork showing black tuck pointing over red stopping mortar, confirming the black joint finish as the original finish throughout the building.

Fig.12.*Area 4*: earlier repairs to original brickwork, incorporating new bricks above *Area 1* brickwork on the elevated forecourt, Pancras Road.

Past repairs

The underlying philosophy of the previous repair works of the 1990s, and the effect it had on the appearance of the original, can be studied in the repairs evident on the brickwork of the elevated forecourt both on Pancras and Euston Road. *Areas 4* and 5 respectively are examined below.

Area 4 (Fig.12): this is located directly above *Area 1*. Seen from a distance, *Area 4* appears to be of a different palette to *Area 1*. There are three main reasons for this:

Firstly, the new bricks used in the 1990s repairs are of a different colour and surface texture to the original, because the originals have lost their fired faces. (Interestingly, the 1990s brick emerges as an excellent match when compared with the protected faces of an original.)

Secondly, the 1990s joints are greyish in colour with a flat finish. As such they match neither the colour nor the finish of the original work, as identified in *Areas 1, 2* and *3* above, although seen in isolation the flush joint finish has the appearance of considered conservation work.

Thirdly, the 1990s joints (horizontal and vertical) are approximately 6–7mm wide and therefore significantly wider than the 4mm horizontal joints of the original brickwork. An important implication of this is that the height of the new coursing is greater than the original and the resulting misfit is evident where repairs and original work adjoin each other, detracting from the quality of the original.

Area 5 (Figs.13–14): The visual implications of the 1990s repairs on the original brickwork and in particular the misfit of the new to the original coursing and finishes are also evident in the Euston Road façade of the elevated terrace.

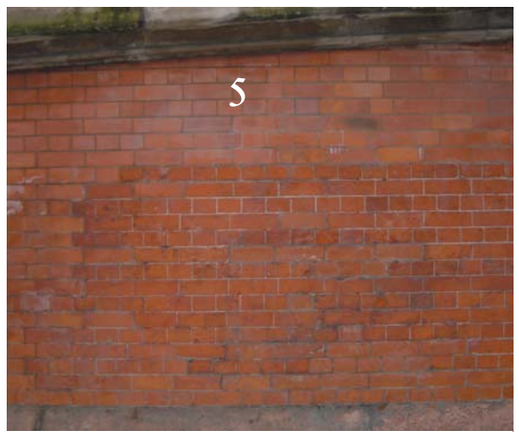

Fig.13.*Area 5*: The elevated forecourt, Euston Road: overview of original brickwork and 1990s repairs incorporating a new Ibstock brick (Tucker) and a 7mm wide greyish joint finish.

Fig.14.*Area 5*: detail showing the misfit between original coursing and the 1990s repairs.

Original mortar mix

With the agreement of English Heritage, samples of mortar were taken for analysis from areas of original work adjoining the demolition, which were established from the above analysis to have been unaffected by later alterations or by more recent repairs.

The minimum quantity of mortar required by the testing laboratory (Rose of Jericho) was 25 to 50g, preferably in the form of a lump. During sample collection from *Area 1* it became evident that it would not be possible to collect sufficient material from the fine joints of the facing brickwork without causing undue damage. It was therefore decided to collect further samples from the bedding joint of the same brickwork, where it adjoined the clock tower, (*Area 6*, in Fig. 8). Two samples, one from the facing joint and one from the bedding joint, were therefore tested.

The results of the analysis revealed that a very strong mortar based on ordinary Portland cement had been used. The two samples were found to be of the same constituents and of similar mix proportions, which confirmed that they were both contemporary as well as original. While the confidence level for each of the results was identified as being moderate (to low for the facing joints sample), each test confirmed the accuracy of the other, thus providing a comfortable level of certainty. The results were as follows:

Mix constituents for both mortar samples:

Binder: Portland cement and non–hydraulic lime

Aggregate: quartz silica sand and limestone

Mix proportions

Sample 1: (facing joint) 1:1: 5 –1:1:6
(cement: non–hydraulic lime: sand)

Sample 2: (bedding joint) 1:1:4
(cement: non–hydraulic lime: sand).

Interestingly, the laboratory analysis did not confirm the use of hydraulic lime in the mix as suggested in the original specification held in the National Archives at Kew, which also identifies its origin from the blue lias limestones of Barrow-on-Soar in Leicestershire. On the other hand although usually associated with hydraulic lime, it is well understood that the blue lias formation also produces non-hydraulic limes as well as Portland cement. It is therefore quite possible that a non-hydraulic or feebly hydraulic form from this source may have been chosen for St. Pancras and that the Portland cement used in the construction work also came from Barrow-on-Soar.

The mortar analysis results also did not show brick dust in the mix – another original specification according to archival texts. However, as demonstrated earlier, red mortar was used in the curved part of the façade onto Euston Road, and it is possible that brick dust was used in this mix. If true, this would confirm the original specification for brick dust in this part of the construction at least. In any case in situ evidence suggests that a variety of mixes was used in the building, as would be expected in such a long construction contract.

Fig.15.An original Gripper brick from the demolition and an Ibstock metric 're-pressed' brick are both photographed in front of *Area 1* of the original brickwork onto Pancras Road.

The Proposals

Matching the brick

By the time the author was instructed, several brick manufacturers had already produced a number of new bricks. Following detailed consultations with the manufacturers, samples of the most promising bricks were now taken to site. Combined with reclaimed examples of the original Gripper bricks, they were photographed against the original wall, in the actual light conditions that a chosen brick would eventually be seen. This exercise confirmed a 're-pressed' brick made by Ibstock as the best candidate (Fig.15).

The brick used in the 1990s repairs was also an Ibstock brick, made at the company's Leicestershire plant from the local clay known as Keuper Marl. This clay provided the closest possible match to that of the original Gripper brick, in that it is typical of the East Midlands clay from which the original Gripper bricks were made. The bricks now proposed were made from the same clay but re-pressed at Ibstock's Roughdales plant at St Helen's, Merseyside. The use of the re-pressed technique, in which clay is first cut to shape and then 're-pressed' into a mould, enabled the new bricks to mimic the now scuffed surfaces of the original Gripper bricks. While the 1990s brick sought to match the original brick in its condition as new, this

time round the underlying conservation philosophy was to match the original brick in its existing condition, as it survives.

Matching the coursing: 3-cut brick

Next, detailed discussions were held with Ibstock and other manufacturers, which aimed to establish the reason for the wider joints appearing in the new work of the 1990s repair. It emerged that modern manufacturing techniques are not as precise as those in the nineteenth century, and that bricks today are manufactured to be coordinated at 10mm joints. Depending on the mortar mix and on the skill of the bricklayer, the minimum joint size that could be successfully achieved was 6–7mm – which explained the misfit of the 1990s work.

To ensure that the courses aligned correctly in the new work, it was therefore necessary to either produce smaller bricks with larger joints (6–7 mm as in the 1990s repairs), or to achieve much finer brick production tolerances. Further discussions with Ibstock established that the latter, which was naturally the preferred option, could only be achieved by means of cutting oversized bricks, after firing, on three sides down to the original Gripper brick size. (This is the same technique used to produce the soft bricks known as 'rubbers' of the required size and shape for gauged brickwork.) It was thought that this method would work well and that the cut bricks could be installed so that the cut side abutted an un-cut side, thus avoiding the accuracy of gauged brickwork and reducing the cost of the cutting process as much as possible.

Cost implications

The increased cost of cutting the bricks proved significant and so ways were sought to re-balance the overall spending of the London Underground project by being inventive elsewhere. This was the reason behind the decision to construct the new internal brickwork, which extends the front façade of the listed building downwards underneath the raised forecourt level, using the metric version of the same brick.[3] In addition, the cut-brick approach had to be considered in the context of the requirements of the CTRL project.

Interestingly, the position of English Heritage until then had been that the two projects should agree one brick and the same brickwork finishes. It was now however, successfully argued that it was indeed appropriate to restrict the use of the cut bricks to the reconstruction of the demolished stairs and arch facing Pancras Road. This was the most prominent façade affected, visible from Euston Road against the main façade of the grade I listed building and on the main approach from King's Cross Station. Further, work required on the Pancras Road elevation by the CTRL project was at the time understood to be sufficiently limited to enable the use of reclaimed Gripper bricks. While the work required on the Midland Road elevation was much more extensive (Fig. 1), English Heritage agreed that the Midland Road elevation was of secondary importance in that it was not the main façade of the listed building. It was also constructed later than the Euston Road elevation and with a different brick (a brick adequately similar to Gripper made by Tucker) and therefore a different brick would be acceptable there.

Dry brickwork samples (metric uncut)

A dry brickwork sample was constructed on the request of English Heritage as the final test prior to their approval of the proposals using a second batch of 're-pressed' brick samples (Figs. 16–17). This revealed the nature of the 're-pressed' brick as a stretcher brick, because the re-pressing treatment created a textured surface on only one side. This meant that banding could occur in the brickwork between stretcher and header courses, which would have not been appropriate. In order to avoid this, the specification agreed with Ibstock included the possibility for mixing 'snapped headers' (stretcher bricks cut in half) in the header course.

Fig. 16–17. Dry brickwork sample in Ibstock metric 're–pressed' bricks (2nd batch) incorporating one Gripper brick (marked G).

At this final approval stage, when offered the opportunity to choose between the brick used in the 1990s repairs or the new proposed brick, English Heritage chose to approve the new brick and associated brick and brickwork specifications.

Mortar sample specification

Once the analysis results were known, sample mortar mixes were prepared to test the colour and texture match with the original. In consultation with the structural engineer it was agreed that a 1:1:6 mix (Portland cement: non-hydraulic lime: sand, all as in the analysis results with the exception of the aggregate) would be structurally adequate. Therefore, the unusual (and unnecessary) strong original mortar mixes (of 1:1:4 and 1:1:5) could be avoided. A less strong mortar would have the advantage of being more porous than the new brick so that weathering would affect the mortar and not the brick, which is good practice.

Three samples were prepared, in the first instance by the contractor, using materials supplied by the laboratory. In all cases the mix, types of cement and lime were as in the analysis results, with ordinary Portland cement and non-hydraulic lime in lime putty form being used. The difference between the three mixes was in the quantities of combination sands, as the original orange sand aggregate was not available for use. The test confirmed the preferred and proposed mix of aggregates as three parts quartz silica sand to three parts limestone dust (both with particles of not more than 1mm), with the additional requirement that when reference panels were prepared, a warmer limestone dust (for example Bath stone dust) should replace the Portland stone dust so as to warm up the mortar colour and bring it closer to the original.

Fig. 18. Sample dry brickwork of the imperial size 're–pressed' Ibstock brick, cut on three sides. The necessary regular fine joint was still not achieved.

Fig. 19. The completed Pancras Road façade.

Fig.20.Reconstruction detail: alignment of new and old brickwork by the Clock Tower.

Fig.22.Reconstruction detail: original brickwork (left); early twentieth-century quoins to stairs return in Charnwood bricks; and reconstructed brickwork (behind reclaimed gates).

Fig.21.Reconstruction detail: new brickwork and reclaimed granite column.

Fig.23.Detail of above showing early twentieth-century Charnwood quoins (left) and new brickwork (right) on stairs return.

Scheme Implementation

Mass production difficulties: the 5-cut imperial brick

Unfortunately, the mass manufacturing of the approved brick proved much more difficult than Ibstock had anticipated and brick tolerances remained too high (Fig.18). As a result a five-cut approach was finally employed to achieve coordination that would match both original brick and joint sizing. In the 5-cut approach all sides of each brick with the exception of the exposed facing side were cut so that the remaining unevenness was all removed. Corner bricks with two exposed sides were also procured, which only had 4-cut surfaces, so that cut surfaces (which had through this process lost their fired skins) would not be exposed to weathering.

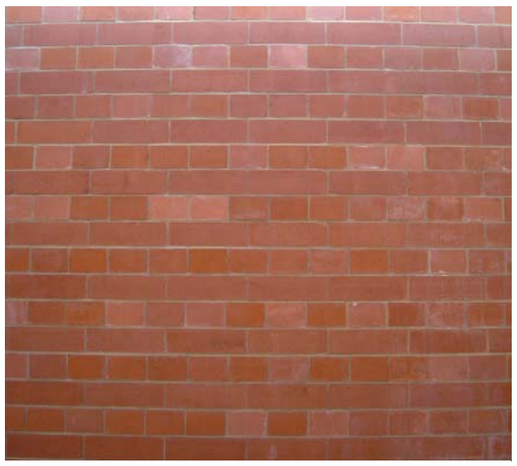

Fig.24.Reconstructed brickwork detail: compare with fig. 6 and 7.

The construction work and coordination of the specification of the new brick to the fine joints of the original brickwork required the employment of specialist techniques, which were developed and tested on site. For example, it was discovered during the construction of the final brickwork samples that the thin joints meant that the mortar dried out too quickly for the normal pace of construction work. To circumnavigate this difficulty, the bricks were immersed in water for at least a couple of hours prior to being laid. In this way, water from the bricks moving through capillary action to the wet joints ensured that bricks and joints dried out together at a normal pace, thus securing appropriate final visual and strength qualities for the new brickwork.

Conservation Philosophy

There are fundamental differences in the approach and underlying philosophy of the current proposals when compared with the repairs that were carried out just ten years ago.

As a starting point, the decision was taken to procure a new brick that would match the brick surfaces as they survive in their weathered condition today, rather than replicating the original appearance when new. Through observation of the original construction and by working closely with the industry, it proved possible to design and procure a brick that could be coordinated to the fine joints of the original brickwork. All along the expectation has been that the reinstated brickwork facing Pancras Road would achieve a colour and finish adequately similar to the original so that from afar the restored wall should appear as a complete entity, but it should be possible to identify the new work on close inspection.

The differences between the original construction and past repairs were to be left as they were, but not to be repeated. At all times the new work sought to adhere to the rules of construction and state of preservation of the original fabric and its appearance (Figs.19–24).

The completed work is testimony itself to the degree to which the aspiration behind the work has been realised.

Eleni Makri *is an accredited conservation architect. She was instructed by Arup and Allies and Morrison Architects as an external consultant to make recommendations and resolve specialist technical matters associated with the London Underground project.*

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Notes

1. *'Scott fought from the outset (1867) to maintain high standards of finish. He had for example decided that he wanted the building to be executed in Gripper's patent bricks from Nottingham … Scott had his way, and Gripper's bricks were used throughout'* Simmons p.53; *'On July 15, 1868, the work being held up through inadequate deliveries of Gripper's bricks, Scott accepted some from Leicestershire', Simmons p.54. 'The core bricks were of Gripper manufacture (Nottingham) and the facings were a red brick from the vicinity of Leicester identified in the frog by the manufacturer's name Tucker'*, Warren p.266. Interestingly, Gripper facing bricks were recovered from the LUL demolition on Pancras Road, confirming the accuracy of Simmons.
2. *'In cleaning the brickwork an initial brushing with stiff brushes was followed by removal of clinker with sharp chisels. The surface was then carefully dressed with a low–pressure air spray with a water mist using stone or glass powder with particle sizes up to 0.5 mm at pressures up to 40 lb per square inch'*, Warren, p.268, on the 1990s programme of works.
3. This work is not discussed here.

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