

London Road Fire Station

Courtyard Metal Stair

Condition Appraisal

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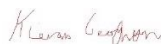
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Table of Contents

1.0	Executive Summary.....	1
2.0	Introduction.....	1
2.1	Background	1
2.2	Summary of Existing Structural Arrangement.....	1
2.2.1	General Form	1
2.2.2	Columns	2
2.2.3	Stair stringers	3
2.2.4	Landing Beams	4
2.2.5	Treads and landing	5
2.2.6	Level 1 wraparound walkway	6
2.2.7	Incoming Walkway beams	8
3.0	Condition and Structural movement during repair works	11
3.1	Original design Issues	11
3.1.1	Notched Iron columns	11
3.2	Lack of Lateral Stability Bracing & Tie beams	14
3.3	Historic Damage.....	14
3.3.1	Landing/ Walkway metalwork.....	15
3.3.2	General Beam corrosion	15
3.3.3	Cracking to Iron Columns / Beams / Stringers.....	17
3.3.4	Historic Interventions.....	23
3.4	Condition Encountered or Movement /Damage Occurring during 2021 repairs.....	27
3.5	Successful repairs (2022)	29
4.0	Conclusions and recommendations	29
5.0	Appendices.....	33

1.0 Executive Summary

This report summarises the structural form of the existing courtyard staircase, it's historic defects & interventions as well as 2021 works to clean, repairs and subsequent further damage which has concluded the stair is beyond repair.

It advises the stair be replaced near like-like to tie into the existing walkways but with contemporary structural materials and design standards.

2.0 Introduction

2.1 Background

The metal stair is original to the building constructed circa 1900 and is metallic frame composed of exposed iron and steelwork (painted).

It was subject to historic movement South Westwards (away from the balconies and adjacent building) and consequential metal cracking. Historically it has been subject various repairs/ interventions, which have generally been unsuccessful or unsympathetic leaving it in an unsafe condition.

Following a process of breaking out concrete walkways & cleaning the metal to enable effective visual inspection, design efforts were focussed on repairs in-situ with a view to retain the stair and prevent further degradation. However condition was worse than anticipated and 2021 repairs have not been entirely successful at arresting movement.

2.2 Summary of Existing Structural Arrangement

2.2.1 General Form

The stair is metallic structure (a mix of iron and steel). In addition to providing vertical circulation, also partially supports the level 1, Level 2, Level 3 walkways. The stair is comprised of 3no. columns bearing at Ground level (on assumed foundations) and 3no. Eastern columns bearing on top of the existing perimeter masonry walls (the Level 2 flat roof terrace).

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The columns are only connected via the iron Stringers or landing beams. The landings & treads are cast iron gratings.



2.2.2 Columns

The 6no. columns are 180x180 Cast Iron square hollow sections, with decorative bevelled corners. These feature decorative cast iron capping to prevent water ingress (but not been successful so suffered internal corrosion). Welded corbels are present under incoming stringers/ landing beams but these are not structural.



Iron columns with bevelled corners.



Columns showing welded brackets for supporting landing beams / stair stringers. Ineffective.

2.2.3 Stair stringers

The stringers are Cast Iron I-sections with narrow stocky flanges. Fixings to columns are via fin plates welded to the square columns. Bolt edge distances were insufficient so over decades so many have broken out the stringers or been repaired.



Stair stringers (supporting handrails)

2.2.4 Landing Beams

Landings are composed of a mixture of cast iron sections and small steel beam sections added historically to support half-landing gratings.



Original cast iron landing beams (bearing into wall), historic mild steel additions and some 2021 replacements.

2.2.5 Treads and landing

These are cast iron gratings. Many of the supporting bearings have generally been replaced historically with new steel angles due to breakages. Treads were re-attached with new bearings in 2021 to reinforce the connections to stringers.



Half

landing 0.33 showing compromised ledger angles / deck supports. Added at later date to poor standard.

2.2.6 Level 1 wraparound walkway

The level 1 walkway wraps around the Southern side of the stair. This is composed of mild steel sections supporting the original concrete slabs.

The steels connect spans between stair columns and to bear on the adjacent masonry wall which was in poor condition due to beam movement / corrosion. During 2021 refurbishment of the walkways, these 3 beams were replaced for new mild steel sections because these were severely corroded & un-repairable (see image below).



Level 1 showing severely corroded mild steel beam. Replaced as part of Balcony works.

Feature cast iron corbels support the Level 1 walkway as it wraps around the staircase. This put a cantilever twist into the columns so may have exacerbated the lean of the stair. Consequently, recent balcony interventions have added columns/beams under to 'prop' the outer edge of the balcony to relieve the stair of load.



Level 1 showing
cast iron corbels (cracked). Defects not shown.

2.2.7 Incoming Walkway beams

The incoming walkway beams (Levels 1,2, 3) were exposed during balcony refurbishment in 2021 and shown to be Mild steel channel sections and very poor condition in places. New beams were added underneath the existing beams (to the columns) to support the balcony without replacing original steels.



Level

2/3

Balcony-Column beams severely corroded: Replacement PFC required.



Level 3

showing pitted beams & notched cast iron (poor detail) which lead to complete cracked columns (crack obscured behind bracket).

3.0 Condition and Structural movement during repair works

The stair can be seen and surveyed to lean in both the Southern direction away from the walkways and also to the West away from the supporting Eastern level 2 terrace. This appears to be due to historic foundation settlement, in conjunction with lack of lateral stability such as Cross Bracing or fixed connections.

3.1 Original design Issues

There are notable problems with the original construction that have lead to poor performance over time.

3.1.1 Notched Iron columns

Columns are notched-out for incoming PFC beams. This is a very poor detail which has led to complete column cracking at level 3.



Column notching at Level 3: Cracking (lower half of column) not visible (obscured behind bracket).



Column notching at Level 3: Fully-cracked section. Column replacement required.



Cast iron column cracked baseplate. Also oversailing side of wall.



Cast iron column cracked baseplate. Column also oversailing both directions.

3.2 Lack of Lateral Stability Bracing & Tie beams

Ignoring ornate iron balustrades, there is no lateral stability system in place for the stair as would be expected. There is no diagonal cross bracing, and beam-column connections are not 'fixed' connections (as shown with connection below showing no connection to 'decorative' corbel). Therefore historic lean of the stair has had no system to prevent further movement.



Half

landing level 2.5 showing cracked column (historic repair attempt) and inactive spandrels providing no stability bracing.

3.3 Historic Damage

The stair has been in a suspect state for some decades as evidenced by previous historic repairs which have largely been ineffective strengthening the structure, nor historically sympathetically.

3.3.1 Landing/ Walkway metalwork

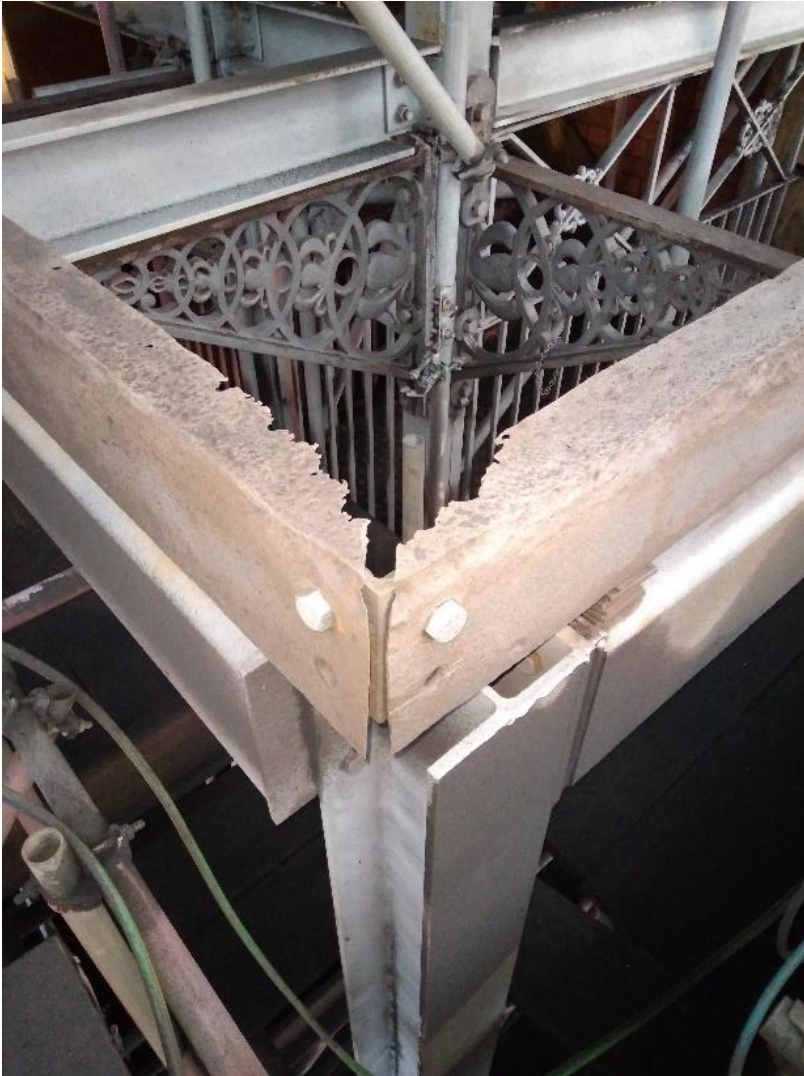
Corrosion damage has been largely focussed on what appears to be Mild Steel elements such as Walkway steels, landing beams. 2021 repairs focussed on replacing these bearings.



Historic additions of mild steel to replace lost Iron have corroded.

3.3.2 General Beam corrosion

As discussed in structural summary, existing walkway steels have suffered corrosion due to concrete-encasement. During 2021 repairs, some have been replaced and some reinforced by addition of additional structure directly under.



Beam-beam corrosion (supported by additional steelwork to avoid replacement).



Beam-column corrosion and connection failure.

3.3.3 Cracking to Iron Columns / Beams / Stringers

Corrosion damage to Cast iron has been less due to its greater inherent corrosion resistance. Damage to Cast iron appears more related to stress cracking, such as column cracking and stair stringer cracking (bolt holes break off).

Cast iron cannot be easily structurally repaired by welding due to the difficulty in site welding Cast Iron (compared to Mild Steel). Repairs therefore tend to be rudimentary mechanical (bolted) strengthening which are difficult to be aesthetically pleasing nor structurally effective.



Cracked landing beam at connection.



Cracked stringers with what appears historic repairs (bolt replacement).



Cracked corbel at bolted connection.



Column cracking



Column cracking (level 2 flat roof)



Iron Column corrosion (pitting)

3.3.4 Historic Interventions.



Historic bolted splice (to 1 face only).

It is clear from visual inspection (see image below), some attempts to site-weld cast iron columns has occurred which has been unsuccessful and may have made the column worse



Completely disconnected column with signs of historic welded repair (unsuccessful).

Historically there have been attempts to add stability bracing with tension cables (see image below), which have not been successful or failed in intervening years.



Tension cables added in 20th century. Ineffective repair. Now removed.

3.4 Condition Encountered or Movement /Damage Occurring during 2021 repairs



Recent stringer connection failure due to stress in beam.



Stringer lateral movement (on plan) away from existing masonry wall (level 2). (Not visible on image).



Further historic column cracking encountered to column bases / baseplates at Level 2 flat roof.

3.5 Successful repairs (2022)



Replacement

tread support brackets (curved metalwork).

4.0 Conclusions and recommendations

Visual inspection and structural appraisal has shown the original iron & steel frame has original design flaws including:

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- Inadequate foundations (as shown by staircase lean in 2 axes).
- Lack of lateral stability bracing to prevent excessive movement from said foundation settlement.
- Beam-column connection flaws including notching a cast iron (which has led to full column cracking).
- Beam-column connection flaws including inadequate bolt edge distances leading to connection failure including stair stringer beams.
- Stair Tread to beam connection flaws leading to historic replacement of bearings with mild steel (which have in turn corroded). Recent repairs have been a partial success.

Naturally it has also suffered significant degradation over its life, which has far exceeded its intended working life including:

- Corrosion to cast iron (pitting),
- Major corrosion to mild steel balconies and historic interventions (mild steel).
- Global stairwell Movement (foundation settlement) has led to column cracking and beam-column connection cracking.

Recent 2021 repairs have uncovered further design flaws and corrosion not visible previously and repairs have been partly unsuccessful due to lack of temp propping:

- Stringer movement on plan.
- Further stringer-column connection cracking.
- Baseplate cracking at level 2 (when opened up) as well as poor detailing (over sails edge).

The overall safety of the stair has worsened (despite the addition of Level 1 walkway propping), due to additional lateral movement that the stairwell has been subject to during tread repair works. Consequently, it is recommended the stair should be deemed unsafe and closed-off pending replacement or further repair works. If dismantled, existing members would need to be proven for re-use to contemporary coded standards (as per new steelwork) and most would undoubtedly be unable to be proven mathematically safe for re-use without visually obtrusive strengthening works and/ or costly physical load testing.

Replacement Stair- Mild Steel

A replacement stair should rectify the original design flaws, including:

- New columns which no-longer over-sail the Level 2 flat roof walls.
- Columns to be located to minimise eccentric of load (such as Balcony beams).
- Provide lateral stability bracing to resist wind loads and unforeseen lateral effects.
- New foundations to replace failed (settled) foundations.

The new stair should be of a contemporary structural steel construction to comply with modern design standards; notably Approved Document A & BS-EN-1993 (Eurocode 3 mild steel construction). However, if desirable steels

may be designed to appear Victorian in nature with careful selection of section types, in conjunction with re-use of non-structural original elements such as non-structural Cast Iron Spandrel brackets.

Other items such as Balustrades, Treads, Gratings are for Architect to determine if intended for re-use in the new stair layout and we will review capability.



Existing Cast-iron spandrel

brackets could be re-attached as non-structural decorative members.

Cast Iron

The original stair was predominantly cast-iron construction which was a rare departure from the rest of the Balconies & internal structure, due to its higher corrosion resistance to environmental exposure than more weather-protected mild steel used throughout the building. Despite this, corrosion has occurred due to its long lifespan beyond originally intended. A replacement stair could not be a like-like replacement due to unsafe design flaws in the original previously noted. Additionally, sourcing of structural-grade cast iron and specialist structural designer requirements would make this likely unfeasible on grounds of procurement. Architect's treads may be more feasible in Iron but grating profile would need to comply with 21st century DDA standards so may not be feasible in cast metal and would require specialist design/ load testing (like retained originals).



Example of replacement mild steel column

mimicking cast iron

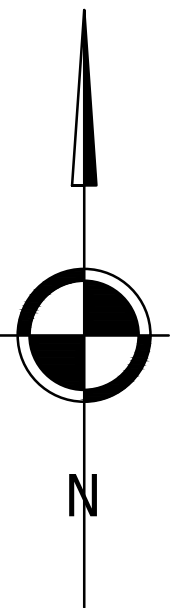
5.0 Appendices

Appendix A: Visual summary of defects and condition status.

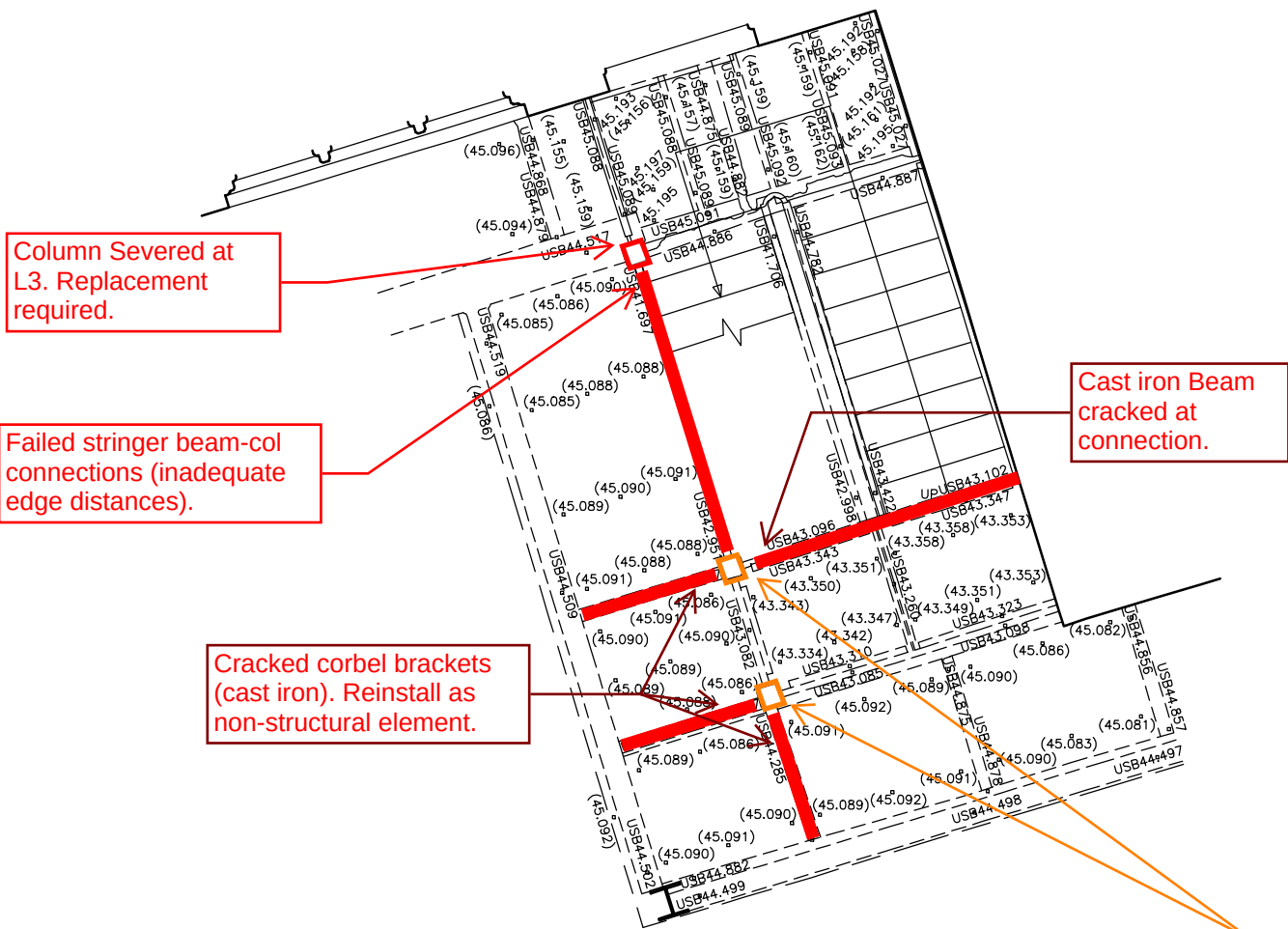
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USB88.88	Underside of Beam
USD88.88	Underside of Duct
USP88.88	Underside of Pipe
USS88.88	Underside of Shutter
USCR88.88	Underside of Cable Rack
CL88.88	Cill Level
HL88.88	Head Level
SP88.88	Arch Springing Level
CR88.88	Arch Crown Level

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- Severe Damage: Replace.
- Poor Condition: Monitor and consider strengthening.

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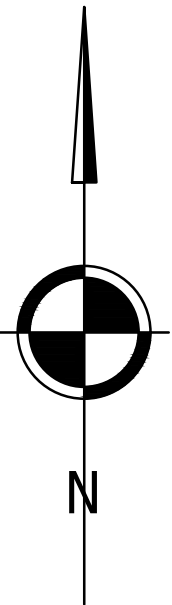
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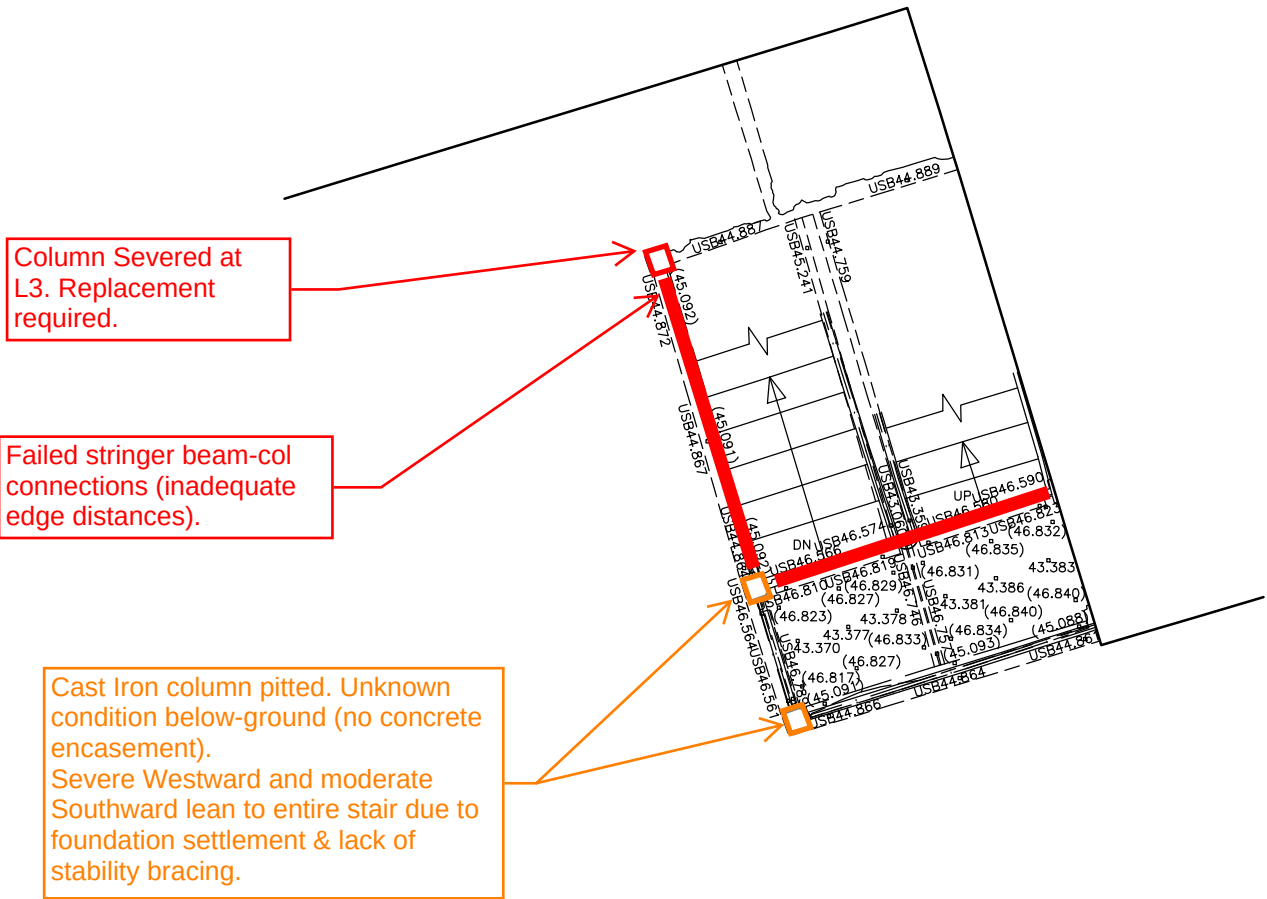
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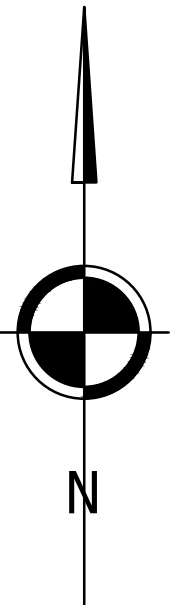
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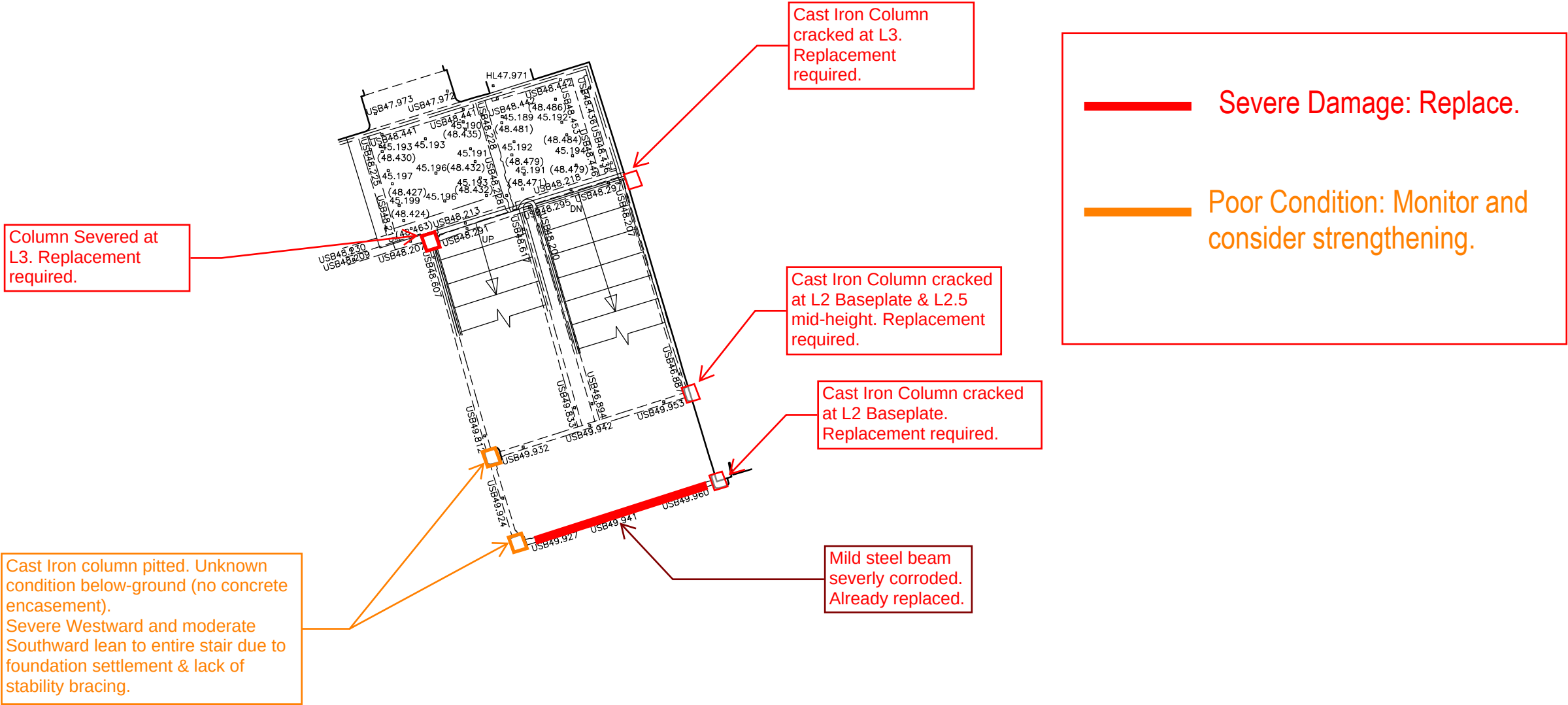
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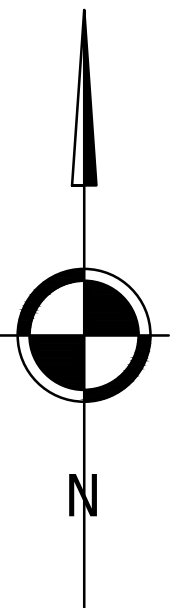
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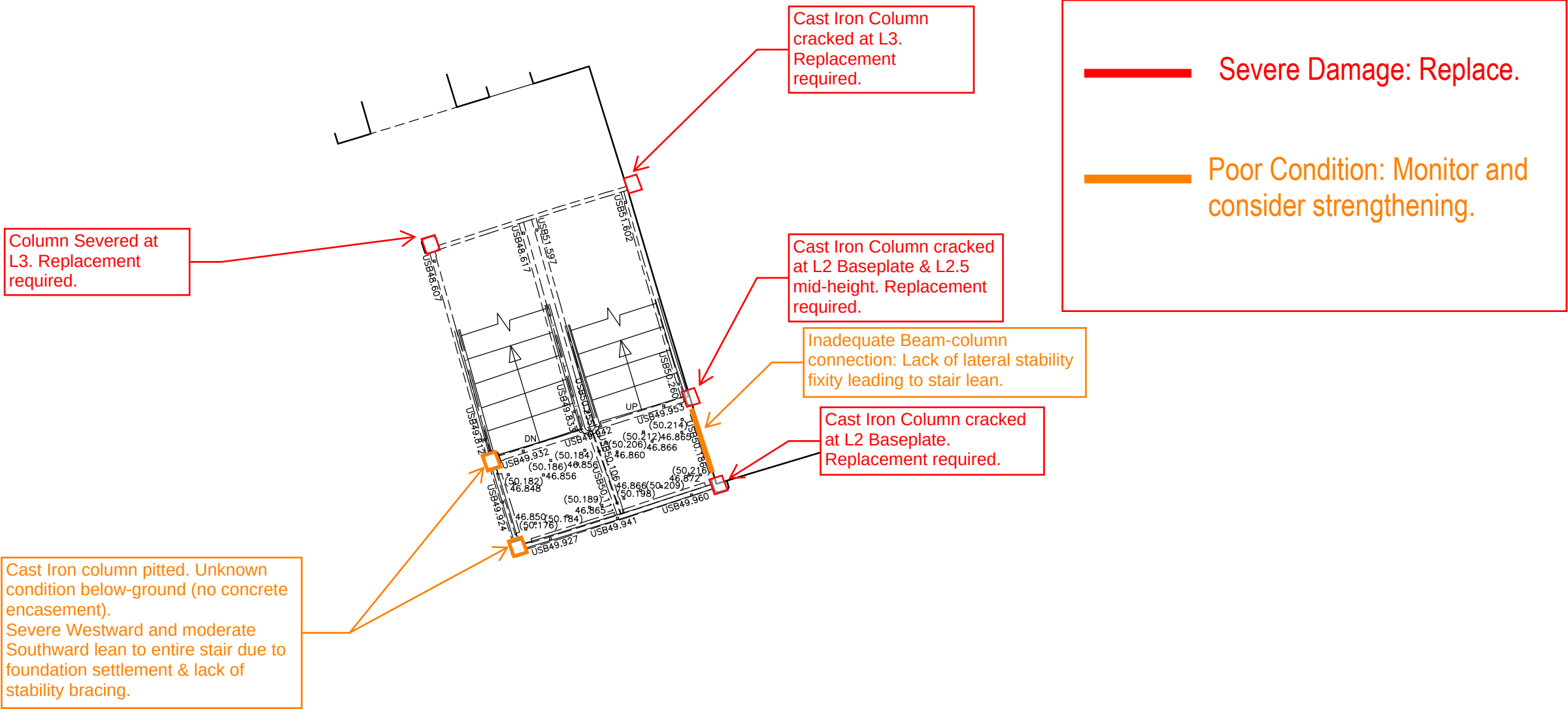
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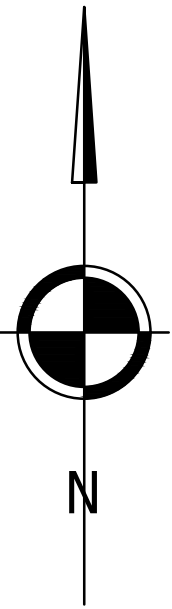
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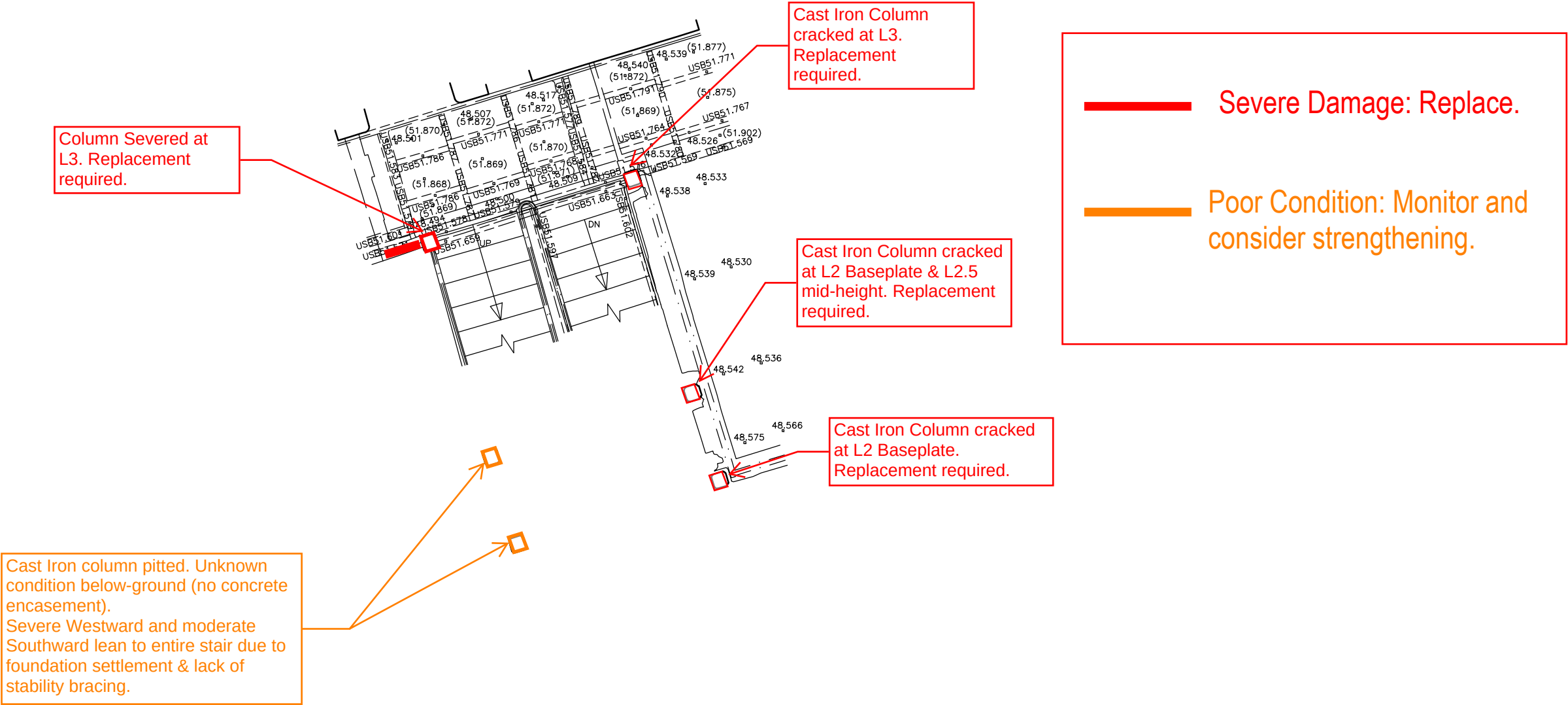
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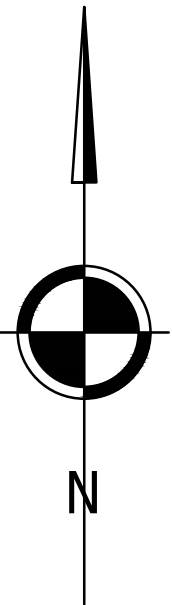
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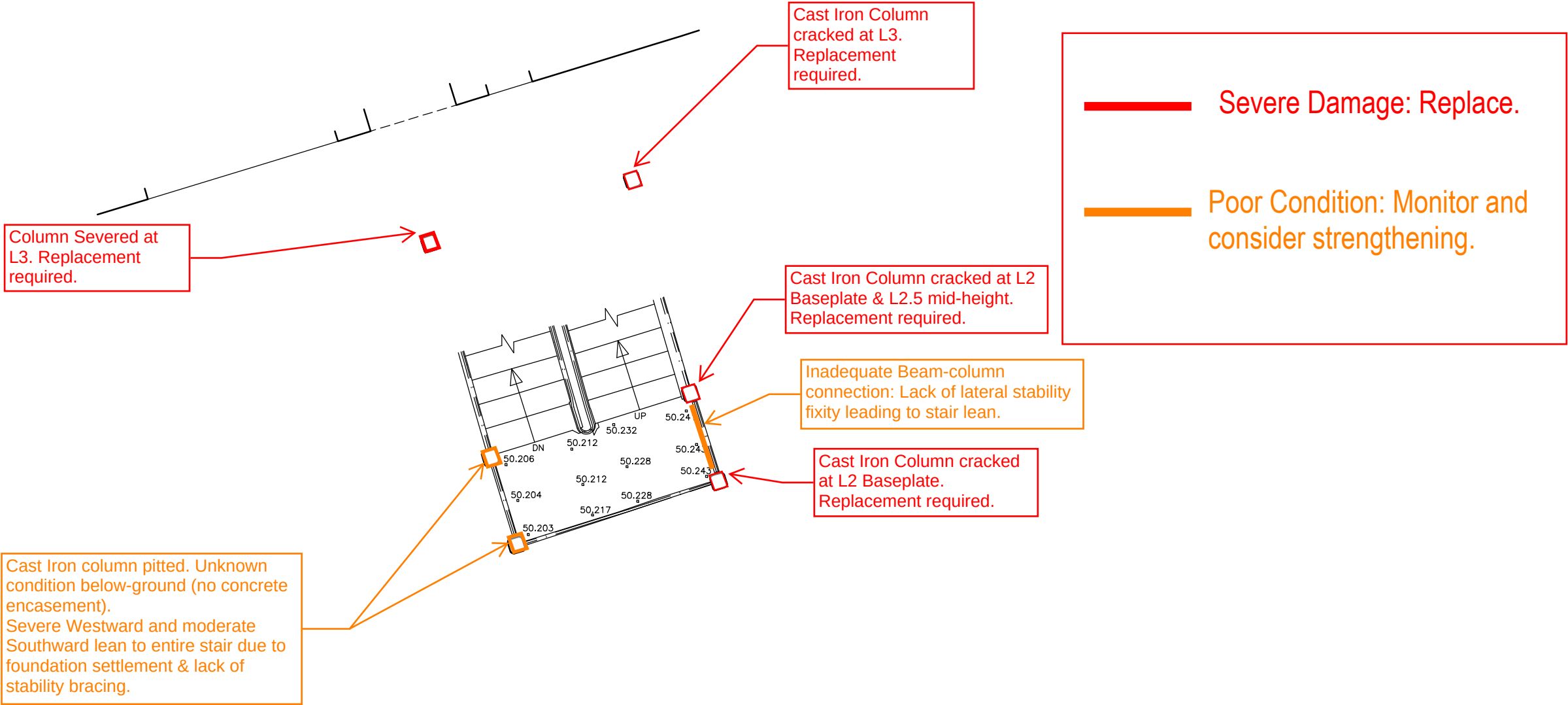
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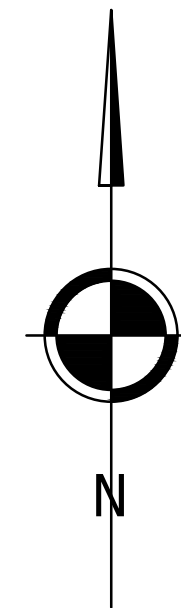
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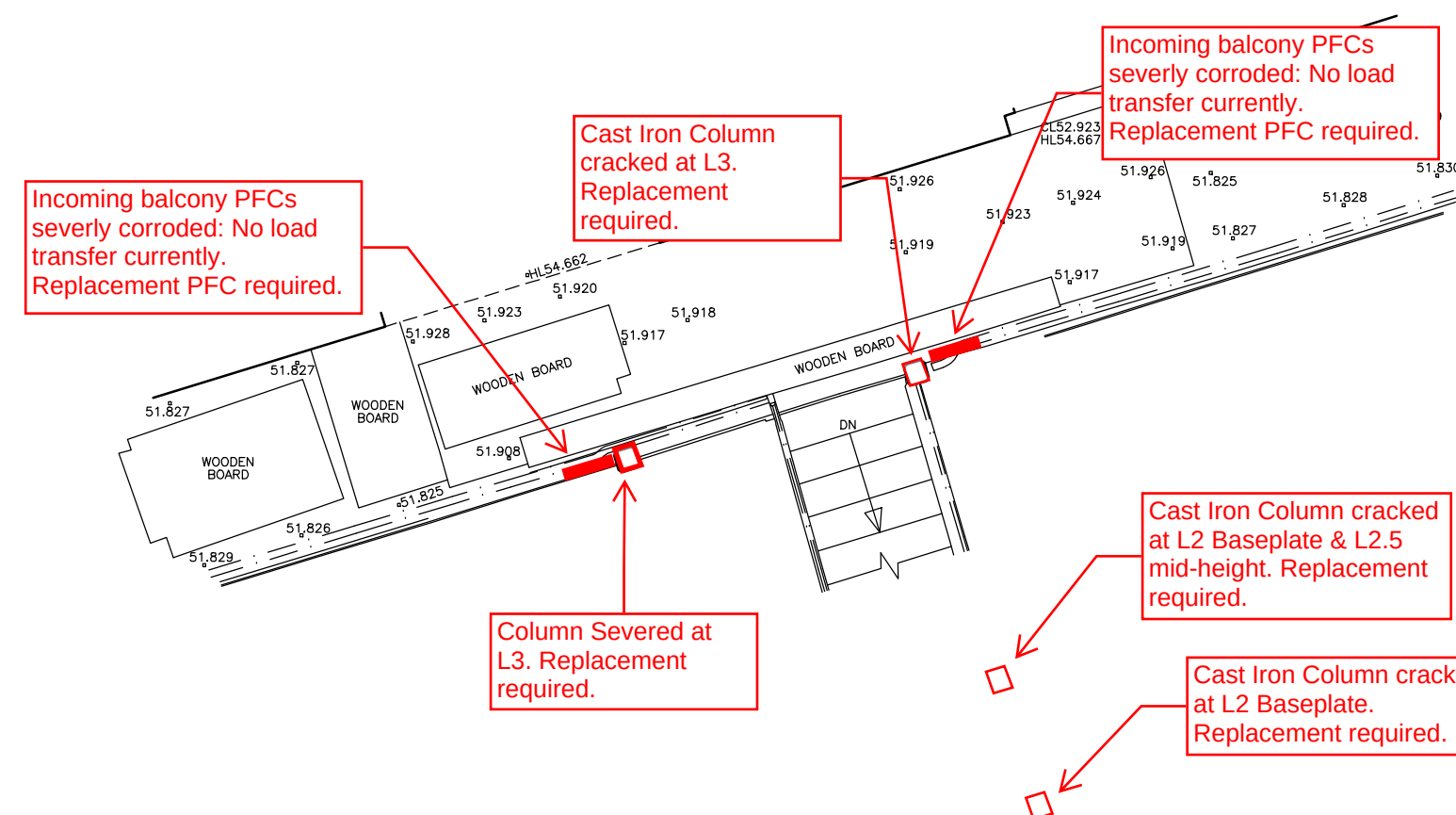
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Severe Damage: Replace.

- **Poor Condition: Monitor and consider strengthening.**

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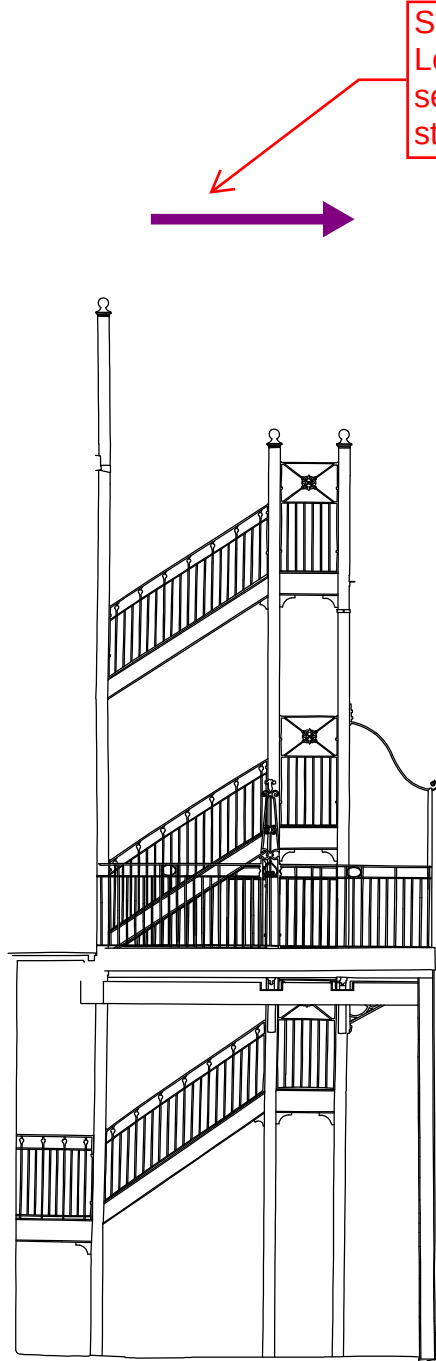
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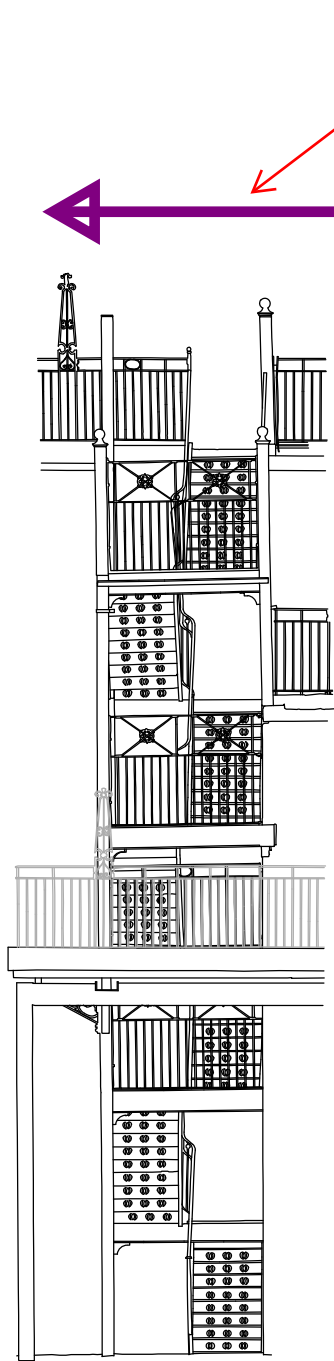
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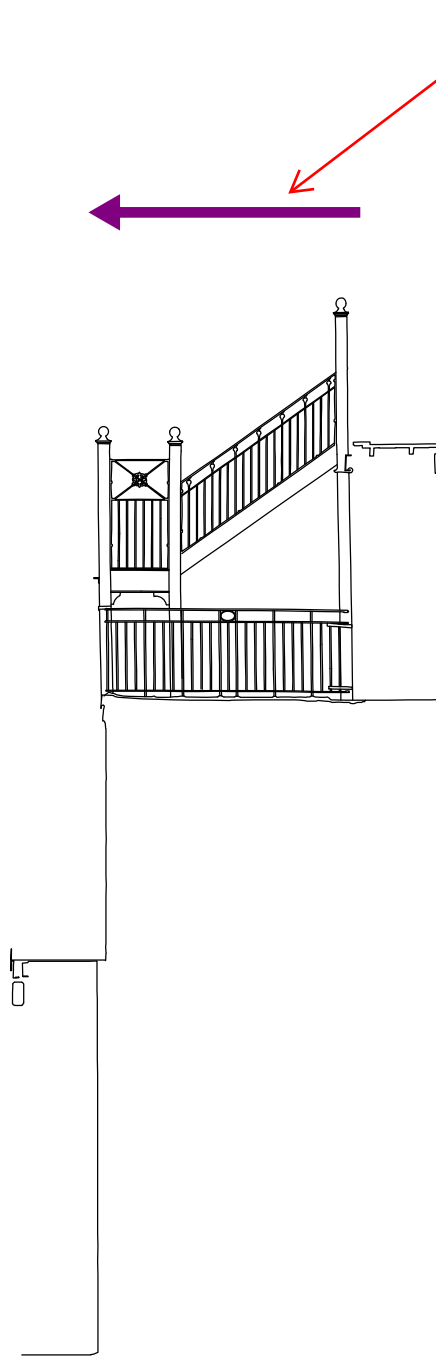
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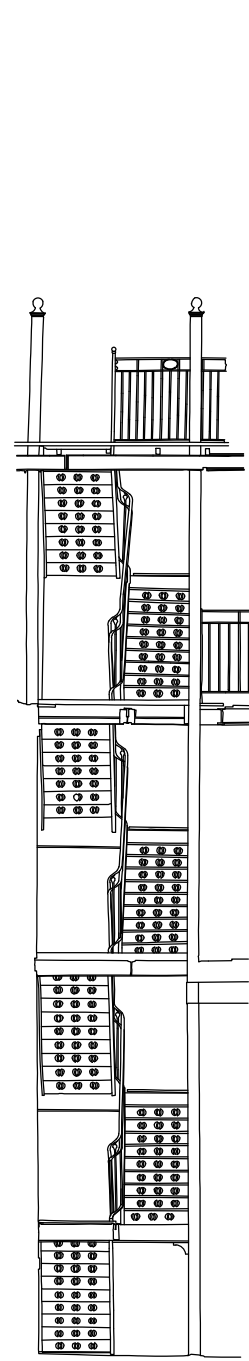
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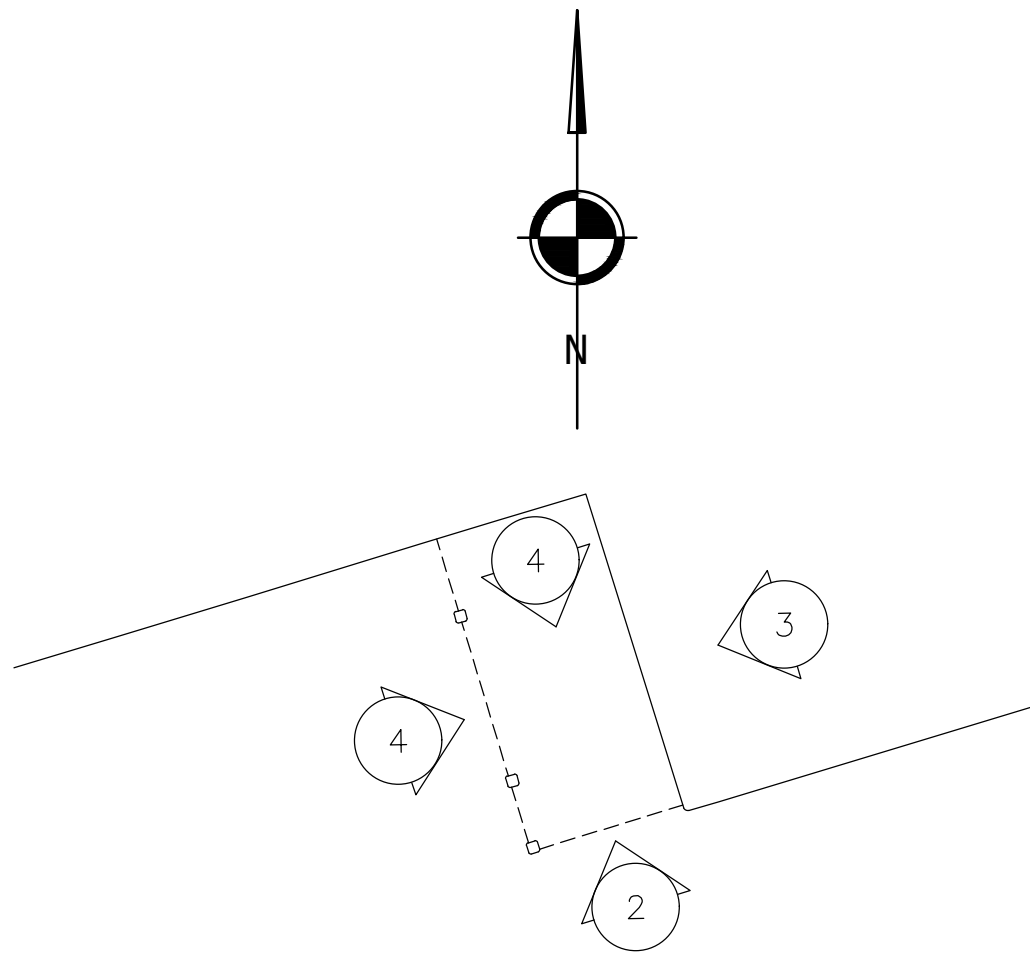
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Elevation 4



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Manchester

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Sheet Size & Drg Number & Revision

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