Archway Bridge Heritage Report.

Historical Background

The following sections on the history of the area and bridge have been reproduced here, by kind permission of Donald Insall Associates, from their Historic Building Report and Heritage Assessment prepared for Transport for London in December 2014.

Development of Highgate and Archway Road

The village of Highgate developed at the south-eastern entrance to the medieval Bishop of London's estate. By 1380, a new road with a steep incline was in use which originated in the city, passing through Holloway, meeting with Highgate Hill. In 1386 a direct route to the north opened as a toll road. This was located at the top of the hill and was probably known as High Gate, where the area derives its name.

There was some ribbon development along Highgate Hill in the 16th and 17th centuries and it became a popular place for the wealthy to build their country retreats. West Hill (connected with St Pancras in the south) was constructed at the end of the 17th century which led to the expansion of the village in the 18th century. Highgate continued to be a desired area and the main period of the development of the area occurred in the 19th century. Smaller scale houses were built among the fine 18th century houses.

Highgate also became one of the main routes from the north to London and acted as a major stopping place on this road. Much of the traffic passing through to the north of England was required to ascend the steep incline of Highgate Hill. The hill was dangerous and the need for a bypass had been recognised for many years. Consequently, in 1809, Robert Vazie , a mining engineer who had previously built a tunnel under the Thames at Rotherhithe , proposed a tunnel beneath the hill. Vazie's proposal was for a single road running approximately northward from the foot of Highgate Hill. This was to be about 2000 yards long, of which 211 yards would be in tunnel and most of the rest in a cutting. In accordance with early 19th century practice, the tunnel was known as an 'archway' and hence the company formed to construct it was called the Highgate Archway Company. This name also lent itself to the name of the new road and the later bridge.

Construction began in July 1810 and by 1812 about 150 yards of the tunnel had been built. However, on the 13th April 1812 the tunnel collapsed. As a result, the plan changed from a tunnel to a cutting and the Company sought guidance from the architect John Nash (1752-1835). Under the revised plan Nash superintended the construction of the cutting and also designed a new bridge to carry Homsey Lane across the new road.

An 1815 enclosure map shows the construction of the new road [plate 1]. The words 'The Archway Company' are annotated along the eastern side of the road. The new road is shown intersecting with Hornsey Road at the bottom of the map. Although the new bridge was constructed in 1812 it does not appear to be depicted at this time. However, it is possible that the details of the map were collected before construction of the bridge and the map was not drawn up until 1815. It is also possible that the map simply lacked this finer detail.

Archway Bridge

The original Archway Bridge was designed in 1812 by the renowned architect John Nash (1752-1835). A painting by Charles Augustus Pugin (1762-1832), engraved by John Hill (1770-1850), depicts a view of the excavated grounds for the bridge in August 1812, with workmen in the foreground and a view of London in the distance [plate 2].

An engraving by Rudolph Ackermann (1764-1834) shows the constructed bridge in 1823 [plate 3]. This shows how Nash's bridge was modelled on a Roman aqueduct with two tiers of arches with a single tall arch comprising the lower tier. The bridge was of stone construction and stone parapets and balustrading lined the top. A 19th-century photograph (undated) reveals that the stone parapets and balustrading were replaced by iron railing with associated lamp standards [plate 4].

An 1896 Ordnance Survey map clearly depicts Nash's bridge (noted as Highgate Archway) spanning across Archway Road [plate 5]. In comparison to the 1815 enclosure map, the OS map also shows how significantly the area had developed during the 19th century. Groups of terraces are depicted running the length of the road with further development to the rear.

By the 1890s Nash's bridge, with an opening 18 feet wide, was too narrow and tunnels were made on either side of the main opening. Eventually, it was decided to build a new wider bridge and to also allow trams to pass underneath. The new bridge was rebuilt under the powers of obtained by the London County Council (LCC). The replacement 120 feet wide single span bridge was built next to the old arch which was then dismantled.

In 1896 the design for the new bridge was selected by the LCC Improvements Committee, from a field of at least four submitted designs. The new bridge was designed by Sir Alexander Richardson Binnie (1839-1917), the London County Council Engineer. The 'Steel Span Highgate Archway Reconstruction' contract issued by the London County Council was signed on the 13lh July 1897 by the contractor, Charles Wall of Ashburnham Works, Lots Road, Chelsea. The contract states that the contractor would be paid £25, 126 plus 19 shillings and seven pence for the works.

Demolition of the old Archway Bridge was under way by the end of 1897 and work began on the new bridge in 1898. Although construction began in 1898 the date depicted on the bridge was 1897 in recognition of the Queen Victoria 's Diamond Jubilee. The bridge officially opened in July 1900. A 1914 Ordnance Survey map shows the new bridge in much the same position as the old bridge [plate 6].

A document of reconstruction drawings produced by the London County Council in June 1897 includes Binnie's elevation drawing of the southern side of the new bridge [plate 7]. The reconstruction drawings also depict the western section of this elevation in more detail, showing the intricacies of the design [plate 8]. It is interesting to note that the large circular detail in the spandrel was to be designed at a later date. (note by author, these roundels are now embellished with three white seaxes with gold pommels on a red shield to represent the logo of Middlesex (minus the crown)). Other details depicted in the document include the proposed new lamps; the central lamps were from page 1999 No. 47 of the catalogue of Messrs M Dewall, Steven and Co Limited and the lamps for the abutments were taken from the design of the lamps on Embankment wall at Charing Cross, although the monogram of M. B. Wand the date 1870 were to be removed to be replaced by L.C.C [plate 9 & 10].

'Suicide Bridge'

Archway Bridge is unfortunately commonly known as 'suicide bridge'. It is unknown how many people have fallen to their deaths from Archway Bridge; even in recent times records kept by the police and the coroners' offices do not contain enough detail necessary to distinguish suicides that have occurred in this location from the many other others that have occurred locally. Estimates do, however, indicate that there is a pattern of fairly frequent actual and attempted suicides since at least the latter part of the 19th century.

An article written on the 4th July 1900 in Daily Chronicle about the new Archway Bridge proclaimed that Nash's previous bridge had been a favoured place for suicides during the 19th century. It stated that people would leap to their death from the stone parapet and balustrades that were on top of the bridge. To prevent this, the stone parapet and balustrades were removed in the late 19th century to make way for 'neat unclimbable' seven feet high iron railings (as depicted in plate 4).

With the railings in place it was hoped that there would be an end to the suicides. It is unclear, however, if these railings actually worked as a preventative. Also, the bridge was soon replaced in 1898 with Binnie's new bridge. Binnie's design did, however, include cast iron anti-climbing rails with rotating spikes above the cast iron balustrade/parapet panels. Although the first reported suicide from the present bridge was not until eight years after its official opening, the bridge soon gained the unfortunate reputation of its predecessor.

In 1963 an article in The Islington Gazette, marking the 150th anniversary of the first Archway Bridge, stated 'There is no available record of the number of people who have plunged to their deaths from the Archway bridge, but it is likely to be over a score'. In 1971 the MP for Islington, Mr Michael O'Halloran, noted that were two or three suicides every year. In 1989 an article entitled 'Bridge of despair' gave details of three deaths that year and several incidents in which individuals appear to have contemplated suicide. In May 1993 the St Pancras corner is quoted in an article in The Ham and High saying that there had been seven suicides in the last four years (possibly taking into account the three previously mentioned in 1989).

A BBC news article dated the 29th June 2013 noted that since 2010 four people had committed suicide from the bridge. As a result, up to 800 people signed a petition calling for anti-suicide measures.

Description and Significance of the Bridge and its Setting

The Setting of the Bridge

The most striking view of the Bridge is from the south, looking up the hill northwards where it is seen spanning at high level across the Archway Road. It is from this viewpoint that the steep sided cutting is best appreciated and the bridge spans across the divide in a single graceful curve reminding one of the exemplary work of the Swiss engineer Robert Maillart.

In the view from the north looking downhill along the Archway Road, the bridge frames the view of the City of London. The abutments can no longer be seen in either view because of the substantial tree planting on the steep embankments to either side. This makes the setting seem even more dramatic as the bridge appears to float from within the tree branches.

The elegant curved iron bridge with filigree panels, decorative balustrade and central lamp post are seen silhouetted against the sky in both views. Whilst the central pier and lamp are clearly visible in both views the end piers with their larger lamps are no longer clearly visible.

It is from Hornsey Lane, which passes over the bridge, that the full beauty of the lamps on their piers and the delicacy of the decorated iron balustrading can best be appreciated.

It is these long distance silhouetted views of the elegant curved structure from the Archway Road and the close up views of the decorated balustrading, piers and lamps from Hornsey Lane that are the most significant.

The Bridge

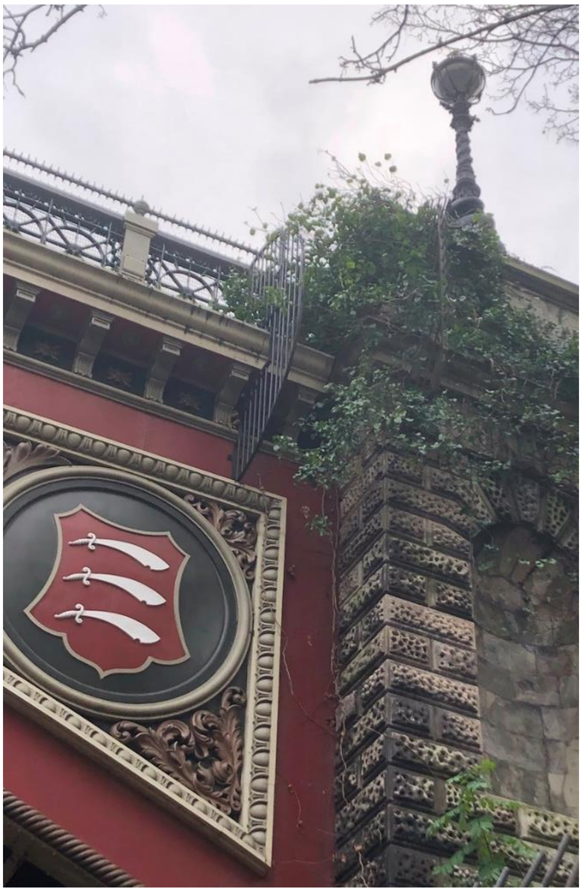
The bridge is a simple iron structure of arched beams and appears to be a direct descendant of the world's first iron bridge constructed only 118 years before in 1779.

The Iron Bridge had a clear span of 30m and consisted of five main semi-circular ribs between stone buttresses whereas the Archway Bridge has a span of 36m and seven curved ribs between stone buttresses. With the central lamp, lamps on each end and the circular detail in the spandrel one cannot help but see similarities and must assume that Binnie had been much influenced by Pritchard and Darby.

The outer iron beams of the Archway Bridge are clad with flat iron panels with recessed spandrels with panel mouldings. Above this is a deep dentil cornice which forms a cap and the base to the balustrade, again not dissimilar to the Iron Bridge, see photo below.

The balustrade is in 16 bays of cast iron filigree panels between cast iron posts with a central cast iron pier surmounted with a cast iron lamp post with griffins rampant to either side. The Portland stone piers at either end have vermiculated relief panels with elegant cast iron lamp posts which are from the same mould as the lamps found on the Thames Embankment at Charing Cross, hence the playful dolphins. Altogether this ensemble, seen from Hornsey Lane, forms possibly the most attractive street furniture in this part of North London.

Unfortunately, because of the number of suicide attempts, there is black steel mesh fixed over the cast iron filigree panels, there are spikes, spiked fan screens, spiked cages and metal plates to cover over potential foot holds and all designed to prevent access to the outer ledge above the cornice.



Assessment

As we have shown the Archway Bridge is not particularly innovative in engineering terms but is a high quality and carefully designed late Victorian structure worthy of its Grade II listing. It is the combined effect of the dramatic setting, with its history of the previous Nash bridge, the elegance of this engineering solution and fine detailing that give the structure its value and significance. Its significance in the history of cast iron bridges should also not be forgotten. The Haringey Conservation Officer agrees:- “Overall, the significance of the Bridge is high”.

However, there are other factors to consider, to quote Donald Insall Associates:-

"The original fabric and the setting of the structure are where the significance resides; later alterations have done little to undermine this. However, what does undermine this significance is the structure's cultural/social position and its dark reputation as 'suicide bridge'.

Cultural associations in heritage have, in more recent times, come to be seen as more important than perhaps in earlier times. However, these are normally understood to be positive aspects of a heritage asset. Here while the aesthetic engineering and historic interest of the bridge are all positive and significant, the structure's dark history means its cultural value is extremely (and I do not believe this to be an exaggeration) diminishing. The continued loss of life attributable to this structure has societal consequences which clouds all other reasoning.

Description and Justification of the Proposals

Background to these Proposals

The Highgate Society, CAAC and Highgate Neighbourhood Forum were invited in September by Haringey to a meeting to discuss the anti-suicide measures being put forward by Haringey engineers. This meeting was only one day before the proposals were put before Islington Council, who, largely because of the pressing need for these measures, approved the plans. Haringey Council followed suit within a few days. It was clear from our meeting that the scheme was a fait-accompli but nevertheless we raised our very real concerns at the visual harm this would do to this valuable heritage asset. Similar concerns were apparently expressed by the Islington Councillors but not having a better alternative felt they had no option but to approve it. We feel there is a much better option available.

Appraisal of the existing suicide measures

The existing measures which have been in place for many years consist of mesh to the inner face of balustrade panels to prevent toe holds, spikes to the top rail and rotating spikes on an additional rail above that. The upper row of spikes do still rotate but only with effort rather than freely and are not really sharp enough or long enough to put off the determined jumper. That said the balustrade with its spikes is not the weakest link. The two end piers and the middle pier are protected by spiked fan screens on the outside of the bridge in theory designed to stop anybody walking along the outer face of the balustrade or jumping from the central pier. It is evident from the number of suicides that these preventative measures are not working.

From video evidence of suicides it is apparent that the usual approach is to climb up onto the end wall which is fairly easy and from there step up onto the end plinth where the lamp standard provides a good solid hand hold. By climbing over this end plinth they by-pass the first fan screen on the outside. From there they descend onto the outer ledge of the bridge where there is a reasonably wide and level foot hold and the parapet provides a good handhold between the spikes. On the spiked fan screen, the spikes are too short and the edge of the screen has a steel rail to help support the spikes but which inadvertently provides a good handhold to allow the determined jumper to swing past it. Once past the spiked fan screen it is fairly easy with good foot and hand holds to edge across to the central section of the bridge over the roadway. The other more direct approach is to climb onto the central pier, again using the lamppost as a steady hand hold and either just jump outwards past the fan screen below or lower oneself, with some difficulty onto the outside ledge before jumping.

Impact of the currently approved proposals - P2018/1482/LBC & HGY/2018/1463

The approach taken by Haringey Engineers and their consultants has been to erect a barrier tall enough and strong enough to prevent access to the balustrading and the piers and to continue this at both ends beyond the piers so they can no longer be seen other than through this hideous fence. Where the fence crosses the abutment walls it is even taller and then finishes with a spiked fan screen of fine mesh. At first glance this appears to be a belt and braces foolproof solution but is an appalingly ugly addition to this grade II listed structure. The actual appearance of the security fence as it would be seen on the bridge has never been presented to the public or the planning committees of Haringey or Islington Councils. We have prepared three accurate photo montages of what is proposed.

Note that a short distance in front of the viewpoint the barrier becomes completely opaque.

Before After

We consider that this fence and the fine mesh end panels seen above seriously detract from the significance of the bridge when viewed from Hornsey Lane. This is the viewpoint where the detail of the cast iron filigree balustrading and the cast iron lamp posts can be appreciated at close quarters. The Haringey Conservation Officer in her report agrees that "there would be considerable harm to the significance of the Bridge, especially its aesthetic value," but quite inexplicably goes on to say "this harm would be less than substantial". In our opinion, and that of most right-minded people, <u>the harm would be substantial</u>. This surely looks more suited to a high security prison than to a grade II listed structure in a conservation area.

The first image below is the one that was used to "sell" the scheme to the planning committees, purporting to be the bridge seen silhouetted against the sky from the Archway Road.

A far more realistic image is presented below.

This visual increase in the bulk and height of the balustrade changes the proportions of the bridge when seen from the principal viewpoints on the Archway Road and in our opinion would cause substantial harm to the significance of the Bridge.

Even setting aside the visual harm this proposal would cause, the engineering led approach to this proposal has still left some possible weaknesses in the design which are fully explained in the Design Report accompanying this application.

Description of the new Proposals and their Implications

The proposals are described on the David Richmond and Partners drawings ABH.18.001, 002 & 003 accompanying this application.

We took as our starting point two other "suicide" bridges which have both had barriers added that have proved to be 100% effective, those at Bloor St Viaduct in Toronto, below left and Grafton Bridge in New Zealand, below right. See page 10 of PLOS report "Comparing Different Suicide Prevention Measures at Bridges and Buildings", attached as Appendix 4.

The stainless steel mesh and polycarbonate seen in these examples both allow fairly clear vision and the inward curve makes the barrier impossible to climb. Whilst the mesh appears to offer finger holds, in reality the wire is too sharp to carry one's body weight by the fingers alone. This has been proven by the use of this same mesh on dozens of high bridges in Switzerland. The illustration above right shows the Grafton Bridge in New Zealand which was a suicide hot spot before this barrier was introduced. The curved polycarbonate prevents climbing and circumvention at the ends is prevented by carrying the polycarbonate down to cover the bottom ledge in the end panel, see right image above. This neatly prevents access along the outside of the bridge from the ends, there being no hand or foot holds for the width of the last panel, approx. 2m. You will notice that the last panel has been graffitied and this would be less of an issue with a fine mesh instead of the polycarbonate.

If the same principle was applied to the Archway Bridge it could look like this:-

The end piers are completely open to be seen, as is the balustrade. The existing mesh panels attached to the balustrade can be removed so that the filligree cast iron panels can be appreciated. In doing so, the footholds revealed would still not allow the fence to be climbed because of the overhang. Anyone climbing the end abutment walls to get onto the end pier and then down onto the outside ledge could get no further than the end mesh panel because it covers all foot and hand holds in exactly the same way as on the Grafton Bridge described earlier. The full description of the effectiveness of these anti-suicide measures is given in the Design Report accompanying this application.

And as seen from the approach along Hornsey Lane compared to the current proposal: -

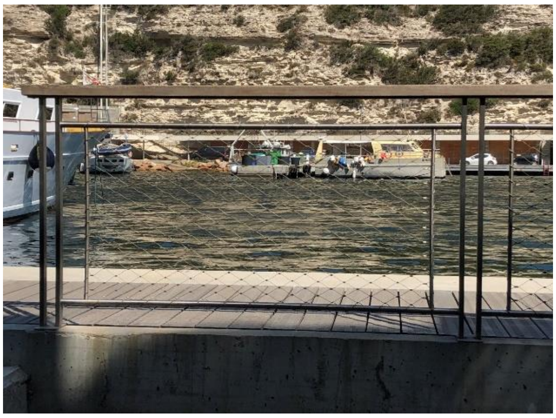
Consented proposal

New proposal

The curved support arms which hold up the mesh do in fact have precedent in that curved support arms were not uncommon on railings in the Georgian and Victorian periods. Even the original Iron Bridge has curved arms supporting the balustrade, perpendicular to the span, see image below.

This proposal is a modern interpretation of this feature and is fundamental to the anti-climb properties of the barrier.

This proposal is far less damaging to the significance of the bridge when seen from Hornsey Lane and also when seen from the Archway Road, where the mesh almost disappears from view. These two images show the mesh in use in other locations.



The new proposal seen from the Archway Road would look like this;-

The effect of the mesh is to reduce the visual weight so that the bridge appears much more like the existing and the harm is much reduced when compared to the recently approved scheme, see image on page 11.

The Heritage report prepared by Donald Insall Associates for the previous applications admitted that the proposals would cause harm:-

"The implications of these additions to the listed structure cannot be thought of as anything other than negative when considered in aesthetic and historic terms. In these simple terms, the effect of these alterations would be harmful, particularly to the setting of the bridge. This harm would be most pronounced in views along Hornsey Lane but, perhaps, less so in views from Archway Road."

These current proposals are less harmful and like the approved scheme are fully reversible, using clamped fittings and unlike the approved scheme do not interfere with the stone piers and walls at either end.

Justification of the Proposals

The primary justification for these proposals is the desire to prevent suicides. The secondary justification is to ensure that the proposals create the least harm possible to the listed structure. Because the proposals are fully reversible, the significant fabric of the structure will all be retained and protected.

As regards 'less than substantial harm' to a listed building, the NPPF states:-

"134. Where a development proposal will lead to less than substantial harm to the significance of a designated heritage asset, this harm should be weighed against the public benefits of the proposal, including securing its optimum viable use."

The planning issue is thus about the balance between the harm done by the proposals and the public benefit of preventing suicides. This balance was weighed in the two recent applications in Haringey and Islington and on balance the applications were approved. This proposal causes considerably less harm when viewed from both Hornsey Lane and from Archway Road so must on balance be considered acceptable.

The concern with the previously approved scheme was that, whilst reversible, why would it ever be taken down. Generations would likely have to live with the consequences of the decisions taken at the end of 2018 to approve the high security fence. We contend that these new proposals will be equally if not more effective and clearly have a much less harmful effect on the appearance of the bridge. To approve this scheme will not only remove the stigma of the title "Suicide Bridge" but also maintain an appreciation of the bridge as originally constructed, rather than one behind a high security fence which would in itself act as a constant reminder of its dark history.

It is the conclusion of this report that the proposals meet the criteria of the planning legislation and policy and they should be consented.

Planning History

- OLD/9999/3296 - No decision
  10/9/91 Removal of cast crow embellishment on south and north face of bridge area replacement with fibre glass & similar material (LBC).

- HGY/1991/0901 - Not determined 10/09/2012
  15/08/1991 Removal of cast iron embellishment on south and north faces of bridge and replacement with fibre glass or similar materials.

- HGY/1991/1051 - Withdrawn
  Listed Building Consent for removal of cast iron embellishment on south and north faces of bridge and replacement with fibre glass or similar materials.
- HGY/1991/0998 - Granted 10/09/1991
  Renovation of cast iron embellishments and replacing damaged or missing castings with new cast iron (Listed Building Consent).

- HGY/1993/1054 - Withdrawn
  Listed Building Consent for waterproofing of bridge deck using spray applied system and fixing of bollards to protect footways from accidental wheel load.

- HGY/2003/0773 & HGY/2003/0771 - Permission granted 01/05/2003
  Listed Building Consent for refurbishment and strengthening to Archway Bridge. Reduction in carriageway width and installing of cast iron kerb. Addition of safety steel panel to bridge.

- HGY/2014/3527 - Permission granted
  Listed building consent for proposed anti-suicide measures by installation of fencing to bridge parapet.

- HGY/2015/0301 – Not determined
  Listed building consent application in connection with proposed anti-suicide measures by installation of fencing to bridge parapet (observations to L.B. Islington)

- HGY/2016/4052,3,4,5 & 6 – All withdrawn
  Approval of details pursuant to conditions (submission of proposed structure details) attached to Listed Building Consent HGY/2014/3527

- HGY/2017/1501,2,3,4 & 5 – All withdrawn
  Approval of details pursuant to condition 1 (3 year expiration of permission) attached to Listed Building Consent HGY/2014/3527

- HGY/2018/1463 - Permission granted
  Listed Building Consent for erection of stainless steel anti-suicide fencing along the bridge in front of the existing fence and in front of the bridge parapets, and removal of the previously installed wire mesh along the bridge fence and spikes on the end and central plinths.

- P2018/1482/LBC – Approve with conditions

  Erection of stainless steel fencing (approximately 3.3 metre-high) in front of the bridge parapets and removal of some of the previously installed features including spikes and mesh

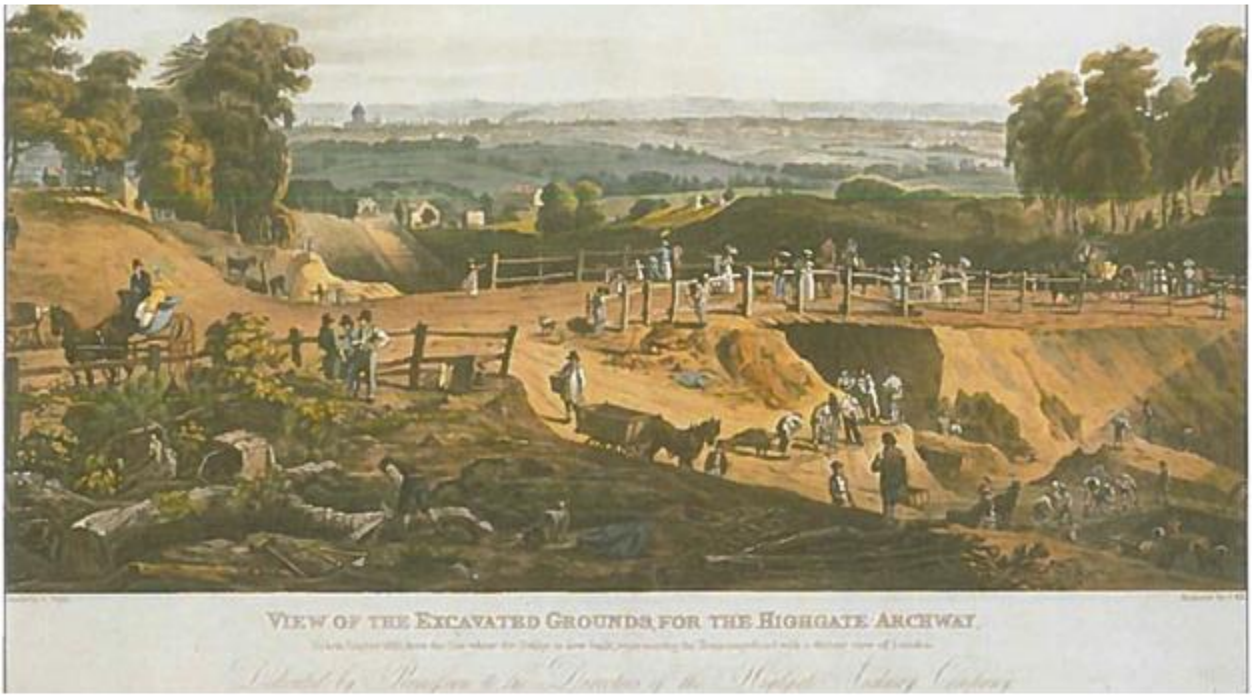
Appendix 1

The following information has been reproduced with kind permission of Donald Insall Associates, from their Historic Building Report and Heritage Assessment prepared for Transport for London in December 2014.

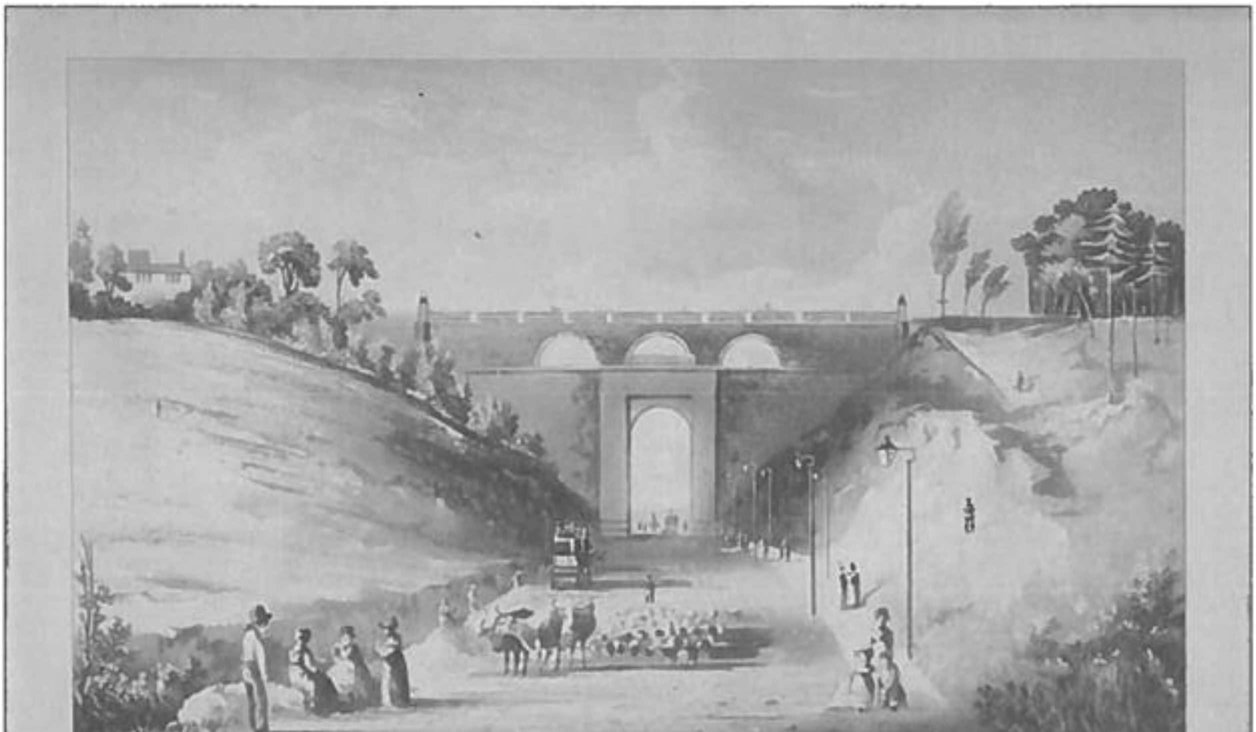
The Plates

1. 1815 Enclosure Map (Haringey Local Archives).
2. View of the Excavated Grounds for the Highgate Archway, Charles Augustus Pugin and engraved by John Hill 1812 (Collage).
3. Engraving of the Nash Bridge by Rudolph Ackermann 1823 (Collage).
4. Nash's 1812 Bridge, undated (Collage).
5. 1896 Ordnance Survey Map (Haringey Local Archives).
6. 1914 Ordnance Survey Map (Haringey Local Archives).
7. South Elevation, 1897 Reconstruction Drawing (LMA).
8. Reconstruction Drawings of Western Side of the Bridge (LMA).
9. Lamps for the Centre, 1897 Reconstruction Drawings (LMA).
10. Lamps for the Abutments, 1897 Reconstruction Drawings (LMA).

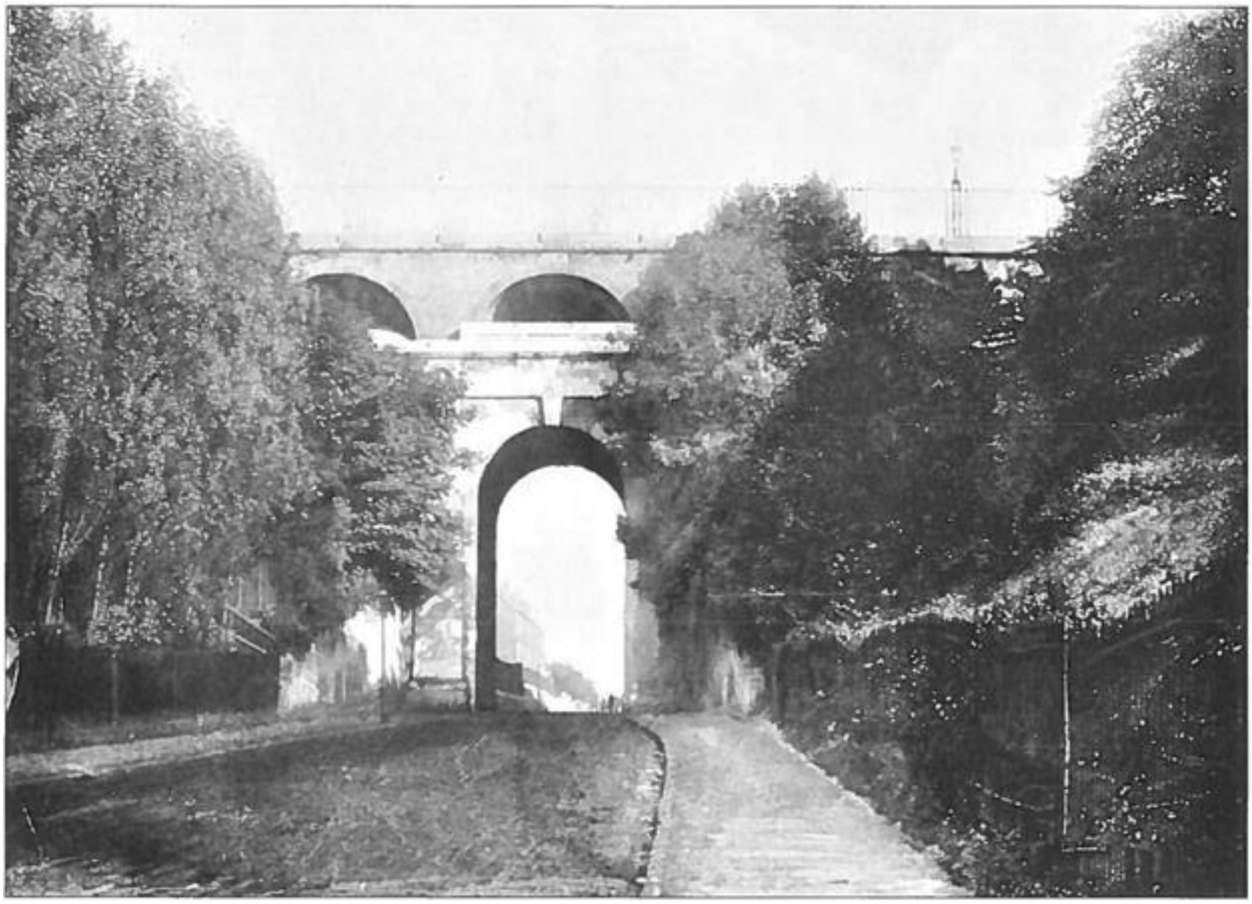
1. 1815 Enclosure Map (Haringey Local Archives).



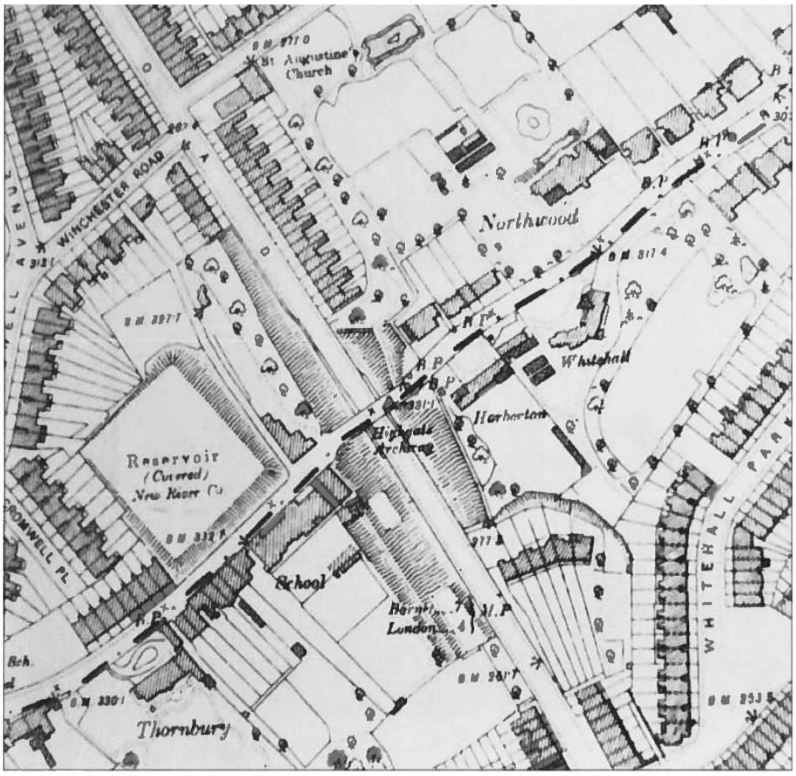
2. View of the Excavated Grounds for the Highgate Archway, Charles Augustus Pugin and engraved by John Hi/11812 (Collage).



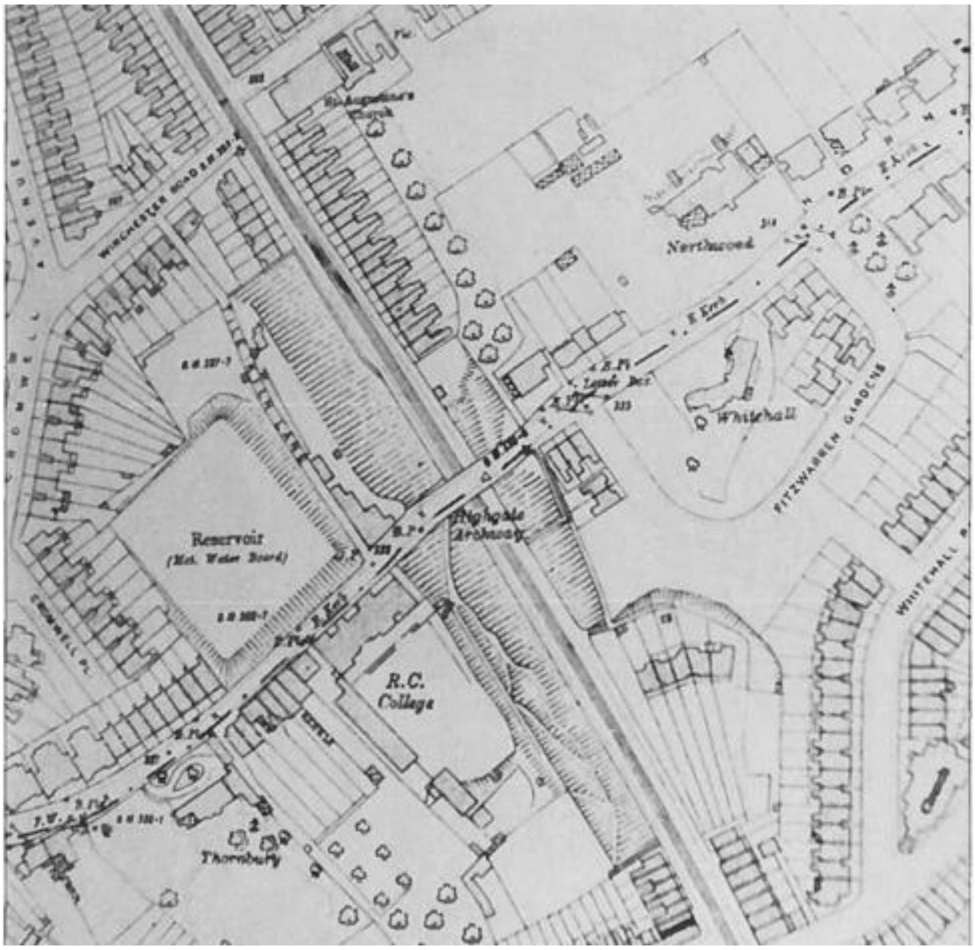
3. Engraving of the Nash Bridge by Rudolph Ackermann 1823 (Collage).



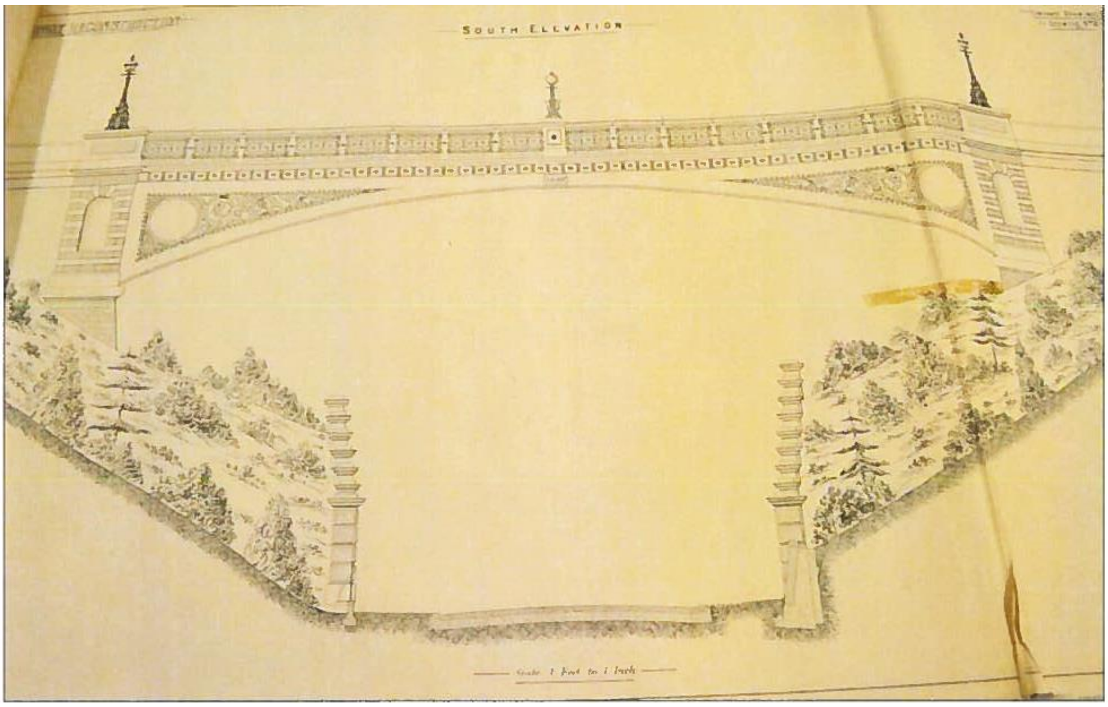
4. Nash's 1812 Bridge, undated (Collage).



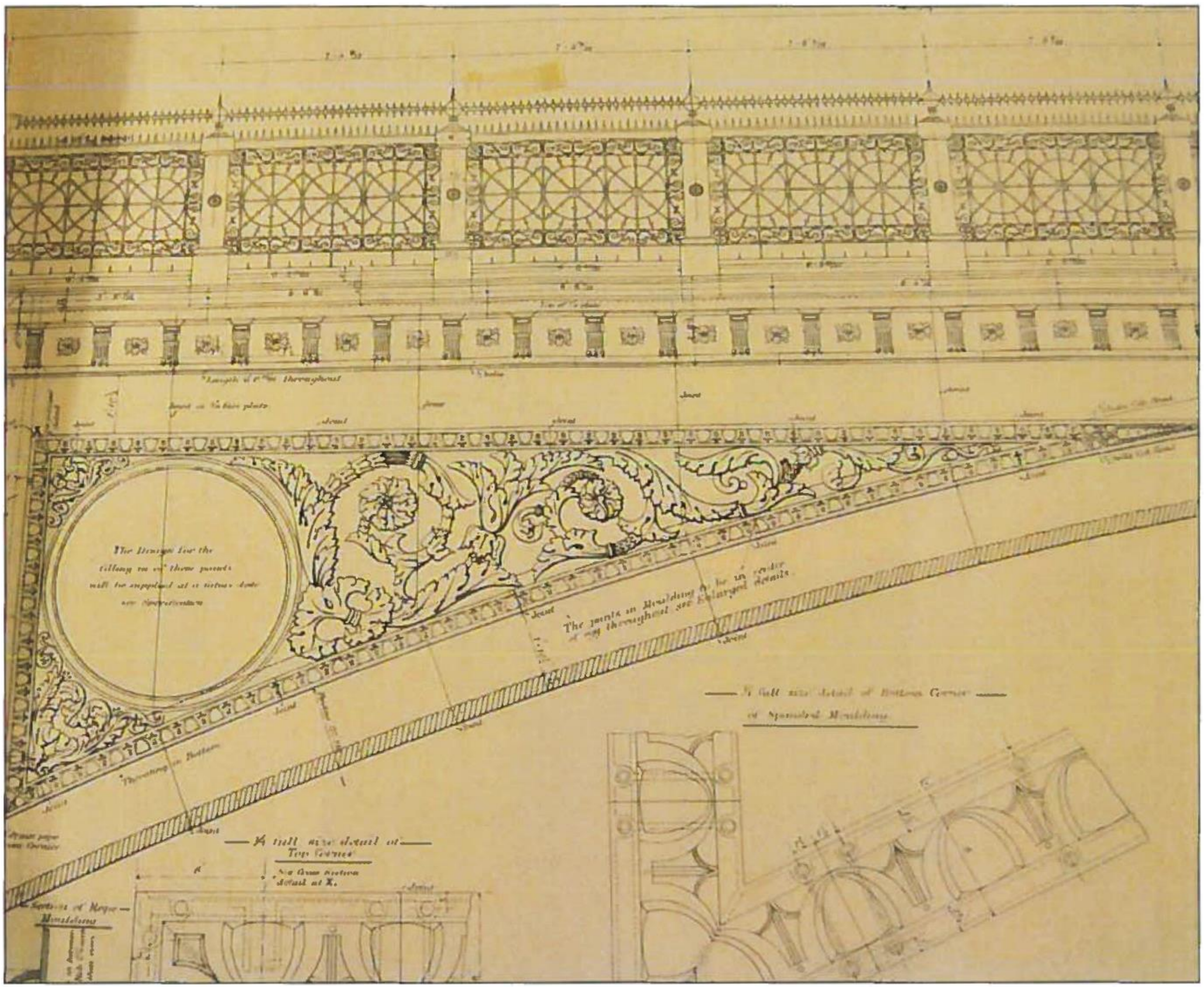
5. *1896 Ordnance Survey Map (Haringey Local Archives).*



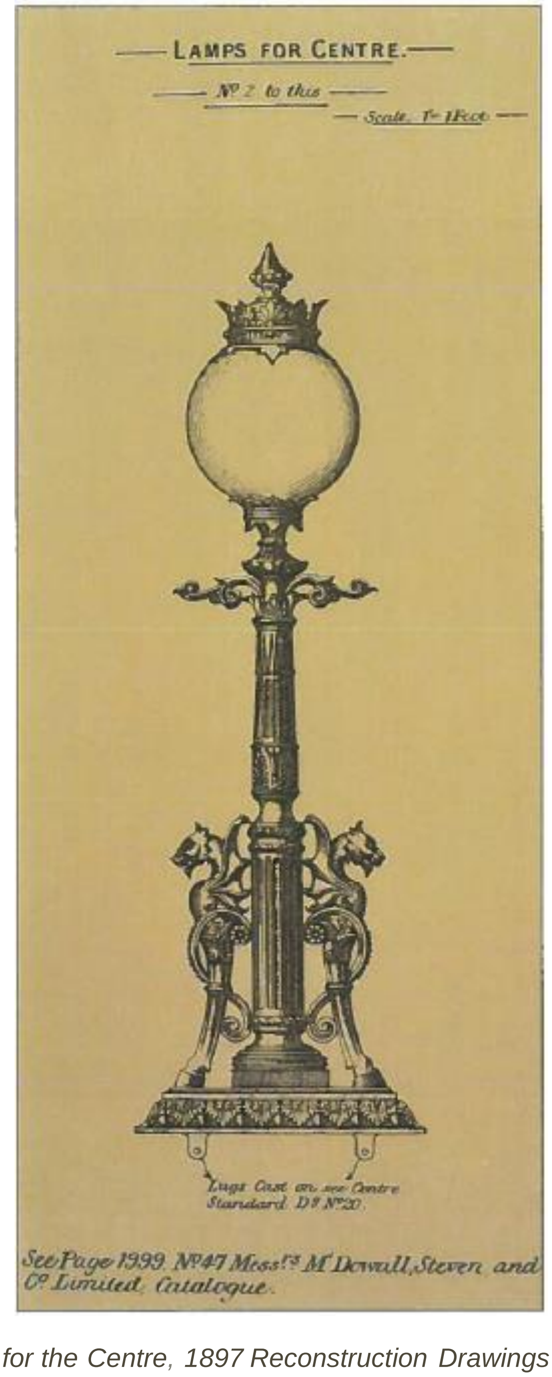
6. *1914 Ordnance Survey Map (Haringey Local Archives).*



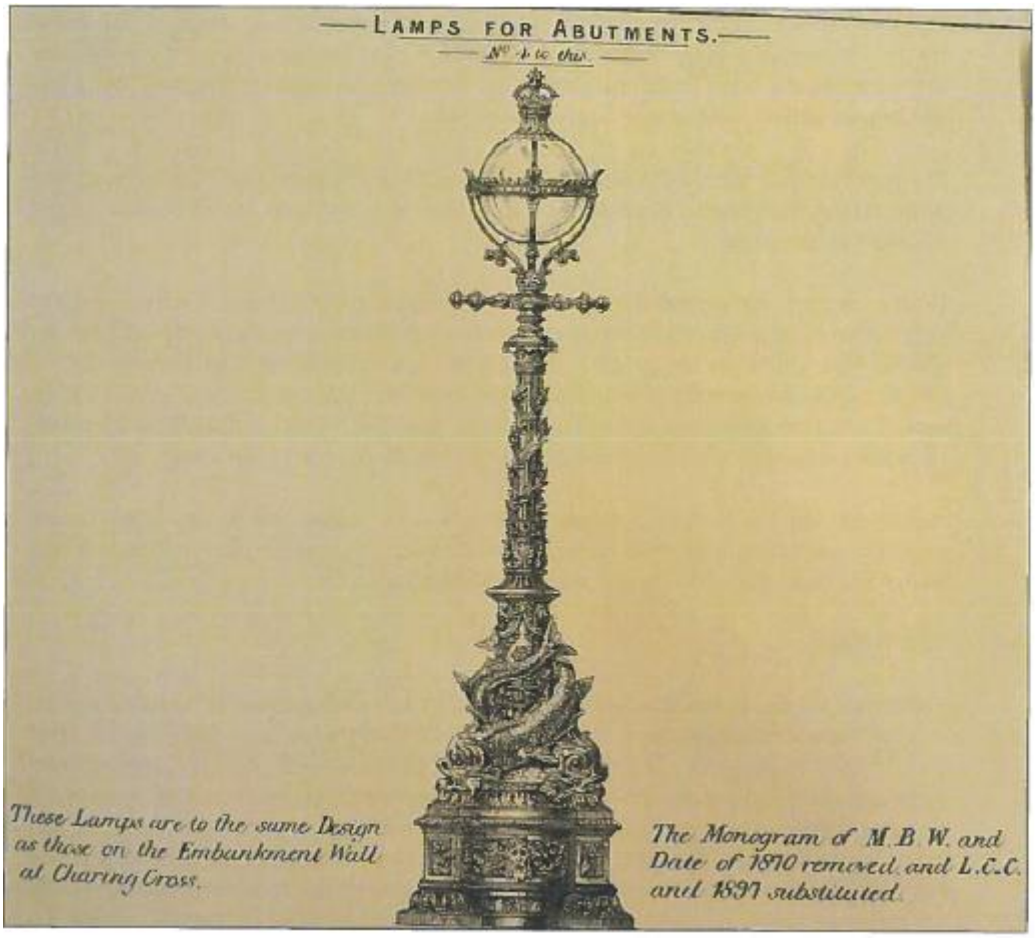
7. *South Elevation, 1897 Reconstruction Drawing (LMA).*



8. Reconstruction Drawings of Western Side of the Bridge (LMA).



9. *Lamps for the Centre, 1897 Reconstruction Drawings (LMA).*



10. Lamps for the Abutments , 1897 Reconstruction Drawings (LMA).

Appendix 2

Grade II listed.

TQ2987SW ARCHWAY ROAD 635-1/6/40 Archway Bridge 29/09/72 (Formerly Listed as: ARCHWAY ROAD Highgate Archway (that part in the London Borough of Islington))

II

Bridge carrying Hornsey Lane over Archway Road and designed to replace a bridge of brick and stone construction designed in 1813 by John Nash. Dated 1897 in panel at crown of arch and completed 1900. By Sir Alexander Binnie, for London County Council. Portland stone, steel and iron. Portland stone piers to either side with splayed bases having vermiculated quoins, the body of the piers rusticated and vermiculated. Segmental-arched span of 120 feet, of steel and cast-iron construction with rope mouldings to archivolt and circular ornament and arabesques in the spandrels; modillion cornice. Balustrade of Portland stone piers to either end, carrying cast iron lamp standards of the type designed by Lewis Vulliamy for the Thames Embankment in the 1860s, with the initials of the LCC on the south-eastern and north-western lamps, and the date 1897 on the other pair; smaller central piers, now painted, with lamp standards flanked by griffins; intermediate piers surmounted by ball and spike finials with spiked rail between; the cast-iron panels between with wheel motifs and scrolling ornament. (Historians' file, English Heritage London Division).

Listing NGR: TQ2911987390

Appendix 3

The following information has been reproduced with kind permission of Donald Insall Associates, from their Historic Building Report and Heritage Assessment prepared for Transport for London in December 2014.

The Engineer: Sir Alexander Richardson Binnie (1839-1917)

The following information has been obtained from the Oxford Dictionary of National Biography:

Binnie, Sir Alexander Richardson (1839-1917), civil engineer, was born at 77 Ladbroke Grove, London on the 26th March 1839. He was the eldest son of Alexander Binnie, a Bond Street wholesale clothier, and his wife, Hannah, daughter of Isaac Carr of Johnby, Cumberland. Binnie was educated privately and articled in 1858 to Terence Woulfe Flanagan, after whose death in 1860 he transferred his pupillage to John Frederic Bateman (later La Trobe Bateman).

From 1862 to 1866 Binnie worked on railway construction in mid-Wales. In 1865 he married Mary (d. 1901), daughter of Dr William Eames, a physician, of Londonderry. They had two sons and three daughters. In 1867, after examination, he was appointed an executive engineer in the public works department of India. He returned from India for reasons of health in 1873. Subsequent to his return he was influential, through approaches to the secretary of state for India, the marquess of Hartington, and the prime minister, for improvements in the terms of service for the public works department. As a mark of appreciation, the PWD engineers presented him with a portrait of himself in 1886.

In 1875 Binnie was appointed waterworks engineer to the city of Bradford, a post of great responsibility following the catastrophic failure of Sheffield's Dale Dyke Dam in 1864. His first concern was to safeguard the security of existing reservoir dams at Stubden, Leeshaw, and Leeming reservoirs by the provision of adequate spillways and for the design and construction of reservoirs at Barden and Thornton Moor. He prepared the scheme for water supply from the Nidd valley which was undertaken under his successor. Binnie understood the fundamental need for reliable hydrological data on which to base the design of reservoirs, leading to a significant publication 'On mean or average rainfall and the fluctuation to which it is subject' (Proceedings of the Institution of Civil Engineers, 109, 1891-2, 3-92).

In 1890 Binnie was appointed chief engineer to the London county council. He was responsible for the construction of the Blackwall road tunnel beneath the Thames in consultation with Sir Benjamin Baker and James Greathead (1889-97) and for the construction of the Greenwich foot tunnel (1899-1902) and the Barking road bridge over the River Lea. In 1891, with Baker, he prepared a report to the London county council on the reconstruction and extension of the main drainage of London and started upon the treatment works at Barking and Crossness which it recommended. He also designed the works for Highgate Archway, for widening the Strand, and for the construction of the Aldwych and Kingsway, connecting the Strand to Holborn.

Binnie was appointed knight bachelor in 1897. At that time, he was working towards the acquisition by the London county council of the private water companies supplying the capital, with a plan for augmenting supplies from the River Wye in Wales. A royal commission, however, recommended the setting up of the separate Metropolitan Water Board. Binnie resigned from the county council in 1901 and on the last day of the year set up his own consultancy at 9 Great George Street, Westminster. He was in partnership with his son William James Eames Binnie (who had been working with him since 1902) from 1904, and for a short time from 1903 his other son, A. T. Binnie, also assisted him; he left the firm to study medicine.

Binnie acted as principal engineering adviser to the Metropolitan Water Board during arbitration relating to the purchase of the water companies in 1903-4. In 1906 he reported to the government of Ireland on the Bann and Lough Neagh drainage scheme. From 1905 to 1907 he served as chairman of the vice-regal commission on the arterial drainage of Ireland. He visited Malta in 1909 to report on water supply. In 1909, on the death of George Frederick Deacon, the practices of Binnie and Deacon were combined as Sir Alexander Binnie, Son, and Deacon. In 1910-11, Binnie reported on the water supply and drainage for St Petersburg and in 1913 on the water supply for Ottawa. He was concerned with many other water and, later, water-power, schemes throughout the world. He published Rainfall, Reservoirs, and Water Supply in 1913, based on a series of lectures commissioned by the Chadwick trustees.

Binnie was admitted as an associate of the Institution of Civil Engineers in 1865 and as a member in 1878. He was elected president in 1905. An arterial aneurysm a few years before his death necessitated the amputation of one leg. From 1892 he again lived at 77 Ladbroke Grove, London, but he died at Beer, Devon, on 18 May 1917 while on holiday. He was buried at Brookwood cemetery, near London.

Appendix 4 - overleaf

PLOS report "Comparing Different Suicide Prevention Measures at Bridges and Buildings"

RESEARCH ARTICLE

Comparing Different Suicide Prevention Measures at Bridges and Buildings: Lessons We Have Learned from a National Survey in Switzerland

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Abstract

The goal of the study was to compare the effectiveness of different suicide prevention measures implemented on bridges and other high structures in Switzerland. A national survey identified all jumping hotspots that have been secured in Switzerland; of the 15 that could be included in this study, 11 were secured by vertical barriers and 4 were secured by low-hanging horizontal safety nets. The study made an overall and individual pre-post analysis by using Mantel-Haenszel Tests, regression methods and calculating rate ratios. Barriers and safety nets were both effective, with mean suicide reduction of 68.7% (barriers) and 77.1% (safety nets), respectively. Measures that do not secure the whole hotspot and still allow jumps of 15 meters or more were less effective. Further, the analyses revealed that barriers of at least 2.3 m in height and safety-nets fixed significantly below pedestrian level deterred suicidal jumps. Secured bridgeheads and inbound angle barriers seemed to enhance the effectiveness of the measure. Findings can help to plan and improve the effectiveness of future suicide prevention measures on high structures.

Introduction

The suicide rate in Switzerland decreased until the year 2000 and remains static in the range of 1'000 suicides per year. Suicide by jumping decreased in the years 1990 to 2013 from 173 to 123 per year. However, jumping from heights (ICD 10 X 80) continues to be the fourth most common suicide method in Switzerland [1]. It is a particularly lethal method of suicide, whereby the mortality rate varies largely depending on jump height and the type of surface below [2, 3, 4, 5, 6]. Suicide by jumping often traumatizes or even seriously hurts third parties [7, 8].

As in other countries (e.g. Taiwan)[9], the majority of suicides by jumping from heights in Switzerland are executed from buildings [10–11]. Still, about one third of all suicide jumps in Switzerland occurred at bridges [10–11]. In contrast to private buildings, public jump sites are better suited for suicide prevention, given that a great number of suicides are often limited to a

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few structures. At these hotspots, substantial suicide preventive effects can be achieved by a few prevention efforts.

Most interventions for suicide prevention on bridges are of a structural nature. Few, such as the Bern Muenster Terrace [8] focus on safety nets. However, the majority of the studies focus on barriers that hinder persons from climbing over. Examples include the Memorial Bridge in Augusta, Maine, U.S.A. [12]; the Bloor Street Viaduct in Toronto, Canada [13]; Clifton Suspension Bridge in Bristol, England [14]; the Jacques-Cartier Bridge in Montréal, Canada [15]; and the Grafton Bridge in Auckland, New Zealand [16, 17]. The barriers have reduced the number of suicides at these sites. However, these studies each focus on one specific jump site, which does not allow direct comparison of the different intervention measures. For example, Pelletier [12] and Sinyor and Levitt [13] showed that barriers with a height of 3.3 meters successfully hinder suicides. Yet, the height of a barrier is not the only criterion that contributes to the effectiveness of a structure. Some of the barriers examined tend to angle slightly inward toward their top ends [17, 15, 13].

Some interventions to prevent jumps from hotspots or other methods of suicide are not feasible for bridges. For example, Skegg and Herbison [18] and Isaac and Bennett [19] found that blocking access roads to hotspots deterred suicide jumps from them. This is not a viable measure for most bridges. King and Frost [20] found that the number of suicides by carbon monoxide poisoning in public parking lots has been reduced by installing aid signs. However, no studies exist that evaluate the effectiveness of aid signs as the sole intervention when used on bridges or other jumping sites, although they are widely installed. Glatt [21] and Zarkowski [22] demonstrated that, if in addition to aid signs, emergency helpline phones were directly available on bridges the phones were used on a regular basis. It must be noted that the regular use of emergency helpline phones should not be equated with the effectiveness of this prevention method [22]. Lester [23] showed that in combination with increased police presence, emergency helpline telephones led to a decrease in the number of suicides at the Sunshine Skyway Bridge in Florida, U.S.A.

Only a few studies concerning the efficacy of measures that ought to raise the probability of third-person interventions exist. For example, Bennewith, Nowers, and Gunnell [24] found that a combination of measures including barriers, closed-caption television (CCTV), and bridge employees monitoring the live CCTV video feed resulted in a reduction of suicide occurrences at the Clifton Suspension Bridge in the U.K. Although the number of events there has remained stable, bridge employees have significantly more often been involved than before the installation of CCTV [24].

Altogether, most publications on bridges and the safeguarding of buildings only examine particular structures and focus on whether a specific intervention can reduce suicides by jumping from heights. Only two studies include several buildings. Cox, Owens, Robinson, Nicholas, Lockley, and Williamson [25] conducted a meta-analysis to evaluate the efficacy of suicide prevention measures at hotspots. The authors concluded that structural interventions are an efficient way of means restriction. Pirkis, Spittal, Cox, Robinson, Cheung, and Studdert [26] demonstrated that despite a shift to other sites, at least 28% of all suicides by jumping within a city can be reduced by structural interventions.

Even if the overall effectiveness of structural interventions such as safety nets and barriers can be viewed as solid findings, no studies have directly compared the different measures in order to recommend the most effective for future safeguarding. The present study aims to determine which factors are the most effective by addressing questions: How high should a barrier be and how deep should a safety net be installed below the pedestrian level to prevent a significant number or all suicides by jumping? Is there further information that can be derived from our Swiss national survey on bridges and buildings?

Methods

To achieve the goal of the study, we examined all available data of suicides throughout Switzerland at jumping sites that have been secured by structural interventions. Jumping hotspots can be physically secured by vertical barriers (e.g., fences, railing elevations) or by horizontal safety nets applied below the pedestrian level. Help signs of the "Dargebotene Hand" (corresponding to the Samaritans) or helpline phones are additional security measures that can be installed. To best examine to which extent these measures effectively prevented suicides, we implemented pre-post analyses by using Mantel-Haenszel Tests, regression methods and calculating rate ratios.

Data Collection

Hotspots. No consensus can be found regarding how a jumping hotspot should be defined. Generally, a hotspot is defined as an accessible, usually public site that is known to be frequently used as a location to commit suicide [27].

The current study included all jump sites in Switzerland, at which occurred at least 0.5 suicides on average per year during any period of 10 years within the whole study period. In order to identify all Swiss hotspots, we first gathered data on all suicides by jumping from heights recorded by the Swiss Federal Office for statistics (BFS) for the years 1990–2010. More detailed data were provided by official bodies such as regional forensic institutes, cantonal and district doctors, as well as police authorities. We mapped these registered suicides to specific jump sites and were so able to make a preliminary identification of 31 hotspots. The BFS data had a publication delay of three years in contrast to the suicide data given by the above mentioned official bodies. The final analyses were carried out including data of the years 1990–2013.

Suicide-prevention measures. Information on the specific suicide-prevention measures executed at each jump site was provided by civil engineering offices and municipalities or obtained through on-site inspection. Interventions to prevent suicide were found at 23 of 31 hotspots. Due to the poor data quality (no exact installation date), seven jump sites where only signs with emergency numbers were attached were excluded from the analysis. An additional jump site was excluded because the structural intervention was conducted outside the specified data collection period. Hence, further analyses were undertaken on 15 jump locations.

All interventions that hinder or make jumping from structures impossible in the sense of means restriction as suicide prevention are considered structural measures. We made a distinction between vertical (barriers) and horizontal (safety nets) structural measures. Furthermore, we assessed for each secured hotspot whether a structural intervention secures the entire hotspot and impedes all jumps of 15 meters or more. This distinction was necessary because some structures are not secured in their entirety; e.g., for some buildings, structural measures have not been installed on their full length, or some bridges only have barriers installed on the road at their base. The cutoff point of 15 meters was chosen according to the recommendations of Moeller and Letsch [28] and Lapostolle et al. [5], who demonstrated that the lethality of a jump exceeds 50% above this height.

However, vertical interventions are not the only elements required for completely securing hotspots. Reisch et al. [11] advised that the head of the bridge also has to be secured (if climbing around is possible), that safety nets have to be installed more than three meters below pedestrian level, and that barriers have to have a minimum height of two meters. We additionally analyzed whether structures that fulfill all of these criteria show higher prevention rates than structures that do not fulfill these criteria.

In the analysis, we use the term *complete* if all of these criteria were fulfilled at a specific structure versus *incomplete* if any of the criteria was not fulfilled. These data were supplemented by data gathered on site visits. For example, elements like inbound angle installations of the barriers or specific places where barriers could be easily climbed over were investigated using a consistent protocol.

Analysis

We used a pre-post analysis comparing data before and after the installation of the measure for all structures and each individual structure.

First, the suicides that occurred the years 1990–2013 were assigned to the pre- and post-intervention phases, according to when they occurred. The mean observation time recorded was 252.00 months (*SD* = 47.14 months; *Min.* = 156.00 months; *Max* = 288.00 months).The mean of the pre-intervention phase was 178.60 months (*SD* = 54.88 months; *Min.* = 48.00 months; *Max* = 264.00 months) and the mean of the post-intervention phase was 73.40 months (*SD* = 49.18 months; *Min.* = 24 months; *Max* = 180 months). Despite its partial safeguarding, the total construction phase of a suicide prevention measure (*M* = 7.30 months; *SD* = 7.19 months; *Min.* = 1 month; *Max* = 27 months) was assigned to the pre-intervention phase.

To test the overall effect of the prevention measures across jump sites, both the Mantel-Haenszel Test and maximum-likelihood methods (negative binominal regression) were calculated. Furthermore, the above-mentioned test procedures were used to include the specific type of intervention measure as a covariate in the analyses and to calculate the overall effects of the measure group *barrier* and *safety net* (negative binominal regression). Note that including the variable *extent* to the model leads, to the combination "complete and nets" with only two observations. For the variable *extent*, only confidence intervals based upon the ML-estimator and the standard error of the rate ratio were calculated. To review the effects of suicide prevention measures at individual bridges, we calculated rate ratios and built confidence intervals based on the standard error (s. e.) of the log rate ratios (log*RR*) and *p*-values based on the test statistic log $RR/s.e.$ (log RR) $\sim N(0.1)$ specified. Additionally, we compared suicide reduction rates of safety nets and barriers as well as complete and incomplete interventions by using Mann Whitney-U tests.

Results and Discussion

Description of Analyzed Jump Sites

Hotspots are anonymized in order to minimize a possible Werther Effect analogous to Beautrais [16]. A total of 15 jump sites could be included in the present study; 13 bridges, 1 terrace, and 1 multi-story car park.

The jump sites were on average 62.94 m high (range 33.80 m to 150.00 m; *SD* = 23.00 m). The average barrier height before the suicide prevention intervention measures were installed was 1.13 m (*SD* = 0.14 m); the highest barrier was 1.30 m high, and the lowest was 0.80 m. On three bridges, the original barrier height could not be determined. On average, the jump sites were 2.75 km (*SD* = 3.71 km) away from a town center. The detailed figures for all analyzed bridges are included in Table 1.

Description of Suicide-Prevention Measures

Of the 15 jump sites, 11 (73.3%) were secured by barriers (fences). Five (45.5%) of these jump sites have complete fences, and 6 (54.5%) have incomplete fences. On average, the security barriers have a height of 2.30 m (*SD* = 0.61 m). After the construction of the security barrier, the minimum railing height is 1.50 m, and the maximum height is 3.30 m. With one exception, all

Table 1. Technical Data of the Included 15 Jump Sites.

Jump site	Type of building	Prevention type	Measure complete	Height (m)	Barriers: Height of railing (m)	Net installed below pedestrian level (m)	Help sign	Additional information from site visits
A	Bridge	Barrier	YES	58	1.9	n.a.	YES	Bridgeheads secured, emergency phones, distance to city center 2.9 km, distance to psychiatric hospital 4 km
D	Bridge	Barrier	NO	23	1.51	n.a.	NO	Inward angle of the barrier, distance to city center 0.7 km, distance to psychiatric hospital 2.8 km
E	Bridge	Barrier	YES	85	1.8	n.a.	NO	Distance to city center 2.6 km, distance to psychiatric hospital 4.8 km
F	Bridge	Barrier	YES	47	3.25	n.a.	NO	Distance to city center 1.3 km, distance to psychiatric hospital 0.7 km
K	Bridge	Barrier	YES	68	2.3	n.a.	YES	Distance to city center 3.1 km, distance to psychiatric hospital 18 km
M	Bridge	Barrier	NO	75	2.65	n.a.	YES	Inward angle of the barrier, climbing around bridgeheads possible, distance to city center 1.5 km, distance to psychiatric hospital 18.2 km
H	Bridge	Barrier	YES	150	2.58	n.a.	YES	Emergency phones, distance to city center 5.5 km, distance to psychiatric hospital 5.8 km
B	Bridge	Barrier	NO	33	2.9	n.a.	YES	Distance to city center 0.8 km, distance to psychiatric hospital 3.1 km
C	Bridge	Barrier	NO	47	2.9	n.a.	YES	Distance to city center 0.7 km, distance to psychiatric hospital 3.5 km
O	Bridge	Barrier	NO	55	1.7	n.a.	NO	Distance to city center 2.1 km, distance to psychiatric hospital 2.1 km
L	Multi-story-parking	Barrier	NO	30	2.4	n.a.	NO	Only the top levels were secured, ramp not secured, distance to city center 0.6 km, distance to psychiatric hospital 1.4 km
N	Bridge	Safety net	NO	103	n.a.	0.5	YES	Width of net 4.0, distance to city center 15.1 km, distance to psychiatric hospital 2.2 km
I	Bridge	Safety net	NO	99	n.a.	4	YES	Width of net 5.2 m, distance to city center 3.4 km, distance to psychiatric hospital 4.4 km
J	Terrace	Safety net	YES	35	n.a.	7	YES	Width of net 6.0 m, distance to city center 0.8 km, distance to psychiatric hospital 3 km
G	Bridge	Safety net	YES	31	n.a.	4	NO	Width of net 5.0 m, distance to city center 0.1 km, distance to psychiatric hospital 4.2 km

Note. Bridges were anonymized in order to minimize Werther Effects.

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vertical barriers were raised to at least 1.70 m. Two of the fences have additional inward angles (bridges D, M). One bridge was additionally secured with side barriers on the bridgeheads in order to prevent climbing around the fences (bridge A). Six of the areas secured by fences have been additionally equipped with aid signs displaying emergency helpline numbers of the "Dargebotene Hand." Four (26.7%) jump sites were secured by safety nets. At 2 (50.0%) sites, the nets secure the complete jump area. Two nets (50.0%) are incomplete. On average, the safety nets have a depth of 3.88 m (*SD* = 2.66 m) below street level. The minimum depth is the net on bridge N with 0.50 m, and the maximum depth is 7.00 m on terrace J. Three of the areas have been additionally equipped with aid signs displaying emergency helpline numbers (see Table 1).

Overall Effectiveness of Jump Site Safeguarding

The Mantel-Haenszel Test, respectively the negative binominal regression of the aggregated data, of the 15 jump sites shows that the rate ratio from pre- to post-installation of structural measures (barriers and safety nets) is $RR_{\mathrm{MH}} = 0.32$, $\mathrm{CI}_{95\%} = 0.23, 0.44$ resp. $RR_{\mathrm{GLM.NB}}$. = 0.3, $\mathrm{CI}_{95\%} = 0.17, 0.44$. This corresponds to a reduction of the occurrence of suicides by 71.7%. In the pre-intervention phase, 327 suicides were carried out during 2679 months. This corresponds to a rate of 0.12 suicides per month or 1.47 per year. In the post- intervention phase, 38 suicides occurred during 1101 months, corresponding to a rate of 0.035 suicides per month or 0.41 per year.

Safety nets. Safety nets led to a 77.1% reduction of suicides. The rate ratio from before to after the installation of safety nets is 0.21, $\mathrm{CI}_{95\%} = 0.07, 0.62$. During 656 months, 55 suicides occurred in the pre-intervention phase. This corresponds to a rate of 0.084 suicides per month or 1.00 per year. In the post-intervention phase, during 364 months, 7 suicides occurred, corresponding to a rate of 0.019 suicides per month or 0.23 per year.

Barriers (fences). Aggregated data of all sites secured by fences show that this intervention led to reduction of suicides by 68.7%. The rate ratio from before to after installing the barriers is 0.34, $\mathrm{CI}_{95\%} = 0.18, 0.64$. In the pre-intervention phase, 272 suicides occurred during 2023 months. This corresponds to a rate of 0.13 suicides per month or 1.61 per year. In the post-intervention phase, 31 suicides occurred during 737 months (0.042 suicides per month or 0.51 per year).

Extent. Complete safety measures led to reduction of suicide by 82.0%. The rate ratio from before and after installing is 0.18, $\mathrm{CI}_{95\%} = 0.10, 0.44$. In the pre-intervention phase, 184 suicides occurred during 1360 months. This corresponds to a rate of 0.14 suicides per month or 1.62 per year. In the post-intervention phase, 23 suicides occurred during 488 months (0.047 suicides per month or 0.57 per year). Incomplete safety measures led to a reduction of suicide by 44.8%. The rate ratio from before and after installing is 0.55, $\mathrm{CI}_{95\%} = 0.45, 0.86$st. In the pre-intervention phase, 143 suicides occurred during 1319 months. This corresponds to a rate of 0.11 suicides per month or 1.30 suicides per year. In the post-interventions phase, 15 suicides occurred during 613 months (0.02 suicides per month or 0.29 per year).

Complete interventions were significantly more effective than incomplete safety measures (Mann-Whittney U test; $p = .029$). No significant difference was found between safety nets and barriers.

Analyses of Individual Structures

The rate ratios of the individual structures show that the efficacy of the safety measures ranges from 2.1% (structure L) to 100% (structures F, H, J, & K). Bridges A, B, and D exhibit a statistically significant effect ($p <. 05$). Due to the absence of suicides in the post-phase, the standard errors at structures F, H, J, and K could not be calculated for statistical-methodological reasons. However, all of the latter analyses would have been statistically significant if one (instead of zero) suicides would have been observed. An overview of the effects of the prevention measures are shown overall and for individual structures in Tables 2 and 3, respectively.

Discussion

The results of the current study provide empirical evidence that structural interventions such as barriers or safety nets show a preventive effect. They are consistent with previously published studies [16, 17, 14, 25, 12, 15, 26, 8, 13]. It has been unclear though if earlier meta-analyses and individual case studies exhibit a publication bias. According to Pirkis et al. [26], it cannot completely be ruled out that only results that show significant effects are published and

Table 2. Reduction of Suicide Rates After Securing Jump Sites by Structural Means: Group Analysis.

Jumpsites	Measure			Suicide rate before installation of the safety measure			Suicide rate after installation of the safety measure			Reduction of suicide rate	
	Type of structural intervention		Were all parts secured that allow lethal jumps?								
	Barriers (Vertical)	Savety nets (Horizontal)		Suicides per year	Suicides observed	Months of observation	Suicides per year	Suicides observed	Months of observation	Prevention rate (%)	(RR*; CI95%)
All	YES	YES	n.a.	1.465	327	2679	0.414	38	1101	71.7	0.30; 0.17, 0.44**
All barriers (overall)	YES	NO	n.a.	1.613	272	2023	0.505	31	737	68.7	0.34; 0.18,0.64**
All safety nets	NO	YES	n.a.	1.006	55	656	0.231	7	364	77.1	0.21; 0.07, 0.62**
All structures that hinder lethal jumps	n.a.	n.a.	YES	1.624	184	1360	0.566	23	488	82.0	0.18; 0.10; 0.44***
All structures that still allow lethal jumps	n.a.	n.a.	NO	1.301	143	1319	0.294	15	613	44.8	0.55; 0.45; 0.86***

Note.

*RR = rate ratio.

**Test procedure: GLM, Negative binominal distribution.

*** Confidence intervals based on the ML-estimator and the standard error of the rate ratio.

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Table 3. Reduction of Suicide Rates after Securing Jump Sites by Structural Means at Each Jump Site.

Jumpsites	Measure			Suicide rate before installation of the safety measure			Suicide rate after installation of the safety measure			Reduction of suicide rate	
	Type of structural intervention										
	Barriers (Vertical)	Safety nets (Horizontal)	Were all parts secured that allow lethal jumps?	Suicides per year	Suicides observed	Months of observation	Suicides per year	Suicides observed	Months of observation	Prevention rate (%)	(RR[1]; CI95%; p-value)
A	YES	NO	YES	3.014	54	215	0.986	6	73	67.3	0.33 ; 0.14, 0.76, p = 0.01[2]
D	YES	NO	NO	3.234	45	167	0.992	10	121	69.3	0.31; 0.15, 0.61, p = <0.01
F	YES	NO	YES	0.727	16	264	0.000	0	24	100.0	rtz[3]
H	YES	NO	YES	0.867	13	180	0.000	0	60	100.0	rtz
K	YES	NO	YES	0.733	8	131	0.000	0	25	100.0	rtz
M	YES	NO	NO	0.385	5	156	0.273	3	132	29.1	0.71; 0.17, 2.97, p = 0.64
B	YES	NO	NO	3.313	53	192	0.250	1	48	92.5	0.08 ; 0.01, 0.55, p = 0.01
C	YES	NO	NO	2.313	37	192	0.750	3	48	67.6	0.32 ; 0.10, 1.05, p = 0.06
E	YES	NO	YES	1.171	24	246	0.571	2	42	51.2	0.49; 0.12, 2.07, p = 0.33
L	YES	NO	NO	1.082	11	122	1.059	3	34	2.1	0.98; 0.27, 3.51, p = 0.97
O	YES	NO	NO	0.456	6	158	0.277	3	130	39.2	0.61; 1.15, 2.43, p = 0.48
J	NO	YES	YES	2.250	9	48	0.000	0	180	100.0	rtz
G	NO	YES	YES	0.903	14	186	0.400	1	30	55.7	0.44 ; 0.06, 3.37, p = 0.43
I	NO	YES	NO	1.205	25	249	0.923	3	39	23.4	0.77; 0.23, 2.54, p = 0.66

(*Continued*)

Table 3. (*Continued*)

Jumpsites	Measure			Suicide rate before installation of the safety measure			Suicide rate after installation of the safety measure			Reduction of suicide rate	
	Type of structural intervention										
	Barriers (Vertical)	Safety nets (Horizontal)	Were all parts secured that allow lethal jumps?	Suicides per year	Suicides observed	Months of observation	Suicides per year	Suicides observed	Months of observation	Prevention rate (%)	(RR[1]; CI95%; p-value)
N	NO	YES	NO	0.486	7	173	0.313	3	115	35.5	0.64; 0.17, 2.49, p = 0.52

Note.

1. RR = rate ratio.

2. Confidence intervals based on the standard error of the log rate ratios.

3. rtz = Reduction to zero.

No statistical analyses can be carried out if no suicide has occurred in the post-intervention period. Therefore, no standard errors are defined, and no confidence intervals are presented.

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other studies that show non-significant or counterproductive data are not released. In contrast to the mentioned studies, the current study has a pre-post design and has systematically examined all bridges with a high occurrence in suicide jumping of one country (Switzerland) and a publication bias can be ruled out. Altogether, the reduction in suicides across all jump sites represents 71.7%. The suicide rate could be reduced from 1.47 suicides per year to 0.41 suicides per year. This figure lies slightly lower than that of Pirkis et al. [26], who found a reduction of 86%. It is to be assumed that this difference can be explained by the fact that ineffective as well as only marginally effective prevention measures were also included in the present study (refer to Table 2 jump sites L, M, N, or O). For the years 1990 to 2013, suicide by jumping in Switzerland in general decreased. However, it is not possible to state definitively whether this decrease can be attributed entirely or at least partly to the interventions mentioned in the current study.

Safety nets were not statistically significant more preventive than safety barriers. Incomplete measures led to an insufficient prevention of suicides. It seems to be more important that a structural measure secures all parts of a bridge that allow lethal jumps, and it seems less important which kind of structural measure (safety net versus barrier) is chosen. More data is needed to determine whether there is in fact a difference between safety nets and barriers.

It is noteworthy that the structural intervention measures at 4 of the 15 examined jump sites led to a complete stop in suicides. These measures were safety nets at jump site J, which are fixed far below street level (7 m), have a wide overhang (6 m) and secure all areas that allow lethal jumps. At terrace J, the full reduction in suicides has been continuing for 15 years. Second, barriers that are very high (at least 2.3 m), secure the jump site across the entire length, and prevent climbing around the bridgeheads also led to a complete elimination of suicides. In the literature, only Pelletier [12] could show similar sustainable results as terrace J. Terrace J can thus be seen as the gold standard in terms of using safety nets to secure a hotspot against this type of suicide. It also seems worthy to note that the specific barrier height that led to the elimination of suicides from this hotspot is slightly lower in the present study than in the given literature [12, 13]. In regard to the low barrier height of 2.3 m at bridge K, further research will show if the termination of occurred suicides can be sustained in the future.

Which exact prevention measure was chosen for a specific structure depended on various factors. If particularly aesthetic factors [16, 17] are weighted, safety nets should be considered as the intervention measure because when seen from a distance, they clearly impair the aesthetic of buildings less than barriers. The depth of the installation of safety nets was mostly limited due to architectural reasons. Some bridge structures do not allow the attachment of safety nets below the depth of 3 m. Here, due to structural reasons, only barriers as safety measures should be chosen; otherwise, only small and inadequate prevention effects can be expected (jump site N, I or G; see Table 2). Safeguarding with safety nets is considerably more expensive compared to barriers. If primarily financial factors are considered, barriers have to be mounted.

It seems astounding that an increase in barrier height to 1.51 m of bridge D already led to a reduction in suicides of 69.3%. It can be assumed that this unexpected strong effect is connected to the inward inclination of the barrier. Thus, the inward tilted barriers at Grafton Bridge [16, 17] and at Bloor Street Viaduct [13] also led to a complete stop in suicides.

Barrier height as well as depth and width of safety nets are central, but non-exhaustive criteria in the safeguarding of constructions. Ultimately, the weakest link in the security chain seems to be crucial with regard to how effective suicide prevention interventions are. This is particularly evident in cases where bridgeheads are climbed around (e.g., bridge M). To achieve the highest possible suicide-preventive effects, bridgeheads should be secured in any case. This result may also explain why aid signs without structural changes are insufficient. They leave several weak links in the security chain that may be closed by police patrols or other measures [23].

Limitations

Along with physical availability, psychological availability by media reports [29, 30, 31] is a decisive factor in the development and maintenance of a hotspot. Effects by media were not included in the present study. Furthermore, the study has not reviewed whether there has been a shift to nearby jump sites as a result of safeguarding a specific jump site. Previous work [14, 32, 12, 26, 8, 13, 18] has shown that the shifting effect caused by safeguarding a specific jump site is minimal or rather has even resulted in a reduction in suicides at nearby jump sites. A further limitation of this study is that in part, calculations had to be carried out with a very small number of cases. Due to the small power of the analyses, the likelihood of finding significant effects is rather small, especially in regard to analyses of individual structures.

Although we included data from several official bodies, it is possible that we missed some rare cases of suicide by jumping (e.g., the body of a person floated away in the river below the bridge). The data spanning from 1990 to 2013 do not allow statements about the time before 1990. It is possible that some early hotspots have been unrewarded. Additionally, we don‘t know how the included hotspots developed before 1990. Furthermore, the date of intervention was not controllable. We had to compare different pre-post periods. Bias cannot be excluded completely. Moreover, the current study does not mention attempted suicides. It is important that additional studies confirm our findings and provide a more complete picture by including suicide attempts.

Data regarding the date of installation dates of helpline phones and most aid signs could not be determined and could therefore not be included in the statistical pre-post analyses. However, at least eight hotspots of the original sample stayed hotspots after the installation of help signs. Help signs on their own were often not sufficient to significantly reduce the number of suicides on hotspots.

Policy and Practice Recommendations

On the basis of the these results, we recommend safeguarding jump sites with a high occurrence of suicide (at least 0.5 suicides per year) by means of barriers or safety nets. Barrier height should be at least 2.3 m, and bridgeheads should specifically be secured in addition to prevent climbing around them. Safety nets should lie significantly below pedestrian level and have a net width adapted to the depth. Based on our data, a depth of 4 m below pedestrian level may be sufficient. Safeguarding should be complete or at least not allow jumps of 15 meters or more. In part, these recommendations were incorporated into the Regulation of the Swiss Federal Road Office regarding the suicide-preventive safeguarding of bridges [11]. These recommendations should be substantiated by further empirical research and, if necessary, adjusted accordingly.

Supporting Information

S1 Table. Incidents Locations 1990–2013.
(XLS)

Author Contributions

Conceptualization: TR.

Data curation: TR.

Formal analysis: TR AH.

Funding acquisition: TR.

Investigation: TR.

Methodology: TR AH.

Project administration: TR.

Resources: TR.

Supervision: TR.

Validation: TR AH.

Visualization: AH.

Writing – original draft: TR AH PM.

Writing – review & editing: PM.

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