VIADUCTS ON THE UNDERGROUND

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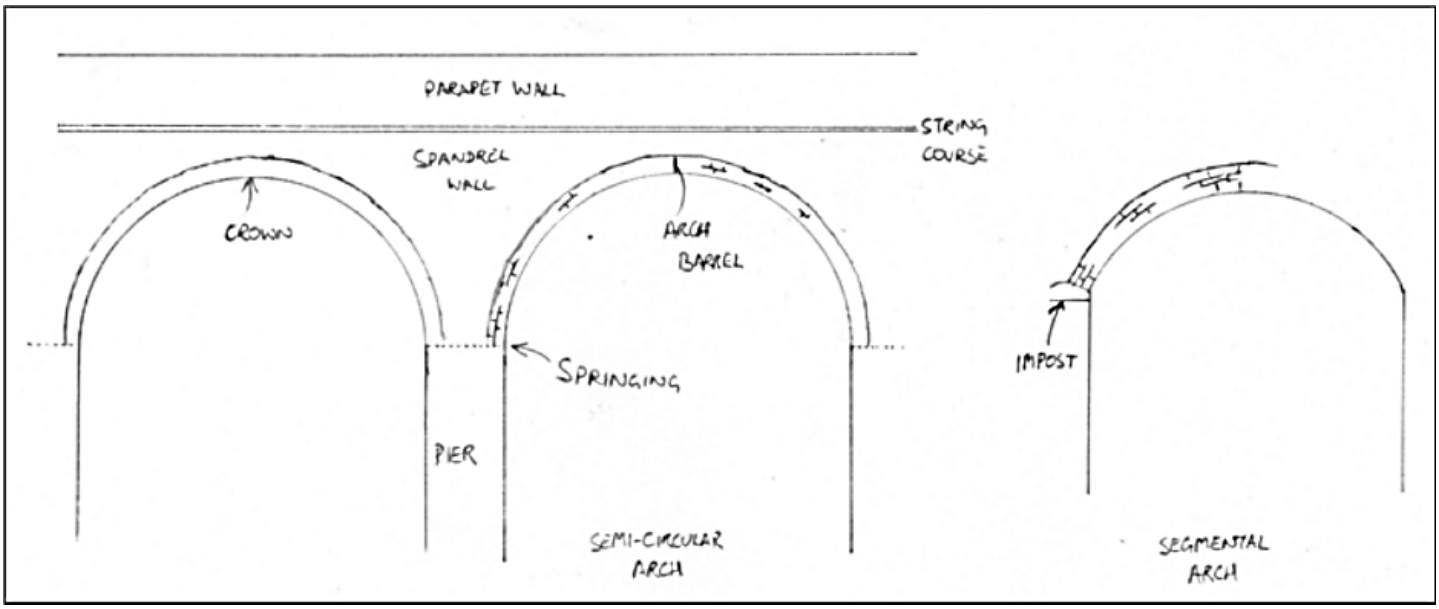
All photos by the author

INTRODUCTION

Despite its name, less than half of the route length of the Underground is beneath the surface. Of the slight majority that is not, there are a number of viaducts carrying trains across roads, rivers and dips in the ground. Many date back to the Victorian period and are constructed of brick, forming a series of arches.[1] This article takes a look at these structures line-by-line and describes their features. The term **viaduct** is being used to describe a series of similar arched structures connected together, as opposed to a single arch, which forms a bridge.

Before starting to look at the viaducts themselves, it is worth defining some of the terms that will be used. The viaducts on the Underground have two different shapes of arch. One is **semi-circular**, i.e., the arches form complete semi-circles and meet the walls of the piers below smoothly. The other is **segmental**; it forms a segment of a circle, less than 180°, and meets the piers at an angle. An **impost** is used at the junction of the arch and the pier to provide the base for the arch at the correct angle.

The arches themselves are usually formed of rings of brickwork – these are the **arch barrels**. Most viaducts carry these right to the arch edge, but a few use large stone **voussoir blocks** in this position. The highest point of the arches is the **crown**, and where they meet the piers is the **springing**. The sides of the viaduct are the **spandrel walls**. These usually continue up to around rail level. Above this, there is usually a **parapet wall** that provides protection to anyone on the viaduct. Many viaducts have a projecting and decorative line of bricks or stonework separating the spandrel and parapet wall levels, called the **string course**. As will be seen, a variety of different decorations have been used, including the use of different coloured bricks and the use of stone as well as brick. Some of these terms are illustrated below.



STRUCTURE NUMBERS

This article provides details of the structure numbers for the viaducts. These are usually shown on metal plates fixed to the brickwork. The numbers run in sequence along each line and consist of a letter code followed by the number of the viaduct (or viaduct section). The letter codes used are as follows:

D	District Line	
E	Edgware branch	Finchley Central – Edgware
HC	Hammersmith & City Railway	Paddington – Hammersmith
KRR	Kensington & Richmond Railway	Hammersmith (Grove Road) – Studland Street Junction
MR	Metropolitan Railway	
O	Ongar branch	Leyton – Ongar
NT	Northern Tube	Golders Green – Edgware

[1] Although the Underground has a number of modern concrete bridges, it does not appear to have any modern concrete viaducts.

P	Piccadilly Line	South Harrow – Rayners Lane
PT	Piccadilly Tube	Bounds Green – Cockfosters
R	Ruislip branch	North Acton – West Ruislip

CENTRAL LINE VIADUCTS

Part of the 1935/40 New Works Programme involved the westward extension of the Central Line from North Acton to Denham (later curtailed to West Ruislip). This section ran parallel to the Great Western Railway line, and was constructed for the LPTB by the GWR. Several short lengths of viaduct were constructed.

BRENT VIADUCT

West of the cutting in which Hanger Lane station resides, a length of viaduct raises the line over the River Brent. This is a brick-built structure consisting of three segmental arches, with the river normally passing beneath the central arch. In times of flood, both the other arches can help accommodate increased flow. The piers are solid, with a refuge above each of them and featuring imposts (i.e., stonework with a flat base and angled top from which the arches 'spring'). Six courses of brickwork form each of the arches, with the uppermost of these projecting slightly from the spandrel. Refuges are provided above the piers, with tapering courses of brickwork beneath each of them. These details mirror the older, and higher GWR viaduct running parallel and to the north. The London Underground structure number for this viaduct is R6.

GREENFORD

To the east of Greenford station, the tracks of the Central Line needed to pass over the triangular junction formed where the GWR main-line met the Castlebar loop line, from West Ealing, coming in from the south. The Central Line tracks diverge slightly from the GWR, and then rise onto a ten-arch viaduct (R18) situated to the north of Conway Crescent. This allows them to pass over the eastern leg of the triangle at a skew; four smaller, semi-circular blind arches form the facing of the south side of the viaduct adjacent to (and because of) the skew. The line from West Ealing is then crossed on a 74-ft-long plate girder bridge (R19), beyond which the viaduct continues with a further three arches (R20).

An embankment then takes the tracks along the north side of the triangle. The two tracks diverge and are then carried by single-track viaducts (R21 westbound / R22 eastbound) consisting of three arches to the lattice truss bridges over the western side of the main-line triangle; these have spans of 135 ft (westbound – R23) and 121 ft (eastbound – R24). Between the viaducts the track into the central bay platform at Greenford rises up. After the truss bridges, the viaducts continue with eleven arches (westbound – R25) and eight arches plus four blind semi-circular arches (eastbound – R26) before the 60-ft elliptical brick arch span over Greenford Road is reached (R28). Another 17 arches of viaduct carry the tracks to the Oldfield Lane bridge, which appears similar to that at Greenford Road but smaller with a span of 45 ft. However, the Oldfield Lane bridge is next to Greenford station, and consists of a pair of single-track brick bridges (R30 westbound / R32 eastbound). In between them, another arch (R31) parallel to the road was built to support the upper machinery chamber for the escalator at Greenford. The arch can be seen in the side wall under the bridge, as it is outlined by large stone voussoir blocks, and the escalator chamber is visible as a reinforced concrete box between the two bridges.

Greenford station itself is built into the remaining six arches of viaduct west of Oldfield Lane (R33). These are slightly narrower than the arches in the rest of the Greenford viaducts, which are all segmental with a 30-ft span and a rise of 9 ft 3 ins.

The unusual, and most distinctive feature of all of the viaducts here is that they are made of concrete. The top parts of each arch are built from a single course of 2-ft concrete blocks down to the point at which they are at an angle of 45° to the horizontal. Below this, the entirety of the structures are made from mass concrete. The arches give the impression of being made from 25 of the blocks, and have a very thin, curved and projecting surround. The edges of the piers have horizontal grooves cast into them to give the impression of stone blocks, and similar grooves are in the spandrel walls. Precast concrete panels formed the parapet walls. The bridge over Greenford Road is slightly odd, in that the south side has a concrete spandrel wall, whereas on the north side this is in brick.

RUISLIP GARDENS

The westbound track here is supported on a concrete viaduct similar to that at Greenford, with twelve arches. The main-line tracks here are at the same level, and on an embankment, and so the viaduct

arches are all blind. They are smaller and lower than at Greenford though, with only 17 blocks in their arch course.

DEBDEN

To the east of London, the Underground acquired several viaducts on the lines of the Great Eastern Railway that were taken over as part of the New Works Programme. North of Debden station, where the railway crosses the Debden Brook, there is a short section of viaduct consisting of five semi-circular arches; this has structure number O77. The brook passes beneath the central span, with field tracks using the two spans either side. The outermost spans are very shallow, with the arches springing from just above ground level.

The viaduct is constructed of red brick, with a simple string course defining the lower edge of the parapet wall. The arch barrels are four courses of brickwork thick. A drain emerges from the brickwork at the mid-point of each pier on both sides of the viaduct, a few rows below the string course, and empties into a drain pipe, which hopefully reduces the risk of water damage.

RODING VALLEY

When the Fairlop loop had been constructed at the start of the twentieth century, a viaduct was built where the tracks passed over the River Roding west of the station at Chigwell. It consists of three semi-circular brick arches supported by solid piers. Typical blue engineering bricks are used throughout, with five courses of them forming each arch. The spandrel walls are plain, without any string course. This makes the viaduct look much more solid above arch level, since the walls continue seamlessly up to form the parapet walls.

Beneath the viaduct, the River Roding passes through the central arch. The easternmost arch accommodates Luxborough Lane, a small track leading to a small lake north of the railway, whilst its counterpart to the west of the river passes over a footpath. Either side of the viaduct, substantial wing walls retain the railway embankment. This embankment caused problems during construction, when its weight caused it to subside into the weak ground over which it was placed. It was rebuilt using a large amount of ash, this being a lighter material.

The structure number is N38.

HAINAULT

The original, two-track station at Hainault was constructed with its platforms on what could be called a pair of brick viaducts. These run from the New North Road, at the north end of the station, to the southern end of the platforms, and also support the buildings behind each platform. However, between the tracks are supported on an embankment, and so the arches do not pass beneath the width of the station.

The arches beneath the southbound platform (on the eastern side) can still be seen, but the northbound platform was rebuilt as an island, with an additional face and track on the western site. Two further tracks to the west are sidings or headshunts for Hainault Depot. These works were carried out in the late-1930s as part of the New Works Programme, in readiness for the Central Line to be extended over the former GER tracks. The arches beneath the northbound platform might still remain *in situ*, buried beneath these works.

CRIPSEY BROOK VIADUCT

No longer on the Central Line, but a part of it until 1994, this structure is on the approach to Ongar station, immediately before the pointwork. Consisting of five semi-circular arches, the piers have shallow buttresses extending out slightly, rising almost to the height of the arch crowns. The spandrel and parapet walls are built of red brick, with the arch barrels and pier buttresses in blue engineering brick. There is a simple string course defining the line where the parapet and spandrel walls meet.

The viaduct (structure number O113) is the lowest point on the Epping – Ongar Railway. It was built as part of the Eastern Counties Railway extension from Loughton by the famous railway contractor Thomas Brassey. As its name suggests, it carries the railway over the Cripsey Brook (which passes through the centre arch), a tributary of the River Roding.

DISTRICT LINE VIADUCTS

PUTNEY BRIDGE VIADUCT

The viaduct was built by Lucas & Aird as part of the MDR's extension from West Brompton to Putney Bridge, opened in 1880. It was required to be "of ornamental character" by the Ecclesiastical

Commissioners across whose land it passed, and who had to approve the design prior to construction. This seems to have resulted in the parapet walls having a recessed panel, rather than being plain, but nothing more than this. Yellow London brick is used for the viaduct.

The most northerly part of the viaduct is at Parsons Green station, across the road from the actual station. Although surrounded by buildings, it is suspected that four arches are here, as the first arch south of the road is numbered '5'. South of Parsons Green, there are sidings either side of the railway, which appears to be on an embankment with retaining walls.

The viaduct resumes at Munster Road (D96), with an arch or two to the north, and then 19 arches (D95A) south to New King's Road (D95). There are another ten arches (D94A) to Grimston Road (D94), and 14 more (D93A) to Hurlingham Road (D93). The section of viaduct southwards includes Putney Bridge station; there are five arches before the platforms are reached, and then the viaduct is largely hidden between the station building to the west, and the metalwork supporting the additional platform that was added in 1910.

The arches are mostly segmental, although some semi-circular arches can be found adjacent to bridges across roads – this might be to adjust the span of the arch to ensure alignment with the existing road.

D93E Viaduct north of Hurlingham Road.

EAST PUTNEY VIADUCT

The line south of Putney Bridge was built in conjunction with the London & South Western Railway (LSWR). Between the southern end of the Putney Railway Bridge, all the way to East Putney station was on viaduct, interrupted only by five metal bridges where roads were crossed. Where the existing LSWR route was crossed, it lay in a cutting and its four tracks were spanned by three arches of the new viaduct (two through the central arch, and one each through the side arches), which have structure number D229.

This viaduct is plainer than the one north of Putney Bridge, presumably as there was no need to please the Ecclesiastical Commissioners. The parapet wall is unornamented, with just a string course three bricks high separating the parapet from the spandrel. The arches are semi-circular, with the barrels formed from five rings of brick. The exception is the most northerly section of viaduct, which has stone string course above a decorative pattern formed from red and yellow brickwork above the arch crowns. The arches on this section use red bricks for their barrels, and have stone key blocks at the crown of each arch. This additional decoration extended to the bridge abutments at each end of this section of viaduct.

The road bridges along the route are at (from north to south):

- Deodar Road (D221)
- Putney Bridge Road (D223)
- Esmond Street (D225)
- Disraeli Road (D227)
- Upper Richmond Road (D231)

The sections of viaduct have the intermediate, even-numbered structure numbers from D222 to D230.

They have, respectively, 10½, 10, 13, 3, and 6 arches (where the half-arch is a small, semi-circular arch filling a gap against the skewed abutment).

D223 Putney Bridge Road (east side).

HAMMERSMITH TO ACTON TOWN VIADUCTS

The longest series of viaducts is that between Hammersmith and reaching west almost as far as Acton Town station. These have the added interest at the eastern end of being built around the pre-existing viaduct built by the Kensington & Richmond Railway (KRR – with was taken over by the LSWR), which now lies disused but originally carried trains via the station at Hammersmith (Grove Road).

The original viaduct was part of the KRR, and ran for 1 mile 23 chains from Hammersmith to Turnham Green station, where the railway then curved south to Richmond. In 1877, the District Railway was extended from its Hammersmith terminus to Richmond over the tracks of the KRR. In order to make the connection, the line had to ascend from the cutting in which the station was sited, pass over what are now named Leamore Street, Cambridge Grove, and Galena Road, connecting into the KRR viaduct at a junction at Studland Street.

Between Cambridge Grove and Galena Road, a fourteen-arch viaduct was built. One arch has a span of 17 ft; the remainder are of 20 ft span. To the west of Galena Road, another eight viaduct arches were built, three with a 20ft span and five of 18 ft span. The arches are segmental and formed of four courses of brickwork; the piers are 3 ft thick.

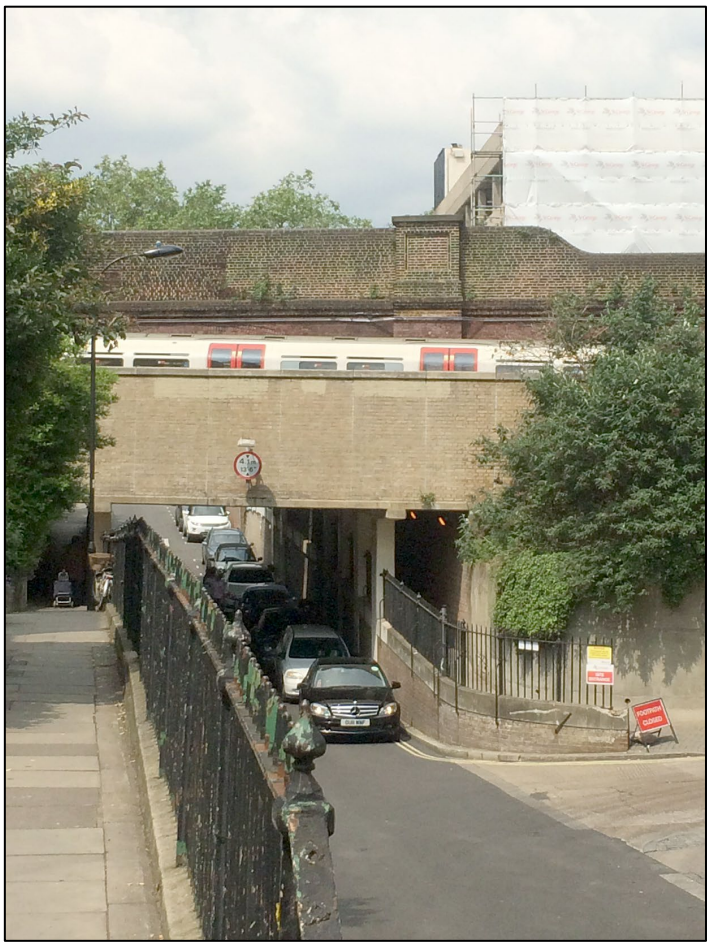
At Cambridge Grove and Leamore Street the road levels had to be lowered to accommodate the new bridges, as the tracks were still ascending to the height of the KRR. To reduce costs only the centre of the roads were lowered, leaving the pavements at a higher level with less headroom, a situation that remains the case today. Metal bridges were used, rather than arches, otherwise even more headroom would have been lost.

***Above**: Kensington & Richmond KR12.*

***Below**: D78C Viaduct on south side of Ravenscourt Park.*

***Above**: D83 Cambridge Grove (south side)*

***Below**: D84, close up.*



***Left**: D77 Goldhawk Road.*

The flat junction at Studland Road was the source of delays as LSWR and District Railway trains crossed each other's paths, and by the early 1900s something had to be done. The LSWR constructed a new pair of tracks west to Turnham Green, allowing the District to have their own route with a grade-separated junction at the latter point allowing the trains to Ealing Broadway to pass over LSWR trains to and from Richmond.

The arrangements for the widening were not entirely straightforward, as it was not just a case of building another viaduct alongside the first. A new station was provided at Stamford Brook to the south of the existing viaduct, solely for the use of the District. Either side of this, most of the widening was also on the south side, but at Turnham Green and Ravenscourt Park stations new single viaducts were built on each side of the LSWR tracks, allowing the side platforms to be converted into islands. The widening means that the original 1877 viaduct is very hard to see; many of the newer arches will have been aligned with the older ones, but photos have been seen showing some complexity in the structures near Ravenscourt Park station.

At The Avenue (now Ravenscourt Avenue) an iron bridge on the LSWR tracks produced a lot of noise, disturbing locals. This was replaced by a shallow elliptical arch across the wide of the old and new viaducts, which reduced the headroom, but also the residential disruption. Since this was built as a single structure, the arch has the single structure number D78A and is formed of six rings of brick, with the exterior edges in red brick.

The main viaduct structures added for the widening are of yellow brick, with a decorative string course that includes a band of red bricks with projecting squares of yellow brick, below a plain stone lintel. The arches have four courses of brickwork forming their barrels, again with red brick edging. Stone imposts support the arch barrels.

In 1916, LSWR services over the northern pair of tracks were withdrawn. The rails remained disused for ten years, after which time an agreement was made between the various railway companies that the line would be used to extend the Piccadilly Line westwards from Hammersmith. It is not the intention of this article to describe the main works, but from a viaduct point of view it was necessary to build an additional pair of tracks from Hammersmith station west to join the disused formation. For reasons of space, and in order to allow the Piccadilly Line to use the centre tracks with the District Line on the outside, these tracks had to be placed outside the existing lines. The eastbound (northernmost) track

could only do this by passing through the original KRR viaduct, which entailed demolishing five arches on the section curving north towards the remains of Hammersmith (Grove Road) station. Despite there being no plans to reinstate services over this structure, it was duly reconstructed with a section of bridge with girders encased in concrete, supported on pillars carefully placed between the tracks. Many years later the viaduct north from here was demolished to allow construction of an office building, but the replacement bridge remains. Piccadilly Line services were extended westwards in 1932.

At Stamford Brook, a new platform was required for the eastbound District Line. The structure for this was placed along the north edge of the viaduct, built from concrete with brickwork at the Prebend Gardens bridge.

D76A Prebend Gardens (north side).

D76A Prebend Gardens (south side).

This complex history has led to a complex set of structure numbers. Running from Turnham Green station eastwards, they are:

	EB District	EB Piccadilly	WB Piccadilly	WB District
Viaduct				D75E
Car park	D76B		D76	
Viaduct *(196-200)*	D76C			
Prebend Gardens	D76A			
Viaduct *(179-195)*	D76D			
Goldhawk Road	D77		D77B	D77A
Viaduct *(133-178)*	D77C			
Ravenscourt Park	D78B		D78	
Viaduct *(118-132)*	D78C			
Ravenscourt Avenue	D78A			
Viaduct *(108-116)*	D78D			
Ravenscourt Road	D79B	D79		D79A
Viaduct *(92-107)*	D79C			
Dalling Road	D80A	D80		D80B
Viaduct *(88-91)*	D80C			
Studland Road	D81B	D81		D81A
Viaduct *(80-87)*	D81C			
Galena Road	D82			
Viaduct *(57-79)*	D82B			
Cambridge Grove	D83A	D83		
Viaduct	D83C	D83B		
Leamore Street	D84A	D84		

The numbers in italics for the viaducts indicate the arch numbers. Many, but not all, of the arches have these shown by cast iron plates with the numbers in white on a black background, positioned part-way up the arch on the left side.

The disused section of KRR viaduct east from the site of Studland Road Junction has structure numbers KR14 to KR10 (west to east). Its bridge over Leamore Street is KR13, and the 1932 girder bridge over the eastbound District Line is KR11.

HAMMERSMITH & CITY LINE VIADUCTS

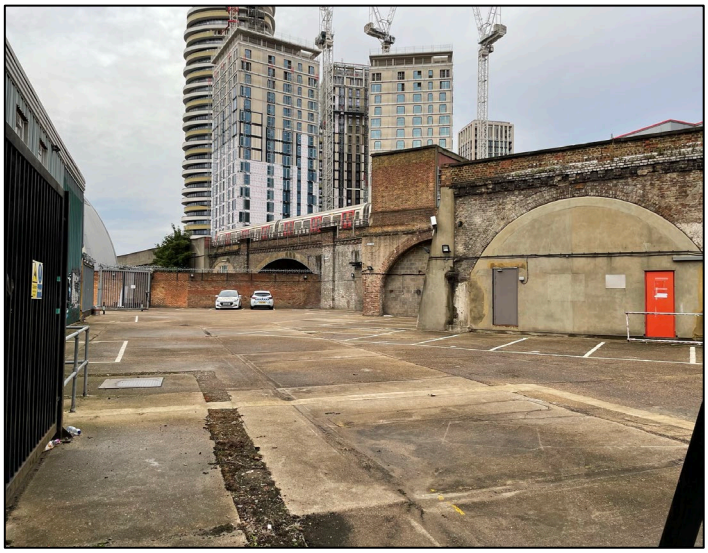
Most of the route of the Hammersmith & City and Circle lines west of Ladbroke Grove station is on a viaduct. The original intention was to build embankments, but the lack of cuttings from which to use the earth for embankments meant that the plans were changed in 1863. Over half the route of the railway (2,640 yards) was on brick viaduct around 20 ft high.

The viaduct consists of around 240 segmental arches of 28 ft span, made from local clay baked into typical yellow London bricks. The barrels consist of four rings of brickwork, springing from the piers where three bands of brickwork project slightly.

D76D viaduct and Wilson Walk.

The piers have plinths at the bottom, and the viaduct is topped with a low parapet wall with a metal railing above. A slight decorative feature at the foot of the wall, on the spandrels, is a string course two bricks high above three courses that form a pattern of alternatively raised and lowered squares one brick wide. A cast iron arch number plate is fixed above the top of each arch, counting from 1 at the eastern end, adjacent to St. Mark's Road. These are painted black with the numbers in white. Many of the lower-numbered arches have had these plates replaced by modern equivalents, with the numbers in black on a white background.

***Above**: HC9 Silchester Road (east side).*



***Above**: HC12 Viaduct alongside Lockton Street, with Latimer Road eastbound platform above.*

***Left**: HC13B Latimer Road viaduct spur. Passenger services ended in October 1940 but freight continued until the early-1950s.*

Many of the roads that pass beneath the viaduct do so through larger spans. Kingsdown Close (HC7), Silchester Road (HC9) and Freston Road (HC13) all have a single arch for the road, with a smaller arch either side for the pavements. All three arches have five bands of bricks forming the barrel, with a central tapered keystone on each side five bricks high. At Freston Road, the piers between the road and pavements are pierced by three opening each, crowned by a semi-circular arch. At the southern end of the viaduct, where it is dropping to ground level, Trussley Road passes beneath a single arch with just 3·3 m clearance. The piers only have five courses of brick between the plinth and springing courses.

Bard Road (HC13C) passes beneath a single segmental arch together with its pavements. There are a handful of other thoroughfares that also pass beneath arches in the viaduct, but these appear to have been provided after the viaduct was built (e.g., to give access to a yard on the other side), and so pass beneath regularly numbered arches.

All of the other roads and railways that cut across the line of the viaduct are spanned by plate-girder bridges. From north to south these are:

- St. Mark's Road (HC5 – this is at the eastern end of the viaduct).
- Bramley Road (HC11/HC11A – with pavements passing through separate side arches).
- West Cross Route (HC14A – this is a concrete girder bridge).
- West London Line (HC15).
- Wood Lane (HC17).
- Uxbridge Road (HC19/HC19A).
- Goldhawk Road (HC21/HC21A).
- Kensington & Richmond Railway (HC23 – disused).

Where two structure numbers are shown, the number with the 'A' suffix is the westbound line.

HC22 viaduct with Goldhawk Road platforms.

All four of the stations on viaduct (Latimer Road, Wood Lane, Shepherd's Bush Market and Goldhawk Road) have their platforms outside the viaduct footprint, supported from beneath on columns, rather than having wider sections of viaduct. The station facilities are housed within viaduct arches, although some parts of the stations are built forward of the viaduct.

At Latimer Road, a short stub of the viaduct carrying the connection to the West London Railway remains. This is just three arches long and retains the structure number HC13B. Where the stub diverges, in the apex between it and the main viaduct, another arch has been constructed with a small building on top.

Train services using the connection were suspended after the viaduct was damaged by bombing on the night of 20 October 1940, and never resumed. The viaduct was patched up and its 20 arches remained as rental properties for London Transport until it was sold to the Greater London Council in 1965. The structure was then demolished as part of the works for the West Cross Route motorway, running alongside the West London Line.

METROPOLITAN AND JUBILEE LINE VIADUCTS

KILBURN VIADUCTS

The Metropolitan Railway (MR) constructed its 'extension line' from the original terminus at Swiss Cottage out to Willesden Green in 1879. North of the station at West Hampstead, the line rises on an embankment to a series of brick viaducts which end at Kilburn station. The original viaduct is used today for the northbound Metropolitan and Jubilee lines and, as it is largely sandwiched between the viaducts for the southbound lines and Chiltern Railways, it is quite difficult to see. The southern end of the viaduct is the abutment for the double-span bridge over what is now the North London Line of the London Overground, the northern span of which has never been used.

The viaducts consist of a series of 32 semi-circular arches of about 30 ft span, except where roads are crossed. Yellow bricks appear to have been used, and the arch barrels were made from five courses of brick. The brickwork colour is not consistent, which might be the result of an 85-ft-long section of this viaduct being destroyed by a bomb on the night of 15 September 1940. The tracks were hastily reinstated on a large wooden trestle structure which remained in place until reconstruction was completed after the war.

At Iverson and Loveridge Roads, wider skew arches were formed of 104 ft and 84 ft span respectively. The acute angle of the skew meant that Joseph Firbank, the contractors, created the segmental arch barrels out of eight separate offset spans, each built from up to twelve bands of Staffordshire blue bricks. The outer faces were laid decoratively, with a chamfered lower edge, four rows set as 'dog teeth', and an upper protruding course. The piers and springing for the viaducts were made from yellow bricks, as were the spandrel and parapet walls. Beneath the parapet wall level, there are about nine courses of red brickwork – perhaps as a form of decoration – with the centre course projecting slightly as a stringer.

Separate arched bridges made of cast iron were installed over Kilburn High Road and Christchurch Avenue, with spans of 87 ft 9 ins and 78 ft. These meet at a triangular abutment located at the junction of the two roads. Both bridges were replaced by structures with steel decks in 1978. The contract, worth £600,000, was let to Higgs & Hill Ltd and was complicated by the bridges on both sides. These were the last two cast iron underbridges on the Underground, the material not having been permitted for new underbridges since 1883. A number of weekend closures were required in 1977/78 to facilitate the work (described in Underground News issues 185, 188, and 195).

In 1899, the Great Central Railway (GCR) opened its terminus at Marylebone, with its route running north parallel to that of the Metropolitan. After reaching the surface at Canfield Place (adjacent to Finchley Road station), the new tracks ran to the west of the existing line, requiring an additional 32-arch viaduct south of Kilburn, constructed by Henry Lovatt. For this structure, Staffordshire blue bricks appear to have been used.

Continued traffic growth in the early years of the twentieth century caused the MR to build a further pair of tracks, thus creating two express and two local lines for their trains, in addition to the GCR services that ran non-stop to Harrow-on-the-Hill. The additional viaduct was built to the east of the original structure, with work starting in June 1913.

All four roads that were crossed by the new viaduct were spanned by metal hog-back lattice bridges, with a single 147-ft span crossing the junction of Kilburn High Road and Christchurch Avenue, and proudly proclaiming the name of the railway company in raised lettering along its parapets. This structure alone weighs around 600 tons, and is supported at each end by a pair of stone piers. The other two bridges are supported by the brick viaduct abutments, which are faced with glazed white bricks.

***Above**: MR12 Iverson Road skew arch detail.*

***Above**: MR11 Viaduct (southbound side).*

***Right**: MR13 viaduct.*

The viaduct structures have ten arches south of Iverson Road, another ten between Iverson and Loveridge Roads, and then eight between Loveridge and Kilburn High Roads.

The contractors for the bridges at Loveridge Road and Kilburn High Road were E.C. & J. Keay of Darlaston, whilst the Iverson Road bridge was built by the Derby firm of Eastwood, Swzingler & Co.

Structure	Northbound lines	Southbound lines
Christchurch Avenue	MR17	MR16A
Kilburn High Road	MR16	
Viaduct	MR15	MR15A
Loveridge Road	MR14	MR14A
Viaduct	MR13	MR13A
Iverson Road	MR12	MR12A
Viaduct	MR11	

CROXLEY VIADUCT

One often-seen view of the Metropolitan Line is a train passing over the Grand Union Canal on a viaduct on the approach to Watford station. This viaduct was built by Logan & Hemingway of Doncaster, who constructed the whole of the branch which opened to traffic in 1925.

The viaduct is in several short sections, separated by bridges and embankments. From the south-west, the railway approaches the canal on a high embankment (one reason for its height is said to be the

insistence of the LNWR that their Croxley Green branch would be extended to Tring, and so would need to pass beneath). A metal bridge, supplied by Eastwood, Swzingler & Co. (as were all of the bridges on the branch) is used for the canal crossing (MLNE7), followed by four semi-circular arches of viaduct (MLNE7A). Another embankment leads north-east before two more viaduct arches (MLNE8) are reached. These then connect to the metal bridges over the River Gade (MLNE9) and Gade Avenue (MLNE10).

The two short viaduct sections are built from purple engineering bricks, as is the large pier between the river and road bridges. The ground here consists of a layer of gravel over rotten (crumbly) chalk, and so piles had to be driven into the ground to a depth of 45 ft in order to support the structures. The piles were pine soaked in pitch, and a steam pile-driver was used to ram them into the ground.

The viaduct arches consist of six rings of brickwork to form the barrels, with no ornamentation other than slight recessed panels along the parapet walls.

NORTHERN LINE VIADUCTS

BRENT VIADUCT

When the London Electric Railway finally started work on the long-anticipated northward extension of the Hampstead Tube from Golders Green to Edgware, the route was complicated by the extensive building that had taken place around the terminus. Golders Green had grown from being a few houses around a crossroads in 1904, to being a thriving suburb of London. The extension had to adopt a new line, curving around the south-west side of the built-up area. Even with the new route, some housing that was only a few years old had to be purchased and demolished. Since the line finished on an embankment overlooking the Finchley Road, the extension would also be elevated to start with. An embankment was originally planned, but this was substituted by a viaduct as this would involve the taking of less land.

There are three viaducts on the line between Golders Green and Hendon Central. The first runs as far as Woodstock Avenue, allowing the trains to pass above Finchley Road, Golders Green Crescent, Hoop Lane, and Golders Green Road. The tracks return to ground level, cutting off a road called The Ridings, which originally linked to Woodstock Avenue and The Ridgeway. The line then continues into a slight cutting, in which it passes under Woodstock Avenue. The level of the latter road was increased by 7 ft in order to pass over the line, leaving the houses either side with their first floor windows at pavement level. As the ground level dropped northwards, the railway tracks left the cutting to join the next section of viaduct. Where they passed Montpellier Rise there was no option but to sever the road, leaving it as two culs-de-sac. This is also one of the locations where one half of a pair of semi-detached houses was purchased and demolished, leaving the remaining house looking rather unbalanced.

NT13A at Woodville Road.

NT13A west side.

The line ascends from this point, although rather than being a true viaduct it consists of two full-height retaining walls containing 2,148 cubic yards of spoil excavated from the cutting. This continues as far as the girder bridge across Elmcroft Crescent, and from then on is a ‘proper’ viaduct, although interrupted by two further girder bridges across Woodville Road, and Highfield Avenue before reaching Brent Cross station, situated partially on an embankment. Northwards, the viaduct resumes, passing over the A406 North Circular Road and the River Brent before finishing at a girder bridge over Shirehall

Lane, beyond which the line is back on an embankment. It is this final section that is the true Brent Viaduct, carrying the tracks up to 34 ft above ground level and consisting of the two main elliptical arches above the road followed by nine smaller segmental arches.

In total, the viaduct sections are 5,100 ft long. Around 8 million bricks were used on the extension – mostly for the viaducts, but some for the retaining walls for the cutting through Golders Green. The majority of the bricks were the typical yellow brick used in London, but some darker brown bricks were also used, as described later. Above the piers, and between the arches, drain holes were provided, feeding into header boxes and down-pipes to channel water to ground level. The construction work was largely manual, with wooden centrings placed on small ledges in the brickwork at the springing level used to support the arches as they were laid. One of the few items of mechanization used were electric hoists, which lifted the wheelbarrows of bricks up to the bricklayers on the viaducts and bridges.

The following bridges were built (with LU structure numbers in parentheses):

- Finchley Road (NT7): steel girder, 88ft long
- Golders Green Crescent (NT8): steel girder
- Hoop Lane (NT9): skew brick elliptical arch
- Golders Green Road (NT10): steel girder, 92 ft long
- Woodstock Avenue (NT11): steel girder, with brick parapets (overline bridge)
- Elmcroft Crescent (NT12): steel girder, 129 ft 6 ins long
- Woodville Road (NT13): steel girder
- Highfield Avenue (NT14 / 14A): two steel girder (one for each track)
- North Circular Road (NT16): a pair of skew brick elliptical arches
- River Brent (NT17): segmental brick arch
- Shirehall Lane (NT18): steel girder

***Above**: NT16 A406 viaduct.*

***Right**: NT16 viaduct arch springing.*

The viaduct sections, between each of these bridges, were given the same structure number as the bridge at their southern end with an 'A' appended (i.e., the viaduct north of Hoop Lane is NT9A), with the exception of Highfield Avenue, where the viaduct to the north is NT14B.

The arched bridges over the North Circular Road and Hoop Lane are slightly more decorative than the other viaduct arches. Their arches are built from brown bricks, with a dog-tooth pattern formed on the outside face, caused by the angle of the bricks making their skew arches. Hoop Lane has six rings for its arch; the North Circular Road arches have seven rings. In both structures the arches spring from a pillar of yellow bricks with plinth courses in brown. Hoop Lane also has a more decorative parapet wall than the rest of the viaduct structures.

The retaining walls at each end of the steel girder bridges were all built of brick, but some slight differences can be observed. The trio of bridges at Elmcroft Crescent, Woodville Road, and Highfield

Avenues all use white glazed bricks, with a few plinth courses of brown bricks. The south side of Finchley Road is similar, but without the plinth courses. The north side is occupied by a shop unit, as are both sides of the Golders Green Road bridge. The walls at Golders Green Crescent and Shirehall Lane are of yellow brick, painted white. Spanning these walls, each bridge consists of a pair of steel I-beams connected by a series of jack-arches perpendicular to the beams and tracks. A photo in the LT Museum collection shows the construction of the longest girder bridge, at Elmcroft Crescent. The two side girders were placed on the railway formation to the south of the bridge, and rolled out across the road once the abutment walls were ready. Since the road sloped downwards, the tower supporting the girders was rolled across a level surface made of wooden baulks laid above the road.

The bridges were built by J. Butler & Co. of Leeds (Highfield Avenue and Shirehall Lane), the Horsley Bridge & Engineering Co. of Tipton (Golders Green Crescent, Elmcroft Crescent, and Woodville Road), the Tees-side Engineering Co., and Sir William Arrol. Those over the four roads listed retain their makers' plates on their side girders.

The sections of viaduct between the bridges are built from yellow brick, and consist of a regular series of segmental arches. The piers between adjacent arches split into three just below the springing course, with neat semi-circular arches comprising three rings of yellow brick at the top. The legs of each pier were joined again at the bottom of each opening by a segmental arch invert in brick. Along the parapets of the viaducts, regular refuges are provided, protected by metal railings. These refuges provide some slight ornamentation from ground level, as they have stepped lines of brickwork beneath the string course of the viaduct. Many refuges are now blocked by cables, and a few have signals placed in them, which are now out of use and which will presumably be removed in time.

DOLLIS BROOK VIADUCT

This structure has the claim to fame of being the point at which an Underground line is highest above ground level, at around 18 m. It was built for the Edgware, Highgate and London Railway (EHLR), which was taken over by the Great Northern Railway (GNR) in 1867 before it opened.

***Above**: Dollis Brook viaduct from Dollis Road.*

***Right**: North side of Dollis Brook viaduct.*

The viaduct was designed by the engineers John Fowler and Walter Brydone, and consists of 13 segmental arches each 32 ft wide at springing level. These are supported by tapered piers, each of which is split into two by a central opening with a semi-circular arch at the top, and a segmental invert arch. Each arch is formed of five bands of bricks. The contractors were Smith, Knight & Co, who had built part of the original Metropolitan Railway earlier in the 1860s.

Red brick is used for the entire structure, although extensive patch repairing has given the north-eastern side a bit of a messy look. It was made wide enough to take a double-track railway despite only having

a single track laid. Work on doubling the track started three days before Britain declared war on Germany, in readiness for the extension of Northern Line services through Mill Hill East and on to Edgware station, but this second track was never used and was lifted during the war for use on damaged French railways.

The viaduct has structure numbers (from north to south) of E3 (arches 1 – 4), E3A (Dollis Brook Road), E3B (arch 5, over the pedestrian path), E3C (over Dollis Brook), and E3D (arches 6 – 11).

MUSWELL HILL VIADUCT

The 1935/40 New Works Programme would have seen the LNER branch to Alexandra Palace taken over by the Northern line. Part of the way along this branch, between Cranley Gardens and Muswell Hill stations, lies Muswell Hill viaduct. This is a 17-arch structure that was built by the EHLR, and was needed to keep an acceptable gradient along the line as it skirted along the edge of Muswell Hill. The EHLR had been authorised in 1862, and the following year they obtained Parliamentary approval for the Alexandra Palace branch. The branch opened in 1873, by which time the EHLR was part of the GNR.

The arches themselves were segmental, with five bands of bricks forming each of the barrels. Blue engineering bricks were used, although spalling of the surfaces over the years has revealed the brick-red inner surfaces of many of them. A simple string course runs immediately above the arch crowns, and the parapet and spandrel walls are plain.

From the Cranley Gardens end, to the south-west, there are two arches, followed by an arch over St James's Lane. The highest point on the viaduct is near its centre, with the remaining arches gradually diminishing in height to the north-east, and today these contain a variety of traders in a small business park called The Viaduct. Some of these have completely infilled their arches, whilst others have structures built within the arch.

At track level, the viaduct forms part of the Parkland Walk, which follows much of the route of the disused line between Finsbury Park, Highgate, and Alexandra Palace. Pedestrians can enjoy views south over London from the viaduct, and continue as far as the site of Muswell Hill station. The viaduct is in relatively good condition, although it could do with removal of foliage above the string course. The arch over St James's Lane has had its eastern edge replaced with red brick at some point in the past.

Had the line become part of the Underground, the arch over St James's Lane would have had structure number AP6, with the pair of arches to the south being AP5 and the remaining 14 being AP7.

BROCKLEY HILL VIADUCT

Construction started on this viaduct in the middle of 1939, as part of the New Works Programme. The viaduct was to form a considerable part of the route between Edgware and a new station at Brockley Hill, on the extension to Bushey Heath. North of Edgware the tracks would lie in a cutting, rising to ground level at Purcells Avenue, and continuing onto an embankment. At the northern end of the embankment, a viaduct would bring the line to the Edgware Way, which would be crossed by a four-span plate girder bridge. A further viaduct would carry the station platforms, with the ticket hall and other facilities beneath at ground level. Another girder bridge would carry the tracks over a service road, before a final section of viaduct would bring the line onto another embankment as it continued north-west towards Elstree South station.

The viaducts were to consist of segmental arches supported by piers of varying height, but at their lowest adjacent to the embankments at each end, and rising to carry the line above the roads. South of Edgware Way there were 21 arches that finished with a triangular abutment to accommodate the skew angle at which road and railway met. This abutment included three small semi-circular arches in its southwestern face. The section north of Edgware Way, including the station, had eleven arches (plus, probably three of the smaller type in the southern triangular abutment). Four of these were to be hidden beneath the platforms and accommodate access roads to the car park, and lock-up garages. To the north of the service road, the viaduct would probably have had seven arches.

Structure numbers were allocated to the viaducts. The viaduct south of Edgware Way was to be T40, and the Edgware Way bridge T41. The next section of viaduct to Brockley Hill station was T42, with the station structure being T43 and T44 (the latter would probably have been the service road). T45 would have been the final section of viaduct north of the station.

Alas, the extension to Bushey Heath was not to be: the intervention of the Second World War, followed by the creation of the Green Belt around London and the financial restrictions in post-War Britain caused its cancellation in 1950. Very soon after the War started, work was halted on the extension. Piers had

been built for the sections of viaduct from Brockley Hill station southwards, with the northernmost six arch barrels also having been constructed, but none of the spandrel walls. Capping was placed on the piers to provide some weather protection, and they were left.

After abandonment of the extension, the section of route south of Edgware Way was quickly sold to developers. The piers on this section were demolished from 9 March 1959 to allow a new housing development to be built. The partially completed arches near the site of the station were demolished by bulldozers in October 1964, with the rubble being taken by lorry to the M1 construction site a mile up the road to be used in the foundations for the new motorway. Today the bases of a few of the piers remain as a monument to this plan that never happened.

PICCADILLY LINE VIADUCTS

ARNOS PARK VIADUCT

The viaduct across Arnos Park was constructed by Sir Robert McAlpine & Sons as part of the extension of the Piccadilly Line to Cockfosters. It lies to the north of Arnos Grove station, and is in two sections. The main section links the embankment carrying the tracks from Arnos Grove as far as Waterfall Road, and consists of 35 arches. A smaller viaduct, just five arches long, is between Waterfall Road and Hampden Way. North of the latter road, the railway is carried by an embankment, and then into a cutting leading to the southern portals of Southgate tunnels.

Short viaduct between Waterfall Road and Hampden Way.

Southgate north tunnel portal with a westbound train heading away.

The main section of the viaduct follows a shallow right-hand curve as it heads northwards, and is 348 yards long. The southernmost five arches are quite shallow, springing from ground level. The next three have very short piers between them. Arches 2, 3, 4, 7, and 8 have been bricked in to form facilities for the adjacent tennis club. The numbering starts from the south end, and cast iron plates bearing the arch number (similar in style used by LT to number bridges) are secured adjacent to each arch. From arch 9 onwards, the piers are split into three below the level of the. This reduces the brickwork required in the viaduct. Two small, semi-circular arches have been built into each pier where the split takes place.

The arches are all segmental with a span of 25 ft. The piers stand on brick plinths very slightly larger than the piers. The height of the plinths varies, allowing the arches and piers to be of a consistent height along the viaduct. To support the wooden frameworks that were used to form the arches, three courses of bricks project slightly from the piers below springing level.

Almost all of the brickwork used in the viaduct structure uses hard reddish-purple bricks. The upper edges of the plinths and the enlarged courses to support the arch framing were made from sloped purple engineering bricks. The parapet walls appear to be of a slightly darker brick than the main viaduct, possibly a red-brown colour, but this might be an effect of weathering. These walls include recesses above every third pier, providing a place of safety for track workers, as well as places to locate signals and signs. The recesses have an attractive stepped appearance at their bottom edges on the outside of the viaduct. Approximately three million bricks were used for this set of viaducts.

One slight oddity about the main section of the viaduct is the numbering. Although it has 35 arches, they are numbered from 1 to 34. This is because the arch over Pymme's Brook (a small stream running through Arnos Park) is counted as a bridge by London Underground, and does not have an arch number. This also explains why this section of the viaduct carries three structure numbers: PT75A for the viaduct south of the brook, PT76 for the arch over the brook, and PT76A for the viaduct between the brook and Waterfall Road, which passes beneath PT77. PT is the series of numbers for the **P**iccadilly **T**ube.

The northernmost arch is unusual in its shape. Waterfall Road runs at an angle of around 45° to the viaduct, and so the arch is only open on the eastern side, and is half the width of the viaduct. The western half of the viaduct is supported by a narrower arch about 12½ ft long, and which is closed on the west side. A railing closes off the open, eastern side, presumably to prevent 'undesirables' from misusing the blind arch. The northern side of the arch forms the abutment to Waterfall Road bridge, which is a conventional girder bridge, built on a skew. The eastern side girder is 104 ft 2 ins long, whilst that on the west is 87 ft 9 ins.

The 64-yard section of viaduct between Waterfall Road and Hampden Way (PT77A) is, in its own way, unusual. From the east it appears to have three arches, but from the west there are five. This is a result of the roads at each end being skewed in opposite directions. The centre three arches are conventional, but those at each end are only open to the west, and form parts of the bridge abutments on the eastern side. The drainage on this section of the viaduct appears to have been renewed in the last twenty years, and a nice touch is the roundel cast onto the header boxes for the guttering. The year appears to be on the bar of the roundel, but is difficult to determine due to the height (possibly 2001).

On the north side of Hampden Way (PT78) a substantial brick abutment supports the road bridge. It also terminates the shallow embankment that leads the tracks northwards to Southgate.

For some unknown reason it has been claimed that the Arnos Park viaduct is the last brick viaduct to have been constructed in the UK. Photographs of the Central Line extension to West Ruislip clearly show the Brent viaduct being constructed from brick in 1937. Two years later, the viaduct at Brockley Hill for the abortive Northern Line extension to Bushey Heath was being built, also from brick, although as this was never completed it might not count.

BOUNDS GREEN VIADUCT

To the south of Arnos Grove station, the land dips where the Bounds Green Brook runs across the route of the railway, immediately north of the North Circular Road. Whilst the latter is carried on a substantial steel girder bridge 173 ft long, either side there is a shallow brick viaduct in the same dark red bricks as used for the Arnos Park Viaduct, which is to be expected as they formed part of the same contract for McAlpine.

The south side has three arches, and the north side has seven. All appear to spring from ground level, and so there are no piers as such. The parapet wall design, together with its refuges, is also the same as for Arnos Park.

The southern end of the viaduct has structure number PT70A, followed by PT71 for the North Circular Road, and PT71A, PT72, and PT72A for the northern section of viaduct (with the brook running beneath the middle of these).

ROXETH VIADUCT

The section of viaduct north of South Harrow station was constructed by the Metropolitan Railway. The line was authorised in the Harrow & Uxbridge Railway Act 1899, but the viaduct section was planned as an embankment. The Metropolitan Railway Act of 1901 substituted the viaduct, which was built at the same time as the rest of the line between Rayners Lane and Uxbridge by the contractors Bott & Stennett who started work in September 1901.

The viaduct contains 71 semi-circular arches each of 34 ft span, built of yellow London brick. They have six courses of bricks around each arch, and a springing course of six brown bricks at the base of each arch. The top layer of bricks in the springing is chamfered, perhaps to aid rainwater run-off. Each pier also has a plinth, which is also topped with a course of brown chamfered bricks. The ground rises towards the south, and as a result the piers get progressively shorter until by arch 26 (Stanley Road) the springing course is at ground level. The parapet wall is also in yellow brick, and has refuges in it every other pier, staggered between the two sides.

Many of the arches are now used for light industry. Each arch was numbered in a northerly direction, with the number shown on a cast iron plate above the arch centre. The structure numbers for the viaduct

are P2 (Northolt Road to Sherwood Road), P4 (Sherwood Road to Stanley Road), P6 (Stanley Road to Roxeth Green Avenue), P9 (Roxeth Green Avenue to Welbeck Road), and P9B (Welbeck Road to the north end of the viaduct.

There are three steel plate-girder bridges crossing larger roads in the viaduct, at Northolt Road (P1), Sherwood Road (P3), and Roxeth Green Avenue (P7). Stanley Road (P5) and Welbeck Road (P9A) both pass through conventional arches of the viaduct.

There is also the unusual concrete viaduct spur that used to lead to South Harrow gasworks; this branches from the main viaduct just south of Roxeth Green Avenue and was opened in 1910 as a single-track spur from the Up (eastbound) line. The gas works remained in operation until the end of March 1954, after which time the track was lifted and the viaduct was demolished, save for three spans adjacent to the main viaduct, numbered P8.