Civic Engineers

Job Title
Fenton House

Report Type
Appraisal of Boundary Walls

Prepared for
The National Trust

Date
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Contents

A3 landscape format

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Revised	n / a

1. Introduction and Brief

On behalf of the National Trust (N.T) Civic Engineers (C.E) have carried out a site survey and options study for remedial works on various boundary wall elements of concern to the N.T surveying team within the Fenton House Estate, in the London Borough of Hampstead. The location of Fenton House is identified in Figures 1 and 2.

This work has been undertaken following an email to Robert Westcott (Civic Engineers) from Adam Rossington (National Trust) on the 26th September 2017, highlighting the following issues:

- A section of the boundary wall leaning towards the public highway
- A delaminating double skin party wall
- A leaning brick pier, which appears to be worsening

An initial site visit was undertaken on the 9th October 2017 by Robert Westcott and Dominique Pitman (both of Civic Engineers) to understand the existing condition of the highlighted structures. Simon Bayley (National Trust) was also in attendance.

This report provides an overview of the existing condition of the structural elements highlighted above, and shown in Figure 2 below. The likely cause of the movements observed and the areas requiring remedial works are identified. Options for remedial works with recommended solutions are identified.

For clarity, the survey work and report are limited to the specific items highlighted. C.E have not surveyed the whole property. It is likely other defects exist.

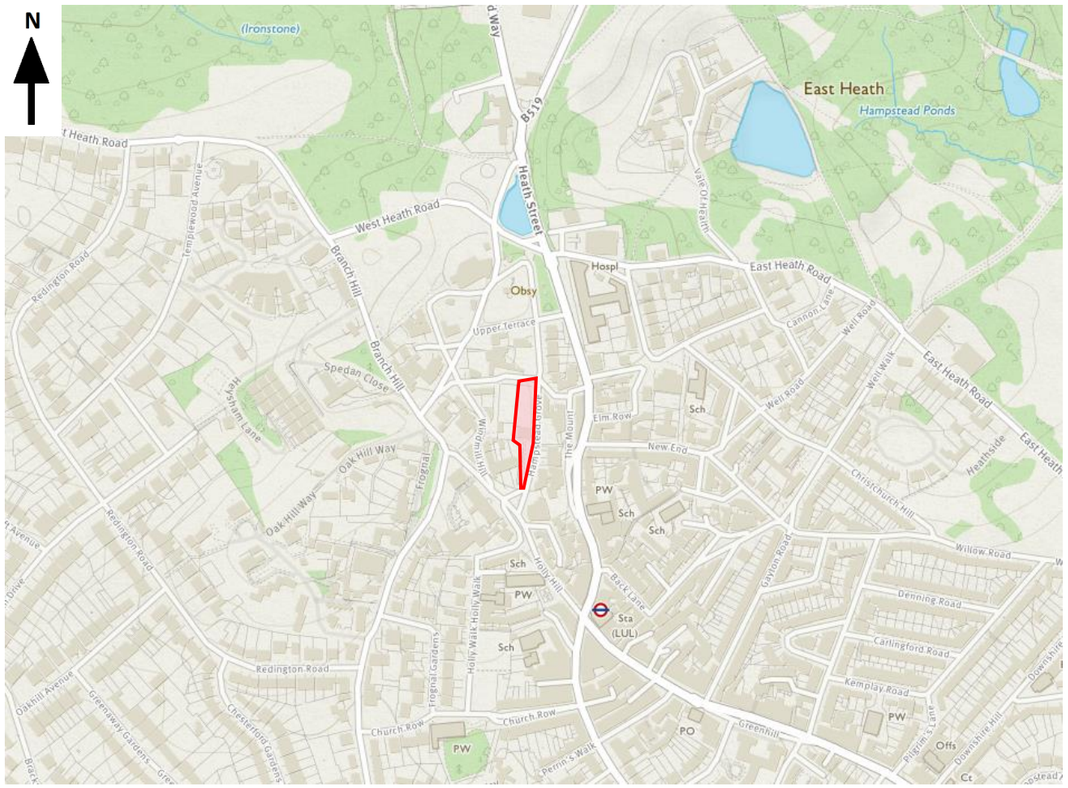


Figure 1 - Location of Fenton House

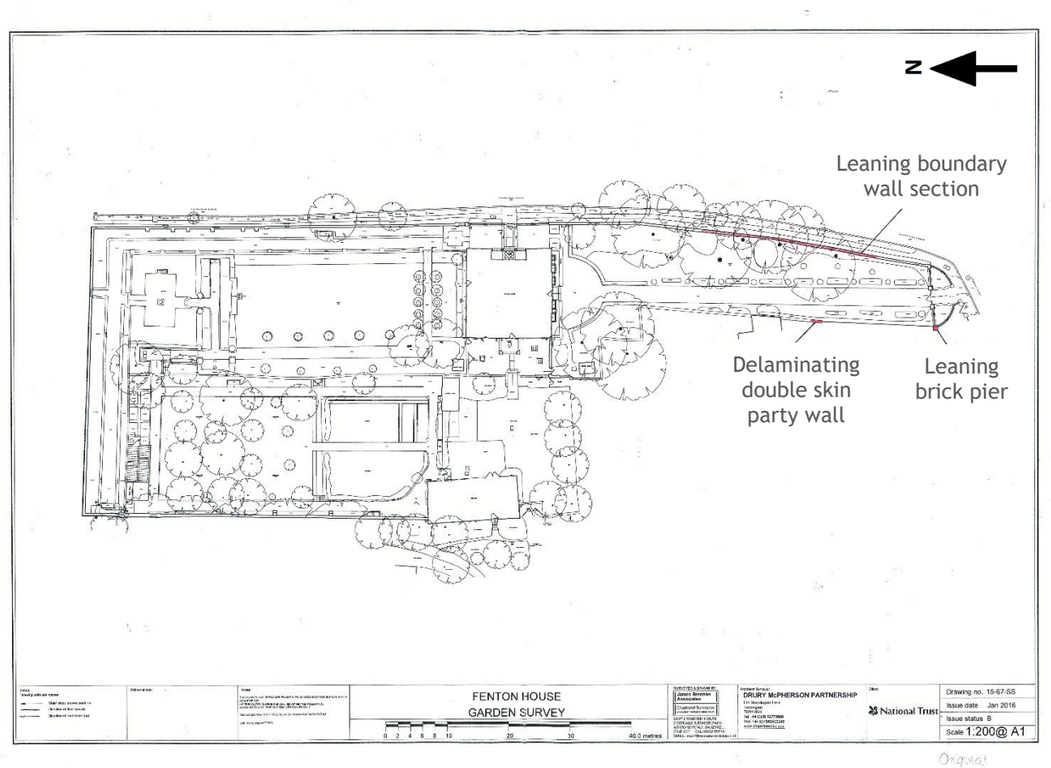


Figure 2 - Location of highlighted structures within Fenton House

2. Desk Top Site Appraisal

In order to understand the existing site arrangement and structure of the highlighted elements, a desk top site appraisal has been completed as part of this study.

The following information has been collated from the National Trust Property Office in Fenton House:

- Fenton House – 'Article for Views'; from circa. 2001.
- 'East Boundary Wall Survey Image', from 2001.
- 'Cliveden Conservation Site Visit to Fenton House' from circa. 2012.
- Fenton House – Quinquennial 2016;

2.1 Description of the Site

The leaning boundary wall

The south-eastern boundary wall is a masonry structure, one and a half bricks wide (measured on site as 360mm), and 2.7 metres tall on the highway side. Deformations of the boundary wall started to cause concern in 1999, more notably along the northern section, and has since seen extensive ivy removal.

Vegetation, including various large trees, identified as Robinia (Quinquennial 2016) are present very close to the boundary wall, with one tree base pushing against the wall. The approximate location of these trees are shown in Figure 3 below.

Double skin party wall

The ownership of the wall is currently uncertain. It is a masonry structure, approximately 1.8m high and 300mm wide, and it sits on a masonry retaining wall, with the adjacent garden at a lower level (approximately 1.8m lower).

Brick pier

The south-western pier is a masonry structure, 700mm by 700mm wide, and at its highest, 3.9m high, leaning in a south-westerly direction into the adjacent property, Enfield House. This movement has caused cracking within the pier, and a joint to open between the pier and the attached brick party wall.

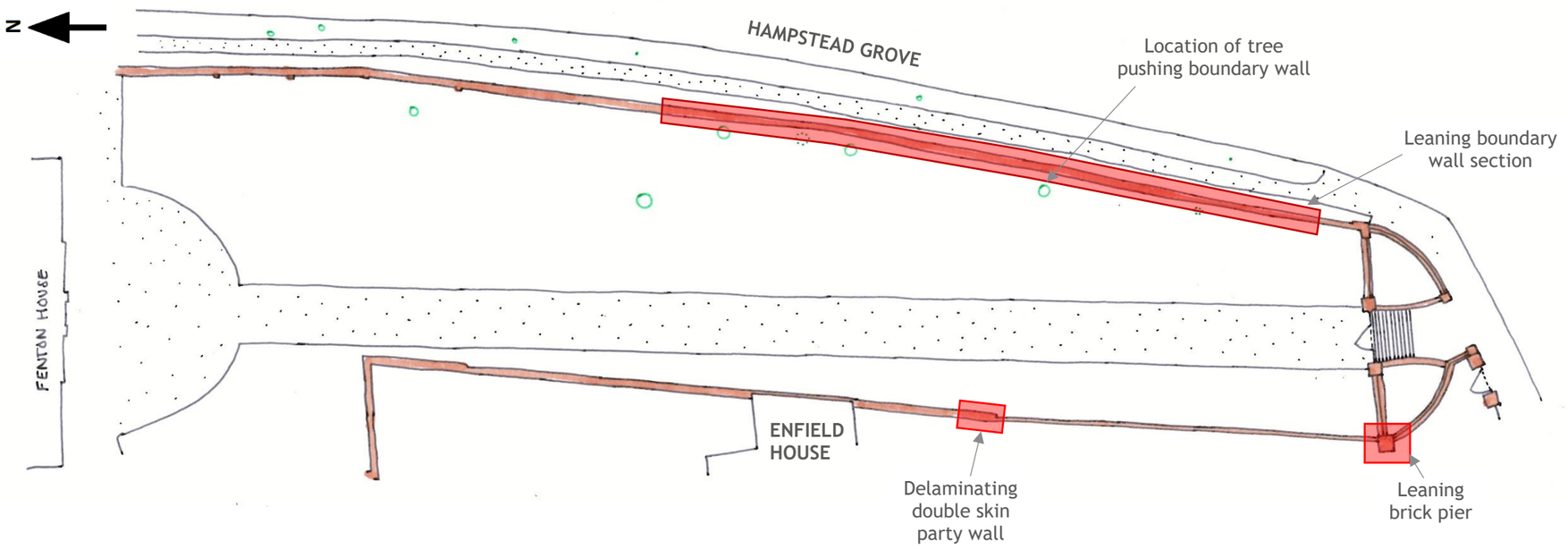


Figure 3 – Site Plan with elements highlighted

2.2 History of Fenton House

Fenton House is a detached property, and is believed to date back to 1693. The house was given to the National Trust in 1952. No exact dates are provided for the surrounding brick walls, although it can be assumed that they were constructed as part of the initial construction of the house in 1693, as the front gate to the south of the property, and associated initials, date back to the second owner of the house, Joshua Gee (1667 – 1730).

Archived information collated from the National Trust Property Office at Fenton House, alongside visual inspection, indicated the section of boundary wall surveyed has been rebuilt in some sections. More specifically, within the surveyed section of the leaning boundary wall, the bottom of the wall where the Robinia pushes the inner face of the wall has been repaired, as also noted in the Quinquennial 2016. However, it is unclear when this was carried out, and from visual inspection, it is clear that damage is continuing to be caused by the tree trunk. See Figure 4 below.

Remedial work took place, described in the archived document 'Article for Views', and is assumed to have been carried out between 2002 and 2016. The report described repairs using steel 'L' shaped supports on the internal face, secured below ground level to a concrete counterweight. This work was carried out on the northern section of the boundary wall between the south and east entrance gates, just north of the surveyed section of the boundary wall.

Figure 4 – Local repairs along surveyed section of boundary wall

2.3 Geology

No site specific geological information is currently available for the site. However, geological information for areas within the near vicinity of the site are available and have been collated from the British Geological Survey (BGS) and is summarised below.

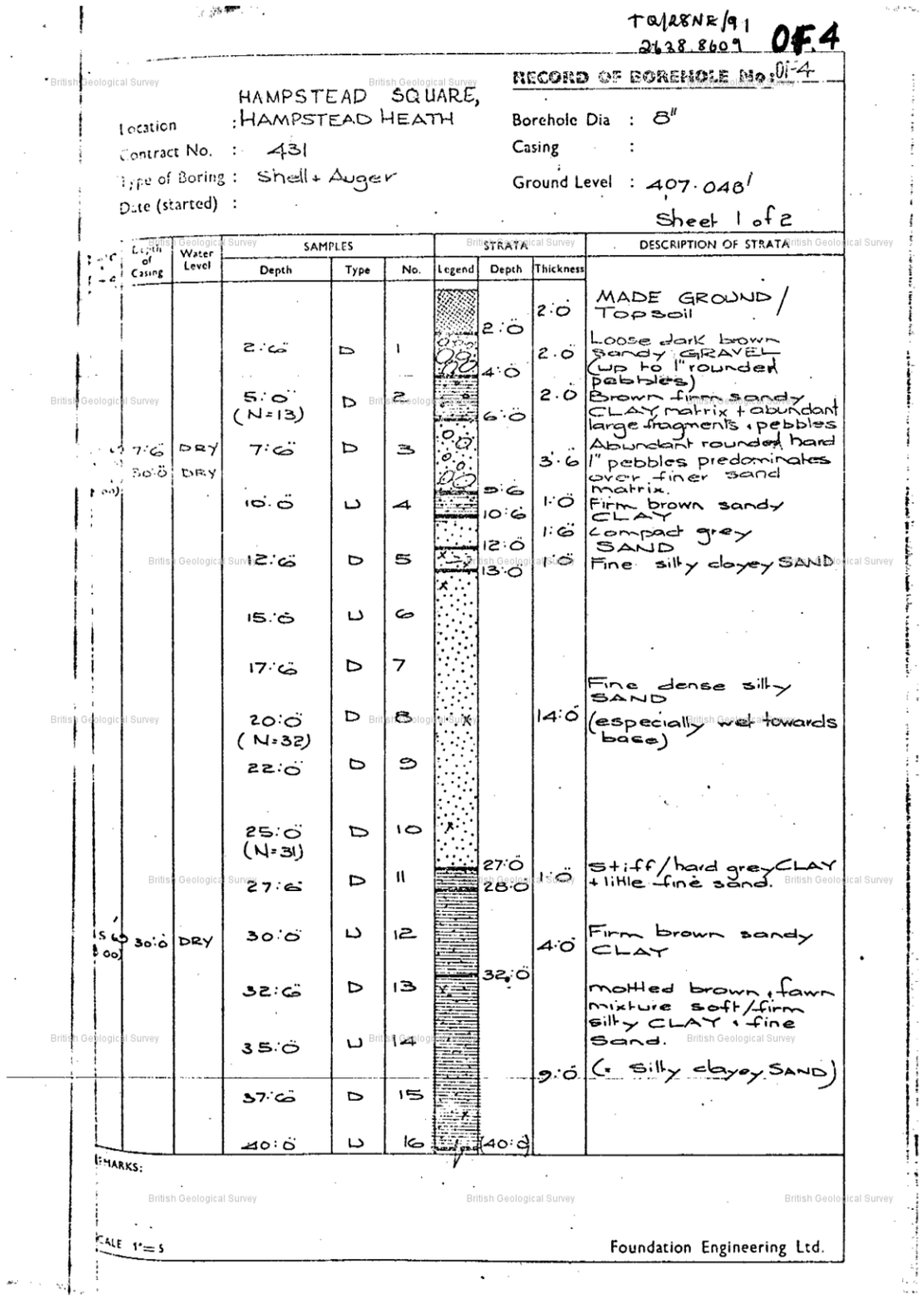
The underlying bedrock geology identified at the site by BGS is Bagshot Formation Sand, overlying Claygate, overlying London Clay (see Figure 5). No superficial deposits have been recorded.

Figure 5 -Local bedrock geology

In order to provide a representative example of what the site geology may be, borehole data from BGS, taken from a topographically similar location within the near vicinity of the site has been used (see Figure 6 below).

Figure 6 – Location of site and borehole locations

Borehole logs publicly available show approximately 0.6m (2') of made ground and topsoil, sitting on approximately 8 metres (27') of Bagshot formation sand, overlying the Claygate member. See Figure 7 for a more detailed description of each layer.



TQ/28NE/91 OF.4
2628.8609

RECORD OF BOREHOLE No: OF.4

Location : HAMPSTEAD SQUARE, HAMPSTEAD HEATH
Contract No. : 431
Type of Boring : Shell + Auger
Date (started) :
Borehole Dia : 8"
Casing :
Ground Level : 407.048'
Sheet 1 of 2

Depth of Casing	Water Level	SAMPLES Depth	Type	No.	STRATA Legend	Depth	Thickness	DESCRIPTION OF STRATA
						2·0	2·0	MADE GROUND / Topsoil
		2·6	D	1		4·0	2·0	Loose dark brown Sandy GRAVEL (up to 1" rounded pebbles)
		5·0 (N=13)	D	2		6·0	2·0	Brown firm sandy CLAY matrix + abundant large fragments + pebbles
7·6	DRY	7·6	D	3		9·6	3·6	Abundant rounded hard 1" pebbles predominates over finer sand matrix.
30·0	DRY	10·0	U	4		10·6	1·0	Firm brown sandy CLAY
		12·6	D	5		12·0	1·6	Compact grey SAND
		15·6	U	6		13·0	1·0	Fine silty clayey SAND
		17·6	D	7				
		20·0 (N=32)	D	8			14·0	Fine dense silty SAND (especially wet towards base)
		22·0	D	9				
		25·0 (N=31)	D	10				
		27·6	D	11		27·0	1·0	Stiff/hard grey CLAY + little fine sand.
		30·0	U	12		28·0	4·0	Firm brown sandy CLAY
		32·6	D	13		32·0		mottled brown, fawn mixture soft/firm silty CLAY + fine Sand.
		35·0	U	14			9·0	(+ silty clayey SAND)
		37·6	D	15				
		40·0	U	16		40·0		

REMARKS:

SCALE 1"=5

Foundation Engineering Ltd.

Figure 7 – Publicly available borehole OF.4 Sheet 1. Ground level is approximately level with the ground level at the southern entrance of Fenton House

3. Site Survey and Observations

A site survey was undertaken on the 9th October 2017 by Robert Westcott and Dominique Pitman (both of Civic Engineers) to understand the existing condition of the highlighted structures. Simon Bayley (National Trust) was also in attendance. The weather was mild and dry. There was access to the highlighted structures from the neighbouring Enfield House, the public highway, and from within Fenton House gardens.

Survey notes have been produced to capture the information gathered, and have been presented in the following sections.

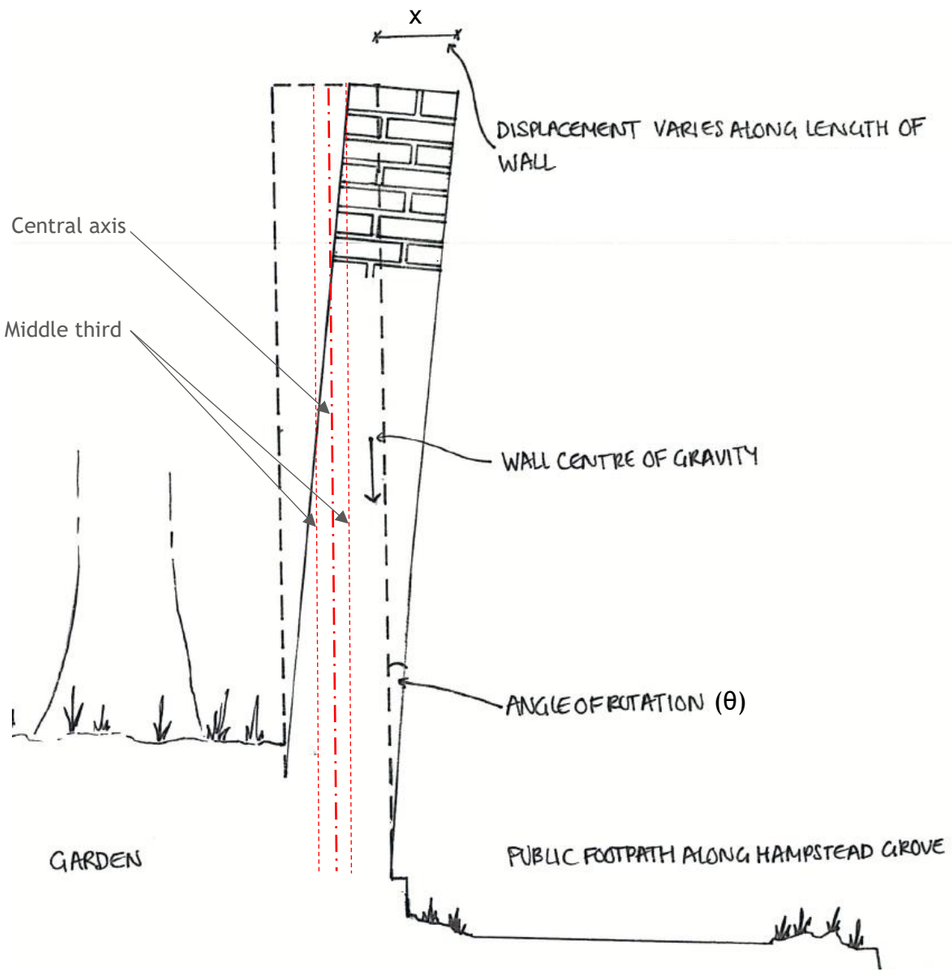


Figure 8 - Overturning of the eastern wall (see Figure 9 for values of x and θ)

3.1 Existing condition of the leaning boundary wall

As outlined in Section 2.1, the wall is leaning in an eastern direction, onto the public highway. Vertical measurements were taken during the site survey along the southern section of the boundary wall. The results can be found below in Figure 9.

	x	θ
	[mm]	[°]
A	185	4.1
B	190	4.2
C	110	2.4
D	125	2.8
E	130	2.9
F	190	4.2
G	250	5.5
H	270	5.9
I	270	5.9
J	160	3.5
K	200	4.4
L	200	4.4
M	110	2.4
N	115	2.5

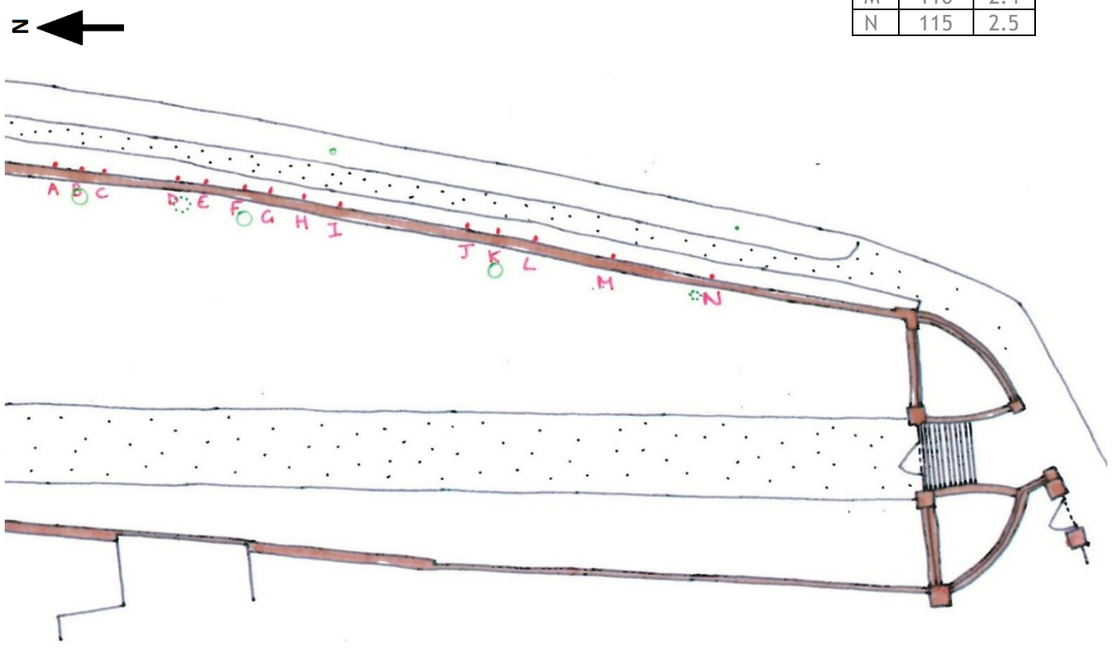
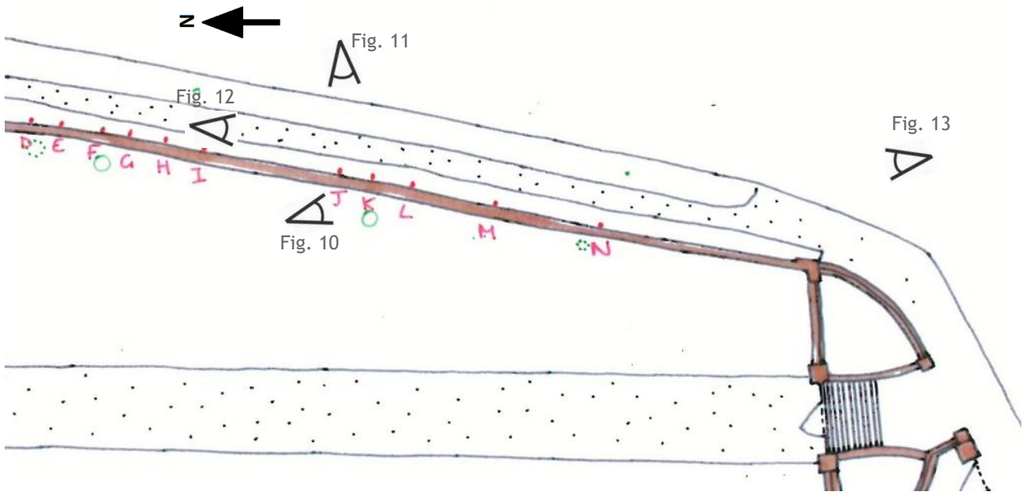


Figure 9 – Location of and measurements taken along the leaning boundary wall

The key observations recorded during the site survey of the eastern leaning boundary wall are presented below:

- The wall is 360mm wide, 2.7m high on the highway side, and 2.15m high on the internal side, tilting by various degrees along the surveyed section.
- The trunk of a large Robinia is touching the inner face of the boundary wall, pushing out the bottom of the wall (at point K in Figure 9, Figures 10 and 11).
- There is evidence of sections along the base of the wall that have been reset and repointed, but continuous pressure has caused localised cracking and fallen bricks onto the pubic footpath (Figure 11).
- Where there have been previous remedial works, namely the steel supports, the wall appears to be more vertical and stable than the southern, unsupported section.
- Measured from the bottom of the wall, at its maximum, the wall leans 270mm (5.9°). This is a critical lean, recognised by the centre of gravity (140mm from the central axis) located outside of the middle third of the base (60mm from the centre) (see Figure 8)



Key Plan

Robinia pushing against the boundary wall at location K (Figure 7)

Figure 10 – Robinia pushing inner side of wall

Robinia pushing against the boundary wall at location K (Figure 7) view from public highway

Figure 11 – External view of point K

Lean of boundary wall

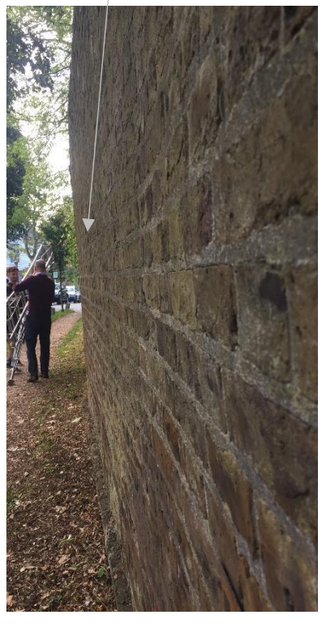


Figure 12 – Lean of wall

Figure 13 – External view of surveyed wall section

3.2 Existing condition of the brick pier

The key observations recorded during the site survey of the brick pier are presented below:

- The pier is 700mm by 700mm in plan, and 3.9m high at its tallest point.
- The western party wall has been rebuilt, and is leaning where it meets the pier. Since this reconstruction, the pier has displaced further, creating a larger joint between the wall and the pier, as shown in Figures 14 and 15.
- Mortar loss where the pier meets the single skin party wall, as shown in Figures 14 and 15.
- Measured from 3.1m down the pier, the pier leans at 120mm (2.2°) to the west, and 200mm (3.7°) to the south. This is a critical lean, recognised by the centre of gravity (120mm from the central axis) located outside of the middle third of the base (116mm from the centre) (see Figure 18).
- Viewing from the adjacent property, there appears to be a horizontal block bonded connection between the pier and the party wall, as shown in Figure 16.

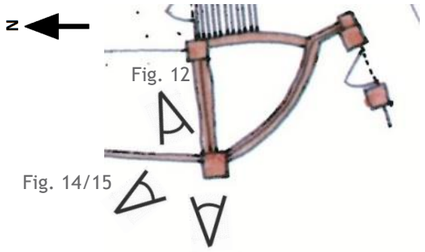
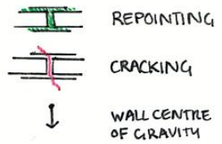


Fig. 13
Key Plan



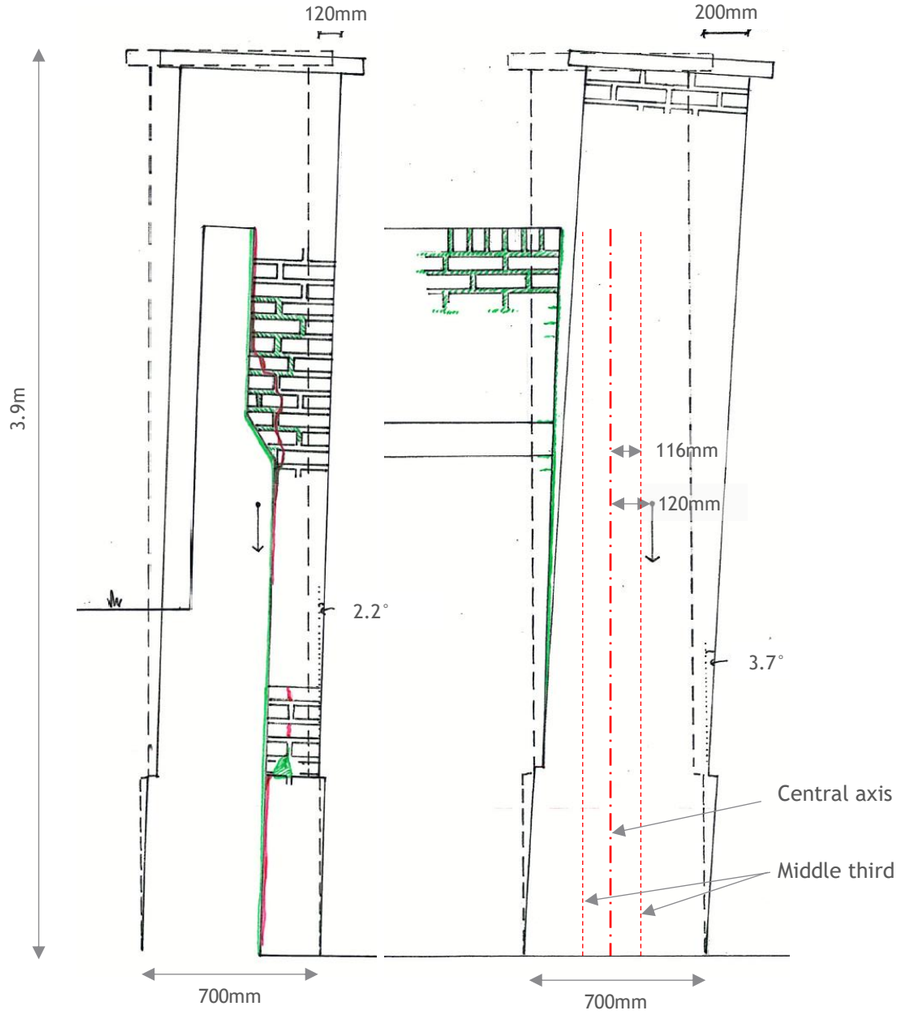


Figure 18 - Northern elevation of pier (left) Western elevation of pier (right)

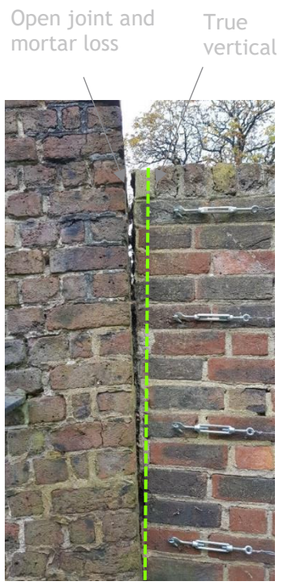


Figure 14

Figure 15

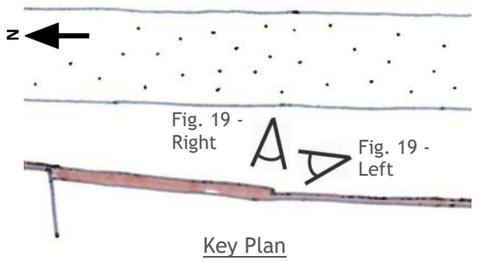
Figure 16

Figure 17

3.3 Existing condition of the double skin party wall

The double skin party wall as an approximate height of 1.8m, and width of 300mm. From the site survey, the double skin party wall appears to be delaminating, where the internal skin is breaking away from the rest of the wall.

The section of the wall where the change from a single skin to a double skin is where the worst of the delamination is, with an open joint at the intersection, as shown in Figure 19 below. As can be seen in Figure 19, this movement has also caused masonry loss.



Key Plan

Figure 19 – Opening from delamination of inner skin

4. Discussion and Recommendations

Based on the site survey observations outlined in Sections 3.1 to 3.3, the causation of each issue has been discussed and recommendations for remedial measures have been identified.

Leaning boundary wall

It is believed that the cause of the tilt along the surveyed section of the wall is likely to be associated with the tree growth near the wall, as the roots undermine and damage the foundations.

The lean is too significant to do nothing due to the risk of collapse into the public highway, remedial works are critical. The following remedial works have been identified, and are outlined further in Section 5.1:

- The wall needs to be stabilised and further overturning prevented.
- Consideration should be given to correcting the verticality of the wall, similar to earlier works carried out to the section further north, as identified in Section 2.2.
- Consideration should be given to removing some of the trees.

Brick pier

The root of the movement of the pier is concluded to be weakness and movement of the ground underneath the pier foundation.

The lean is too significant to do nothing due to the risk of collapse into the public highway, remedial works are critical. The following remedial works have been identified, and are outlined further in Section 5.2:

- The pier needs be stabilised and further overturning prevented.
- The open joint between the pier and the wall is to be repaired to prevent ingress of water or vegetation.
- The existing tie between the pier and connecting wall should be improved.
- Consideration should be given to stabilising the foundation by improving the ground conditions underneath it.

Double skin party wall

It is believed the delamination occurring in the party wall is caused from plant roots initially, most likely ivy roots, that have now been removed. Further delamination has occurred from the internal cavity filling up with debris and broken mortar, alongside ingress and retention of water, which expands when freezing, causing an increase in pressure.

The following remedial works have been identified, and are outlined further in Section 5.3:

- Internal layer should be stabilised, by tying the layers together effectively.
- The cavity should be filled in and closed up to prevent water ingress.
- Vegetation should be monitored to prevent further delamination along the party wall.

5. Options Study

An options study has been completed for the remedial actions required for each structure highlighted. The options considered, and the associated advantages and disadvantages, are outlined below.

5.1 Leaning boundary wall

5.1.1 Option 1 – Tie to new post and concrete counterweights

Option 1 is to tie into a newly constructed post. These posts and the foundations would be positioned in between the existing trees to try to minimise root damage. A site investigation with trial pits and boreholes will be required to define the details.

Advantages

- Long term solution;
- Visually consistent;
- Minimal intervention along the public highway;
- No loss of historic footprint.

Disadvantages

- Visual intervention above ground;
- Visually doesn't appear stable from the highway;
- Root and trunks growth will continue to cause damage at the walls base;
- Groundworks required, which could damage existing roots.

5.1.2 Option 2 – Tie as in Option 1 and pull vertical with new buttresses

Option 2 is to tie into a newly constructed post, as in Option 1, and slowly pull the wall back upright. A method similar to what was used in the northern section of the wall would provide visual consistency.

Additional Advantages to Option 1

- Appears more stable from the highway.

Additional Disadvantages to Option 1

- Higher upfront cost;
- Higher intervention and risk of damage to masonry during the works.

5.1.3 Option 3a – As Option 1 or 2, plus removal of adjacent trees

Option 3a is to do as described in either Option 1 or 2, combined with the removal of nearby trees.

Additional Advantages to Option 1/2

- Removal of the cause of wall damage, mitigates risk of subsequent damage to the wall.

Additional Disadvantages to Option 1/2

- Loss of trees in garden; visually unappealing.

5.1.4 Option 3b – As Option 1 or 2, plus creation of space for tree growth locally at base of wall

Option 3b is to do as described in either Option 1 or 2, combined with the opening up of spaces which are to be supported with lintels, to provide room for the tree roots to grow (see Figure 20 below).

Additional Advantages to Option 1/2

- Allows for the retention of trees;
- Mitigates risk of subsequent damage to the wall.

Additional Disadvantages to Option 1/2

- Loss of historic footprint;
- Possibility of reduced security.

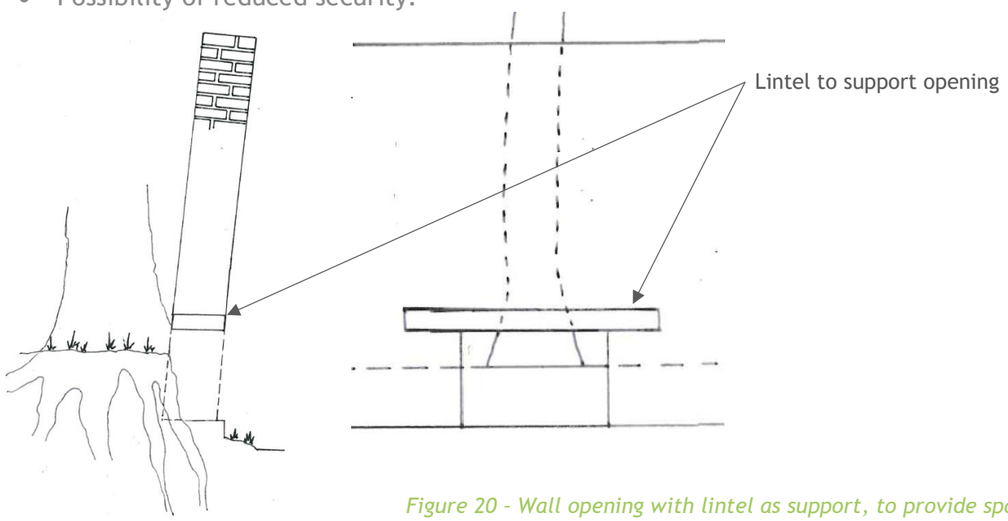


Figure 20 – Wall opening with lintel as support, to provide space for growth of trees. Left: Section. Right: Elevation

5.2 Brick pier

5.2.5 Option 1 – Tie in pier

Option 1 is to tie in the pier into the connected party wall using Cintec anchor sleeves (see Figure 21). The pier would rely on the wall as a counterweight. It appears to do this currently, although the connection is of poor quality.

Advantages

- Minimal loss of historic fabric;
- Minimal visual intervention;
- No groundworks required;
- Minimal intervention with the adjacent property;
- No dismantling or further investigation required.

Disadvantages

- Could produce cracking in connecting wall from increase in stress. However, calculations suggest there is a small risk.

5.2.6 Option 2a – As Option 1, with underpinning of the foundations

Advantages

- Minimum loss of historic fabric;
- Minimal visual intervention;
- Addresses the cause of the movement and reduced risk of passing problems into the connecting wall;

Disadvantages

- Groundworks required in neighbouring property;
- Further investigation required, in the form of trial pits and boreholes;
- Longer working time;
- Higher cost.

5.2.7 Option 2b – As Option 1, with ground improvement stabilisation, such as Uretek type

Additional Advantages to Option 2a

- Simpler and faster to install.

Additional Disadvantages to Option 2a

- Subject to survey of ground conditions.

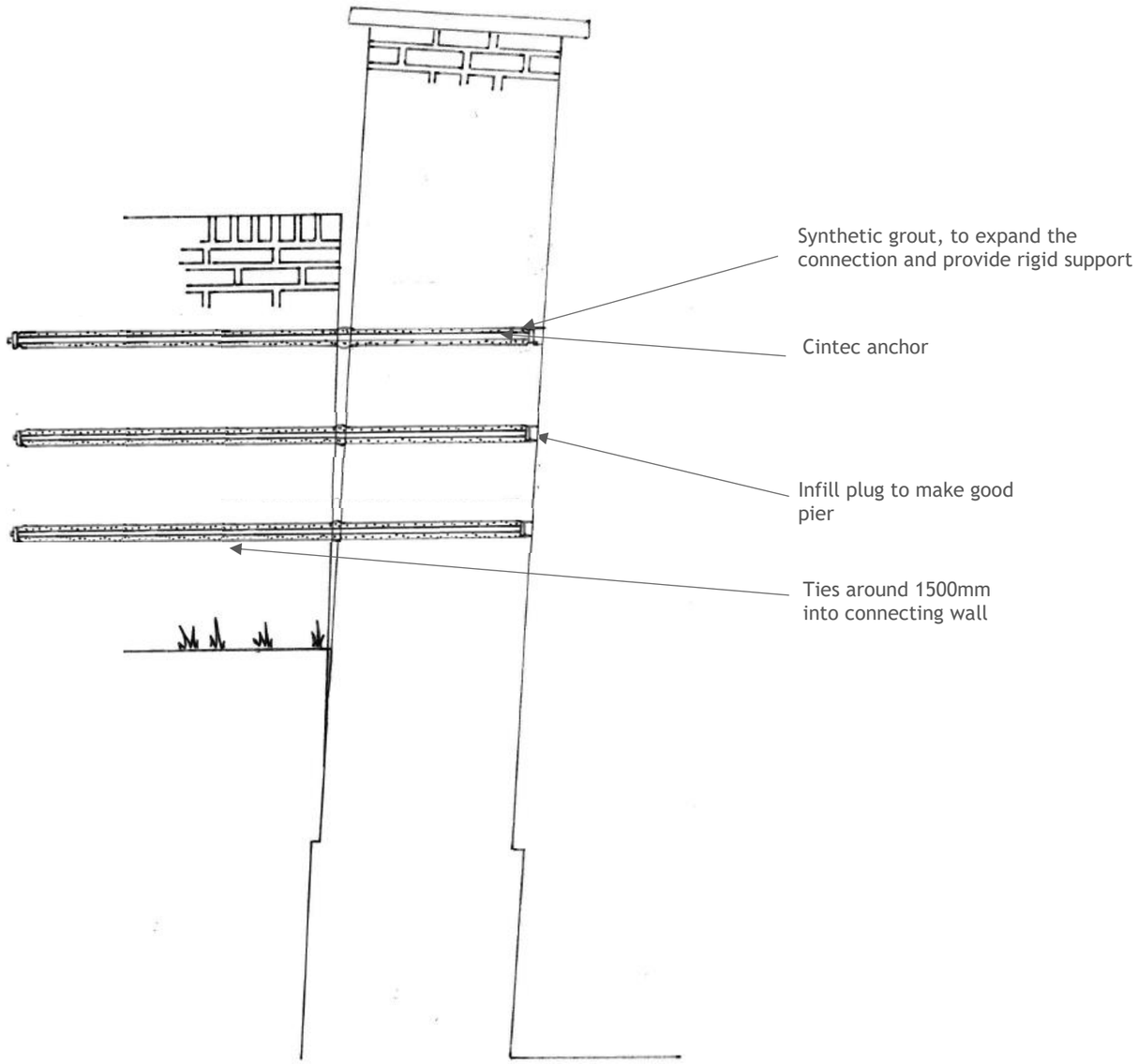


Figure 21 - Western elevation of pier showing Cintec cementitious sock anchors ties between the pier and the connecting wall

5.3 Double skin party wall

5.3.1 Option 1 – Do nothing

Option 1 is to do nothing to the inner skin and allow it to deteriorate and collapse naturally over time. Once the inner skin has collapsed a replica could be built in this location.

Advantages

- No upfront costs or work;

Disadvantages

- Visually unappealing until collapse and reconstruction;
- Could spread the delamination along the wall, and can lead to more expensive work in the long-term;
- Instability could become a health and safety risk to visitors and neighbours.

5.3.2 Option 2 – Repair wall and tie layers together (see Figure 22)

Option 2 is to carry out local repairs to the wall, ensuring the void is filled and sealed to prevent water ingress. The internal face will be stabilised using resin grouted stairib ancon bars or similar through the wall.

Advantages

- Long-term solution;
- No dismantling required, retaining original masonry used.

Disadvantages

- Visible intervention above ground.

5.3.3 Option 3 – Record, remove and rebuild

Option 3 is to record the current structure and its condition before removing and re-building it, using as much reclaimed masonry as possible, ensuring it is sealed to prevent water ingress.

Advantages

- Minimal loss of structural heritage;
- Original masonry reused;
- Long term solution.

Disadvantages

- Higher upfront cost;
- Conservation specialist may be required to complete the works.

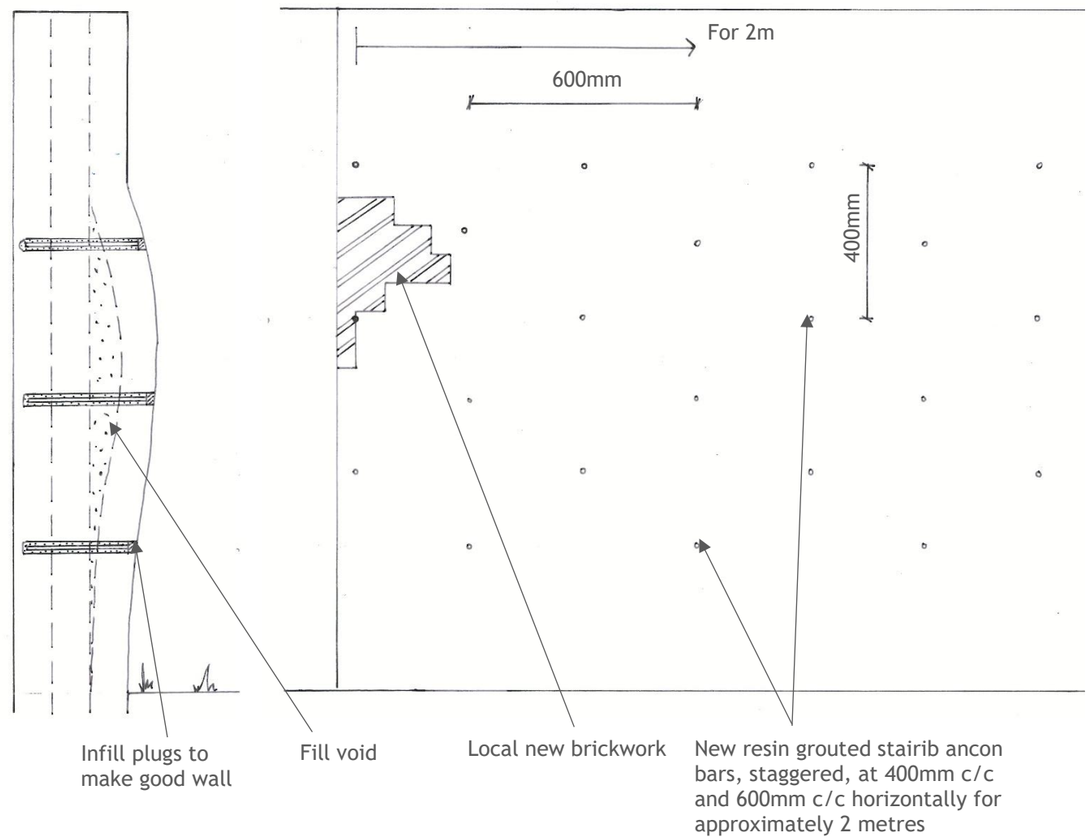


Figure 22 – Option 2, local repair of wall, inner skin stabilised with ties and voids filled, Left: Elevation, Right: Section

6. Conclusions and Risks

In conclusion, it is believed that vegetation and poor ground conditions supporting the foundations are the cause of the highlighted structural faults.

Due to the critical condition of the leaning boundary wall and the brick pier, it should be an aim to carry out remedial works on these elements fairly soon.

Potential remedial strategies for each element are outlined in Section 5. Consideration and discussion of these options is needed.

The key health and safety risks associated with the proposals outlined above include:

- Temporary stability of the boundary wall and brick pier;
- Working on a public highway;
- Working near utilities (brick pier);
- Working around large trees.

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