40 Leighton Road

Ground Movement and Building Damage Assessment Report

August 2021

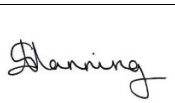
Mat Jones and Louise Willocks
40 Leighton Rd
Kentish Town
London
NW5 2QE

Draft Report

Report No. 70572-2

Document Verification

Prepared for	Prepared by
Mat Jones and Louise Willocks 40 Leighton Rd Kentish Town London NW5 2QE	Ground and Project Consultants Ltd, The Hub First Floor 19-23 Stamford New Road Altrincham Greater Manchester WA14 1BN

Signatures and Approvals				
Reviewer	G Manning BSc (Hons) MSc FGS		Date	29/07/2021
Author, and Approver	J Smithson BSc (Hons) MSc FGS CGeol		Date	5/08/2021

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1 Introduction

Ground and Project Consultants Ltd (GPCL) have been instructed by Mat Jones and Louise Willocks to carry out a Ground Movement Assessment for the proposed basement at 40 Leighton Road. A Basement Impact Assessment has been previously carried out (Reference 70572-1), dated April 2021.

The objectives of this report are to ascertain the expected ground movements and degree of any building damage at the structures adjacent to the site.

The scope of this report and approach are as follows:

- Summarise the expected ground conditions at the site;
- Develop an understanding of the proposals and their relationship to adjacent structures;
- Carry out an assessment of ground movement following the principles and procedures set out in C760 “Guidance on Embedded Retaining Wall Design”;
- Carry out a parallel check using Geo5 ‘Sheeting Check’ software and GEO5 ‘FEM’.

This report has been prepared and approved by Jon Smithson, BSc, MSC, FGS, CGeol who is a chartered geologist with over 35 years’ experience.

2 Background Information

2.1 Site Description

The site is located at 40 Leighton Road, Kentish Town, London, NW5 2QE. The site is in the London Borough of Camden. The National Grid Reference for the site is 529199, 185173.

The site is currently a two-storey terraced property with basement. It is understood the basement is approximately 2.5m in height. A small area of hardstanding is present to the front of the property and a garden with semi-mature trees to the rear of the property approximately 14m in length. The garden is accessed from the basement via steps which has a level higher than the basement but lower than the ground floor.

The site is bound and adjoined by Leighton Road to the north, 38 Leighton Road to the west, 42 Leighton Road to the east. Peckwater Health Centre is to the south. The terraces to the east of the property (No. 42) appear to have partial basements from Google Earth with stairs leading up to the front door. It is understood that the basement of No. 42 extends beneath the footprint of the main building. The property to the west (No. 38) has a basement extension visible on photos from the Existing Drawings and Photos in Appendix A. It is understood that the basement at No. 38 starts approximately 5m or 6m back from the front of the property and extending below a rear extension and external patio.

It is believed that the walls of the existing structure are underpinned by adjacent basement walls of the neighbouring properties or the original footings where no basement extensions have taken place.

There is a mature tree on the pavement to the front of the property.

No underground railways are anticipated beneath the site.

The site is in a Conservation Area.

The site is at approximately 40.2m AOD. The wider area slopes gently to the southeast at less than 2 degrees.

2.2 Proposals

The proposals for the site comprise the redevelopment of an existing residential property including the deepening of the existing basement to approximately 3.5m bgl (excavating approximately 1m deeper than existing), the addition of a basement light well to the front of the property, an extension with skylight to the rear of the property, removal of internal walls (including in the basement), extension of the first floor to the rear and the addition of a loft floor with new roof plan. A new garden room is also proposed to the rear of the garden to the very south of the site.

The construction method proposed includes casting new retaining walls in segments, installing lateral props at high and low level as the excavations progress. The floor slab is proposed to be partially suspended.

2.3 Geology

The ground investigation revealed that the geology comprises Made Ground to depths of up to 1.4m bgl, overlying firm to stiff London Clay Formation proven to 10.45m bgl. Roots were recorded to 1.5m bgl.

2.4 Hydrogeology

The London Clay Formation is an unproductive aquifer. Groundwater was not encountered during drilling or monitoring (>5.3m bgl), well below basement depth. However, groundwater levels may vary seasonally.

3 Assessment of Ground Movement

Movements have been assessed for the neighbouring properties and structures as follows:

- 38 Leighton Road
- 42 Leighton Road

Drawings which have been used in assessing basement and distances to adjoining and nearby structures are included in Appendix A. It is understood that the existing basement is to be deepened from approximately 2.5m bgl to 3.5m bgl, level with the proposed basement extension.

This assessment has taken into account that the underpinning will be in a hit and miss sequence and that shoring and horizontal propping will be used. Whilst it is acknowledged that the basement depth and excavation will be shallow relative to existing foundations ***the construction method should not leave existing foundations unsupported or vulnerable to ground movement from unsupported excavations or steeply battered excavation slopes.***

It is important to note that CIRIA report C760 is written for embedded retaining walls. Therefore, movement calculations for the excavation of soil and installation of underpins does not strictly apply to C760. There is no recognised method for calculating ground movements due to underpinned basements. C760 is used as a convenient and recognised approach. We have not included for the wall installation as the wall is not installed into the ground with the hit and miss underpinning method. Calculations have been carried out using Geo5 Sheeting Check software for the basement retaining walls.

It is recognised that settlements are generally minor where care in construction and appropriate precautionary measures are taken in this type of basement construction.

It is recommended that where the understanding of movements is significant, appropriate instrumentation should be installed to monitor ground movement before and during construction.

Design drawings developed by the engineer have been reviewed and used to inform this assessment.

The following key assumptions have been made:

- The detailed design of the basement (and associated temporary works) has been carried out by an appropriately qualified and experienced structural engineer, to current professional standards and best practice.
- The maximum excavation depth is approximately 3.5m below existing ground level.

- The method of basement construction will be as per the drawings, see note above, and will be carried out with due skill and care by an appropriately experienced contractor.
- A high wall stiffness has been assumed.
- The wall will be propped promptly using closely spaced props in the temporary case.
- In the permanent case the wall will be permanently propped at floor level and ceiling level.

For the purposes of the calculations, the parameters of the subject properties have been estimated as included in Table 1.

Table 1: Property Dimensions and Proximity

Property	Distance from basement (m)	Height (m)	Length (m)	Width (m)	Differential Basementdepth (m)
38 Leighton Road	0	9	16.5	5	3.5*
42 Leighton Road	0	9.5	10	5	2

***Front part of house only, rear has 2.5m basement**

It is assumed that the soils are competent soils as encountered in the ground investigation. Made Ground is encountered to approximately 1.4m bgl, overlying firm to stiff clay of the London Clay Formation. Groundwater was not encountered.

The ground model used during the analyses is shown in Table 2 below. Characteristic values have been assigned to the weathered London Clay obtained from SPT correlations and published research. Values of Young's modulus have been derived using the empirical formula $E_u=400C_u$ outlined in CIRIA C580.

Table 2: Ground Model

Strata	Unit Weight (kN/m^2)	Effective angle of friction (deg)	Effective cohesion (kPa)	Drained Youngs Modulus, E' (MPa)[1]	Poisson Ratio
Made Ground	17	22	0	8	0.3
London Clay	18	25	0	14	0.2

[1]Based on $E' = 0.6E_u$ for stiff clays. Look, B., 2007. *Handbook of geotechnical investigation and design tables*.

4 Assessment of Building Damage

4.1 Movement due to wall installation and excavation following C760

The following ground movements have been calculated in relation to ground movements, using Figure 6.16 in C760.

Table 3: Damage Assessment using the Burland Scale

Property	**Maximum Vertical Deflection Δ (mm)**	**Maximum Horizontal Movement dh (mm)**	**Building Damage Assessment**
38 Leighton Road	3	1	1 Very Slight
42 Leighton Road	1	2	1 Very Slight

*In addition to assessing ground movement, some consideration should be given whether to include an allowance for the shrinkage of the dry pack at the wall. It is considered that the dry pack may shrink nominally at the wall only. Burland Scale categories 0, 1, and 2 refer to aesthetic damage, category 3 and 4 relate to serviceability and function, and 5 represents damage which relates to stability. The main objective of design and construction is to maintain a level of risk to buildings no higher than category 2 where only aesthetic damage is considered acceptable.

Note that the figures above do not necessarily represent the total ground movement but the maximum differential movements which are predicted to be experienced by the building. The ground movement and building damage calculations are appended.

The calculations assume that the wall is propped and that the wall and excavation are adequately supported in the temporary case.

There are a number of key points to note in using this assessment:

- Most ground movement will occur during excavation of the basement and construction so the adequacy of temporary support will be critical in limiting ground movements.
- The speed of propping and support is key to limiting ground movements and limiting unpropped wall heights.
- Good workmanship will contribute to minimising ground movements.
- The calculation assumes the wall is in competent soil as per the findings of the ground investigation.

Ground movement can be minimised by adopting a number of measures, including:

- Ensuring that adequate propping and support is in place at all times during construction.
- Installation of the first (stiff) support quickly and early in the construction sequence.
- Avoid leaving ground unsupported.
- Minimise deterioration of the unexcavated soil mass by the use of blinding/ covering with a waterproof membrane.
- Avoid overbreak.
- The control and appropriate design of any dewatering process must ensure that fines removal and drawdown are minimised.

It must be noted that the movements are calculated values based on the findings and methods of CIRIA C760. Larger movements may be generated if anyone or any combination of the above recommendations and/or assumptions are not heeded or if ground conditions are different from those anticipated by the investigation.

The actual magnitude of these movements will depend upon a number of factors described above and the nature of the ground expected may give rise to larger movements.

4.2 Geo5 Sheeting Check Analysis

Further assessment of the basement construction on the adjacent properties has been carried out using "Sheeting Check" developed by GEO5. The results are included in Table 4 below.

Table 4: Geo 5 Sheeting Check Results

Property	Maximum Vertical Movement (mm)	Distance from the wall (m)	Maximum Horizontal Movement (mm)	Building Damage Assessment
38 Leighton Road	2.6	1	2.6	0 Negligible
42 Leighton Road	6	0.7	6	1 Very Slight

The results are broadly in line with the CIRIA C760 method results. The output sheets are provided in Appendix D. Note that since a basement already exists the maximum movement is taken for the last stage only.

Computer analysis demonstrates that ground movements are highly sensitive to prop and wall stiffness, so the use of stiff props both in the temporary and permanent cases is essential.

4.3 Geo5 FEM Analysis

Analysis of ground movement has been carried out using GEO5 FEM software to provide a check and generate a visualisation of ground movement.

Property	Maximum Vertical Movement (mm)	Maximum Horizontal Movement (mm)
38 Leighton Road	1	0
42 Leighton Road	1	0

The calculated settlements are similar to those calculated using the C760 method. The output is included within Appendix D.

5 Monitoring

Expected movements are such that they may not manifest themselves in monitoring through survey work. The GMA has predicted that building damage will fall into the "very slight" category. We suggest the system of alerts and actions in table 3 below. These should be developed and finalised by the Structural Engineer.

Table 5: Monitoring Alerts and Actions

Amount of horizontal/vertical movement recorded	**Action**	**Comments**
0 to 3mm	None, continue monitoring	Damage likely to be negligible
+/- 3mm	Inform engineer, engineer to visit site	Damage likely to be negligible or very slight
+/- 6mm	Cease work. Inform engineer, engineer to visit site and advise on changes to working practice etc	Damage likely to be slight or worse

6 Conclusions

The results of the Ground Movement Assessment and Building Damage Assessment have found that the potential risk to the neighbouring properties is in the Very Slight category. This is understood to be an acceptable level of risk.

The basement will be constructed mainly in the London Clay Formation with some Made Ground near the surface. Uncontrolled groundwater seepages may cause fines to washout in the short term. Most ground movement will occur during excavation of the basement and construction so the adequacy of the temporary support will be critical in limiting ground movements.

Monitoring should be carried out to make sure the movements are within acceptable limits.

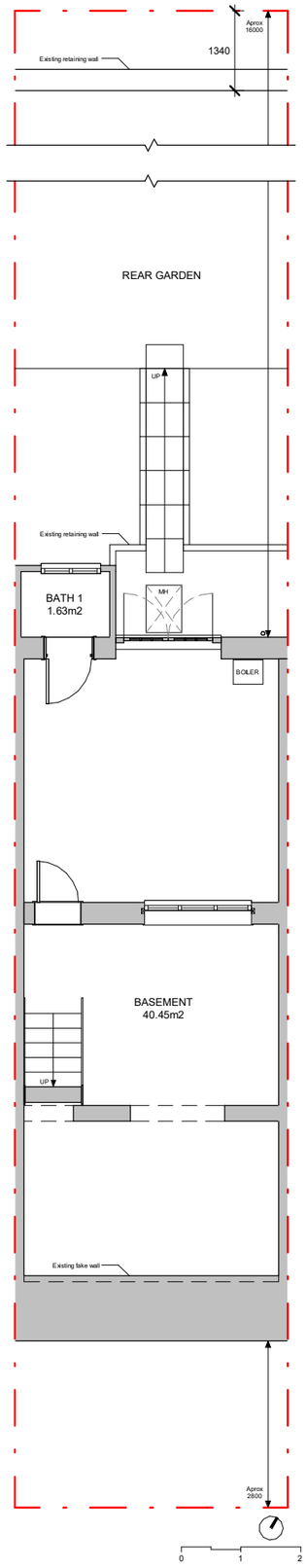
Appendix A

Drawings

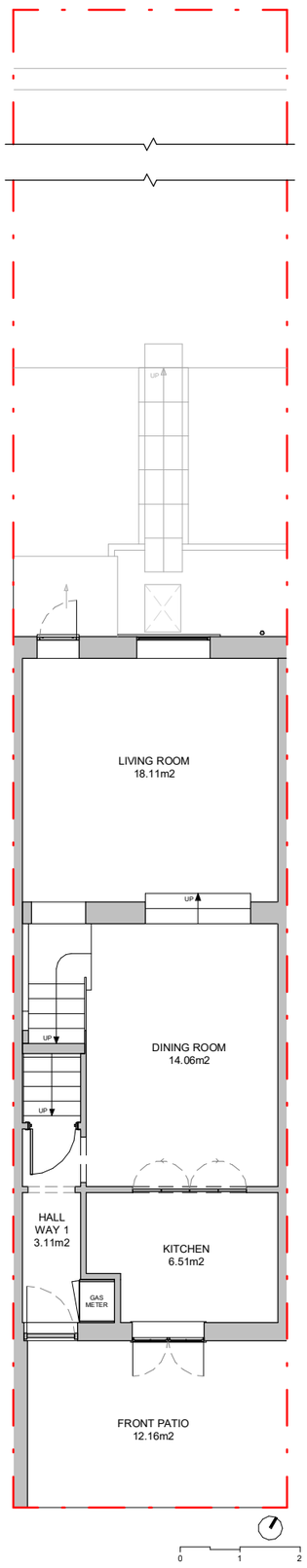
EXISTING PLANS

KEY LABEL

- Boundery line
- Existing walls



BASEMENT PLAN — SCALE 1:100 @A3



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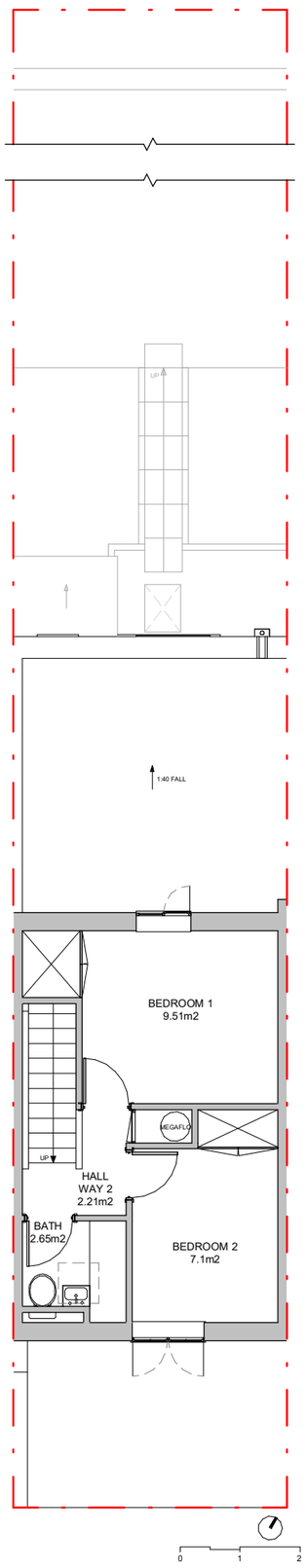
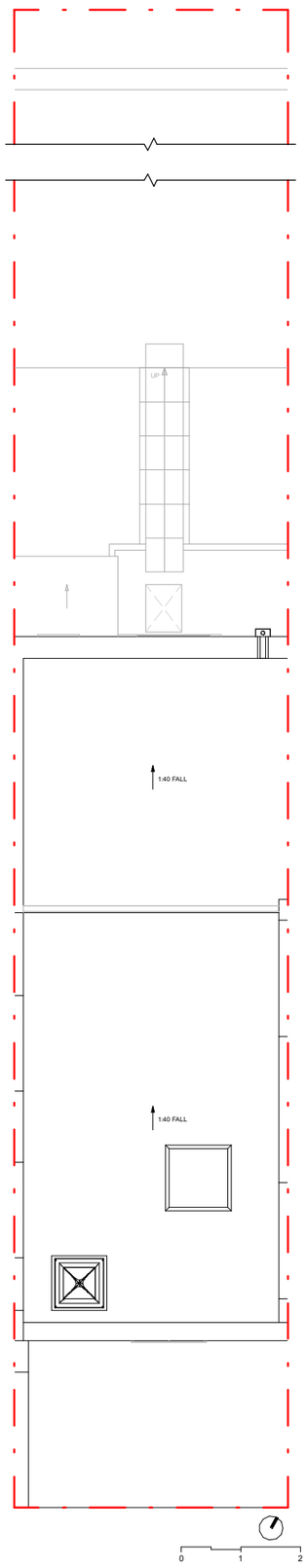


FIRST FLOOR PLAN — SCALE 1:100 @A3



ROOF PLAN — SCALE 1:100 @A3

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PROJECT:
BASEMENT EXTENSION + ONE STOREY REAR EXTENSION + MANSARD

ADDRESS:
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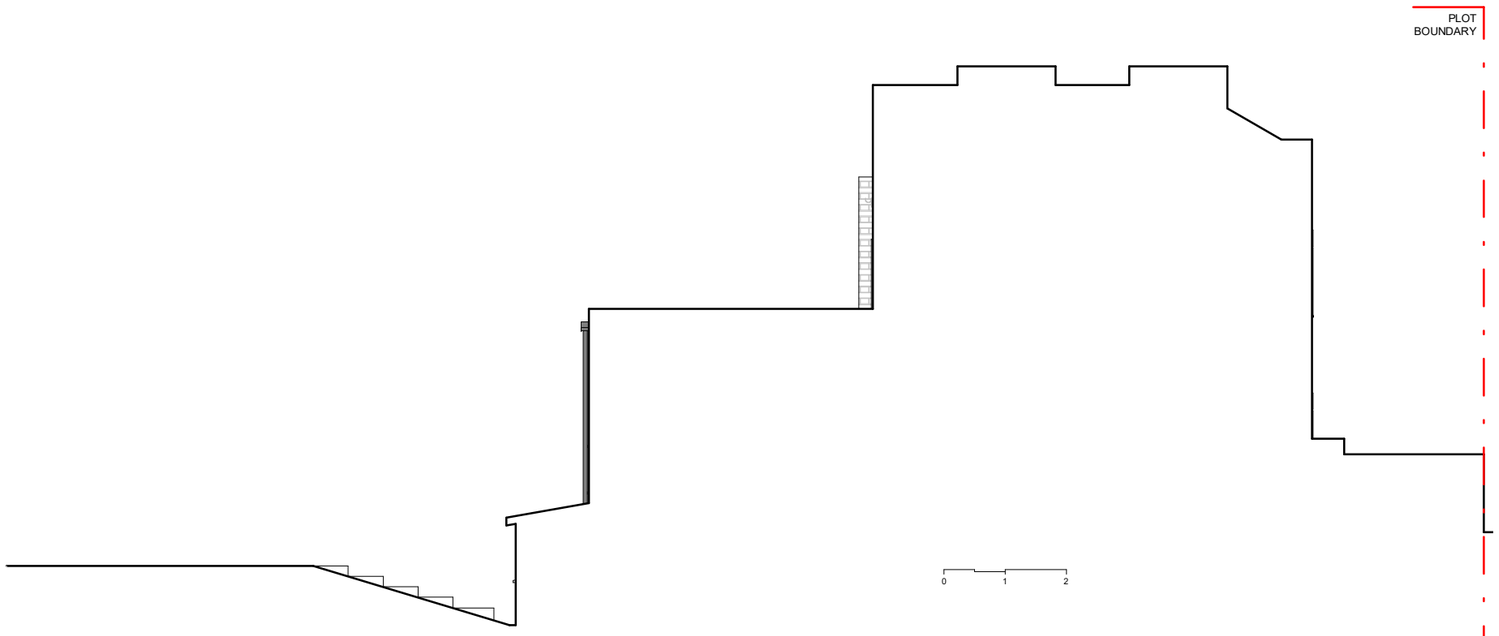
TITLE:
EXISTING
PLANS

DATE:	PROJECT NUM:
08/01/2021	P-019
SCALE: 1/100 (@ A3)	DRAWING NUM: EX-01
REV: A	STATUS:

EXISTING ELEVATIONS

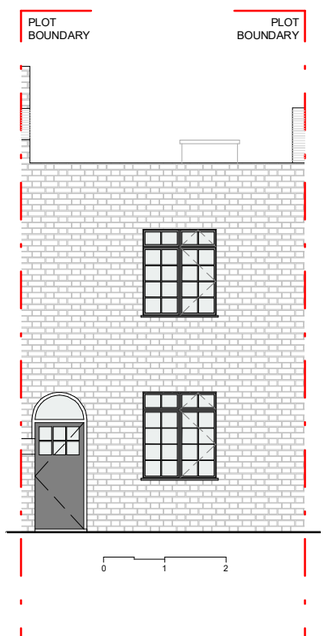
KEY LABEL

- Boundery line



LEFT HAND SIDE ELEVATION

SCALE 1:100 @A3



FRONT ELEVATION

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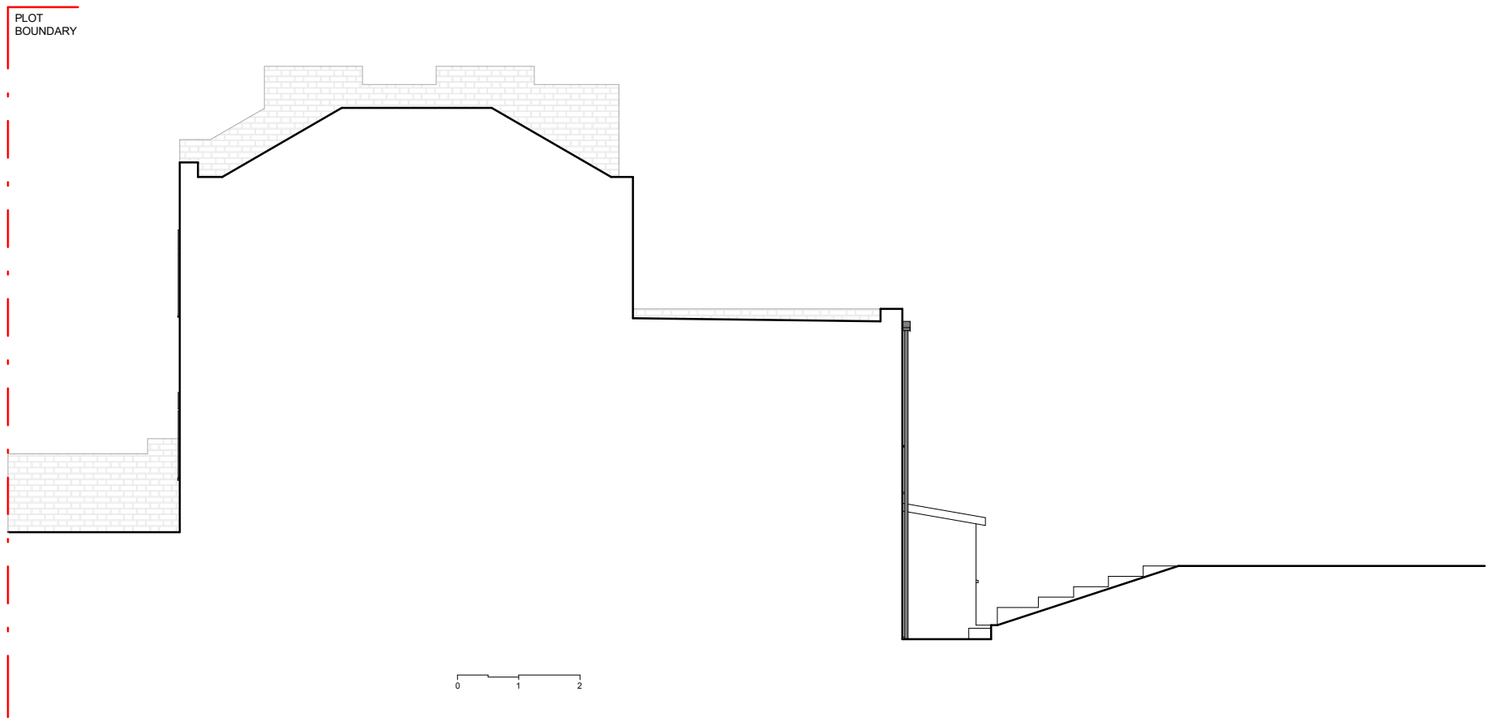

RIGHT HAND SIDE ELEVATION

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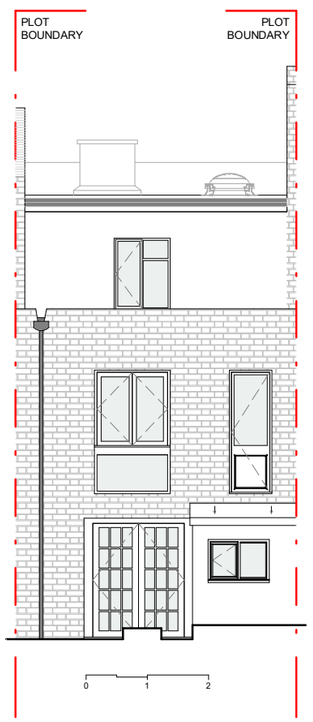

REAR ELEVATION

SCALE 1:100 @A3

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TITLE:
EXISTING
ELEVATIONS

DATE:	PROJECT NUM:
08/01/2021	P-019
SCALE: 1/100 (@ A3)	DRAWING NUM: EX-02
REV: A	STATUS:

SITE PHOTOGRAPHS

01 11/12/2020

- No.40 Front Elevation

02 11/12/2020

- No.40 Front Elevation context

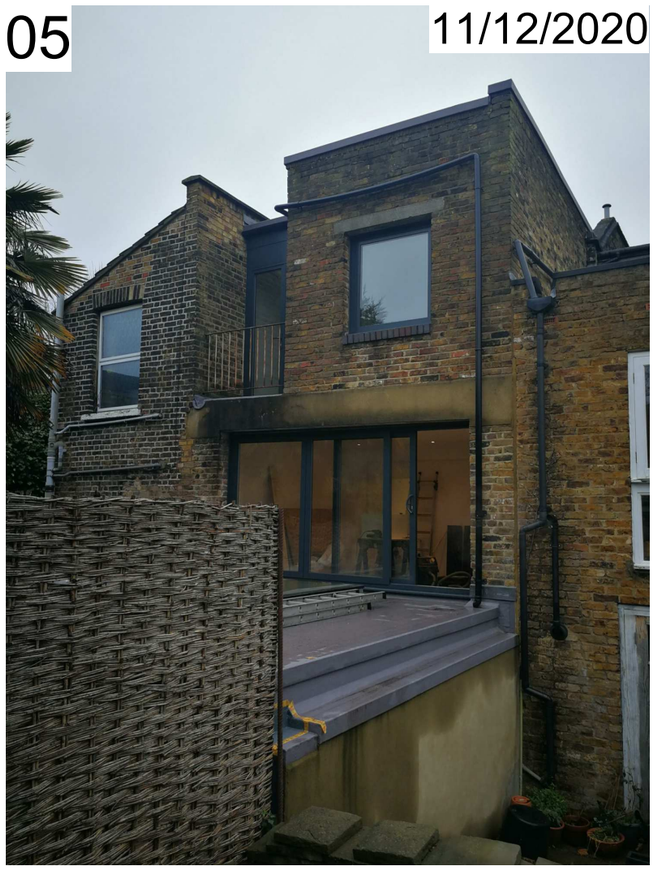
03 11/12/2020

- No.40 Rear Elevation

04 11/12/2020

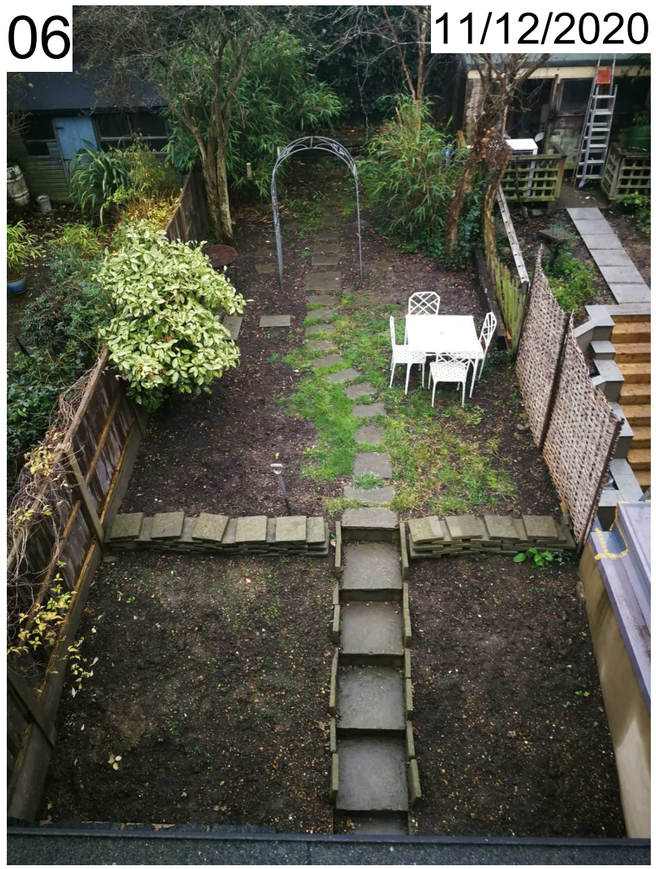
- No.42 (Left Hand Side Neighbour) rear elevation context

05 11/12/2020



- No.38 (Rigth Hand Side Neighbour) rear elevation context

06 11/12/2020



- No.40 Rear Garden

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PHOTOGRAPHS

DATE:	PROJECT NUM:
08/01/2021	P-019
SCALE: 1/100 (@ A3)	DRAWING NUM: EX-03
REV: A	STATUS:

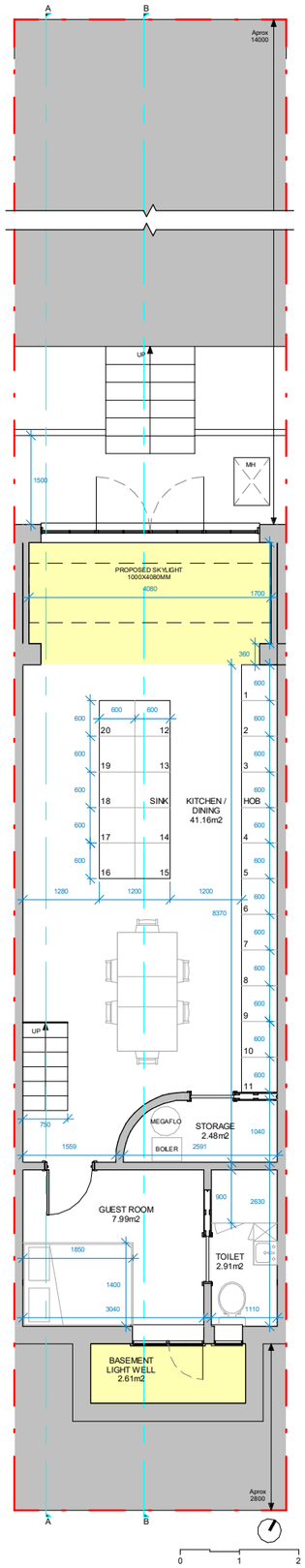
PROPOSED PLANS

NOTE:

- DEMOLITIONS OMITTED FOR CLARITY
- DESIGN SUBJECT TO INVESTIGATION

KEY LABEL

- Boundery line
- Existing walls
- Proposed Stud wall
- Proposed External wall
- Proposed new floor
- Proposed new roof
- Demolished wall



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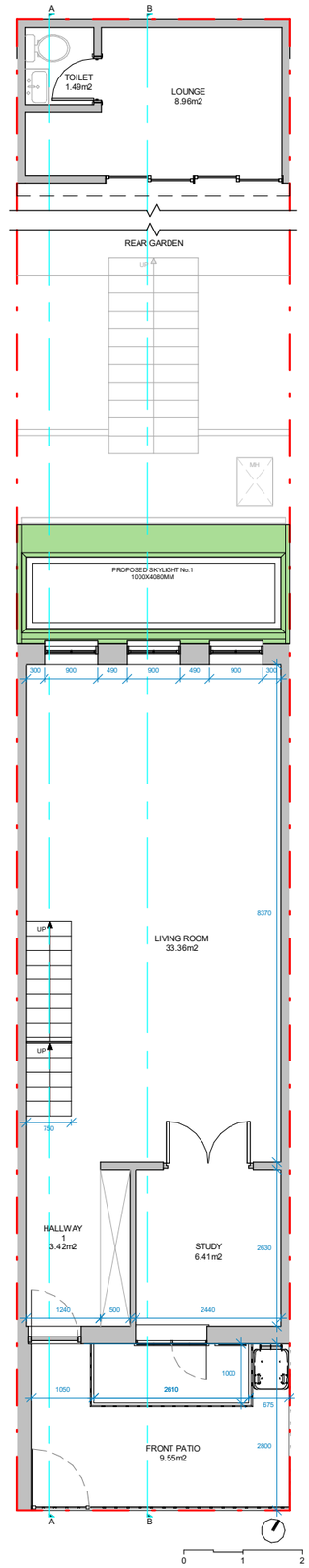

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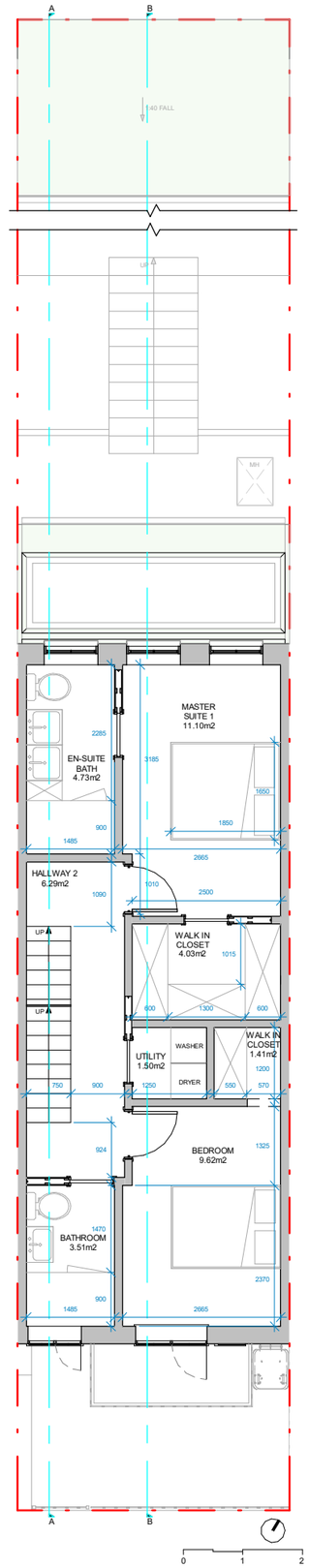

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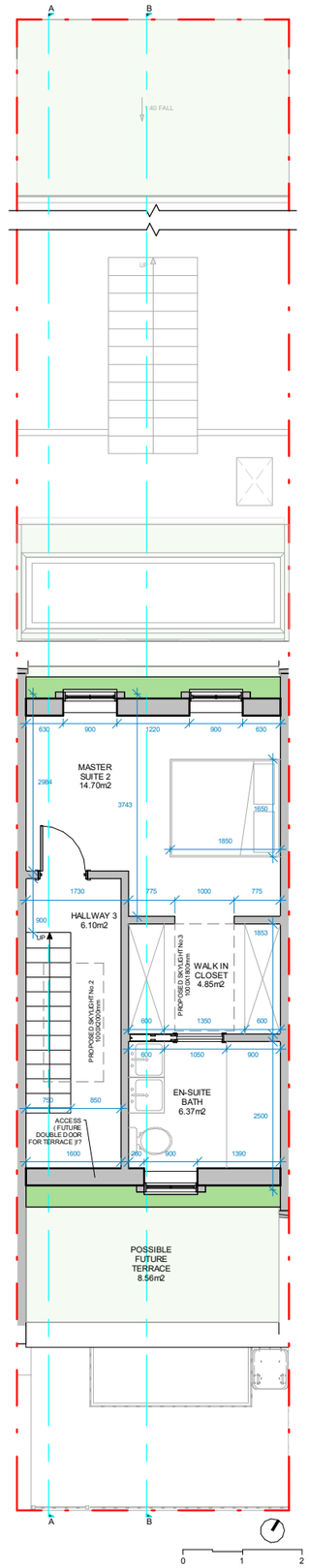

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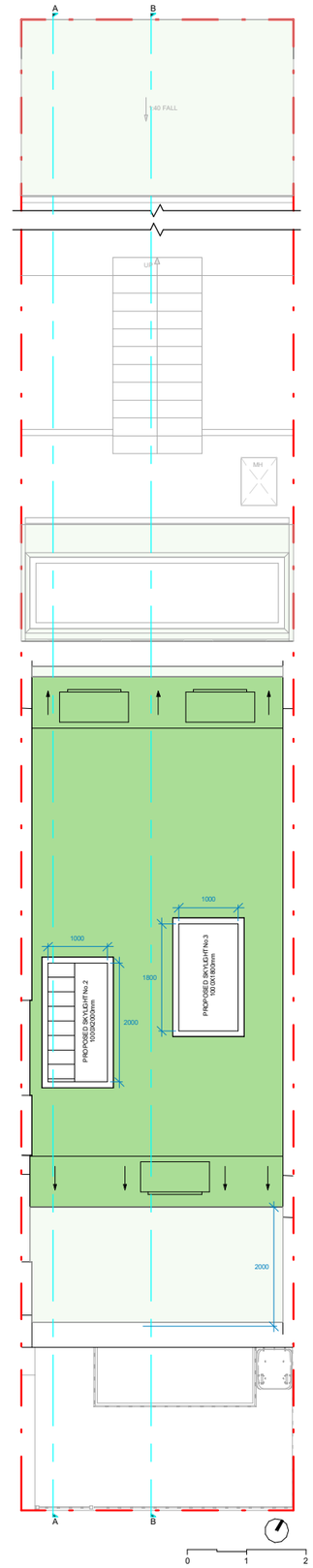

ROOF PLAN ***SCALE 1:100 @A3***

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DATE: 19/01/2021

PROJECT NUM: P-019

SCALE: 1/100 (@ A3)

DRAWING NUM: PR-01

REV: A

STATUS:

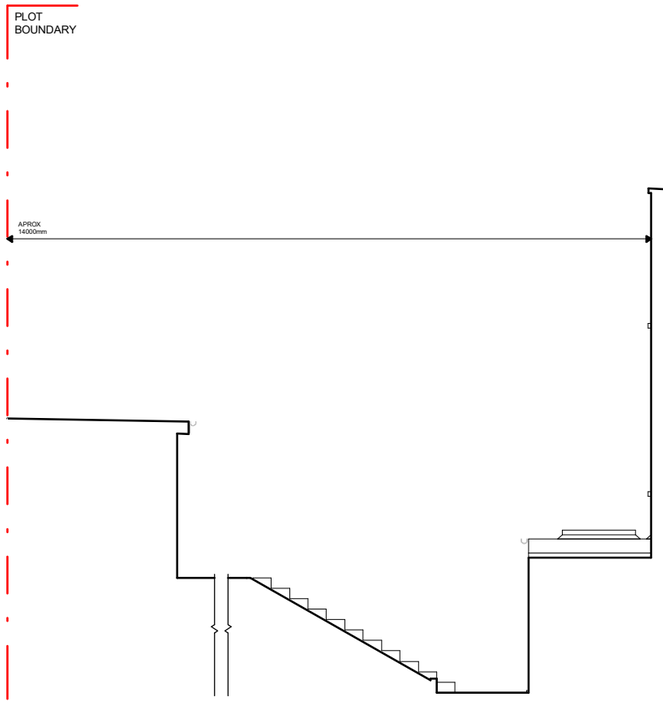
PROPOSED ELEVATIONS

NOTE:

- DEMOLITIONS OMITTED FOR CLARITY
- DESIGN SUBJECT TO INVESTIGATION

KEY LABEL

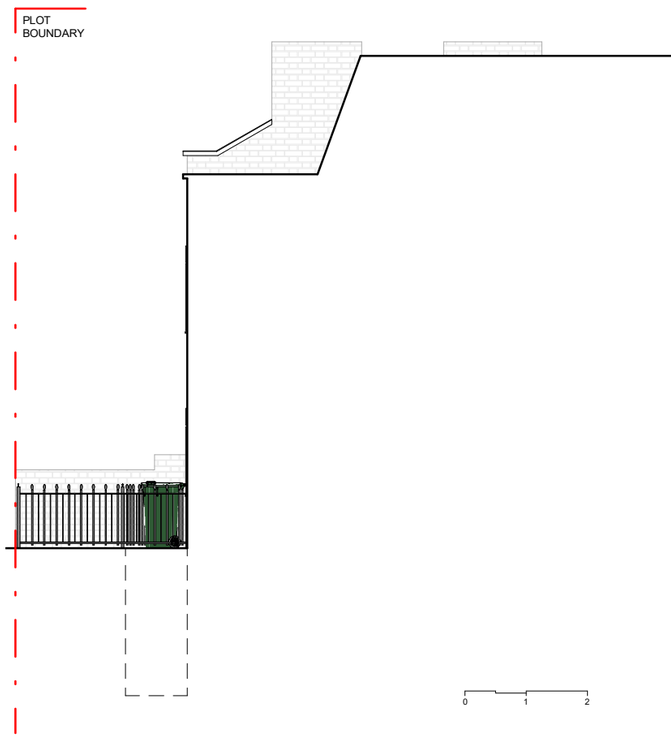
- Boundery line



LEFT HAND SIDE ELEVATION

SCALE 1:100 @A3

FRONT ELEVATION ***SCALE 1:100 @A3***



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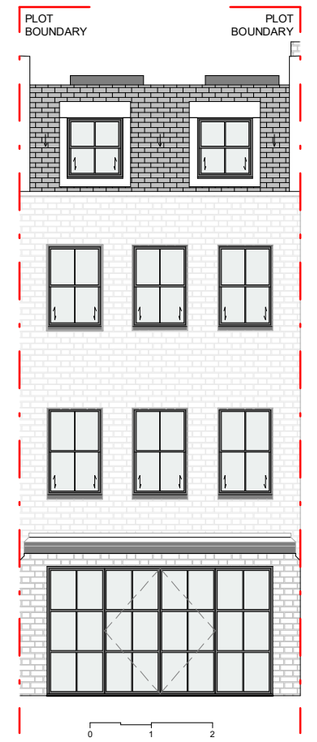

REAR ELEVATION ***SCALE 1:100 @A3***

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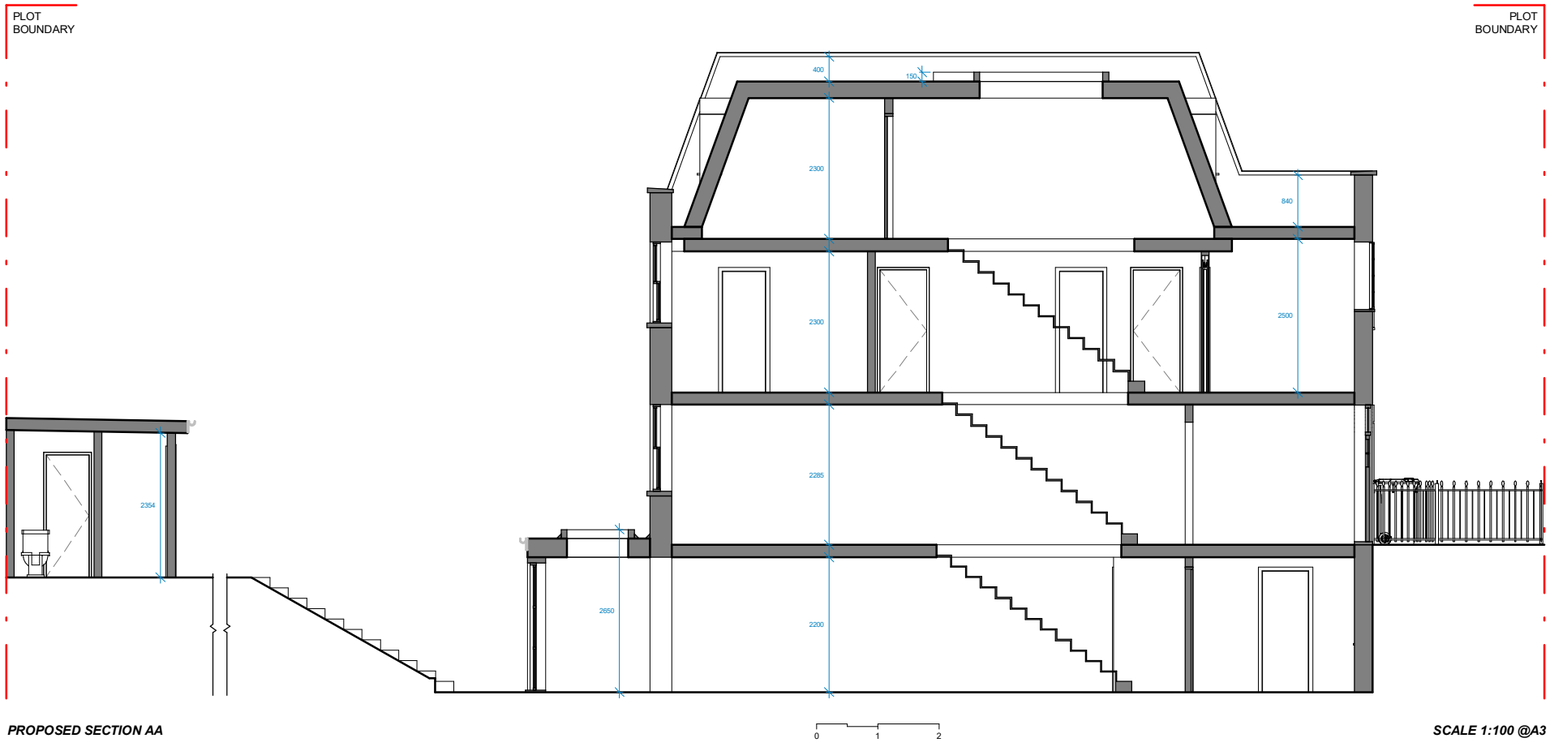
ELEVATIONS

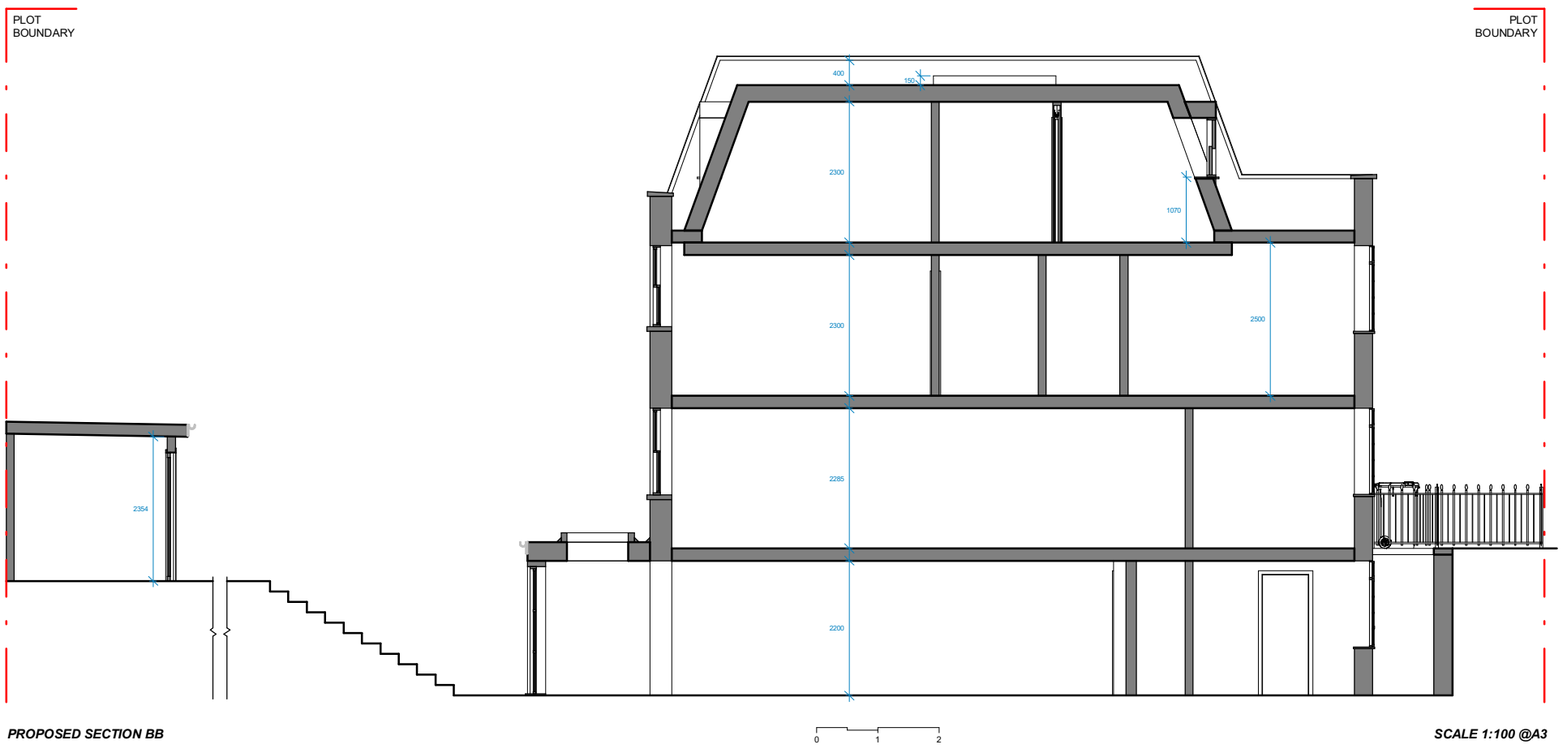
DATE:	PROJECT NUM:
19/01/2021	P-019
SCALE: 1/100 (@ A3)	DRAWING NUM: PR-02
REV: A	STATUS:

PROPOSED SECTIONS: AA & BB



PROPOSED SECTION AA

SCALE 1:100 @A3



PROPOSED SECTION BB

SCALE 1:100 @A3

Proficiency
Design & Build

663 FINCHLEY ROAD, HAMPSTEAD
LONDON
NW2 2HN

TEL.02074356231
PROFICIENCYARCHITECT@GMAIL.COM
WWW.PROFICIENCYLTD.CO.UK

RIBA
Royal Institute of British Architects

arb
Architects Registration Board

PLEASE NOTE

1. All dimensions to be verified on site.
2. All dimensions are in milimeters.
3. No work shall commence until all approvals and agreements have been obtained.
These include, Planning, Building Regulations, Thames Water and party Wall.
4.

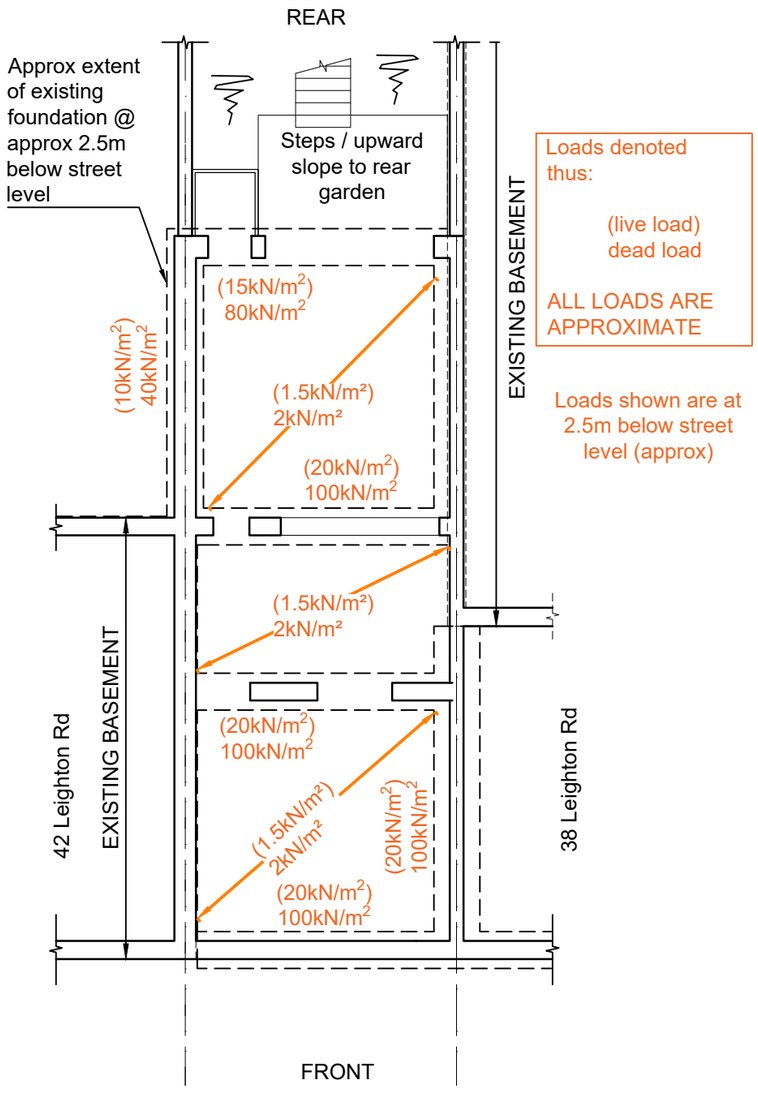
CLIENT:
MAT & LOUISE

PROJECT:
BASEMENT EXTENSION + ONE STOREY REAR EXTENSION + MANSARD

ADDRESS:
40 LEIGHTON RD, LONDON
NW5 2QE

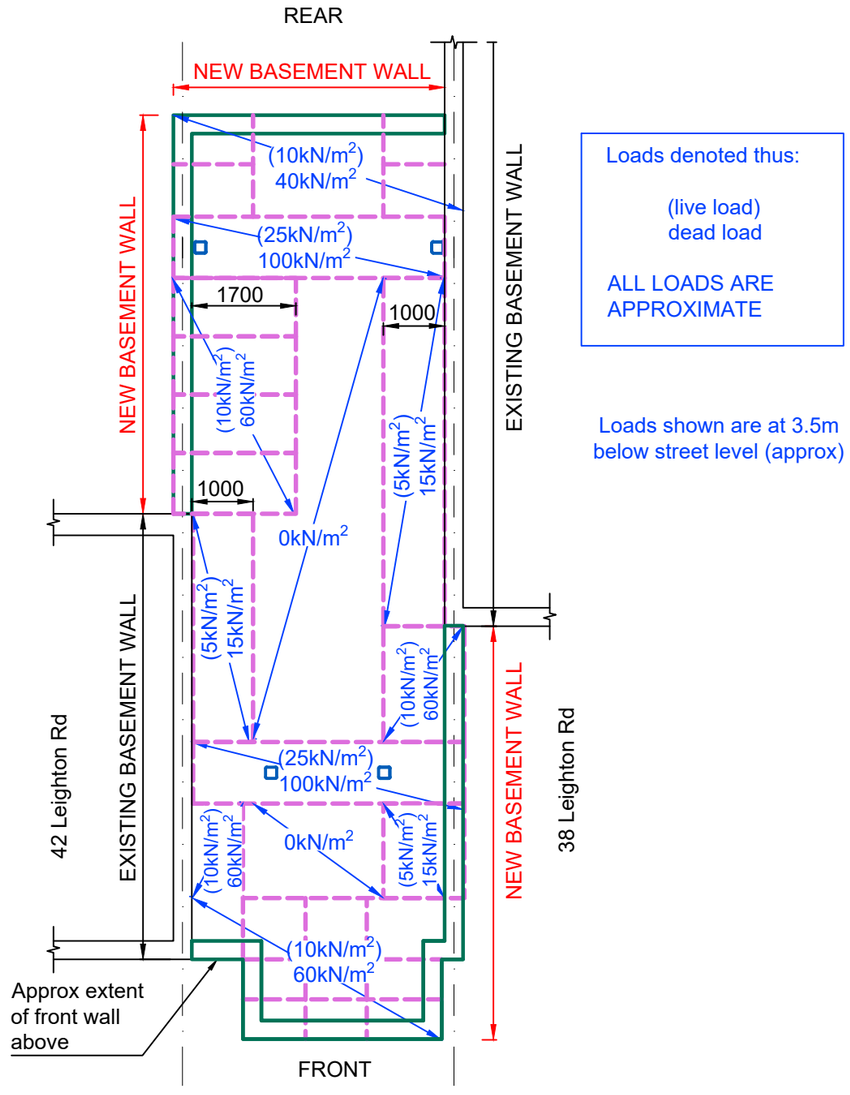
TITLE:
PROPOSED
SECTIONS: AA & BB

DATE:	PROJECT NUM:
19/01/2021	P-019
SCALE: 1/100 (@ A3)	DRAWING NUM: PR-02
REV: A	STATUS:



Basement Existing

Scale 1:100



Basement Proposed

Scale 1:100

Rev	Date	By	Amendments
-	09.03.2021	SC	First Issue

Job Number	Dwg Number
210221	SL-101
Scale: As shown @A1	Rev: -
By: SC	Approved by: GW

Client: Matthew Jones & Louise Willcocks

Property: 40 Leighton Road, Kentish Town, Camden, NW5 2QE

Drawing Title: Foundation Loading

Croft Structural Engineers
Clockshop Mews,
r/o 60 Saxon Rd,
London, SE25 5EH.
020 8684 4744
www.croftse.co.uk

Issued for **INFORMATION ONLY**

Appendix B

Calculation Spreadsheets

Ground and Project CONSULTANTS LTD

Project:	40 Leighton Road		
Project No.	70572		
Calc Title	Ground Movement Assessment for 38 Leighton Road		
Date:	28 July 2021	**Rev**	0

Assumptions

Calculations based on C760 Fig. 6.15 assume system stiffness =1000, FOS against base heave >3. zero at 3 x excavation depth as Fig. 6.11 a) and b)

High Stiffness	0.0075

Movement Calculations for Excavation

Horizontal Distance from wall/excavation depth (m)	Distance (m)	Horizontal Movement/ Wall Depth (%)	Horizontal Movement (mm)	Relevance to adjacent properties
0.0	0.0	0.15	5.3	NS
0.2	0.7	0.1425	5.0	
0.4	1.4	0.135	4.7	
0.6	2.1	0.1275	4.5	
0.8	2.8	0.12	4.2	
1.0	3.5	0.1125	3.9	
1.2	4.2	0.105	3.7	FS
1.4	4.9	0.0975	3.4	
1.6	5.6	0.09	3.2	
1.8	6.3	0.0825	2.9	
2.0	7.0	0.075	2.6	
2.2	7.7	0.0675	2.4	
2.4	8.4	0.06	2.1	
2.6	9.1	0.0525	1.8	
2.8	9.8	0.045	1.6	
3.0	10.5	0.0375	1.3	
3.2	11.2	0.03	1.1	
3.4	11.9	0.0225	0.8	
3.6	12.6	0.015	0.5	
3.8	13.3	0.0075	0.3	
4.0	14.0	0	0.0	

Vertical Distance from wall/excavation (m) depth	Distance (m)	Settlement/ Excavation Depth (%)	Settlement (mm)	Relevance to adjacent properties
0.0	0	0.040	1.40	NS
0.2	0.7	0.050	1.75	
0.4	1.4	0.070	2.45	
0.6	2.1	0.080	2.80	FS/ max
0.8	2.8	0.075	2.63	
1.0	3.5	0.070	2.45	
1.2	4.2	0.060	2.10	
1.4	4.9	0.060	2.10	
1.6	5.6	0.050	1.75	
1.8	6.3	0.040	1.40	
2.0	7	0.035	1.23	
2.2	7.7	0.030	1.05	
2.4	8.4	0.025	0.88	
2.6	9.1	0.020	0.70	
2.8	9.8	0.015	0.53	
3.0	10.5	0.010	0.35	
3.2	11.2	0.005	0.18	
3.4	11.9	0.000	0.00	

Deflection Ratio

	38 Leighton Road
dh	1.58
Delta	0.70

Ground and Project CONSULTANTS LTD

Project:	40 Leighton Road		
Project No.	70572		
Calc Title	Ground Movement Assessment for 38 Leighton Road		
Date:	28 July 2021	**Rev**	0

Combined for Wall Installation and Excavation

	38 Leighton Road	
dh	1.0	
Delta	2.9	allow 5mm dry pack to equal max settlement

Movement Assessment

38 Leighton Road			
Horiz Strain (%)	dh/L	0.02	
Deflection Ratio (%)	Delta/L	0.06	
From Graph Fig 6.27 c	Damage Category	V Slight	
From Graph Fig 6.27 b	Try elim	0.075	upper limit of damage category Table 6.4
L/H	0.5	Therefore eh/elim	0.3
Reading off Fig 6.27 b for closest L/H curve this gives Delta/L/ elim		0.9	
L	4500		
Therefore Delta = L x Reading x elim			
Delta (mm)	3.0	Notes	
Delta for combined wall installation and excavation is less :Damage category is confirmed as	V Slight		

Ground and Project CONSULTANTS LTD

Project:	40 Leighton Road		
Project No.	70572		
Calc Title	Ground Movement Assessment for 42 Leighton Road		
Date:	28 July 2021	**Rev**	0

Assumptions

Calculations based on C760 Fig. 6.15 assume system stiffness =1000, FOS against base heave >3. zero at 3 x excavation depth as Fig. 6.11 a) and b)

High Stiffness	0.0075

Movement Calculations for Excavation

Horizontal **Distance from wall/excavation depth (m)**	**Distance (m)**	**Horizontal Movement/ Wall Depth (%)**	**Horizontal Movement (mm)**	**Relevance to adjacent properties**
0.0	0.0	0.15	3.0	NS
0.2	0.4	0.1425	2.9	
0.4	0.8	0.135	2.7	
0.6	1.2	0.1275	2.6	
0.8	1.6	0.12	2.4	
1.0	2.0	0.1125	2.3	
1.2	2.4	0.105	2.1	
1.4	2.8	0.0975	2.0	
1.6	3.2	0.09	1.8	
1.8	3.6	0.0825	1.7	
2.0	4.0	0.075	1.5	
2.2	4.4	0.0675	1.4	
2.4	4.8	0.06	1.2	
2.6	5.2	0.0525	1.1	FS
2.8	5.6	0.045	0.9	
3.0	6.0	0.0375	0.7	
3.2	6.4	0.03	0.6	
3.4	6.8	0.0225	0.4	
3.6	7.2	0.015	0.3	
3.8	7.6	0.0075	0.1	
4.0	8.0	0	0.0	
Vertical **Distance from wall/excavation (m) depth**	**Distance (m)**	**Settlement/ Excavation Depth (%)**	**Settlement (mm)**	**Relevance to adjacent properties**
0.0	0	0.040	0.80	NS
0.2	0.4	0.050	1.00	
0.4	0.8	0.070	1.40	
0.6	1.2	0.080	1.60	
0.8	1.6	0.075	1.50	
1.0	2	0.070	1.40	
1.2	2.4	0.060	1.20	
1.4	2.8	0.060	1.20	
1.6	3.2	0.050	1.00	
1.8	3.6	0.040	0.80	
2.0	4	0.035	0.70	
2.2	4.4	0.030	0.60	
2.4	4.8	0.025	0.50	
2.6	5.2	0.020	0.40	FS
2.8	5.6	0.015	0.30	
3.0	6	0.010	0.20	
3.2	6.4	0.005	0.10	
3.4	6.8	0.000	0.00	

Deflection Ratio

	42 Leighton Road
dh	1.95
Delta	0.40

Ground and Project CONSULTANTS LTD

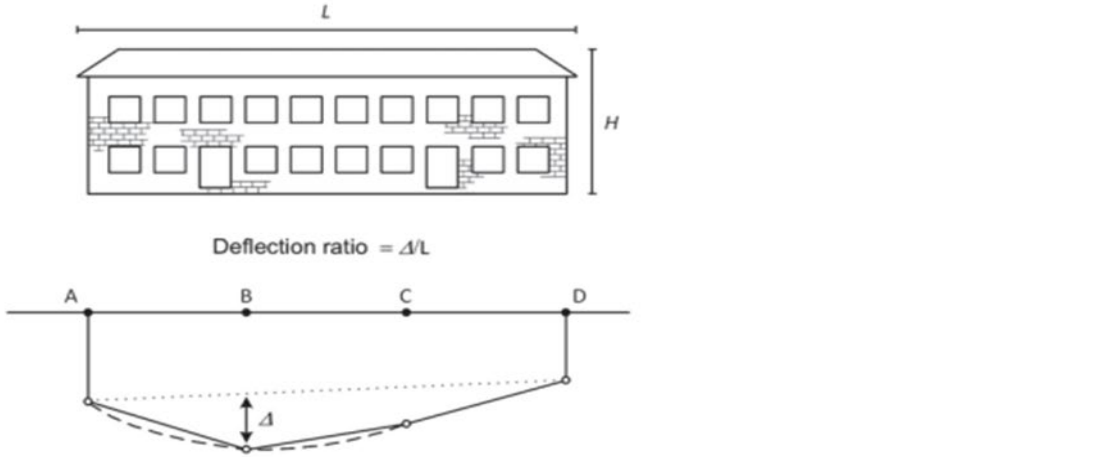
Project:	40 Leighton Road		
Project No.	70572		
Calc Title	Ground Movement Assessment for 42 Leighton Road		
Date:	28 July 2021	**Rev**	0

Combined for Wall Installation and Excavation

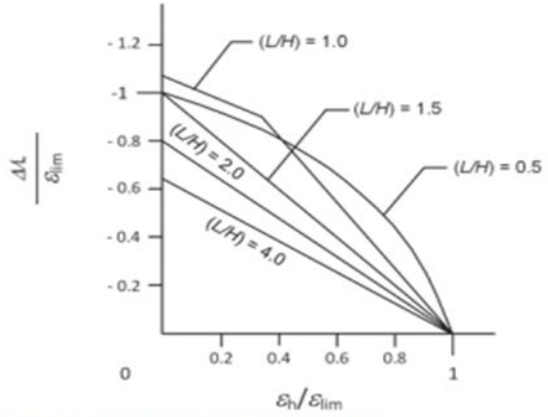
	42 Leighton Road
dh	2.0
Delta	1.2

Movement Assessment

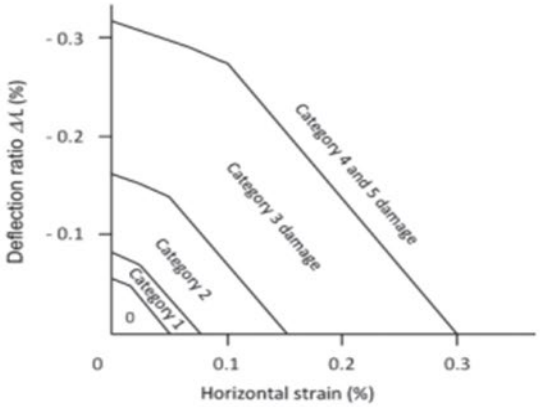
42 Leighton Road			
Horiz Strain (%)	dh/L	0.04	
Deflection Ratio (%)	Delta/L	0.02	
From Graph Fig 6.27 c	Damage Category	V Slight	
From Graph Fig 6.27 b	Try elim	0.075	upper limit of damage category Table 6.4
L/H	0.5	Therefore eh/elim	0.5
Reading off Fig 6.27 b for closest L/H curve this gives Delta/L/ elim		0.65	
L	5000		
Therefore Delta = L x Reading x elim			
Delta (mm)	2.4	Notes	
Delta for combined wall installation and excavation is less :Damage category is confirmed as	V Slight		



a Definition of deflection ratio



b Influence of horizontal strain on $\Delta/L/\varepsilon_{lim}$



c Relationship between damage category and deflection ratio and horizontal tensile strain for hogging for $(L/H) = 1.0$

Note

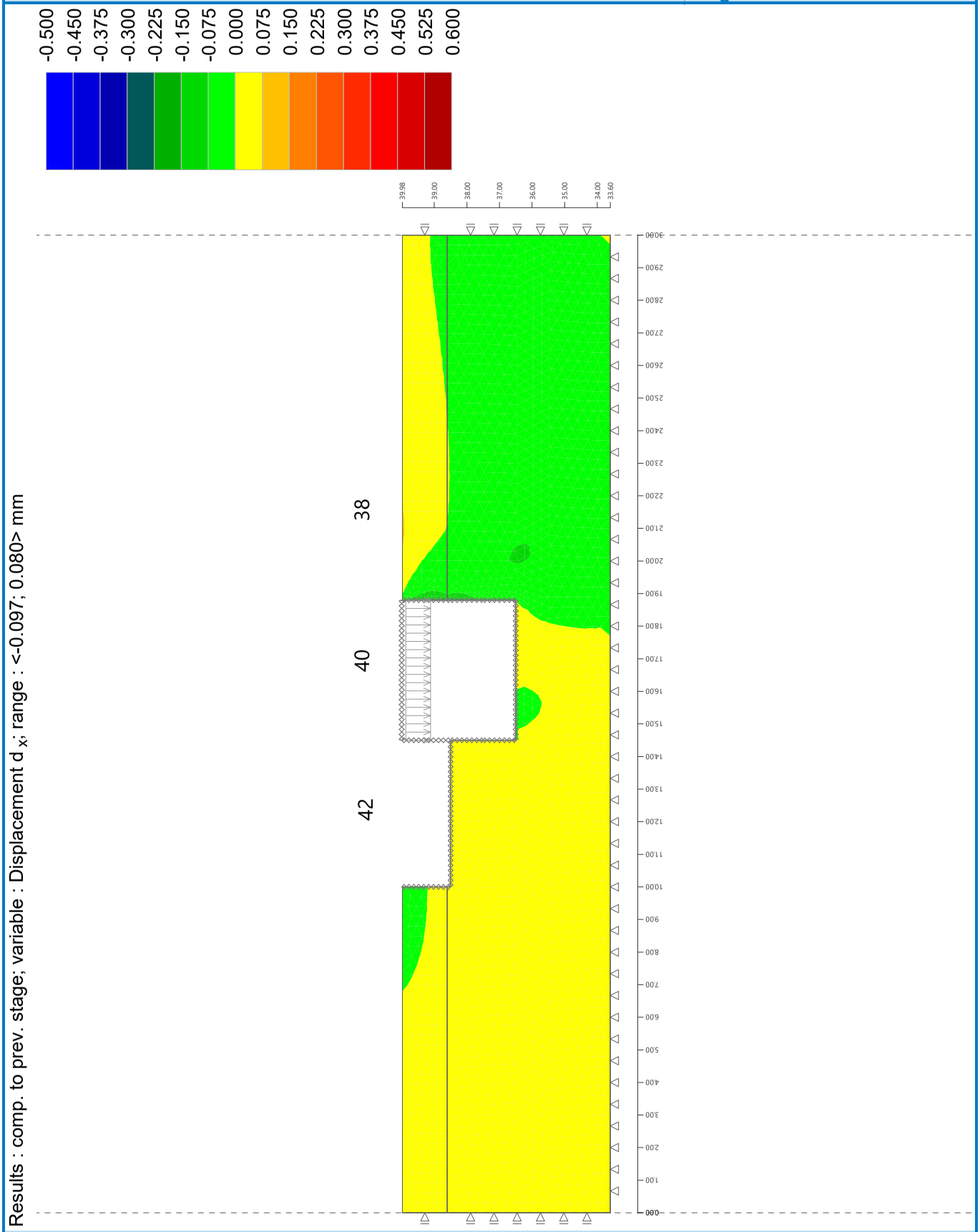
By adopting values of ε_{lim} associated with various damage categories given in Table 6.4, figure (b) can be developed into an interaction diagram showing the relationship between Δ/L and ε_h for a particular value of L/H figure (c) shows such a diagram for $(L/H) = 1.0$.

Figure 6.27 Relationship between damage category, deflection ratio and horizontal tensile strain (after Burland, 2001)

Appendix C

Geo5 Outputs

Name : **Stage : 3**

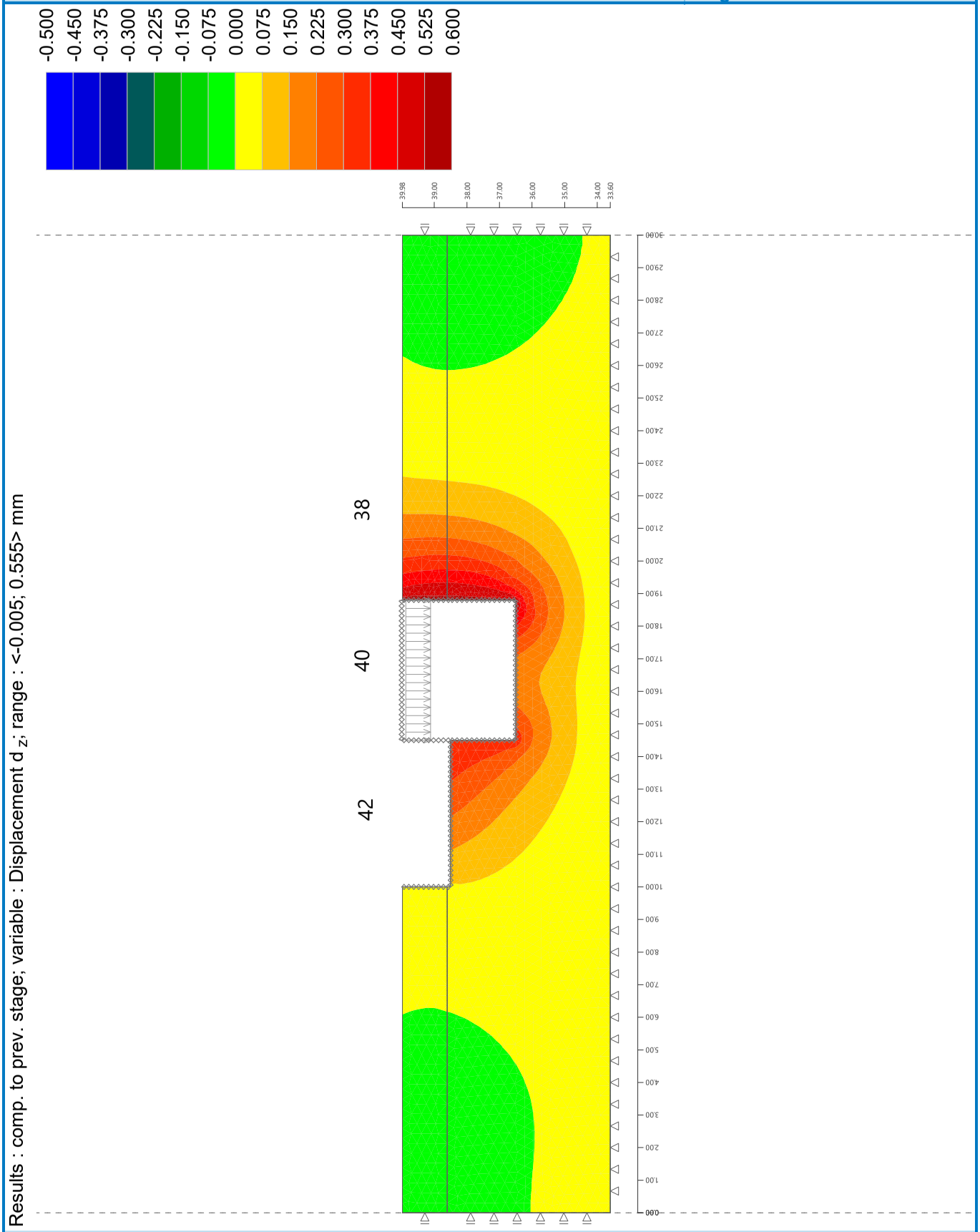


Stress analysis was successfully completed.

Analysis settings : **standard**

Attained loading = 100.00 %

Name : **Stage : 3**



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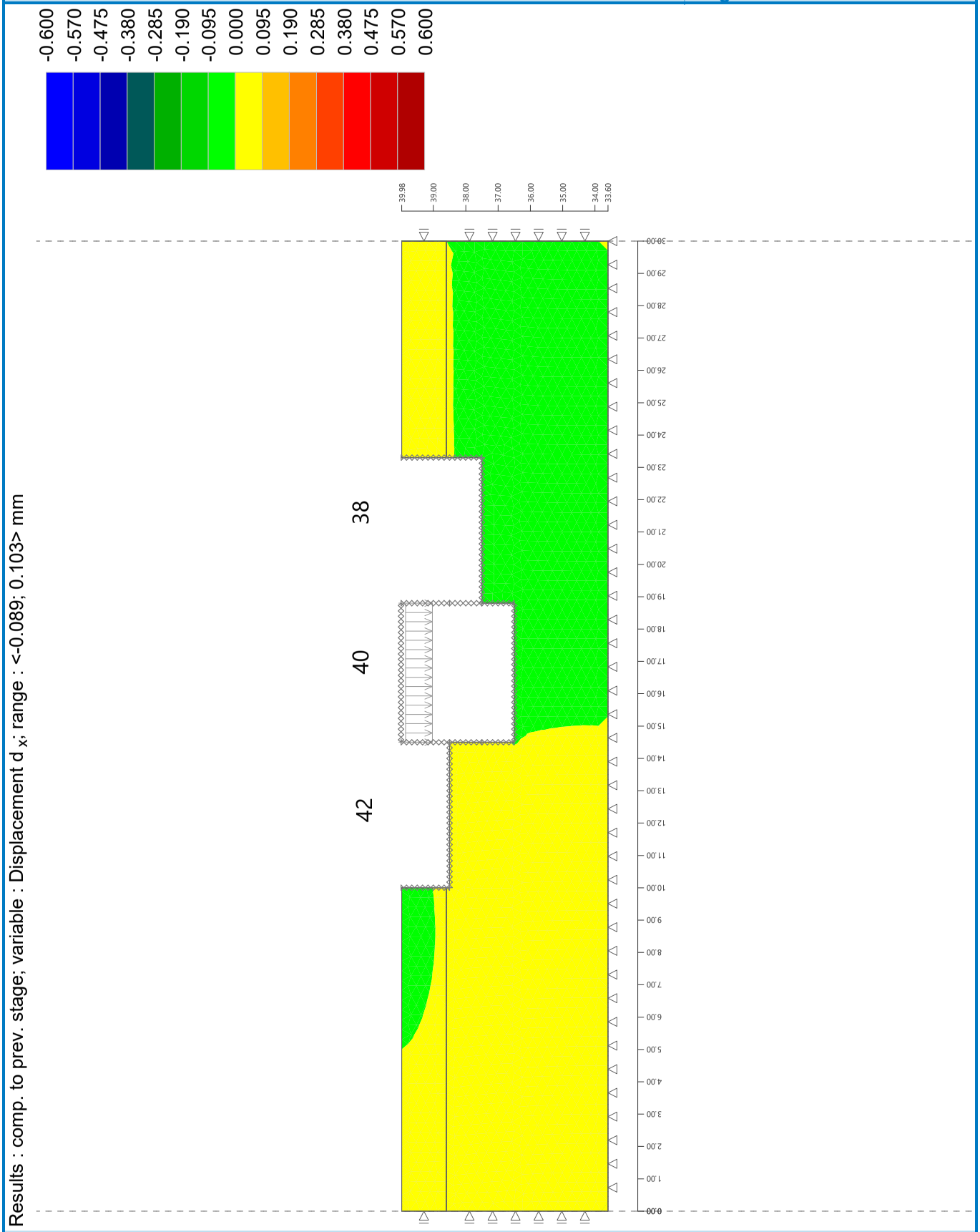
Analysis settings : **standard**

Attained loading = 100.00 %

Name : **Stage : 3**

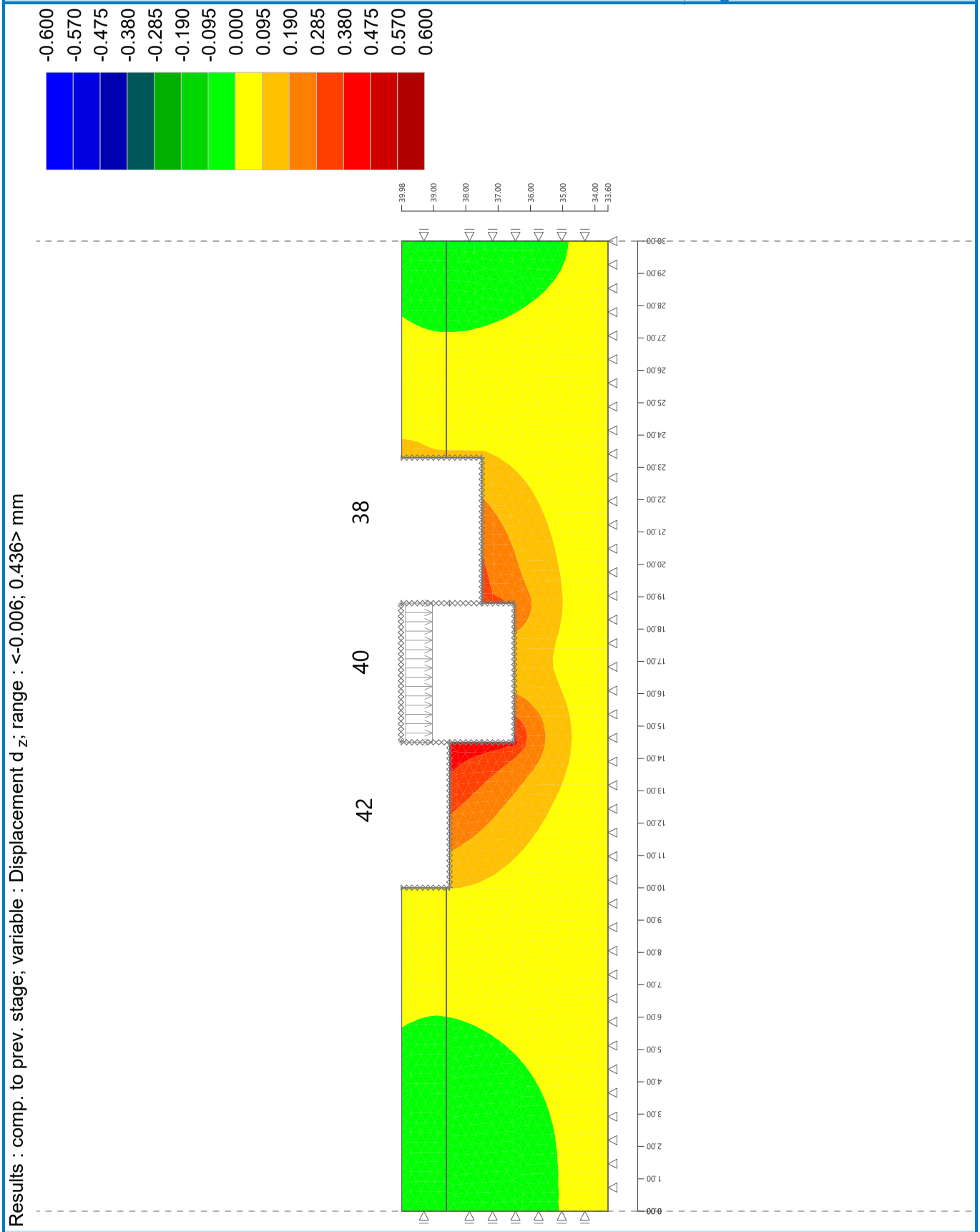


Stress analysis was successfully completed.

Analysis settings : **standard**

Attained loading = 100.00 %

Name : **Stage : 3**



Stress analysis was successfully completed.

Analysis settings : **standard**

Attained loading = 100.00 %