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E24724.G06_Rev4

Mr Greg Colbran
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**REDFERN NSW 2016**

# Impact Assessment on Sydney Metro Assets Proposed Mixed Development 2 Mandala Parade, Castle Hill, NSW

## 1. INTRODUCTION

At the request of Deicorp Pty Ltd (the Client), EI Australia (EI) has prepared this Impact Assessment Report for 2 Mandala Parade, Castle Hill, NSW (the site). The purpose of this report was to compute a numerical analysis to assess the potential impact of the proposed development on the Sydney Metro assets located adjacent to southern elevation of proposed deep excavation at an offset of about 26.0m.

### 1.1. BACKGROUND

This report follows on from previous Impact assessment report (Report No E24724.G06_Rev3 dated 18 February 2022). This revision of the report will address the comments and issues raised by Sydney Metro. Furthermore, it includes sensitivity analysis of potential impact of Showground Station walls with respect to different magnitudes of locked-in stresses adopted for founding high strength sandstone bedrock.

EI has previously completed a Geotechnical Investigation (GI) report (Report No E24724.G03_Rev2, dated 9 July 2021) and a Groundwater Take Assessment (GTA) report for the proposed development (Report No.E24724.G12 dated 5 November 2021). The geotechnical findings and recommendations provided in our GI report were interpreted to geotechnical parameters as input data for the numerical analysis to assess the impact of proposed development on Sydney Metro assets. The outcome of in-situ testing as well as recorded groundwater were utilised to model the groundwater, its potential drawdown and subsequent impact to be incorporated in this report.

Additionally, the following documents were utilised to assist in the preparation of this impact assessment report:

- Structural Assessment Report Prepared by ABC Consultants – Report No. 20025.SAR Dated April 2021;
- Structural Drawings prepared by ABC Consultants – Drawing No.S01.101 (Rev P3 dated 12 April 2021), S01.105 (Rev P5 dated 11 November 2021), S01.106 (Rev P1 dated 12 April 2021), S01.111 (Rev P4 dated 12 April 2021), S01.112 (Rev P4 dated 12 April 2021), S01.113 (Rev P4 dated 12 April 2021), S01.114 (Rev P4 dated 12 April 2021), S01.121 (Rev P4 dated 12 April 2021), S01.122 (Rev P5 dated 11 November 2021) and S01.125 (Rev.P3, dated 12 April 2021);
- Survey plan prepared by INTRAX – File no. S119051 dated 9 November 2018;
- TfNSW Showground Station Box Excavation Structural Plans – Drawing Nos. NWRLTSC-THY-SHW-DN-DRG-325411 (Rev 51 dated 2 October 2015), 325431 (Rev 51 dated 29 April 2016), 325432 (Rev 50 dated 20 August 2015), and 325433 (Rev 52 dated 26 October 2015);
- TfNSW Showground Station Work As Executed drawings – Drawing Nos. NWRLOTS-NRT-SHW-SS-DRG-433051, sheets 1-3 (Rev X0 dated 6 May 2019), 433393, sheets 1-3 (Rev X0 dated 6 May 2019);
- TfNSW Showground Station Architectural Plans – Drawings Nos. NWRLOTS-NRT-SHW-AR-DRG-613101 (Rev 0 dated 9 November 2016),613105 (Rev 0 dated 9 November 2016), 613110 (Rev 00.01 dated 2 August 2018), 613111 (Rev 00.05 dated 18 January 2019), 613112 (Rev 00.05 dated 31 January 2019), 613113 (Rev 00.06 dated 26 March 2019),613114 (Rev 00.04 dated 12 October 2018), 613115

(Rev 00.05 dated 18 January 2019), 613116 (Rev 00.02 dated 2 August 2018), 613141 (Rev 00.05 dated 18 January 2019), 613145 (Rev 00.04 dated 18 January 2019), 613146 (Rev 00.04 dated 18 January 2019), and 613147 (Rev 00.03 dated 18 January 2019);

- TfNSW North Horizontal and Vertical Track Alignments – Drawing Nos. NWRLOTS-NRT-SWD-PW-550536 and NWRLOTS-NRT-SWD-PW- 550607 (Rev X0 dated 24 August 2018); and
- Sydney Metro Corridor Protection Technical Guidelines – Version 2 dated April 2021.

Based on the provided documents, EI understands that the proposed development involves the construction of four 20-storey mixed use buildings overlying a common podium structure with a stepped 6-storey basement. The lowest basement level (B06) will require a Finished Floor Level (FFL) of RL 70.20m AHD. It is understood that a Bulk Excavation Level (BEL) of RL 69.1m will be required for the lowest basement level, which includes allowance for the construction of the basement slab. To achieve the BEL, excavation depths of 19.00m Below Existing Ground Level (BEGL) at the Doran Drive end of site to 26.60m BEGL at the Andalusian Way end of site have been estimated. Locally deeper excavations may be required for footings, service trenches, crane pads and lift overrun pits.

## 1.2. Sydney Metro Asset

Based on supplied information referenced in **Section 1.1**, we understand that metro infrastructure adjacent to southern elevation of proposed basement outline comprises of Hills Showground Station with metro tracks running east to west. The Sydney Metro Northwest is a rail infrastructure project which was completed in mid-2019. The station box closest wall is at the setback of about 26.0m from proposed shoring system.

The metro box excavation methodology adjacent to proposed development involved excavation of  soil and low strength sandstone using stabilising berm and mass concreting followed by vertical excavation of high strength sandstone to designed excavation level (RL 72.0m AHD).

The Showground Station metro box adjacent to southern elevation of proposed basement outline at final construction stage comprises of 400mm thick precast concrete walls with roughened outer surface. The gap between founding high strength sandstone bedrock and pre-cast concrete panels were backfilled with self-compacting grout.

It is also noted that Showground Station Metro Box basement slab and walls have been designed as drained.

In this analysis, Construction of Showground Metro Station box has been incorporated to assess its contribution in stress-relief of the founding sandstone bedrock.

The structural parameters of Metro Station concrete walls adopted in this analysis are shown in **Table 4**

## 1.3. Shoring Wall System

Based on the structural drawings prepared by ABC Consultants referenced above, we understand that the proposed excavation will be supported by the following shoring system adjacent to southern elevation (SW5) and metro tunnels:

- Anchored soldier pile wall consisting of 600mm diameter piles at 2400mm centre-to-centre spacing to retain fill/residual soil and low strength sandstone, with 180mm thick shotcrete panels and strip drains installed between the piles. The pile toes are to be founded at RL 85.4m AHD.
- Three row of anchors on eastern end of southern elevation and two rows of anchors on western end of southern elevation to be installed and prestressed to a working load of 20-40 tonnes at 45 degrees below the horizontal. Anchors are to be 9 m to 15 m in length and 2.4m spaced apart.
- Excavation will continue by vertical cut from pile toe level (RL85.4m AHD) to proposed bulk excavation Level (RL 69.1m AHD).

# 2. FINITE ELEMENT ANALYSIS

Finite Element Analysis (FEA) of the proposed excavation sequences has been undertaken using PLAXIS 2D Ultimate (Version 21.01.00.479). PLAXIS 2D is a commercially available finite element package intended for the two dimensional analysis of deformation and stability in geotechnical engineering. It is equipped with features to deal with various aspects of geotechnical structures and construction processes using robust and theoretically sound computational procedures.

## 2.1. Model Geometry

The modelled section is perpendicular to southern elevation and extended to Mandala parade. The location of this section is shown in **Figure 1.**

The critical subsurface conditions of the GI boreholes was utilised to establish the geological model and material parameters for the analysis. The geological model was assumed to be consistent across and beyond the site. More detailed descriptions of the subsurface conditions are available in the GI report. The locations of the boreholes are also shown on **Figure 1** attached. The subsurface profile for the model is presented in **Table 1** below.

**Table 1 Adopted Geological Model [1]**

| Unit | Material [2] | Modelled Depth to top of Unit (m BEGL) [1] | Modelled RL of top of Unit (m AHD) [1] | Modelled Thickness (m) |
|---|---|---|---|---|
| **1** | **Topsoil/fill** | Surface | 94.3 | 1.8 |
| **2** | **Clayey Sand Residual Soil** | 1.8 | 92.5 | 0.5 |
| **3a** | **Class IV-III Sandstone** | 2.3 | 92.0 | 5.1 |
| **3b** | **Class II/III Sandstone** | 7.4 | 86.9 | -[3] |

***Notes:***
1 Based on the GI report prepared by EI.
2 For more detailed descriptions of the subsurface conditions, reference should be made to the borehole logs in the GI report.
3 Assumed to extend to termination depth.

## 2.2. MODELLING OF GROUNDWATER LEVEL

Based on EI's GTA report, it is noted that groundwater levels recorded within monitoring wells varied between 78.1m AHD to 93.4m AHD.

Given the inconsistency in recorded groundwater with consideration of geological subsurface condition, EI notes that measured groundwater levels are most likely representing perched water trapped within sandstone discontinuities and defects, or water running between soil-bedrock interface due to significant differences in permeability coefficients of two layers. Hence, the reported water levels measured in wells do not present an actual aquifer within shallow ground. It should be emphasised that design of Metro Box lowest basement slab has been designed as drained which justifies this assumption.

However, to incorporate the critical condition in our FEA, EI has conducted a sensitivity analysis with respect to different groundwater conditions to assess the difference in potential impact on Showground Station Metro box. This FEA has been conducted with no modelled groundwater level and groundwater RL of 93.4m which is based on highest groundwater levels recorded in EI Groundwater Take Assessment (GTA) report.

In this analysis, we have assumed that temporary dewatering where required will be undertaken within basement excavation level to RL 69.1m AHD. Hence, the basement condition is considered to be drained. In this report, the effect of dewatering due to construction of Showground Metro Station box is considered in staged construction. However, it should be noted that dewatering will not impose any detrimental impact as it is within high strength sandstone bedrock.

## 2.3. PARAMETERS FOR THE MODEL

### 2.3.1. Geotechnical Soil Parameters

The geotechnical model for the soil and rock units is described in **Table 1** above. The parameters adopted for the modelling were derived from observed stratigraphy, laboratory testing from the GI report and published correlations for the material encountered as part of the geotechnical investigation. The parameters adopted for the PLAXIS 2D finite element modelling are presented in **Table 2** below.

The PLAXIS modelling has been carried out using Mohr-Coulomb model.

**Table 2 Geotechnical Parameters for PLAXIS Model**

| Geotechnical Unit | | Material Model | Material | c' (kPa) | ϕ' (°) | $\gamma_{unsat}$ (kN/m$^3$) | $\gamma_{sat}$ (kN/m$^3$) | E'50 (MPa) | Poisson's Ratio, v' | y reference (m AHD) | E increment (MPa/m) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Unit 1** | | Mohr Coulomb | General Fill Silty Clay | 5 | 26 | 18 | 19 | 7.5 | 0.3 | - | - |
| **Unit 2** | | Mohr Coulomb | Residual Soil – Silty Clay Very Stiff to Hard Consistency | 15 | 28 | 19 | 20 | 20 | 0.3 | - | - |
| **-Unit 3** | | Mohr Coulomb | Class V-IV Sandstone | 200 | 35 | 23 | 23 | 250 | 0.25 | - | - |
| **Unit 4** | | Mohr Coulomb | Class II/III Sandstone | 500 | 50 | 24 | 24 | 1700 | 0.25 | 86.90 | 10 |

### 2.3.2. Modelling of In-Situ Horizontal Stresses in PLAXIS

The existence of significant horizontal in-situ stress in bedrock, particularly in the Sydney basin is well established, the release of which during the basement excavation may cause adverse impact on the stability of the excavation faces and thus increase the movements.

Based on the supplied structural drawings (referenced above), the metro tracks are oriented along southern elevation of site boundary. Hence, the principal stress is assumed and modelled to run in the direction perpendicular to the metro tracks (the x-axis) in a north-south orientation in the model as this is the most conservative assumption.

The initial volumetric strain and $K_o$ of Class II/III sandstone were adjusted to model the in-situ stress as per Oliveira and Parker (2014). We consider Class V – IV Sandstone layer to have been effectively 'stress relieved'.

The modelled volumetric strains as results of in-situ stresses adopted in the PLAXIS 2D model are shown in **Table 3**

**Table 3 Adopted Parameters to Model In-Situ Stresses for PLAXIS 2D Model**

| Geotechnical Unit | Mass Young's Modulus (MPa) | Correlation Formula | Adopted $\varepsilon_x$ in PLAXIS 2D Model (%) | $K_{O,x}$ |
|---|---|---|---|---|
| **Class II/III Sandstone** | 1700 | $\sigma_1 = 0.9 + 2.9\sigma_v$ | 0.053 | 2.9 |

Based on preliminary assessment of proposed shoring system and geological profile within the site, EI notes the release of locked-in stresses of sandstone will the leading aspect for determination of the induced movement on the metro wall resulted from basement excavation.

As stated in **Section 2.3.2** of this report, the in-situ stress predicted by Oliveira and Parker (2014) were utilised in this analysis. Oliveira and Parker methodology states that there is an interrelationship between the in-situ stress and the ground condition, namely the rock mass quality and the mass Young's Modulus. For the class III and II sandstone, Oliveira and Parker suggests that the principal in-situ stress can be estimated using equations outlined above where $\sigma_v$ is the overburden pressure.

However, simply adopting these values into model resulted in excessively high and unreasonable predicted movement. Based on similar jobs previously completed by EI, this methodology tends to overestimate the induced movement in most circumstances. Furthermore, it does not incorporate the effect of defects, joints and discontinuities within the sandstone bedrock.

Therefore, EI has carried out sensitivity analysis with respect to modelled locked-in stress at 100%, 75% and 50% of suggested values by Oliveira and Parker. As direction of principal stress is varied across different Sydney regions and can't be reliably estimated, EI has accounted for worst scenario where the principal stresses are perpendicular to proposed excavation (north-south)

The modelled volumetric strains as results of in-situ stresses for all scenarios adopted in the PLAXIS 2D model are shown in **Table 4**

**Table 4 Adopted Parameters to Model in-Situ Stress for Sensitivity Analysis**

| Condition | Geotechnical Unit | Mass Young's Modulus (MPa) | Correlation Formula | Adopted $\varepsilon_x$ in PLAXIS 2D Model (%) | $K_{O,x}$ |
|---|---|---|---|---|---|
| **100%** | **Unit 4** | 1700 | $\sigma_1 = 0.9 + 2.9\sigma_v$ | 0.053 | 2.9 |
| **75%** | **Unit 4** | 1700 | - | 0.040 | 2.9 |
| **50%** | **Unit 4** | 1700 | - | 0.029 | 2.9 |

### 2.3.3. Structural Parameters

The structural design parameters of soldier pile wall, anchors and Showground Metro Station walls are adopted from the structural drawings referenced in **Section 1.1**. Some parameters given in **Table 5** and **Table 6** were assumed, based on similar developments previously analysed by EI, and were not provided by the Client at the time of writing this report.

EI notes for model simplicity and quality meshing, structural anchors are modelled via fixed-end anchor elements in this Finite Element Analysis and the outcome might not represent the actual stress-distribution of anchors within sandstone bedrock. However, given the significant stiffness value of bedrock and anchors substantial setback from metro box, there will be no additional stresses and subsequent strains on the Metro box walls.

However, to address the concern raised by Metro, EI has conducted a sensitivity analysis where anchors are modelled using node-to-node and geogrid elements to assess its stress distribution within sandstone bedrock.

At the time of writing this report, no detailed design of anchors has been provided to EI. Therefore, the analysis has been conducted using in-house data from previous jobs with similar project scope and comparable geological profile. EI note that if final design of anchors differs notable from what was assumed in this report, the analysis must be revised.

**Table 5 Structural Parameters – Plate**

| Structural | Thickness (m) | Diameter (m) | Spacing (m) | Unit Weight (kN/m/m) | E (kPa) | $I_{xx}$ ($m^4$/m) | Poisson's Ratio, v | EA (kN/m) | EI ($kNm^2$/m) |
|---|---|---|---|---|---|---|---|---|---|
| **Soldier Pile Wall** | - | 0.6 | 2.4 | 7.27 | 3.28E+07[1] | 4.45E-3 | 0.2 | 3.86E+06 | 86.94E+03 |
| **Station Box pre-cast walls** | 0.4 | - | - | 4.80 | 3.28E+07[1] | 5.3E-3 | 0.2 | 13.12E+06 | 175.5E+03 |
| **Lowest Basement Slab** | 0.3 | - | - | 3.60 | 3.28E+07[1] | 2.25E-3 | 0.2 | 9.84E+06 | 73.80E+03 |

*Notes:*
1 The analysis parameters were assumed based on existing in-house data and past experience.

**Table 6 Structural Parameters – Anchors**

| Structural | Spacing (m) | Total Length (m) | Bonded Length (m) | EA (kN/m) | Pre Stress Load (kN) |
|---|---|---|---|---|---|
| **A1** | 2.4 | 9[1] | 4.2 | 88.20E+3[1] | 200 |
| **A2 – 2nd row** | 2.4 | 12[1] | 6.2 | 88.20E+3[1] | 300 |
| **A2 – 3rd row** | 2.4 | 15[1] | 8.2 | 88.20E+3[1] | 300 |
| **Metro Box Concrete Slabs** | - | - | - | 9.84E+06[1] | - |

*Notes*
1 The analysis parameters were assumed based on existing in-house data and past experience.

**Table 7 Structural Parameters – Geogrid**

| Structural | Spacing (m) | EA (kN/m/m) |
|---|---|---|
| **Anchor Bond Length** | 2.4 | 36.75E+03 |

## 2.4. Applied Loading / Surcharge

The following surcharge loads have been applied in the model. Surcharge loading has been modelled by direct input to the PLAXIS analysis:

Mandala Parade road traffic has been modelled as a uniformly distributed load of 20kPa over 12.0 m width with a setback of 2.5 m from southern site boundary.

Pedestrian footpath has been modelled as a uniformly distributed load of 5kPa over 2.5m width abutting southern elevation of proposed basement outline.

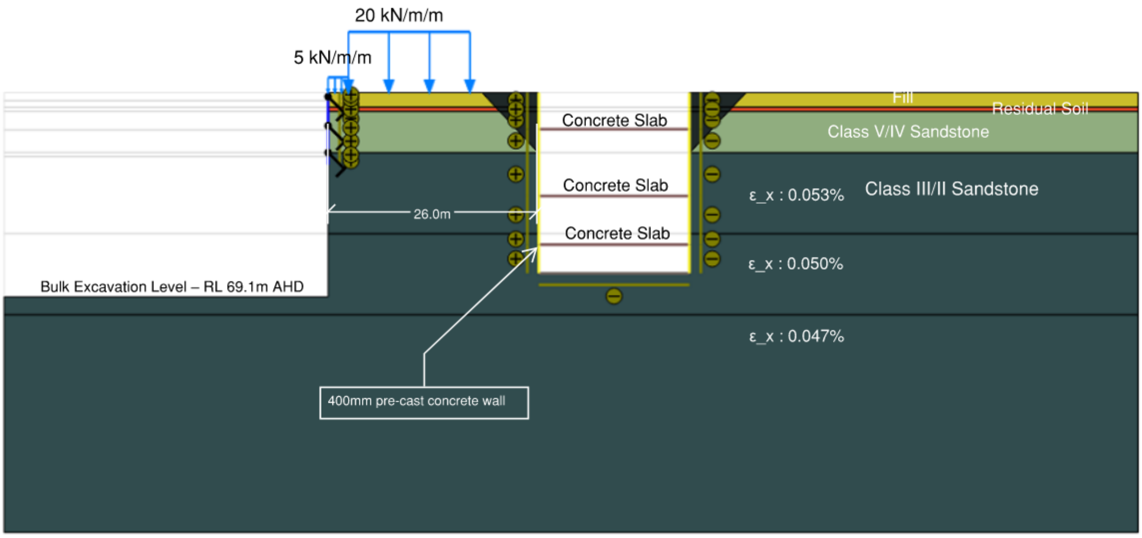
## 2.5. Model Phases

The excavation was modelled in PLAXIS 2D using the following phases. Minor simplification of the excavation and construction sequence has been adopted where necessary in order to produce a practicable FEM model.

- Phase 0 – Existing ground conditions on the subject site;
- Phase 1 – Apply equivalent horizontal strain referenced in **Section 2.3.2;**
- Phase 2 – Apply existing surcharges of road and footpath;
- Phase 3 – Construct Showground Metro Station Box;
- Phase 4 – Reset displacements and construct soldier pile wall;
- Phase 5 – Excavate to first 0.5m below proposed A1 – first anchor level (RL 93.30m);
- Phase 6 – Install and prestress first row of anchors;
- Phase 7 – Excavate to 0.5m below proposed A2 – second row anchor (RL 89.70m);
- Phase 8 – Install and prestress second row of anchors;
- Phase 9 – Excavate to 0.5m below proposed A2 – third row anchor level  (RL 86.40m);
- Phase 10 – Install and prestress third row of anchors (Toe Anchor);
- Phase 11 – Excavate and dewater to RL 69.1m AHD.

# 3. RESULTS OF FEM ANALYSIS

An overview of the final model (100%VS, No water) can be seen in **Image 3.1** below with the x, y arrows indicating the positive directions along these axes.




**E24724.G06_Rev4 – Model Overview**

**Image 3 1 Overview of PLAXIS Model**

Outputs and results from PLAXIS analysis are shown in **Appendix A**. A plan showing the location of the section in relation to the excavation attached **Figure 1.**

## 3.1. SENSITIVITY ANALYSIS

**Table 8** presents the likely movements of soldier pile wall, pre-cast concrete walls and base of Metro box for three different locked-in stress conditions as outlined in **Section 2.3.2** of the report. These analyses indicate the modelled locked-in stress is the main factor in determination of overall movement of proposed soldier pile, Metro station concrete slabs and wall.

**Table 8 Summary of PLAXIS Analysis – Maximum Horizontal Displacement**

| Condition | Structures | Soldier Pile Wall | Base and Northern Wall of Metro Station | Metro Box Southern Wall |
|---|---|---|---|---|
| 1<br>100%<br>Volumetric Strain | Maximum Horizontal Displacement ($U_x$) (mm) | 33.25 | 6.65 | 5.28 |
| | Maximum total movement (IUI) (mm) | 33.70 | 8.81 | 5.31 |
| 2<br>75%<br>Volumetric Strain | Maximum Horizontal Displacement ($U_x$) (mm) | 29.07 | 5.89 | 4.67 |
| | Maximum total movement (IUI) (mm) | 29.44 | 7.84 | 4.7 |
| 3<br>50%<br>Volumetric Strain | Maximum Horizontal Displacement ($U_x$) (mm) | 25.45 | 5.38 | 4.28 |
| | Maximum total movement (IUI) (mm) | 25.76 | 7.11 | 4.31 |

**Table 9** presents the predicted movements of proposed shoring system and Metro Station box with two modelled groundwater conditions briefed in **Section 2.2** of the report. Based on the outcome of the sensitivity analyiss, it is noted that design groundwater level will have no detrimental impact on Metro Station box.

**Table 9 Sensitivity Analysis of Groundwater Conditions**

| Condition[1] | Structures | Soldier Pile Wall | Base and Northern Wall of Metro Station | Metro Box Southern Wall |
|---|---|---|---|---|
| 1<br>No modelled Groundwater | Maximum Horizontal Displacement ($U_x$) (mm) | 33.25 | 6.65 | 5.28 |
| | Maximum total movement (IUI) (mm) | 33.70 | 8.81 | 5.31 |
| 2<br>Modelled groundwater at RL 93.4m AHD | Maximum Horizontal Displacement ($U_x$) (mm) | 30.13 | 7.67 | 7.06 |
| | Maximum total movement (IUI) (mm) | 31.03 | 9.09 | 7.27 |

**Table 10** presents the predicted movements of proposed shoring system and Metro Station box with two anchor modelling condition briefed in **Section 2.3.3** of the report to assess the distribution of stresses within sandstone bedrock and its potential subsequent strain on Metro Box. Based on the outcome of the sensitivity analysis, is it noted that the effect of the anchors pulling the rock mass near the station box is marginal, and rocks anchors are unlikely to cause detrimental impact on Metro Station box.

**Table 10 Sensitivity Analysis of Anchor Modelling Conditions**

| Condition[1] | Structures | Soldier Pile Wall | Base and Northern Wall of Metro Station | Metro Box Southern Wall |
|---|---|---|---|---|
| 1<br>Anchors are modelled as fix-end elements | Maximum Horizontal Displacement ($U_x$) (mm) | 33.25 | 6.65 | 5.28 |
| | Maximum total movement (IUI) (mm) | 33.70 | 8.81 | 5.31 |
| 2<br>Anchors are modelled with Node-to-node and Geogrid elements | Maximum Horizontal Displacement ($U_x$) (mm) | 35.38 | 6.77 | 5.35 |
| | Maximum total movement (IUI) (mm) | 35.88 | 9.07 | 5.39 |

# 4. CONCLUSIONS

The following conclusions can be drawn from the outcome of Finite Element Analysis:

1. Given the weak bond between subsurface ground condition and pre-cast concrete walls, metro box concrete frame will remain unaffected to movement of sandstone block resulted from stress-relief as it shifts towards the northern direction.

2. Based on the outcome of sensitivity analyses with a major respect to different factors, it is noted that modelled lock-in stress of high strength sandstone is governing factor in determination of maximum displacement of proposed soldier pile wall and metro box slabs and walls. It is noted that this assessment is based on a critical conservative assumption that principal stresses are perpendicular to proposed excavation. Furthermore, the modelled locked-in methodology does not incorporate the effect of joints and discontinuities within the sandstone bedrock which allows the sandstone block to displace independently or within the gaps tripped by joints or faults.

3. Proposed excavation is predicted to induce maximum displacement of 9.1mm on the Showground Metro box.

It should be noted that 2D analysis does not take into consideration 3D effects such as the propping effect from the corners and load shedding through the capping beam. The use of a 2D model is inherently conservative for the situation under consideration, for the properties adopted in the geological model and thus the predicted displacements are likely to be conservative also, although the extent to which this is the case is difficult to quantify.

Given the assumptions outlined above and conservativeness of using 2 dimensional PLAXIS, EI notes that predicted movement is likely to be an overestimate of induced movement on metro box walls and slabs resulted from basement excavation. Hence, EI conclude that proposed development will not detrimentally impact the Sydney Metro station box along southern elevation of proposed basement outline.

If the construction stages or the development vary from those modelled above, the FEA should be reviewed.

## 5. LIMITATIONS

Your attention is drawn to the document "Important Information", attached as **Appendix B** at the end of this letter report. The statements presented in this document are intended to advise you of what your realistic expectations of this report should be. The document is not intended to reduce the level of responsibility accepted by EI, but rather to ensure that all parties who may rely on this report are aware of the responsibilities each assumes in so doing.

This letter report was prepared by EI for the sole use of Deicorp Pty Ltd for the particular project and purpose described. No responsibility is accepted for the use of any part of this letter report in any other content or for any other purpose.

EI has used a degree of care, skill and diligence normally exercised by consulting engineers in similar circumstances and locality and has relied on the accuracy of information provided by Deicorp Pty Ltd. No other warranty expressed or implied is made or intended.

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## 6. CLOSURE

Please do not hesitate to contact the undersigned should you have any questions.

For and on behalf of:
**EI AUSTRALIA**

**Authors**

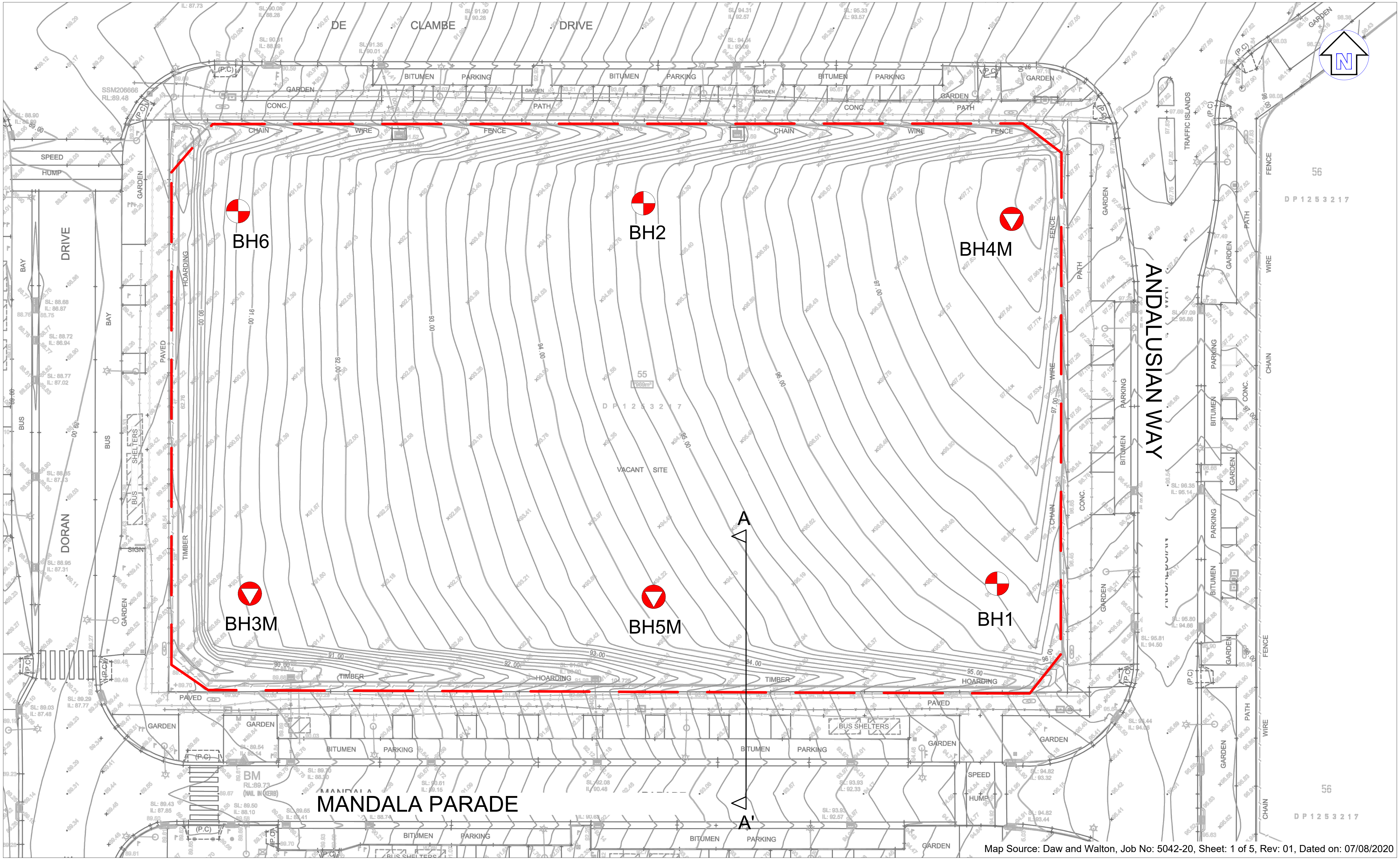
**Saman Kazemi**
Geotechnical Engineer

**Technical Reviewer**

**Stephen Kim**
Senior Geotechnical Engineer

Attachments: Figures
Appendix A – PLAXIS 2D Outputs
Appendix B – Important Information

# FIGURES




**LEGEND**

- Approximate Site Boundary
- Approximate geotechnical borehole location
- Approximate geotechnical borehole/monitoring well location
- Section A - A'

eiaustralia
Contamination | Remediation | Geotechnical
Suite 6.01, 55 Miller Street, PYRMONT 2009
Ph (02) 9516 0722 Fax (02) 9518 5088

| | |
|---|---|
| Drawn: | S.Ka |
| Approved: | S.Kim |
| Date: | 04/5/2022 |

**Deicorp Pty Ltd**
Impact Assessment Report
2 Mandala Parade, Castle Hill NSW
Borehole and PLAXIS Section Locations

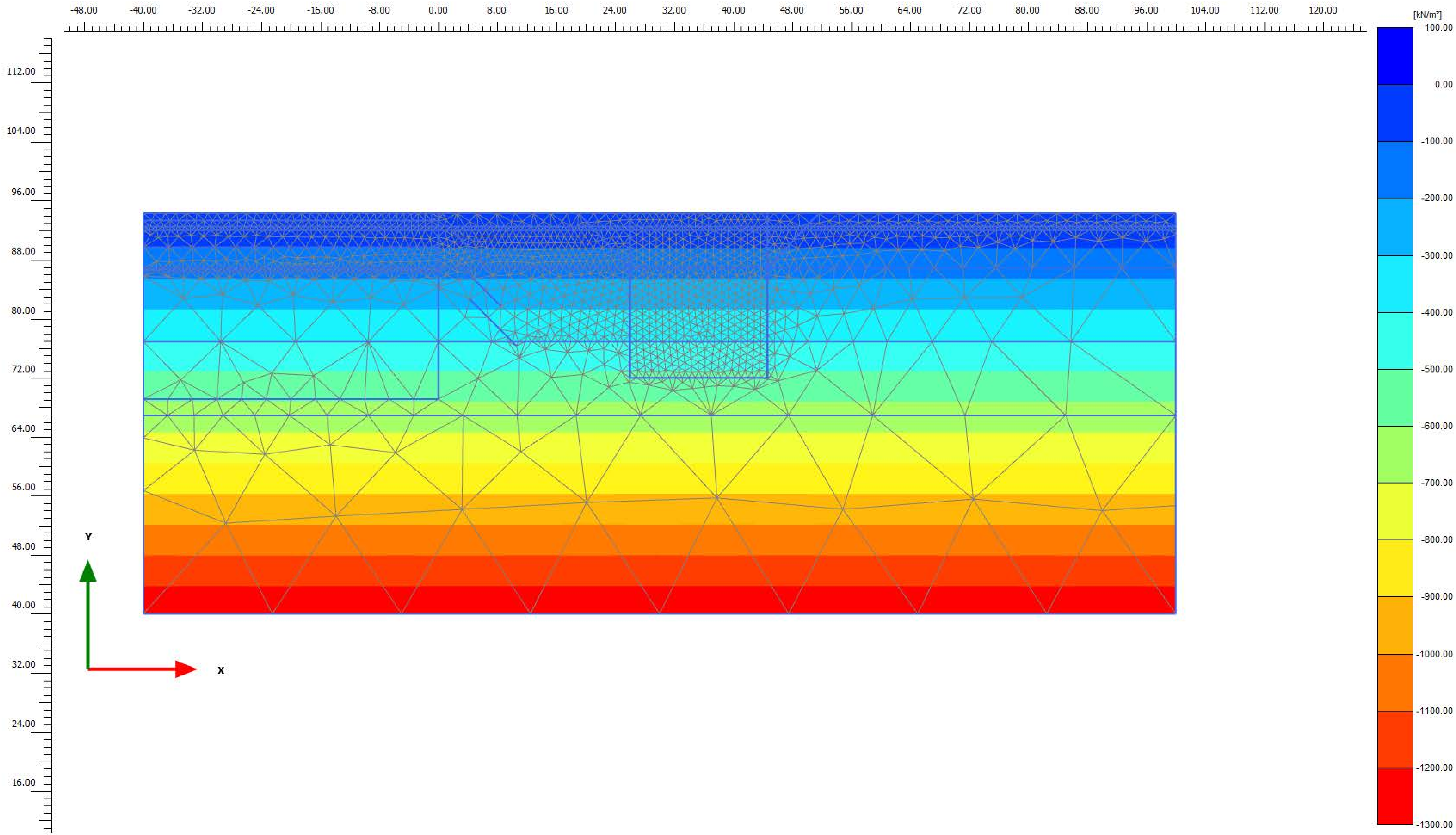
Figure: 1

Project: E24724.G06_Rev4

# APPENDIX A

# PLAXIS 2D Outputs

Output Version 21.1.0.479



**Cartesian total stress $\sigma_{yy}$ (scaled up $5.00*10^{-3}$ times)**

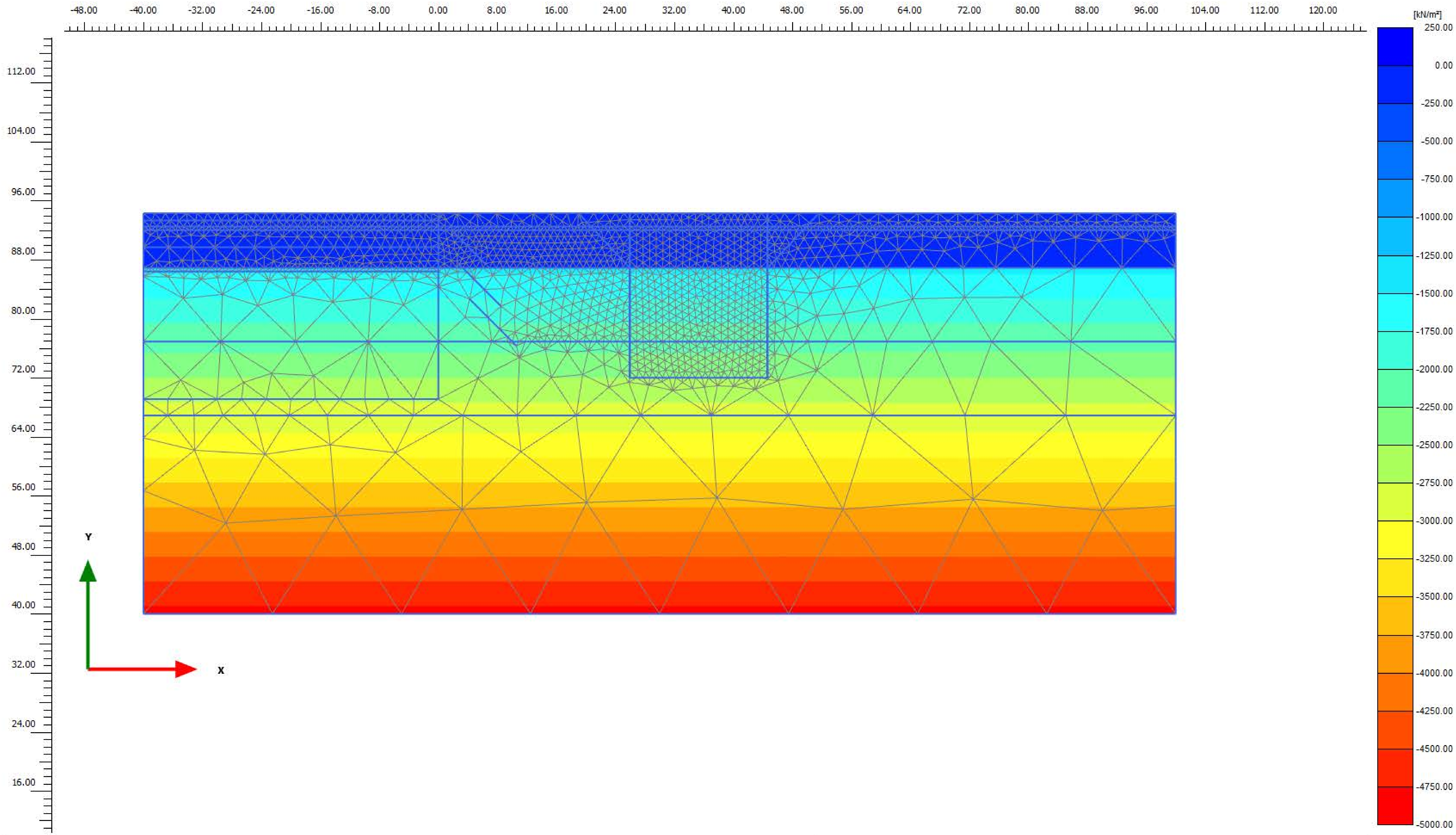
Maximum value = $1.313*10^{-3}$ kN/m² (Element 74 at Node 20884)

Minimum value = -1290 kN/m² (Element 3234 at Node 8384)

| Project description | Date |
|---|---|
| E24724.G06.Rev 4 Castle Hill Development – In-situ Stresses | 4/05/2022 |

| Project filename | Step | Company |
|---|---|---|
| E24724.G06.Rev4 Castle Hill Proposed Development – ... | 2 | EI Australia |

Output Version 21.1.0.479




**Cartesian total stress $\sigma_{xx}$ (scaled up $0.500 \times 10^{-3}$ times)**

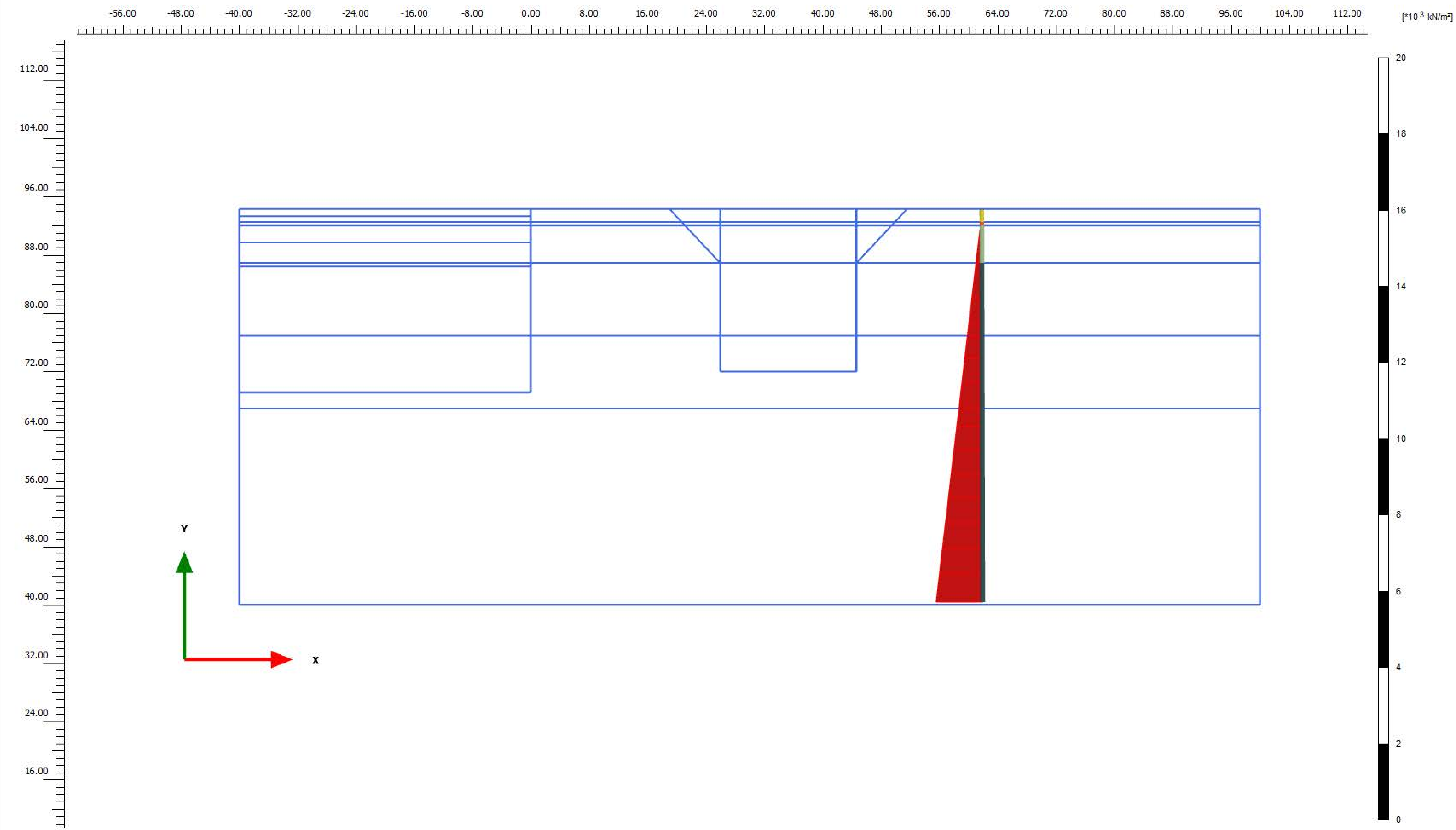
Maximum value = $3.216 \times 10^{-3}$ kN/m² (Element 201 at Node 13692)

Minimum value = -4828 kN/m² (Element 3234 at Node 8384)

| Project description | Date |
|---|---|
| E24724.G06.Rev 4 Castle Hill Development – In-situ Stresses | 4/05/2022 |

| Project filename | Step | Company |
|---|---|---|
| E24724.G06.Rev4 Castle Hill Proposed Development – ... | 2 | EI Australia |

Output Version 21.1.0.479




**Cartesian effective stress σ'$_{yy}$ (scaled up 5.00*10$^{-3}$ times)**

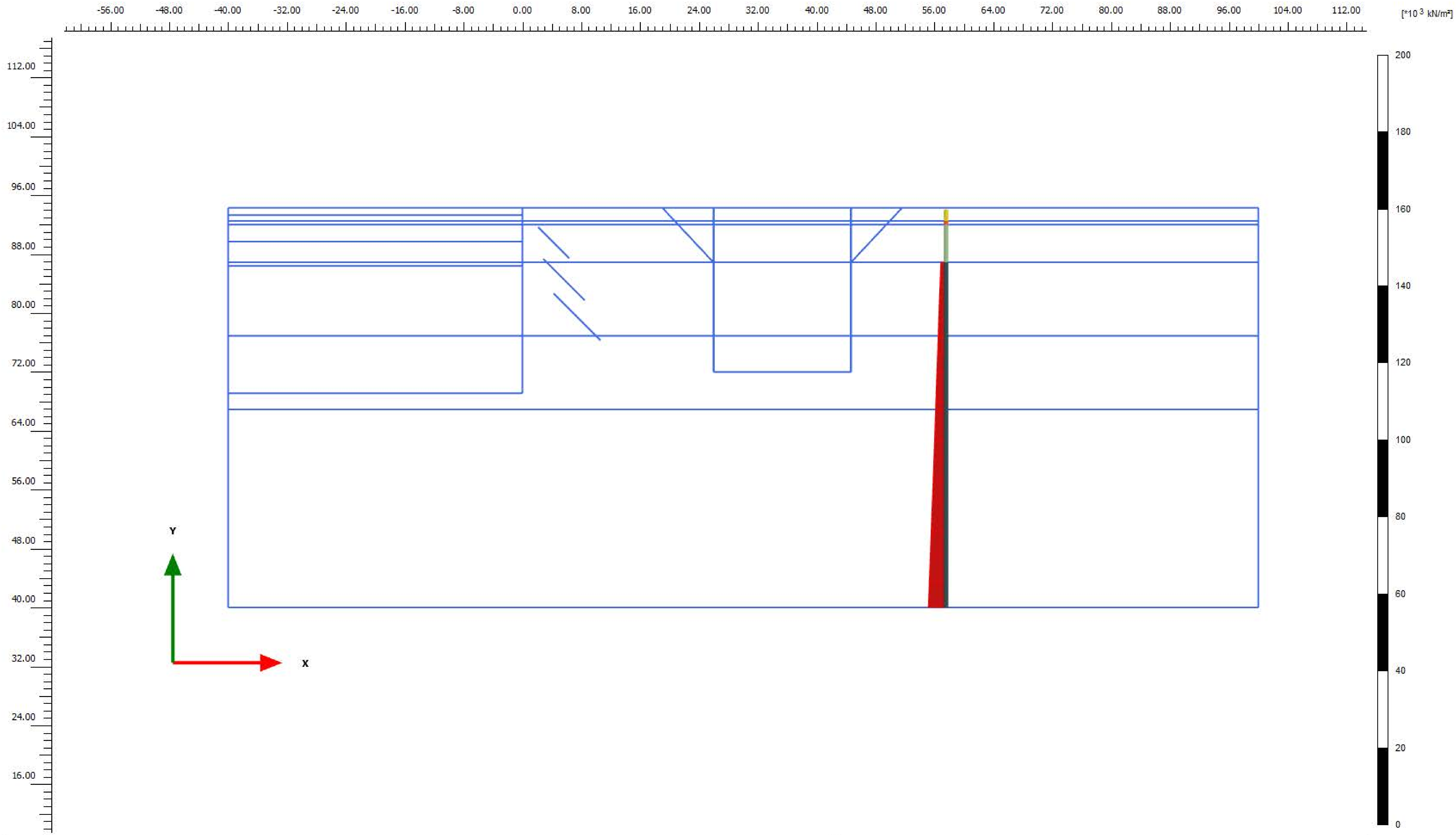
Maximum value = -2.030 kN/m²

Minimum value = -1281 kN/m²

| Project description | | Date |
|---|---|---|
| E24724.G06.Rev 4 Castle Hill Development – in-situ stresses | | 4/05/2022 |

| Project filename | Step | Company |
|---|---|---|
| E24724.G06.Rev4 Castle Hill Proposed Development – ... | 2 | EI Australia |

Output Version 21.1.0.479




**Cartesian effective stress $\sigma'_{xx}$ (scaled up $0.500 \times 10^{-3}$ times)**

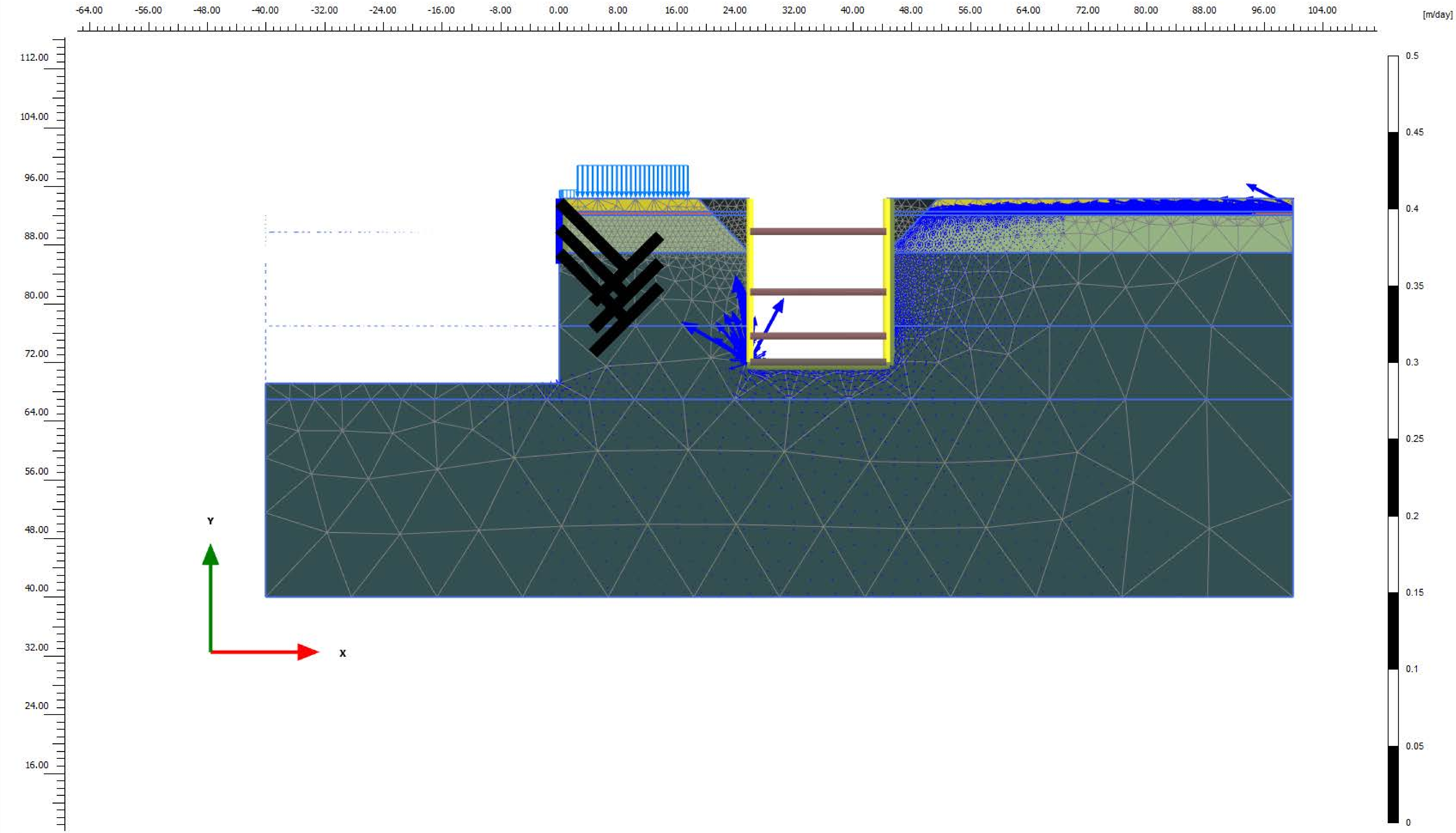
Maximum value = -2.478 kN/m²

Minimum value = -4828 kN/m²

| Project description | Date |
|---|---|
| E24724.G06.Rev 4 Castle Hill Development – In-situ Stresses | 4/05/2022 |

| Project filename | Step | Company |
|---|---|---|
| E24724.G06.Rev4 Castle Hill Proposed Development – ... | 2 | EI Australia |

Output Version 21.1.0.479




**Groundwater flow |q| (scaled up 200 times)**

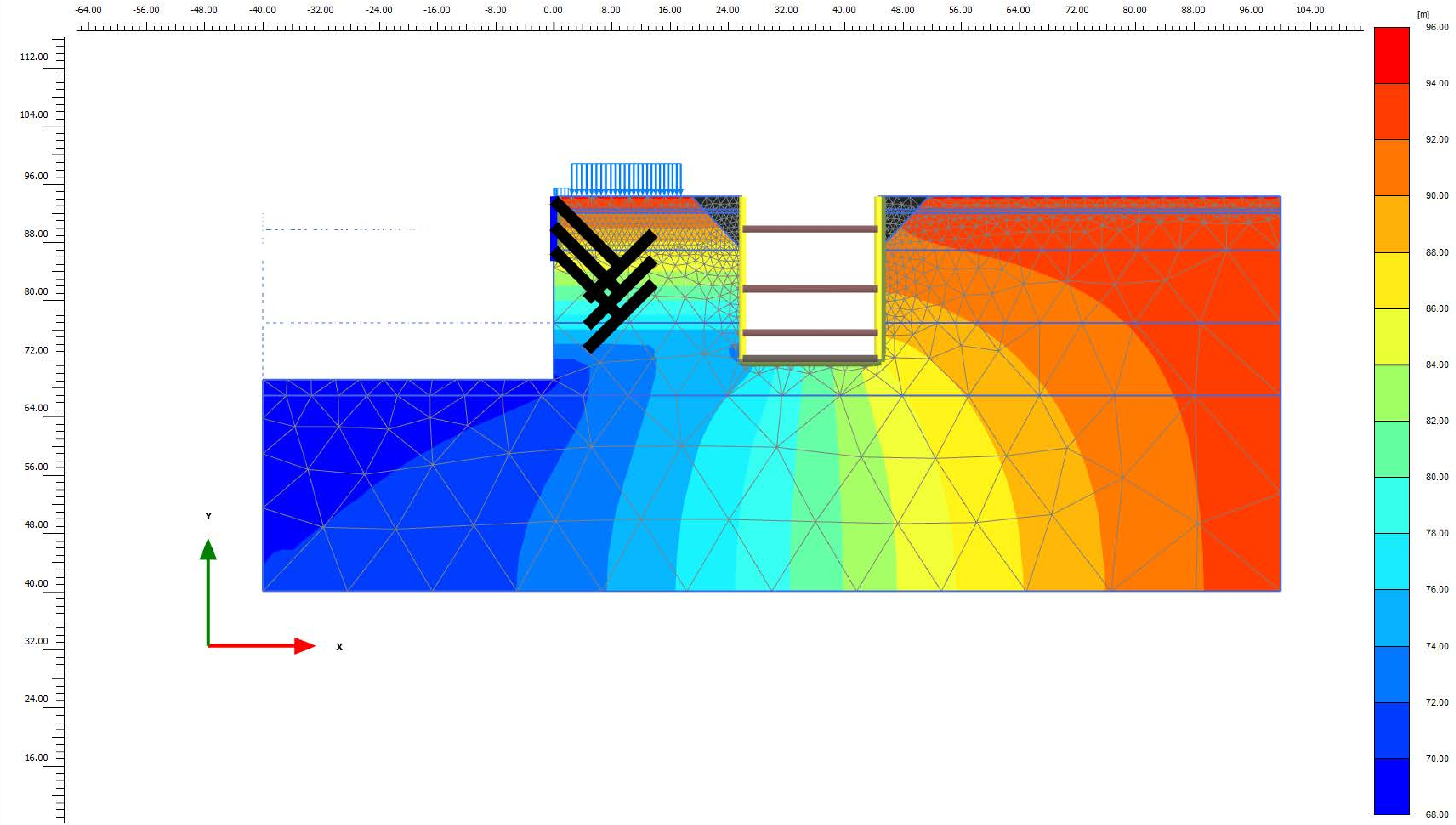
Maximum value = 0.06143 m/day (Element 5054 at Stress point 60638)

Minimum value = $0.6219 \times 10^{-9}$ m/day (Element 1019 at Stress point 12224)

| Project description | | Date |
|---|---|---|
| E24724.G06.Rev 4 Castle Hill Development –Dewatering | | 4/05/2022 |

| Project filename | Step | Company |
|---|---|---|
| E24724.G06.Rev4 Castle Hill Proposed Development – ... | 107 | EI Australia |

Output Version 21.1.0.479



**Groundwater head (scaled up 0.0500 times)**

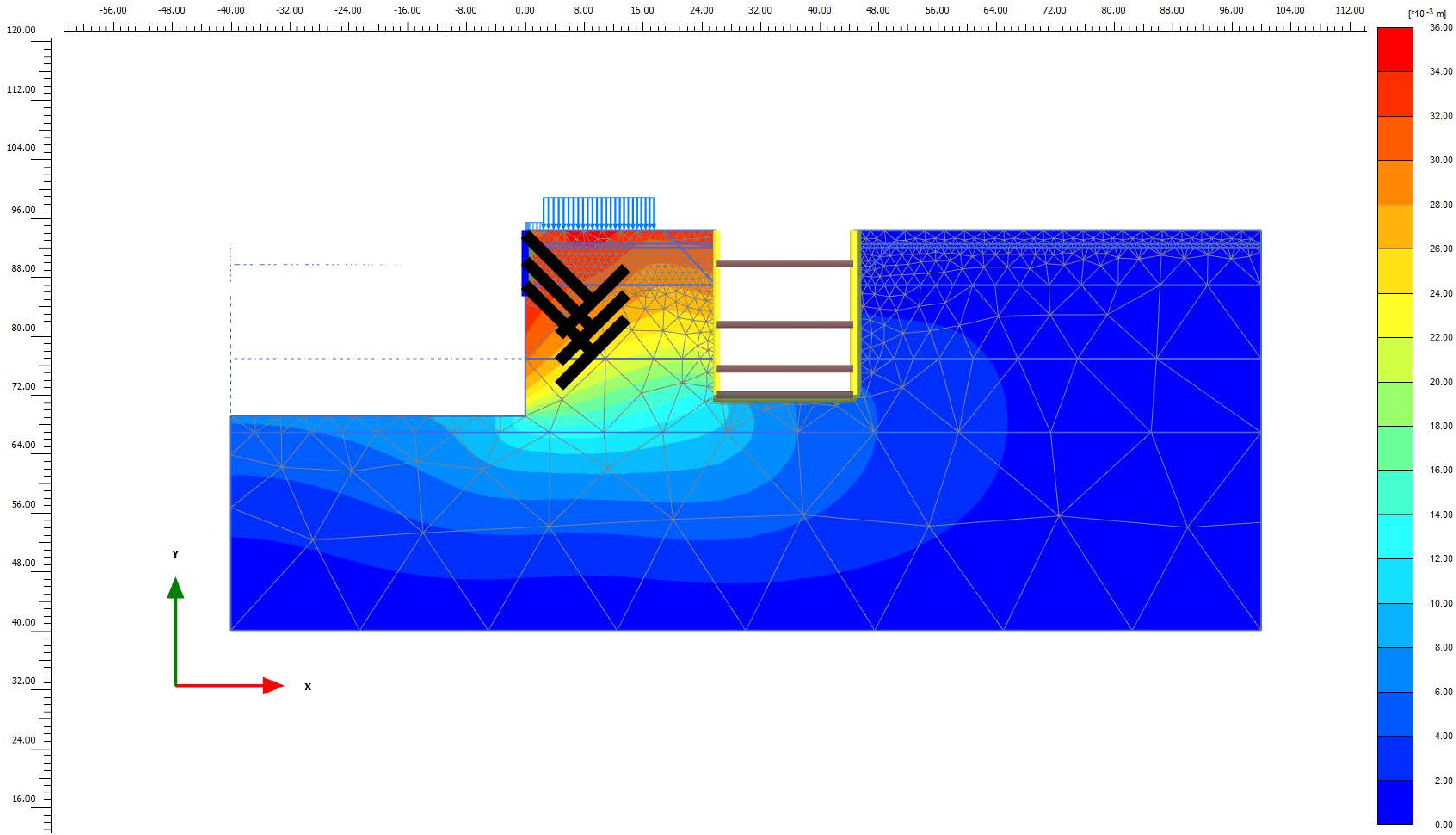
Maximum value = 94.30 m (Element 336 at Node 25932)

Minimum value = 69.10 m (Element 4935 at Node 9371)

| Project description | | Date |
|---|---|---|
| E24724.G06.Rev 4 Castle Hill Development – Groundwater Head – Analysis with Water | | 4/05/2022 |

| Project filename | Step | Company |
|---|---|---|
| E24724.G06.Rev4 Castle Hill Proposed Development – ... | 107 | EI Australia |

Output Version 21.1.0.479



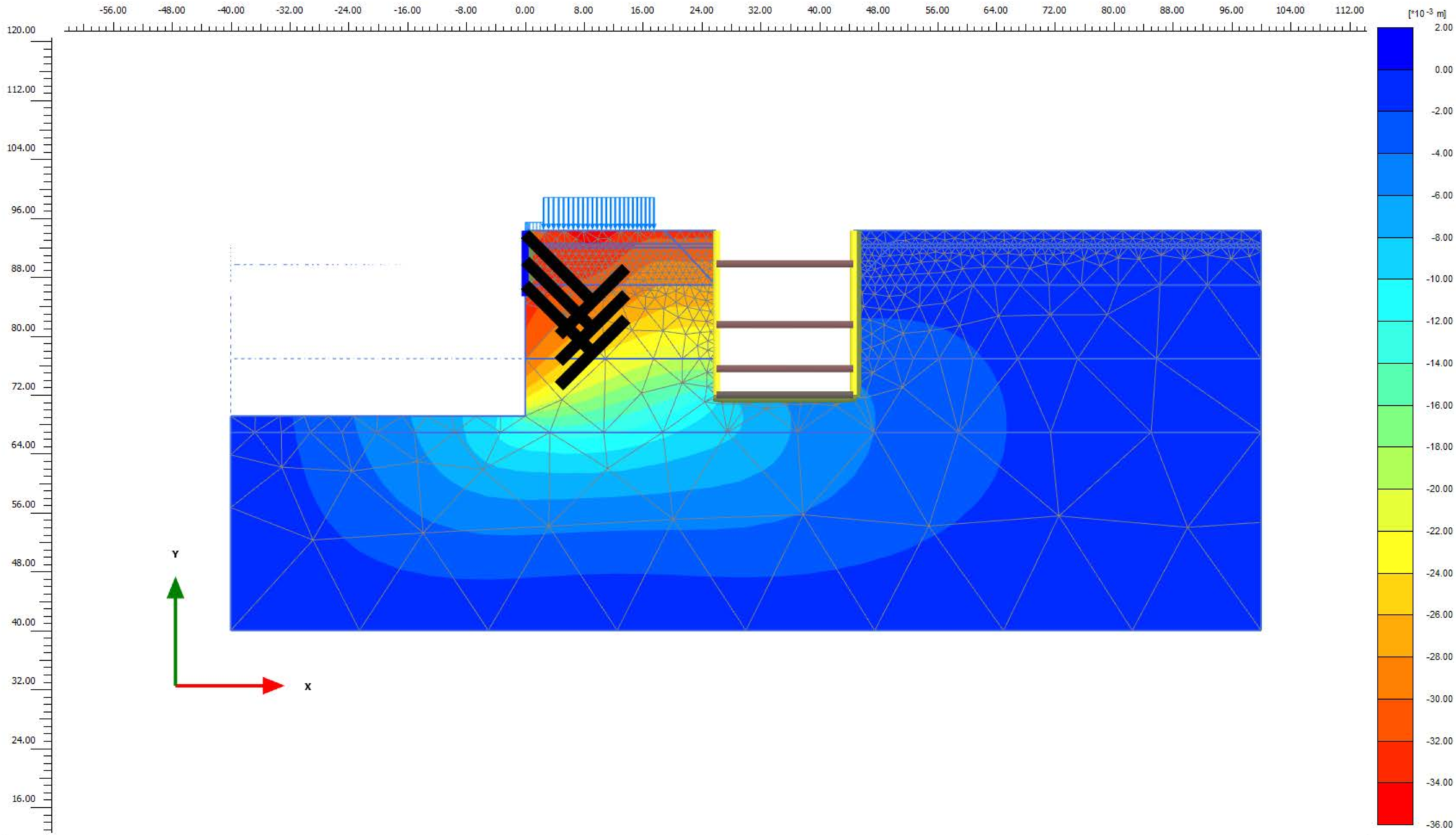

**Total displacements |u| (scaled up 100 times)**

Maximum value = 0.03470 m (Element 345 at Node 8083)

| Project description | Date |
|---|---|
| E24724.G06.Rev 4 Castle Hill Development – 100%VS Nowater | 4/05/2022 |

| Project filename | Step | Company |
|---|---|---|
| E24724.G06.Rev4 Castle Hill Proposed Development – ... | 54 | EI Australia |

Output Version 21.1.0.479




**Total displacements $u_x$ (scaled up 100 times)**

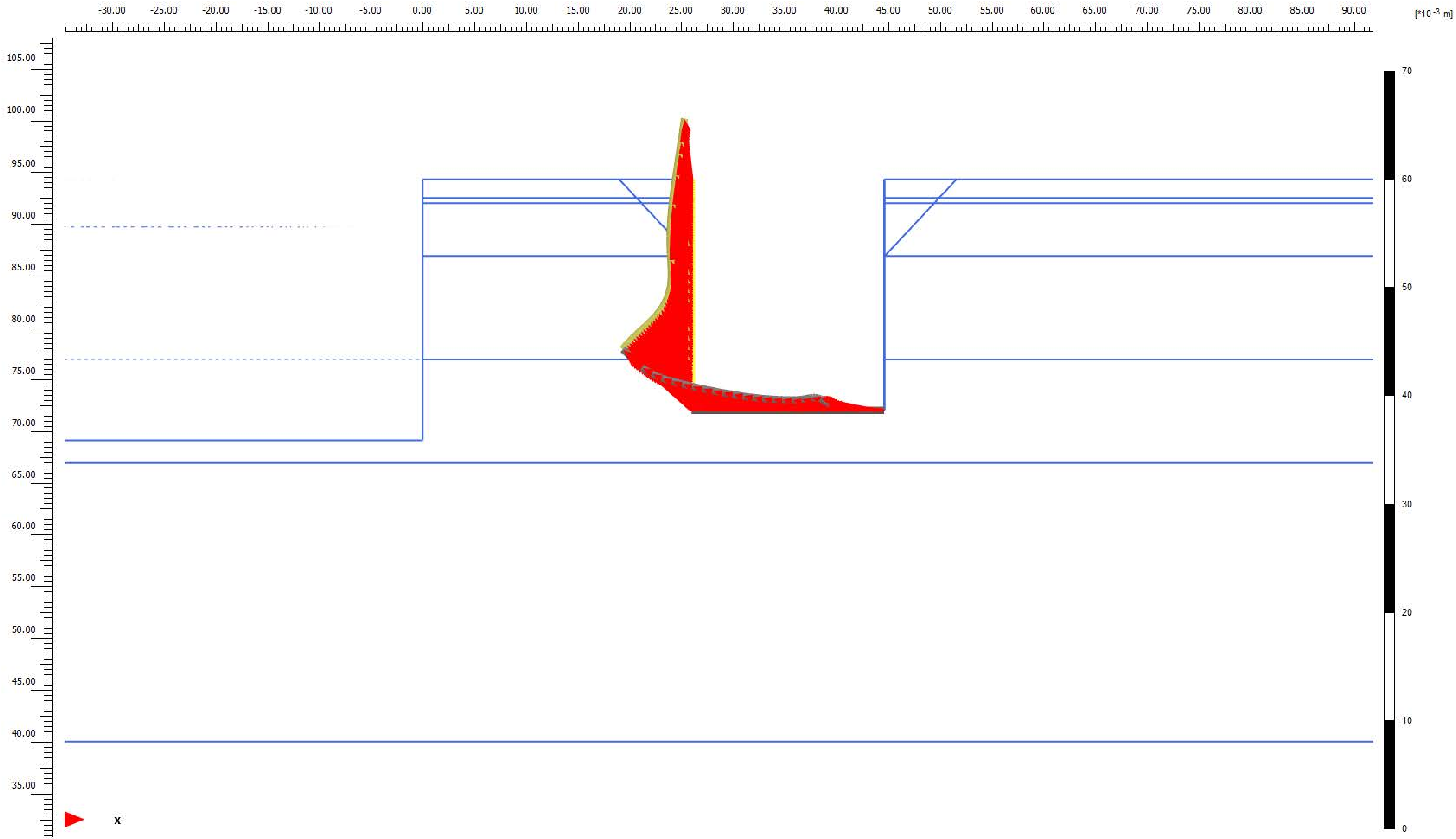
Maximum value = 0.000 m (Element 214 at Node 13031)

Minimum value = -0.03465 m (Element 345 at Node 8083)

| Project description | Date |
|---|---|
| E24724.G06.Rev 4 Castle Hill Development – 100%VS Nowater | 4/05/2022 |

| Project filename | Step | Company |
|---|---|---|
| E24724.G06.Rev4 Castle Hill Proposed Development – ... | 54 | EI Australia |

Output Version 21.1.0.479




**Total displacements |u| (scaled up 1.00*10$^{3}$ times)**

Maximum value = 8.881*10$^{-3}$ m (Element 53 at Node 10196)

| Project description | Date |
|---|---|
| E24724.G06.Rev 4 Castle Hill Development – 100%VS Nowater | 4/05/2022 |

| Project filename | Step | Company |
|---|---|---|
| E24724.G06.Rev4 Castle Hill Proposed Development – ... | 54 | EI Australia |

Output Version 21.1.0.479

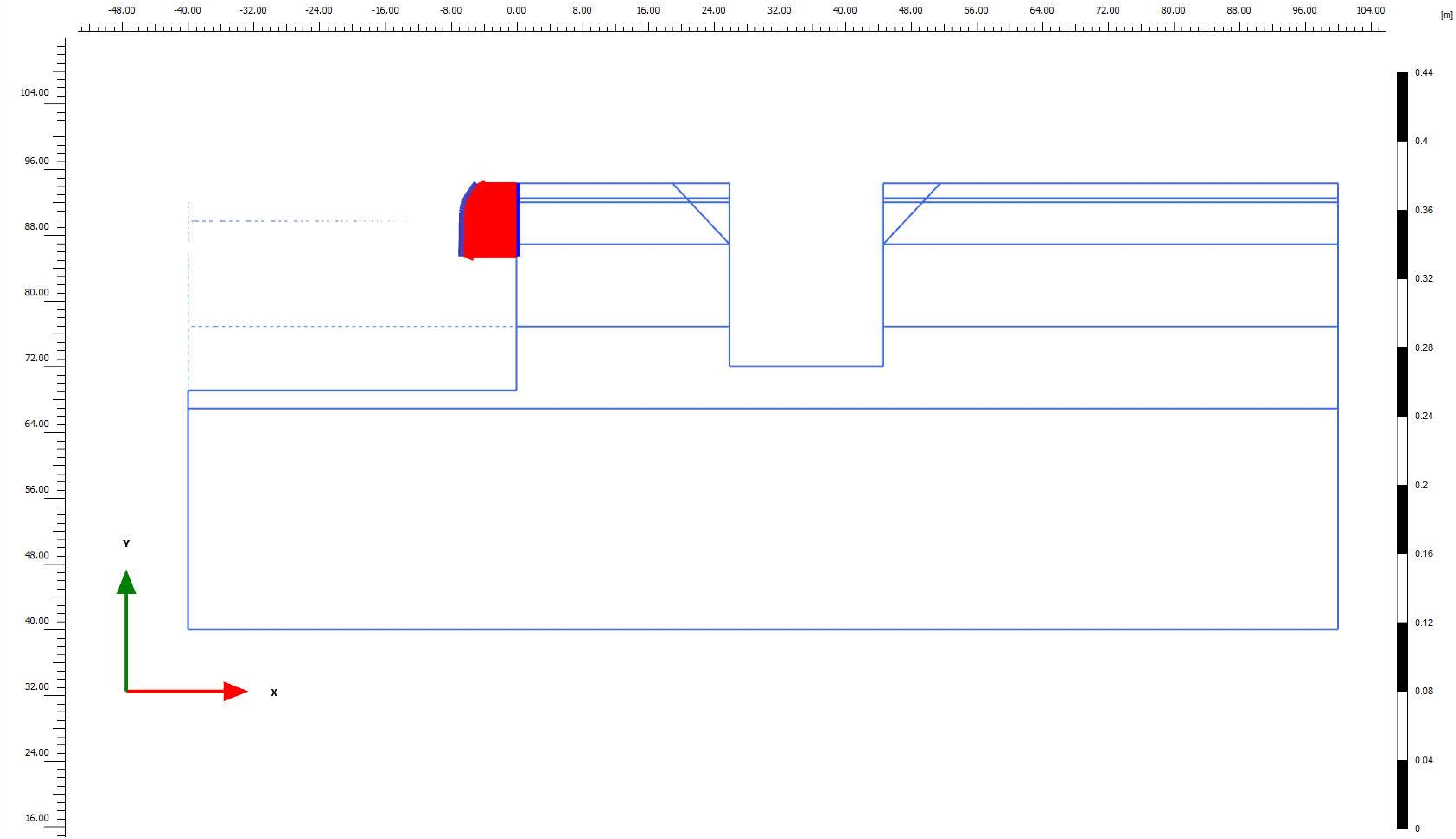
**Total displacements $u_x$ (scaled up $1.00*10^3$ times)**

Maximum value = $-0.6791*10^{-3}$ m (Element 4 at Node 20515)

Minimum value = $-6.650*10^{-3}$ m (Element 53 at Node 10196)

| Project description | Date |
|---|---|
| E24724.G06.Rev 4 Castle Hill Development – 100%VS Nowater | 4/05/2022 |

| Project filename | Step | Company |
|---|---|---|
| E24724.G06.Rev4 Castle Hill Proposed Development – ... | 54 | EI Australia |




**Total displacements $u_x$ (scaled up 200 times)**

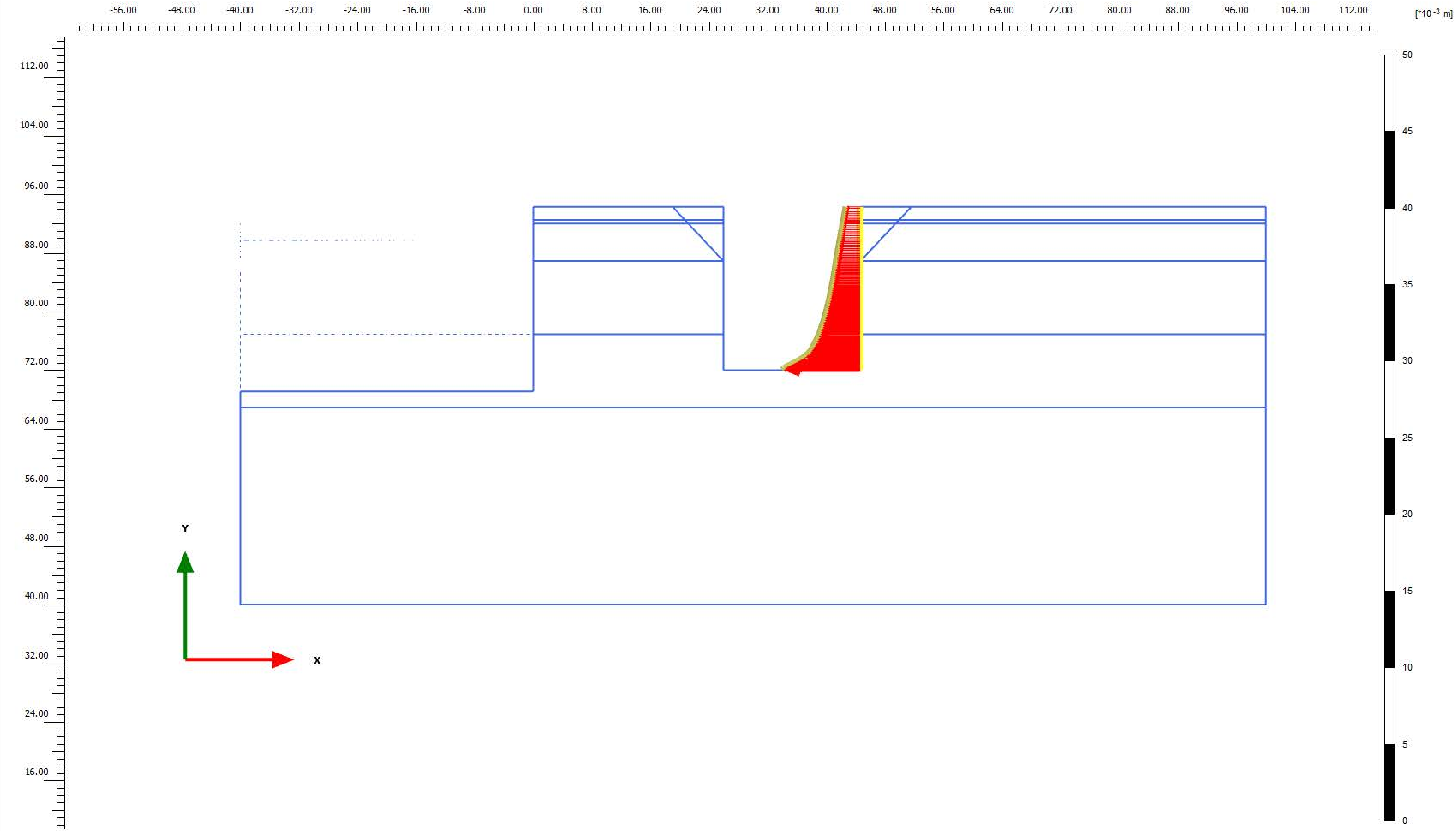
Maximum value = -0.02417 m (Element 1 at Node 3070)

Minimum value = -0.03325 m (Element 28 at Node 6754)

| Project description | Date |
|---|---|
| E24724.G06.Rev 4 Castle Hill Development – 100%VS Nowater | 4/05/2022 |

| Project filename | Step | Company |
|---|---|---|
| E24724.G06.Rev4 Castle Hill Proposed Development – ... | 54 | EI Australia |

Output Version 21.1.0.479



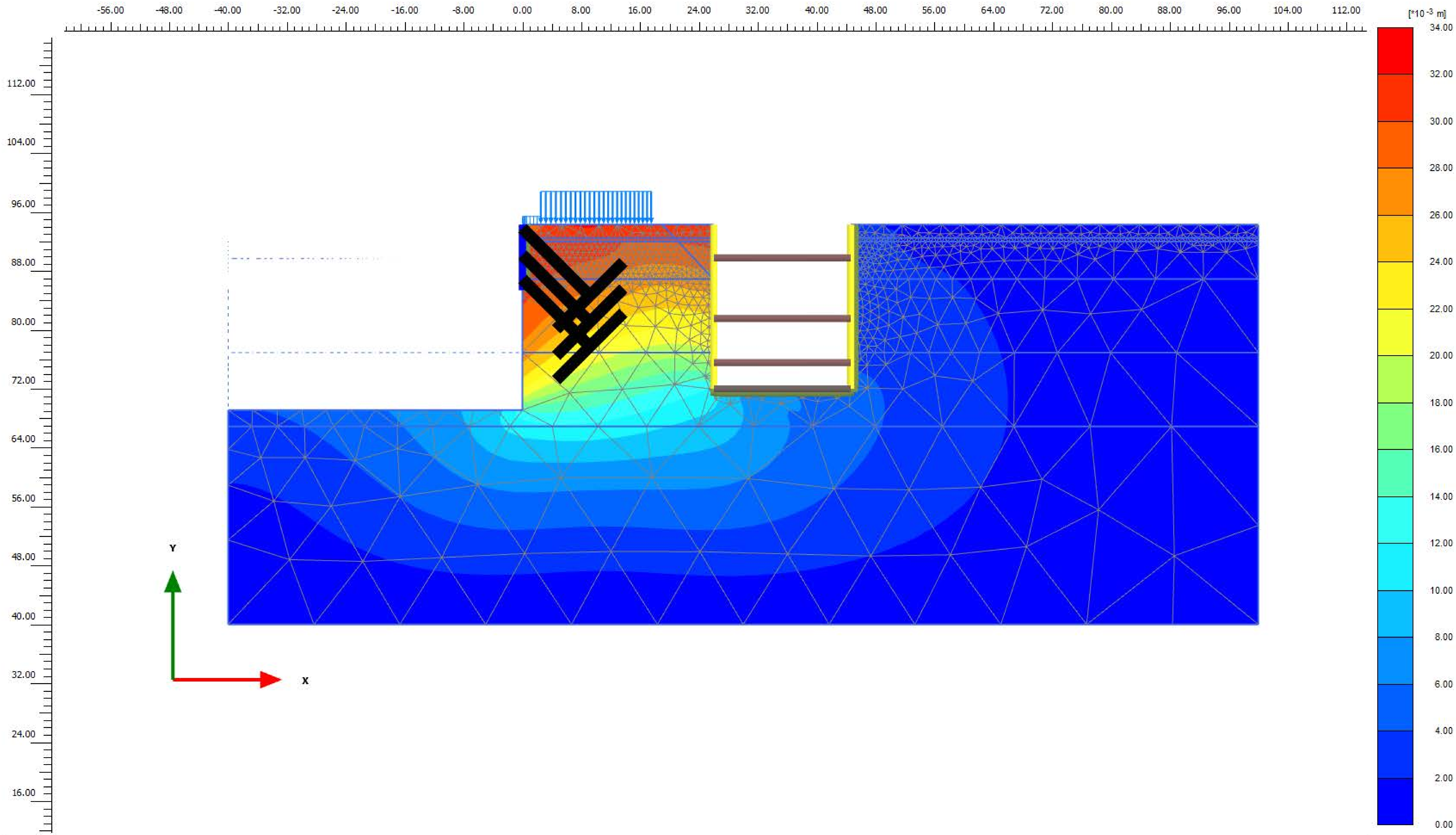

**Total displacements $u_x$ (scaled up $2.00*10^3$ times)**

Maximum value = $-0.9475*10^{-3}$ m (Element 6 at Node 24499)

Minimum value = $-5.276*10^{-3}$ m (Element 57 at Node 11888)

| Project description | Date |
|---|---|
| E24724.G06.Rev 4 Castle Hill Development – 100%VS Nowater | 4/05/2022 |

| Project filename | Step | Company |
|---|---|---|
| E24724.G06.Rev4 Castle Hill Proposed Development – ... | 54 | EI Australia |



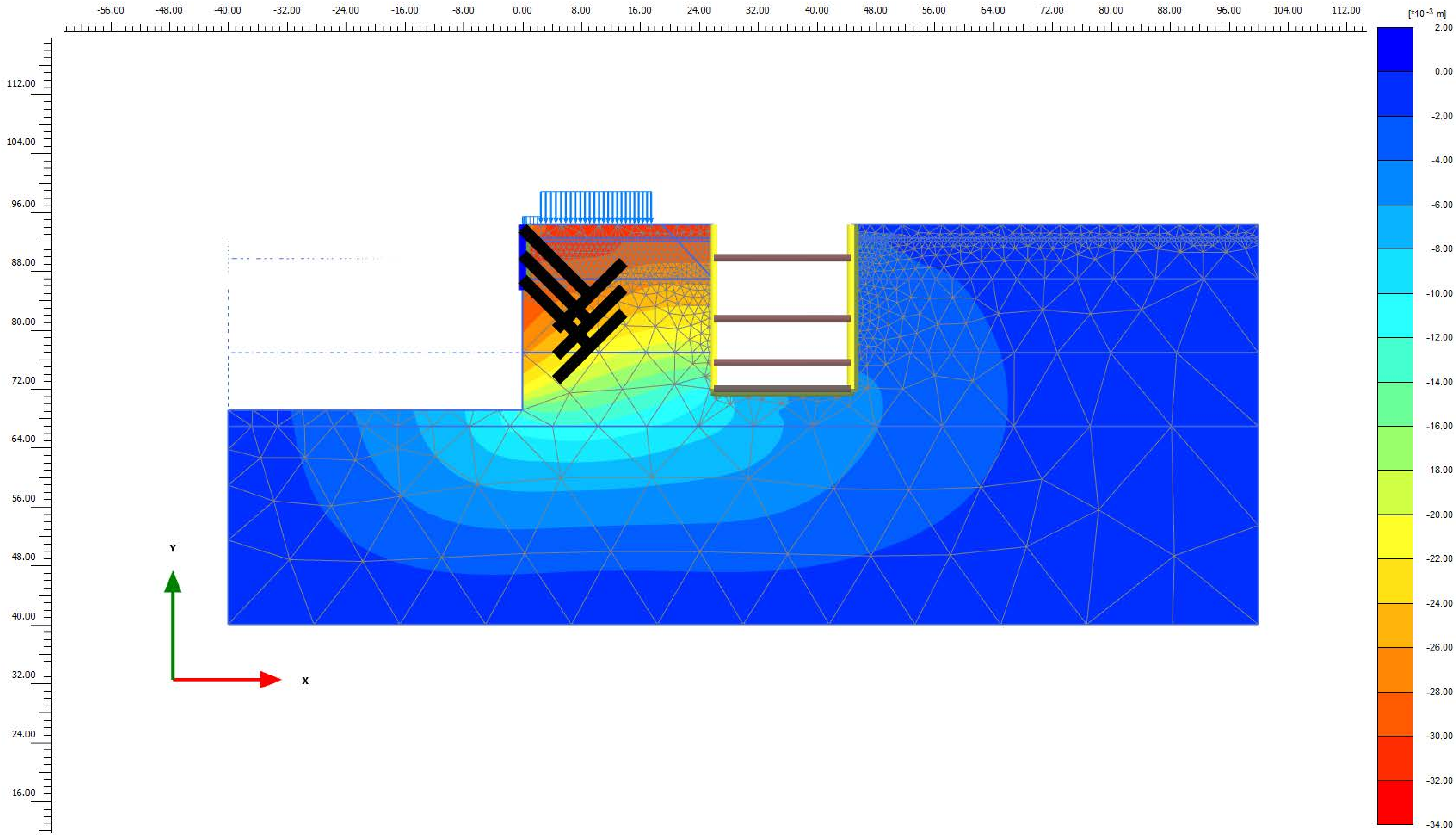

**Total displacements |u| (scaled up 100 times)**

Maximum value = 0.03219 m (Element 104 at Node 30499)

| Project description | | Date |
|---|---|---|
| E24724.G06.Rev 4 Castle Hill Development – 100%VS with Water | | 4/05/2022 |

| Project filename | Step | Company |
|---|---|---|
| E24724.G06.Rev4 Castle Hill Proposed Development – ... | 107 | EI Australia |

Output Version 21.1.0.479




**Total displacements $u_x$ (scaled up 100 times)**

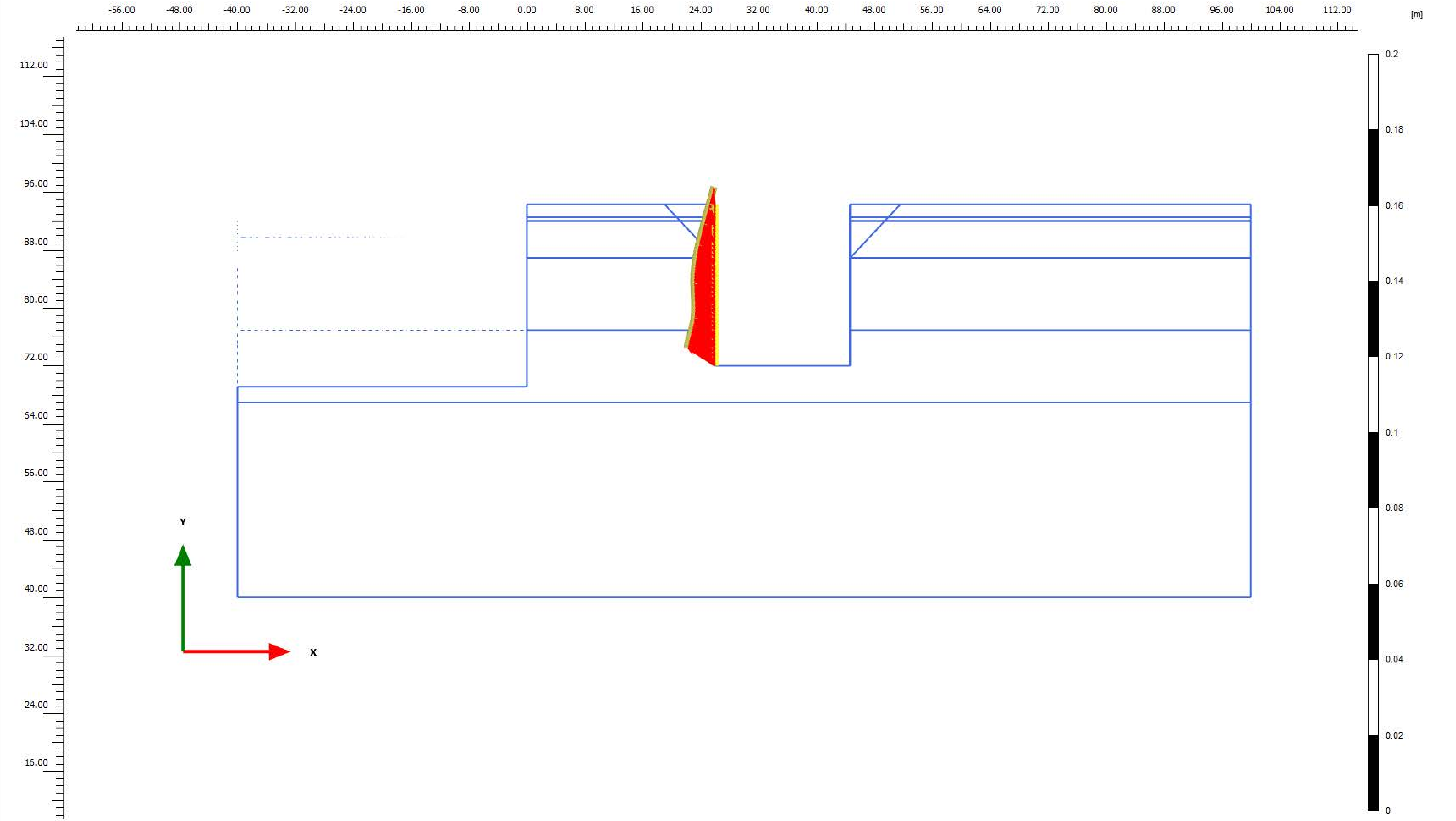
Maximum value = 0.000 m (Element 366 at Node 15823)

Minimum value = -0.03197 m (Element 503 at Node 14248)

| Project description | Date |
|---|---|
| E24724.G06.Rev 4 Castle Hill Development – 100%VS with water | 4/05/2022 |

| Project filename | Step | Company |
|---|---|---|
| E24724.G06.Rev4 Castle Hill Proposed Development – ... | 107 | EI Australia |

Output Version 21.1.0.479

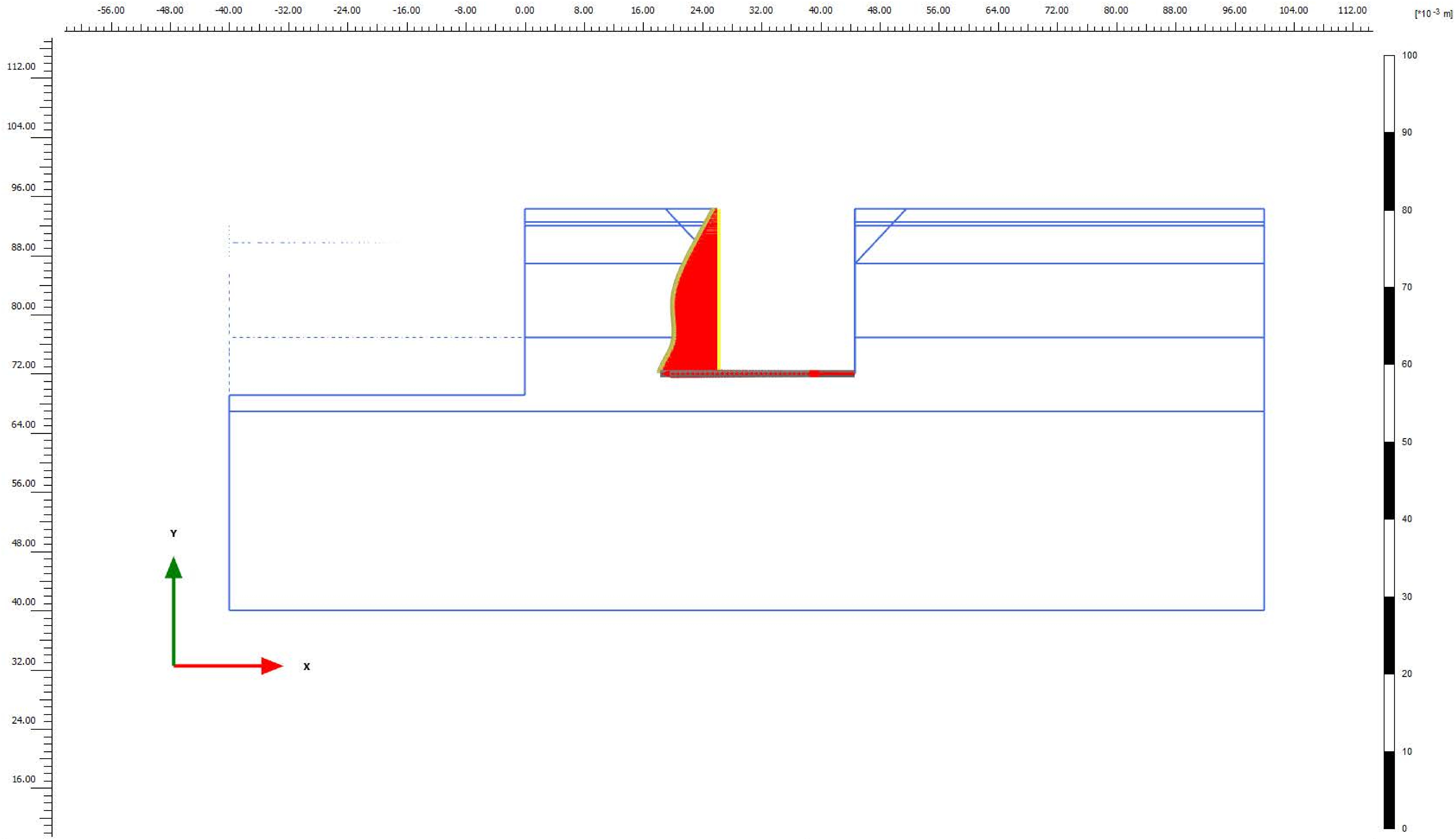



**Total displacements |u| (scaled up 500 times)**

Maximum value = $9.090*10^{-3}$ m (Element 78 at Node 11717)

| | | | |
|---|---|---|---|
| eiaustralia | Project description<br>E24724.G06.Rev 4 Castle Hill Development – 100% VS with Water | | Date<br>4/05/2022 |
| | Project filename<br>E24724.G06.Rev4 Castle Hill Proposed Development – ... | Step<br>107 | Company<br>EI Australia |

Output Version 21.1.0.479




**Total displacements $u_x$ (scaled up $1.00*10^3$ times)**

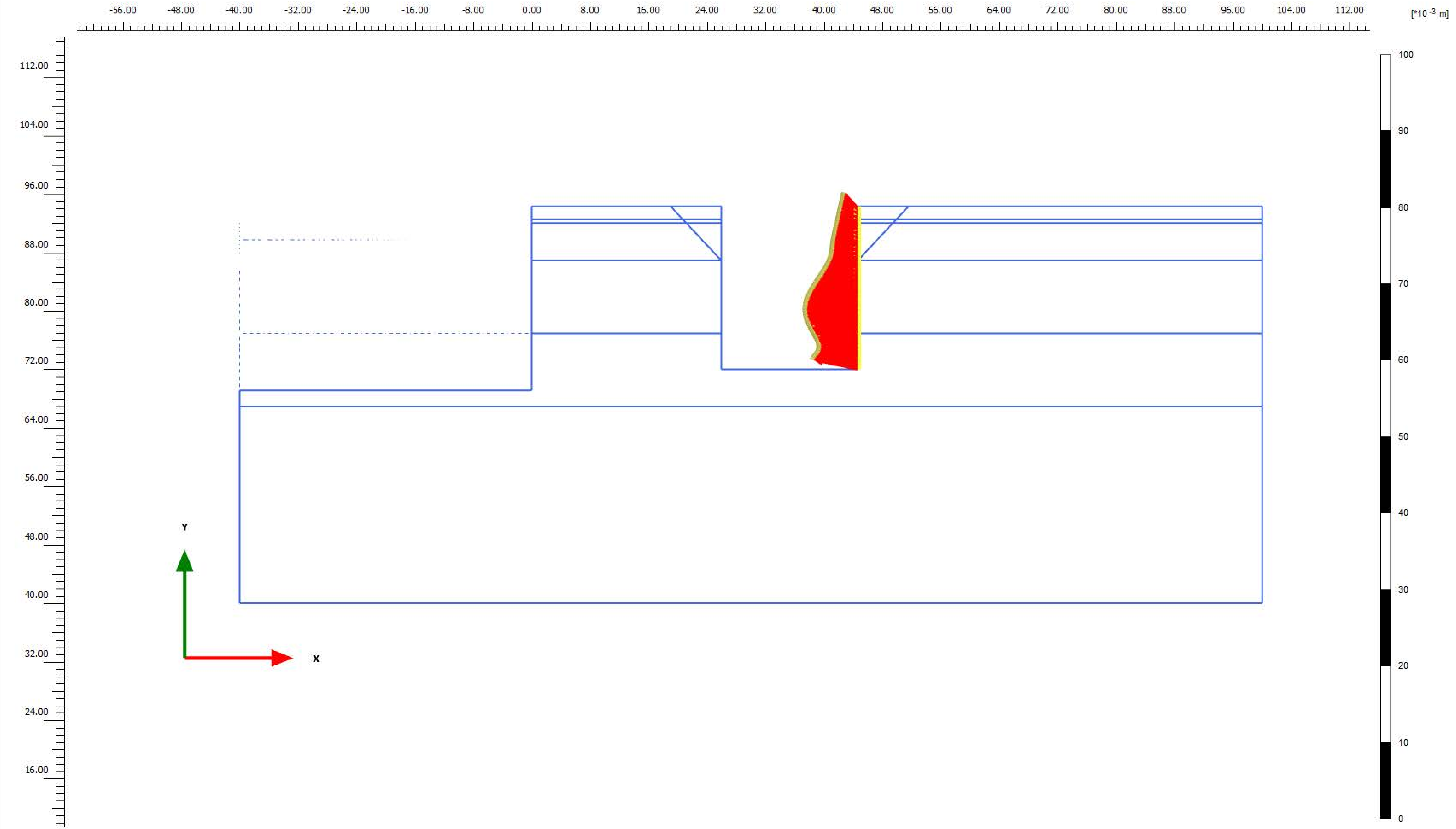
Maximum value = $-0.3174*10^{-3}$ m (Element 5 at Node 32665)

Minimum value = $-7.698*10^{-3}$ m (Element 78 at Node 11717)

| Project description | Date |
|---|---|
| E24724.G06.Rev 4 Castle Hill Development – 100% VS with Water | 4/05/2022 |

| Project filename | Step | Company |
|---|---|---|
| E24724.G06.Rev4 Castle Hill Proposed Development – ... | 107 | EI Australia |

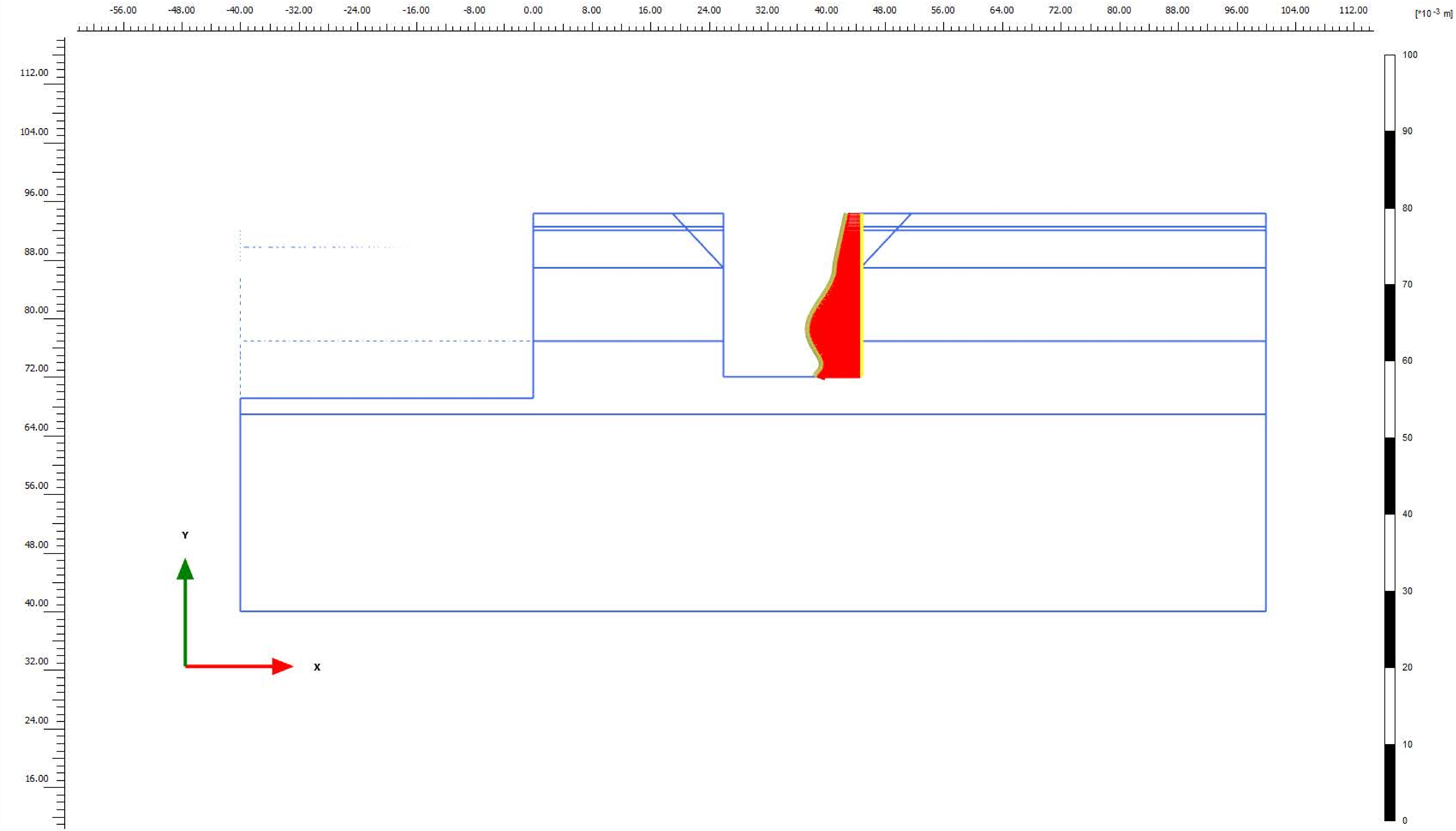
Output Version 21.1.0.479




**Total displacements |u| (scaled up 1.00*10$^3$ times)**

Maximum value = 7.265*10$^{-3}$ m (Element 68 at Node 23795)

| | | | |
|---|---|---|---|
| Project description: E24724.G06.Rev 4 Castle Hill Development – 100% VS with Water | | | Date: 4/05/2022 |
| Project filename: E24724.G06.Rev4 Castle Hill Proposed Development – ... | Step: 107 | Company: EI Australia | |




**Total displacements $u_x$ (scaled up $1.00*10^3$ times)**

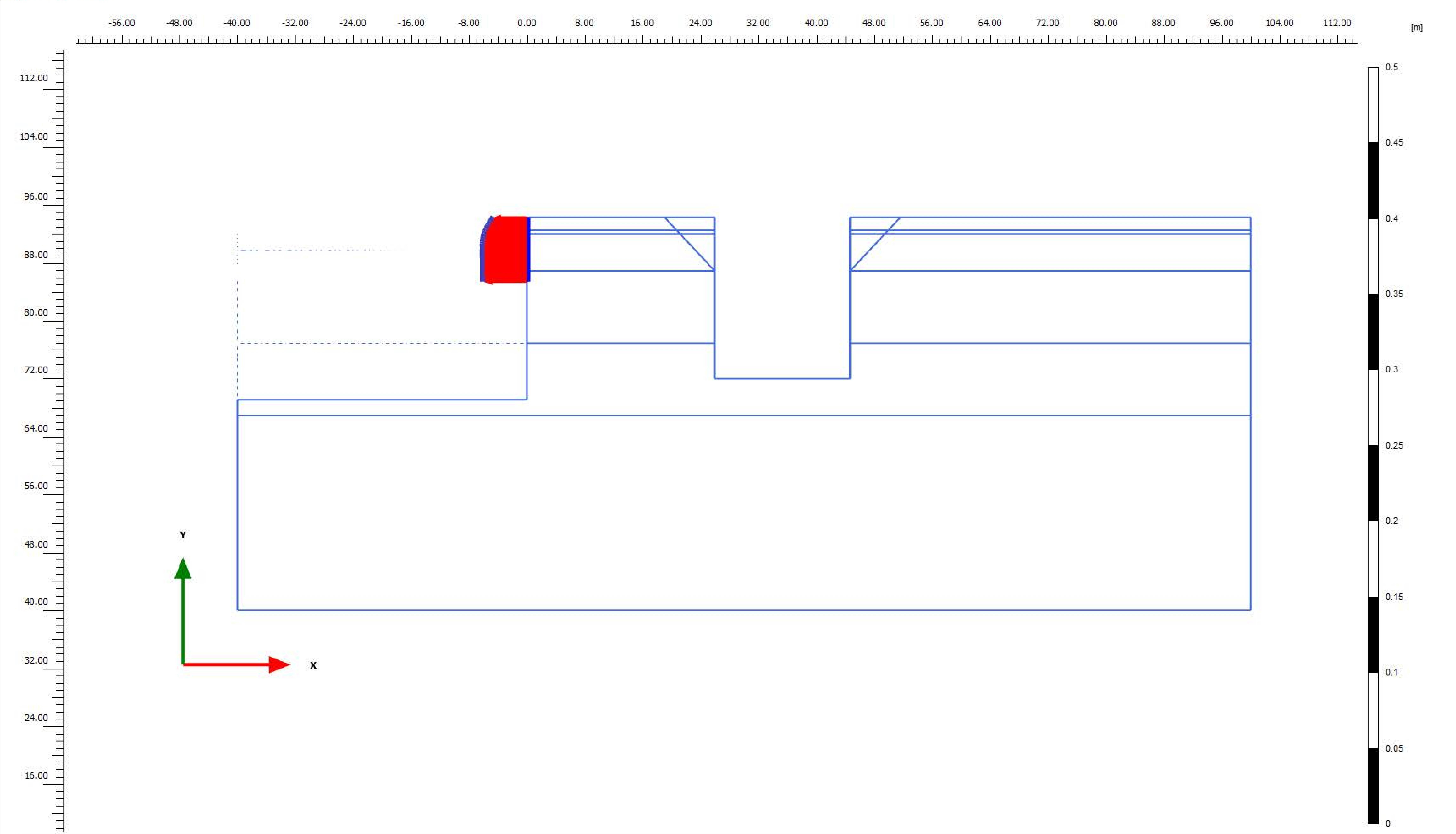
Maximum value = $-1.755*10^{-3}$ m (Element 8 at Node 38700)

Minimum value = $-7.063*10^{-3}$ m (Element 68 at Node 23795)

| Project description | Date |
|---|---|
| E24724.G06.Rev 4 Castle Hill Development – 100% VS with Water | 4/05/2022 |

| Project filename | Step | Company |
|---|---|---|
| E24724.G06.Rev4 Castle Hill Proposed Development – ... | 107 | EI Australia |

Output Version 21.1.0.479



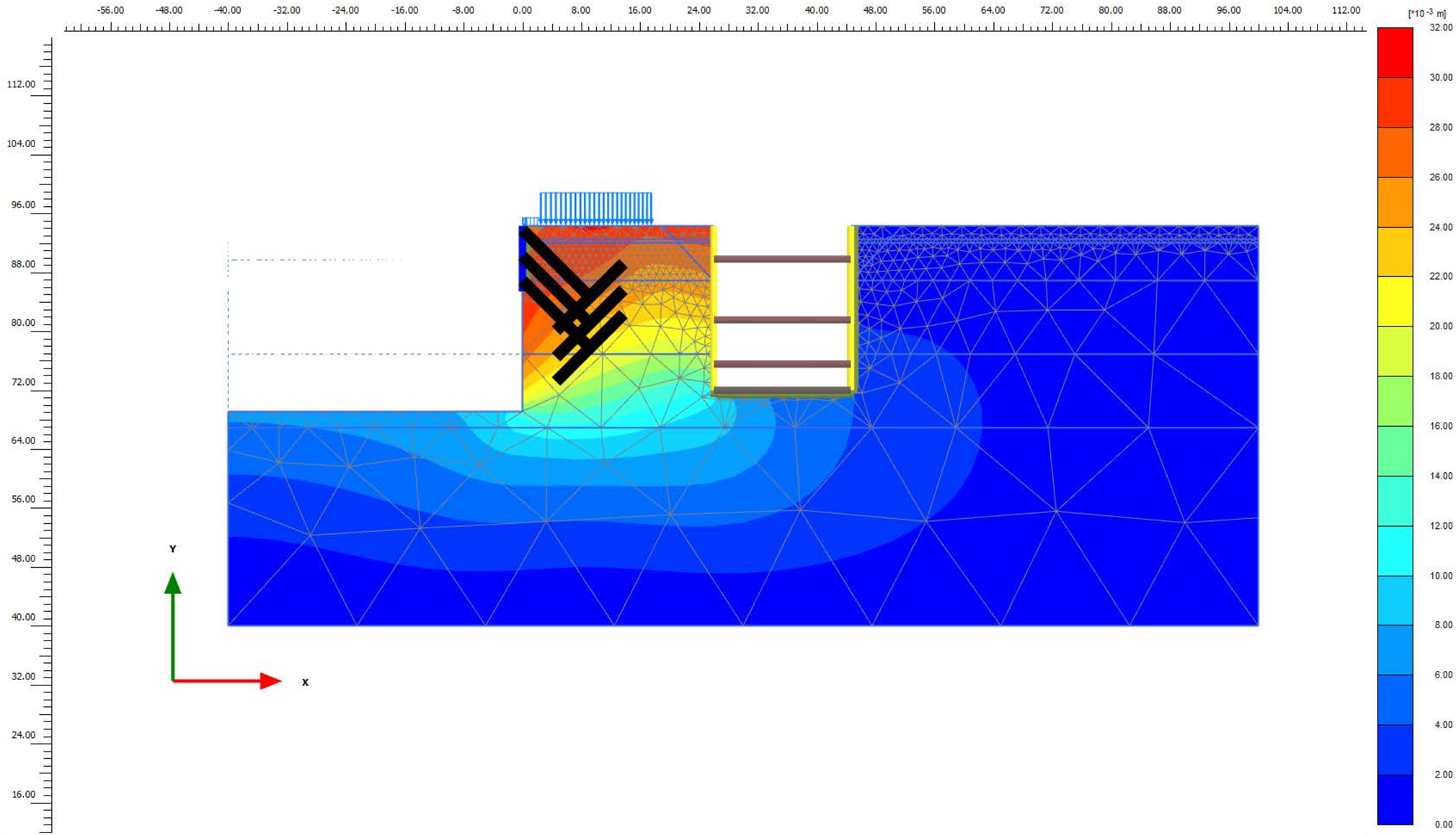
**Total displacements $u_x$ (scaled up 200 times)**

Maximum value = -0.02284 m (Element 1 at Node 6950)

Minimum value = -0.03013 m (Element 34 at Node 4762)

| | | | |
|---|---|---|---|
| eiaustralia | Project description<br>E24724.G06.Rev 4 Castle Hill Development – 100% VS with Water | | Date<br>4/05/2022 |
| | Project filename<br>E24724.G06.Rev4 Castle Hill Proposed Development – ... | Step<br>107 | Company<br>EI Australia |

Output Version 21.1.0.479

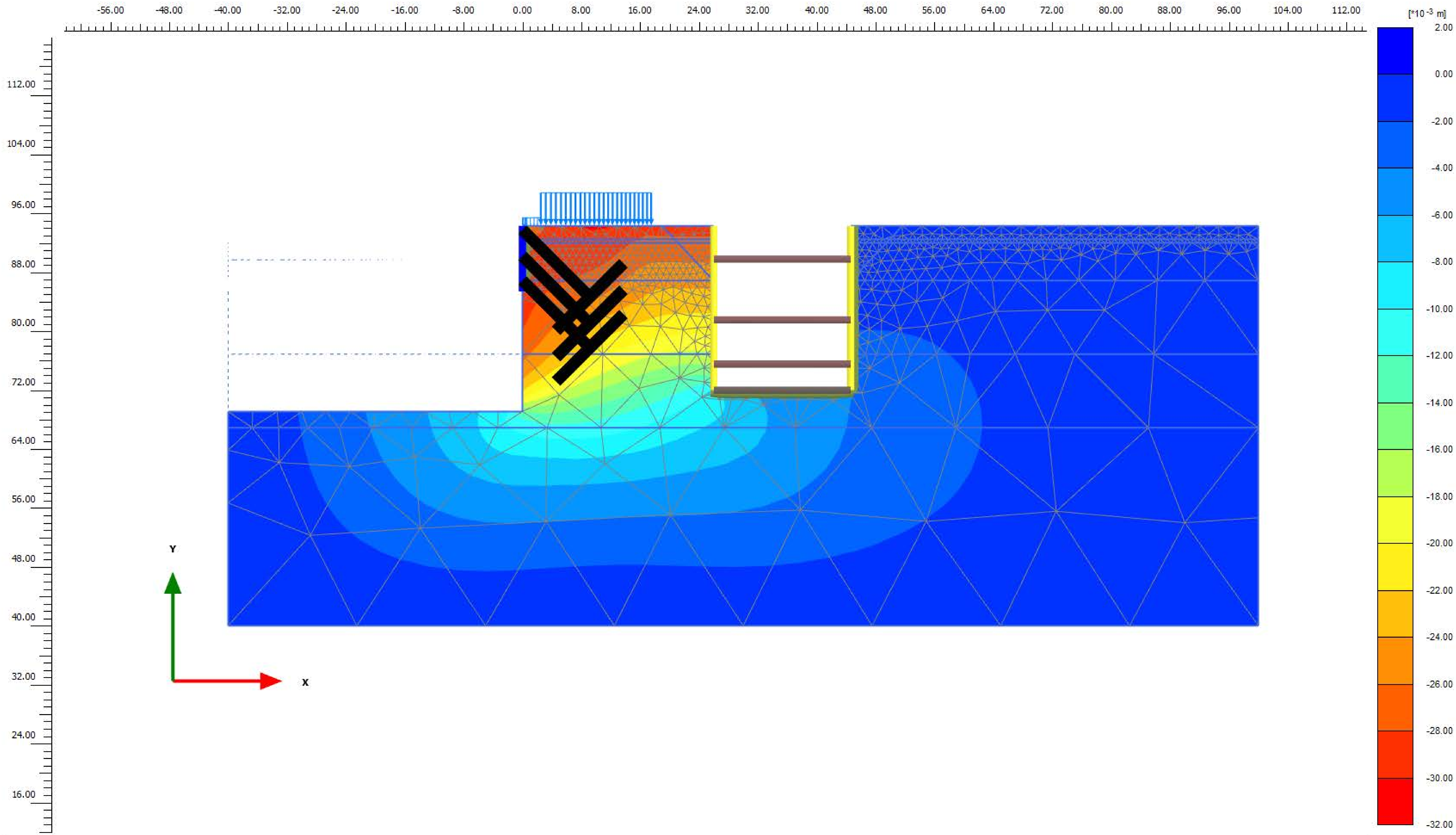



**Total displacements |u| (scaled up 200 times)**

Maximum value = 0.03023 m (Element 345 at Node 8084)

| Project description | | | Date |
|---|---|---|---|
| E24724.G06.Rev 4 Castle Hill Development – 75%vs | | | 4/05/2022 |
| Project filename | Step | Company | |
| E24724.G06.Rev4 Castle Hill Proposed Development – ... | 41 | EI Australia | |

Output Version 21.1.0.479



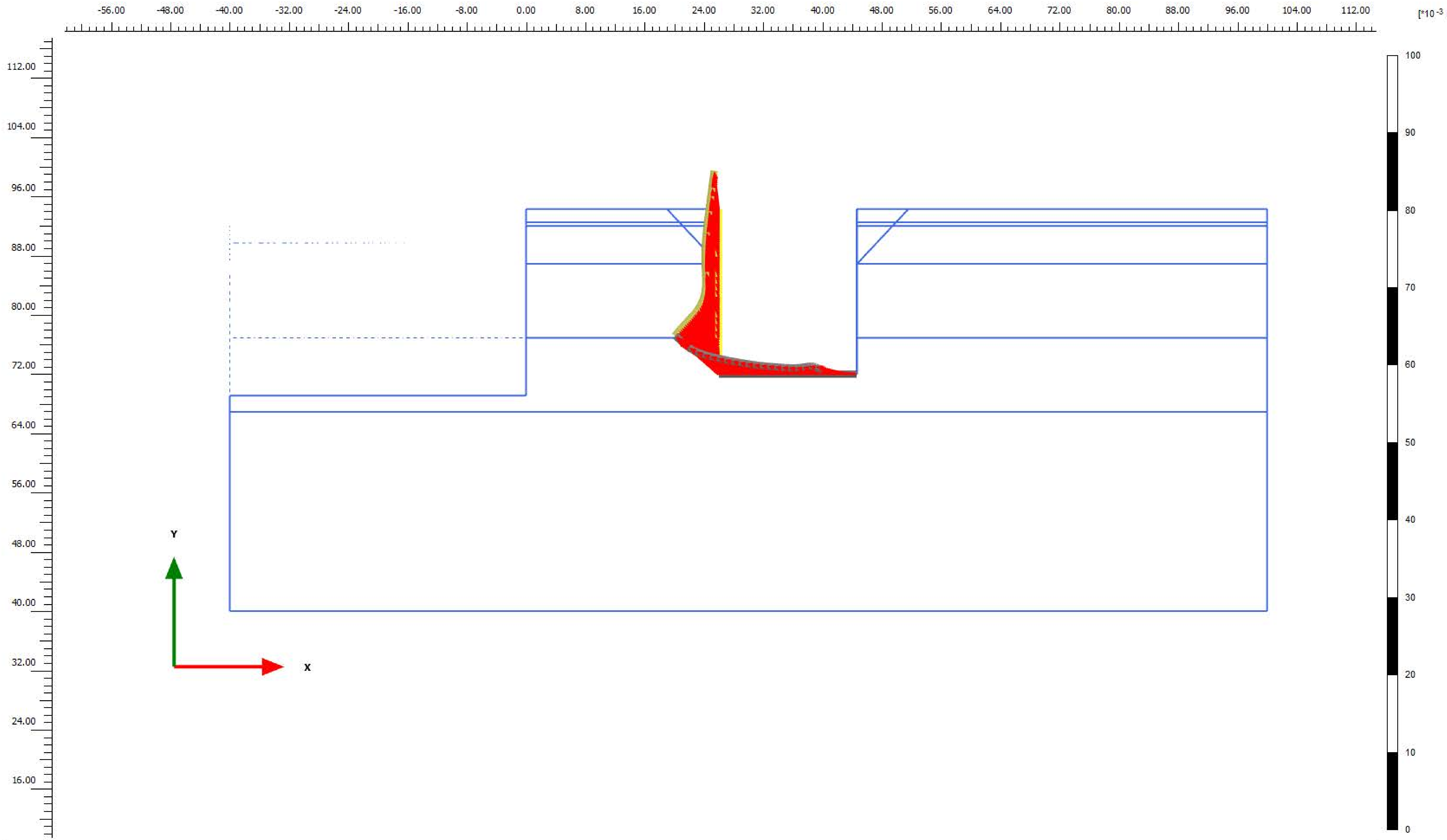

**Total displacements $u_x$ (scaled up 200 times)**

Maximum value = 0.000 m (Element 214 at Node 13031)

Minimum value = -0.03020 m (Element 345 at Node 8083)

| Project description | | Date |
|---|---|---|
| E24724.G06.Rev 4 Castle Hill Development – 75%vs | | 4/05/2022 |

| Project filename | Step | Company |
|---|---|---|
| E24724.G06.Rev4 Castle Hill Proposed Development – ... | 41 | EI Australia |

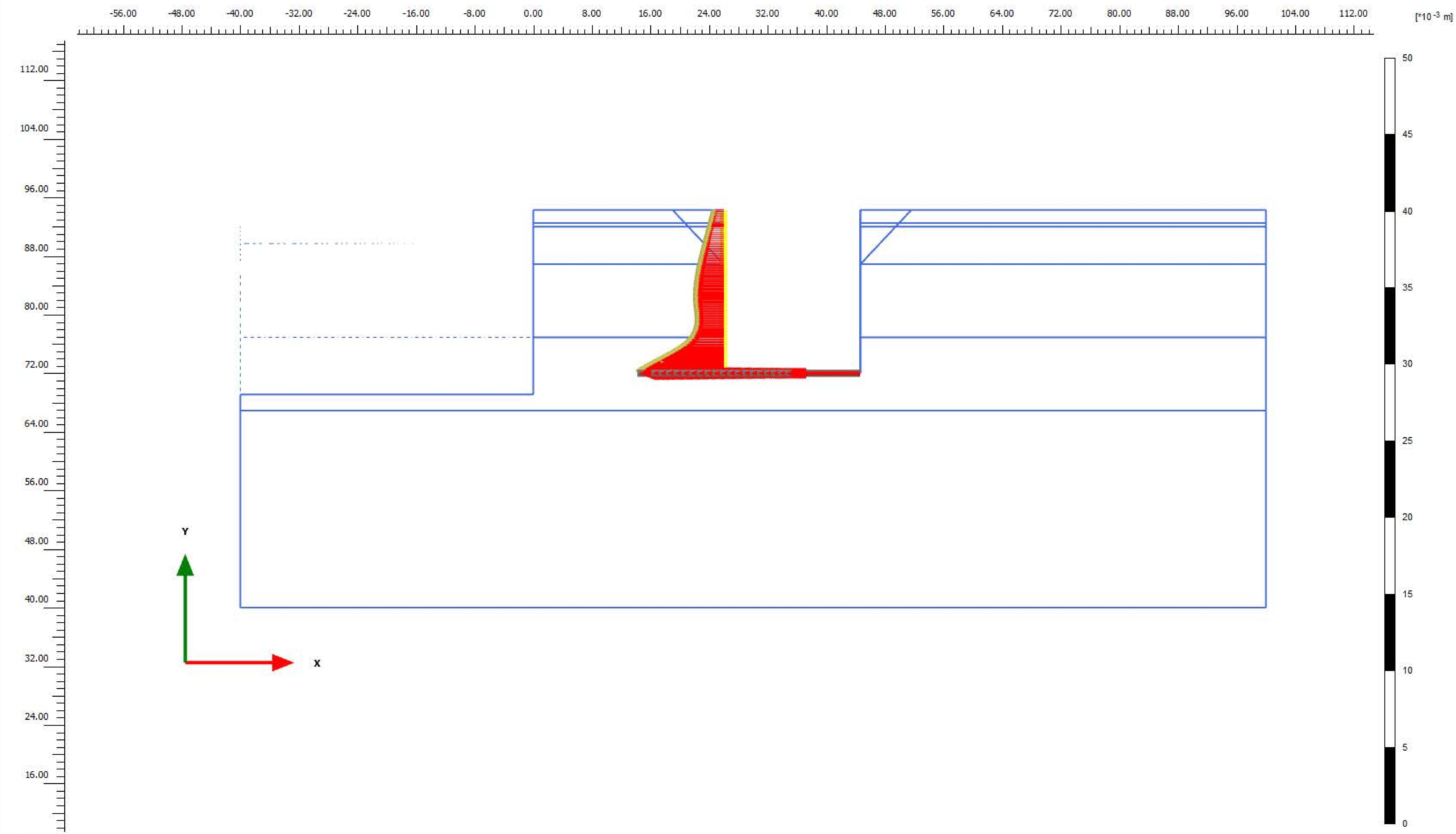



**Total displacements |u| (scaled up 1.00*10³ times)**

Maximum value = 7.843*10⁻³ m (Element 53 at Node 10196)

| Project description | | Date |
|---|---|---|
| E24724.G06.Rev 4 Castle Hill Development – 75%vs | | 4/05/2022 |
| **Project filename** | **Step** | **Company** |
| E24724.G06.Rev4 Castle Hill Proposed Development – ... | 41 | EI Australia |

Output Version 21.1.0.479

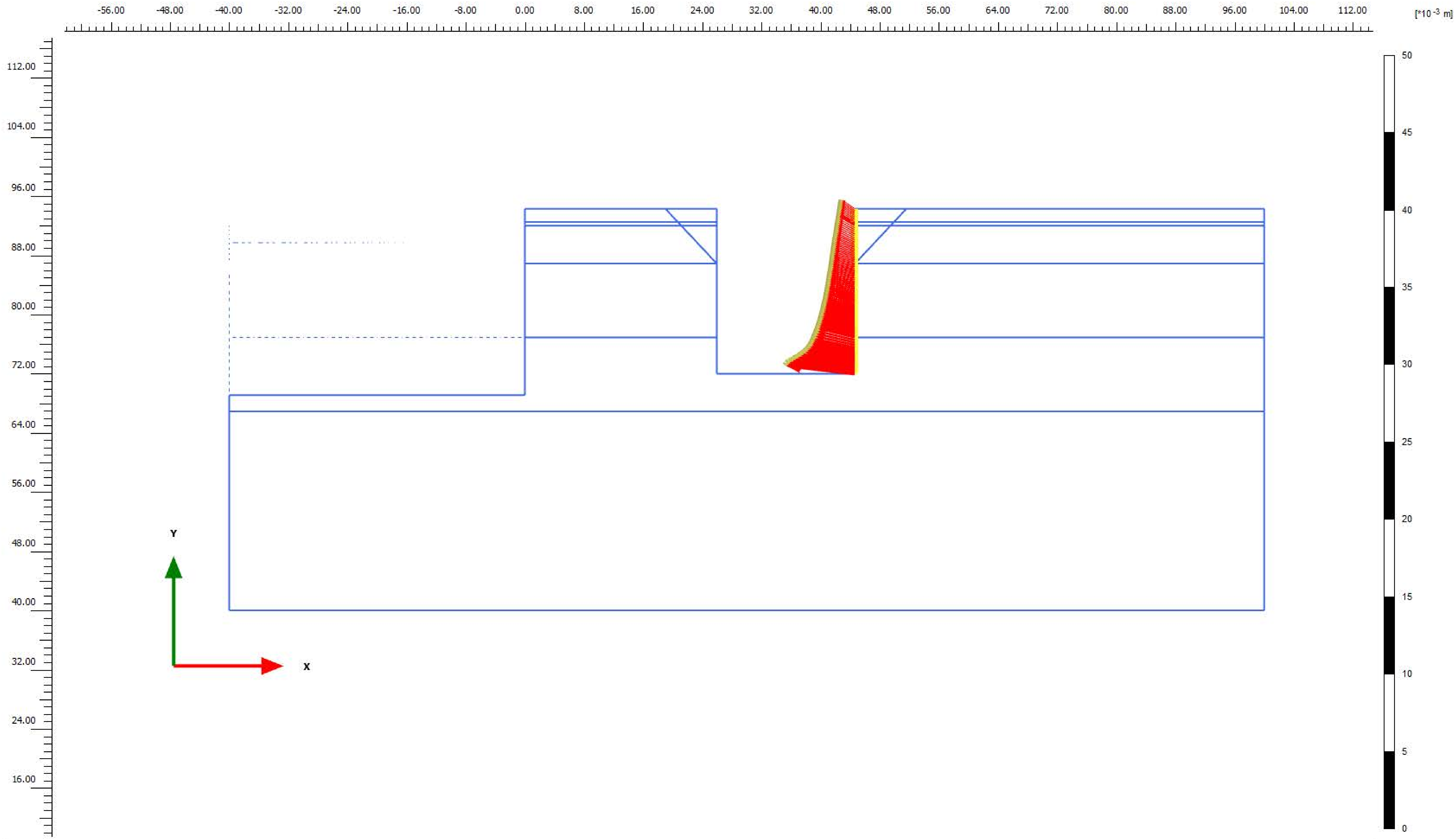



**Total displacements $u_x$ (scaled up $2.00*10^3$ times)**

Maximum value = $-0.6123*10^{-3}$ m (Element 4 at Node 20515)

Minimum value = $-5.894*10^{-3}$ m (Element 53 at Node 10196)

| | | | |
|---|---|---|---|
| Project description<br>E24724.G06.Rev 4 Castle Hill Development – 75%vs | | | Date<br>4/05/2022 |
| Project filename<br>E24724.G06.Rev4 Castle Hill Proposed Development – ... | Step<br>41 | Company<br>EI Australia | |



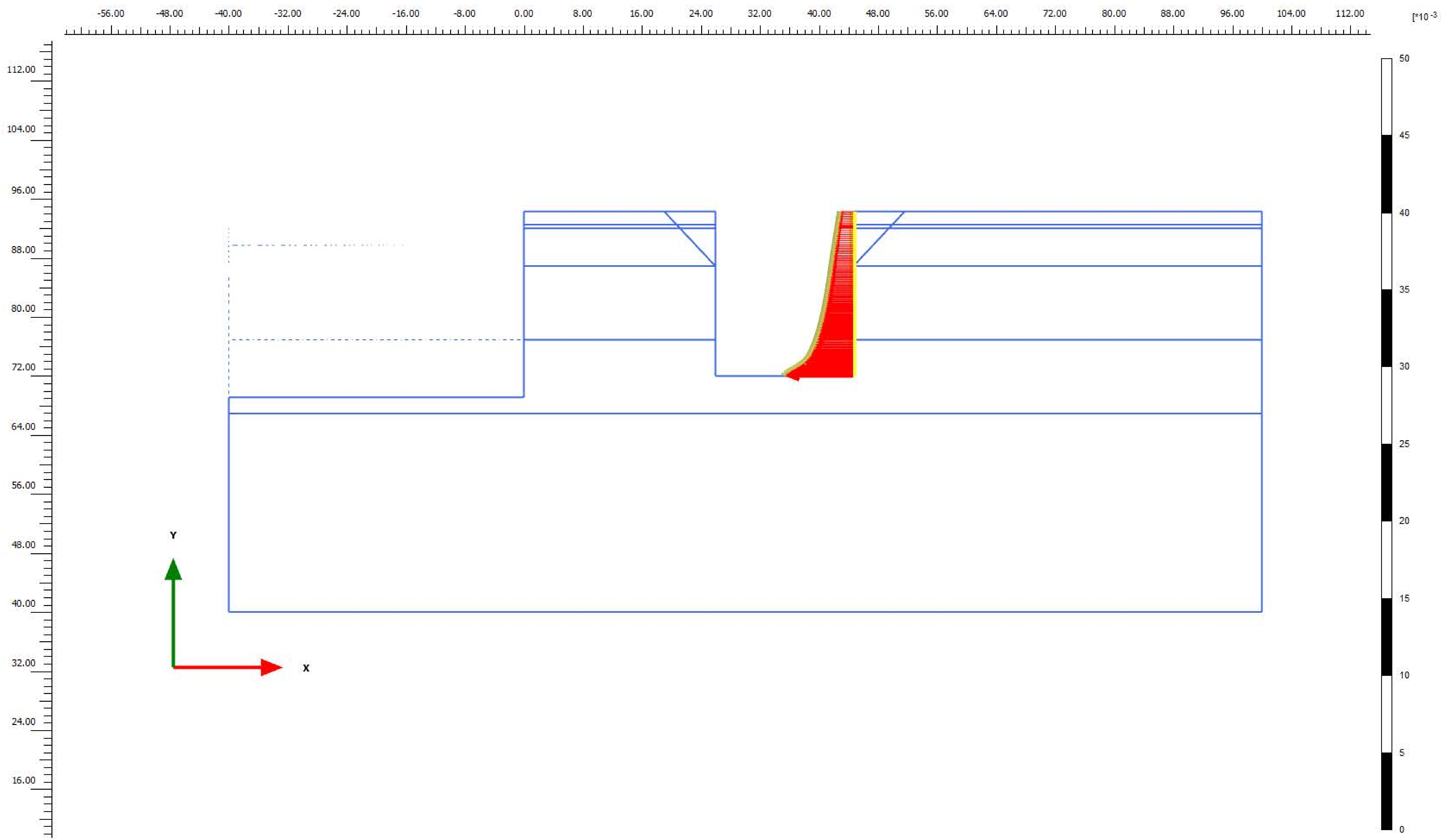

**Total displacements |u| (scaled up 2.00*10$^{3}$ times)**

Maximum value = 4.698*10$^{-3}$ m (Element 57 at Node 11888)

| Project description | | Date |
|---|---|---|
| E24724.G06.Rev 4 Castle Hill Development – 75%vs | | 4/05/2022 |

| Project filename | Step | Company |
|---|---|---|
| E24724.G06.Rev4 Castle Hill Proposed Development – ... | 41 | EI Australia |

Output Version 21.1.0.479



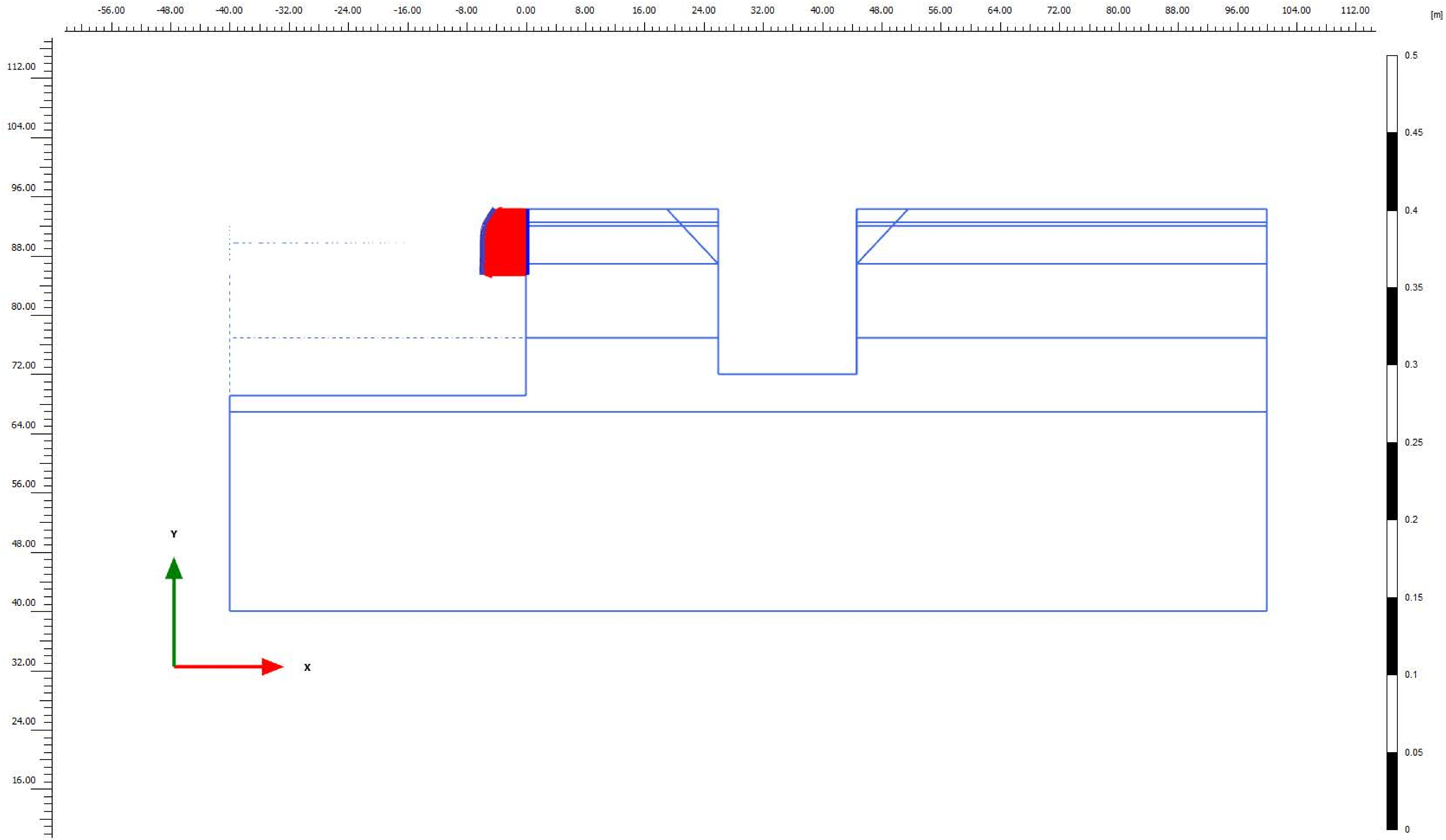

**Total displacements $u_x$ (scaled up $2.00*10^3$ times)**

Maximum value = $-0.8473*10^{-3}$ m (Element 6 at Node 24499)

Minimum value = $-4.667*10^{-3}$ m (Element 57 at Node 11888)

| Project description | | | Date |
|---|---|---|---|
| E24724.G06.Rev 4 Castle Hill Development – 75%vs | | | 4/05/2022 |
| **Project filename** | **Step** | **Company** | |
| E24724.G06.Rev4 Castle Hill Proposed Development – ... | 41 | EI Australia | |

Output Version 21.1.0.479



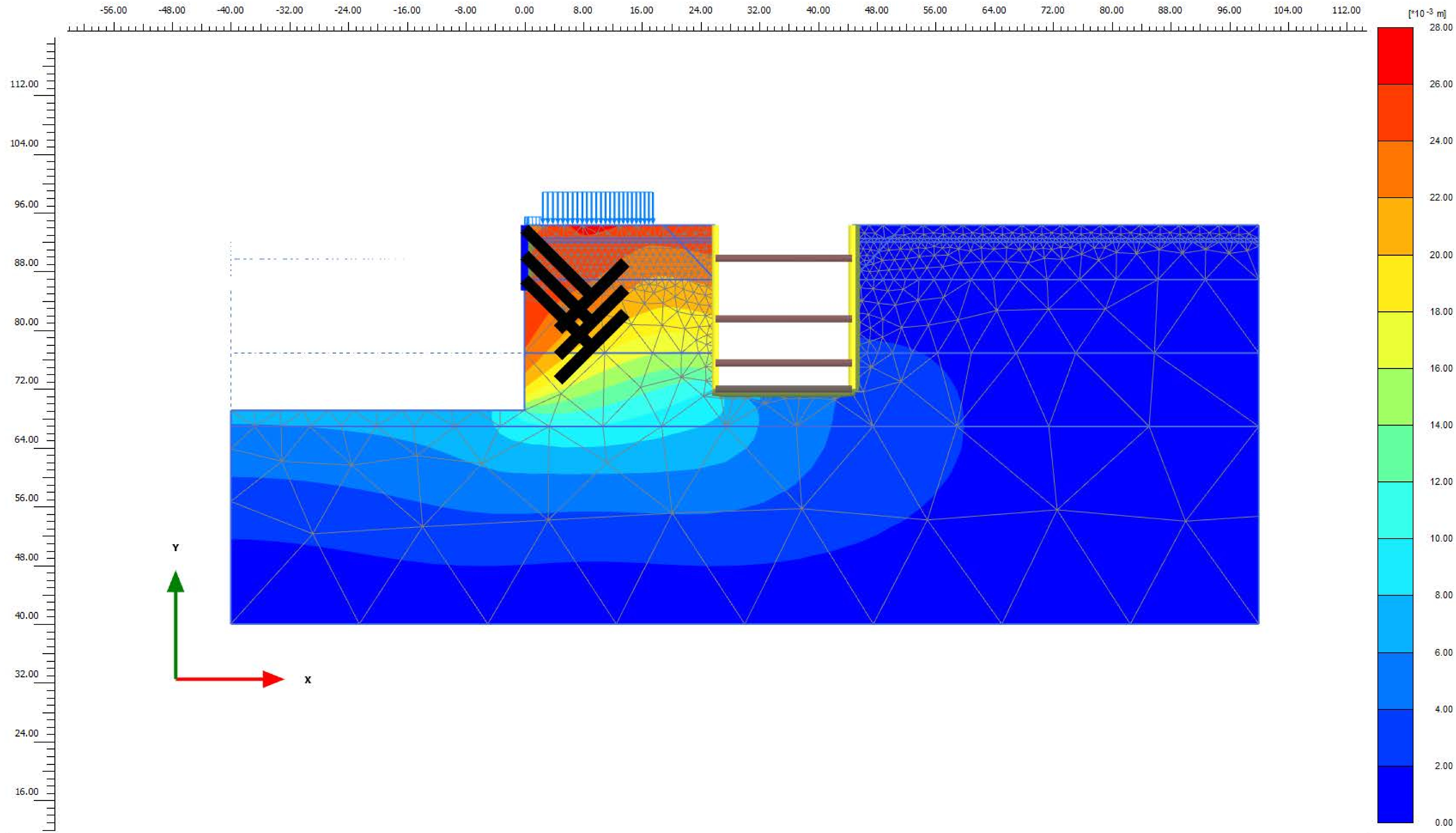

**Total displacements $u_x$ (scaled up 200 times)**

Maximum value = -0.02055 m (Element 1 at Node 3070)

Minimum value = -0.02907 m (Element 28 at Node 7537)

| | | | |
|---|---|---|---|
| eiaustralia | Project description<br>E24724.G06.Rev 4 Castle Hill Development – 75%vs | | Date<br>4/05/2022 |
| | Project filename<br>E24724.G06.Rev4 Castle Hill Proposed Development – ... | Step<br>41 | Company<br>EI Australia |

Output Version 21.1.0.479

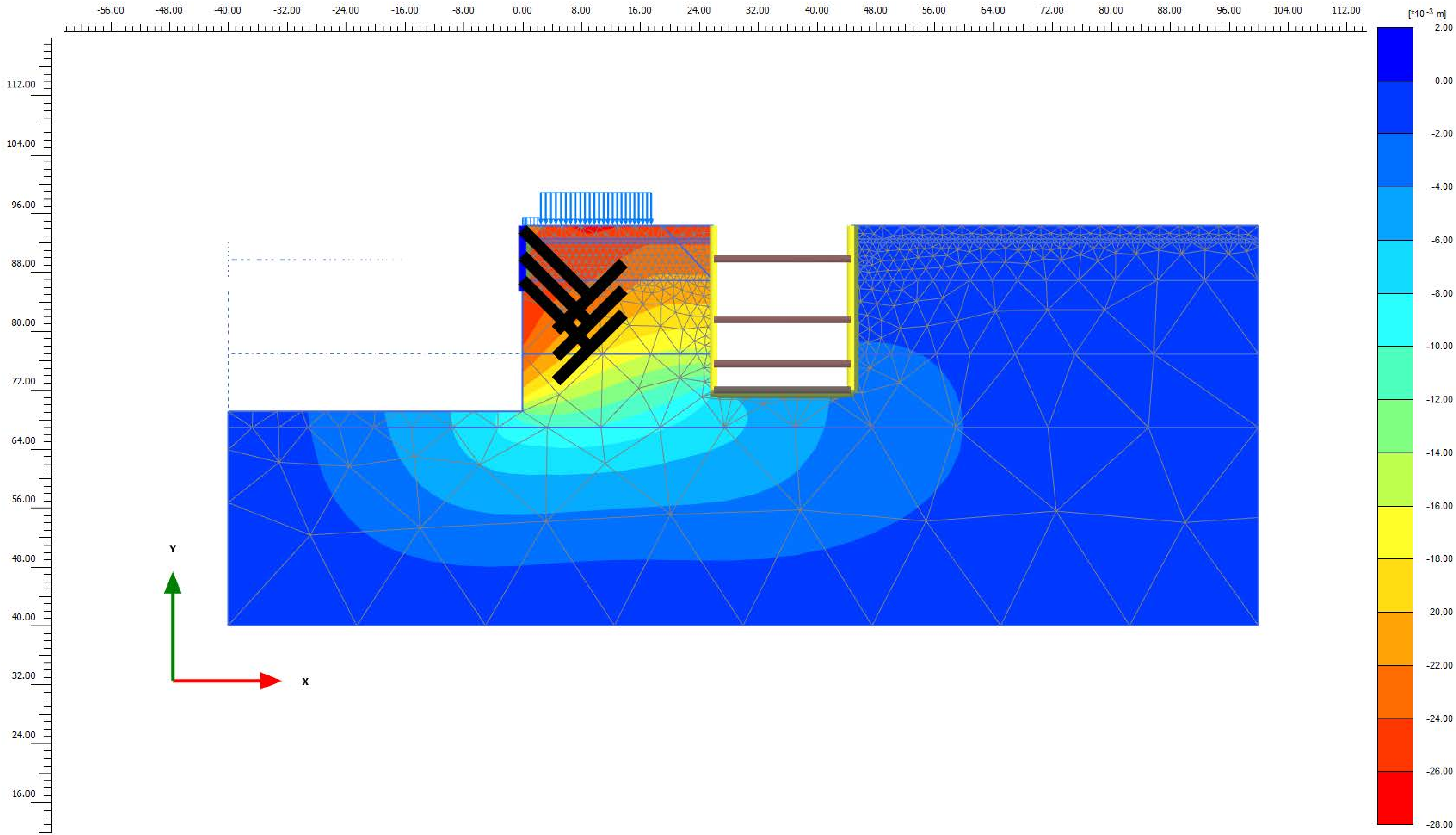



**Total displacements |u| (scaled up 200 times)**

Maximum value = 0.02630 m (Element 345 at Node 8084)

| | | | |
|---|---|---|---|
| Project description<br>E24724.G06.Rev 4 Castle Hill Development – 50%vs | | | Date<br>4/05/2022 |
| Project filename<br>E24724.G06.Rev4 Castle Hill Proposed Development – ... | Step<br>31 | Company<br>EI Australia | |

Output Version 21.1.0.479

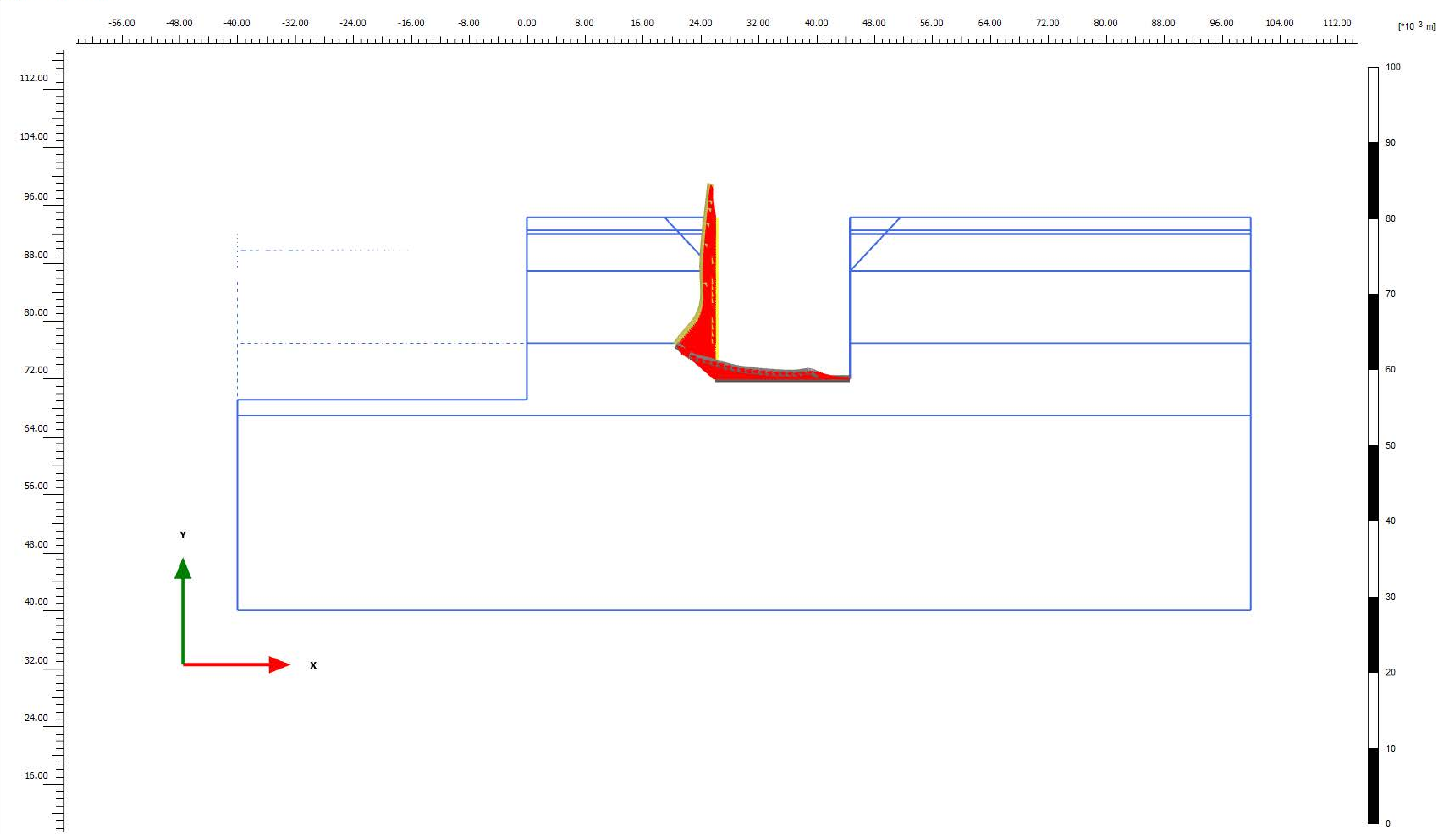



**Total displacements $u_x$ (scaled up 200 times)**

Maximum value = 0.000 m (Element 214 at Node 13031)

Minimum value = -0.02627 m (Element 345 at Node 8083)

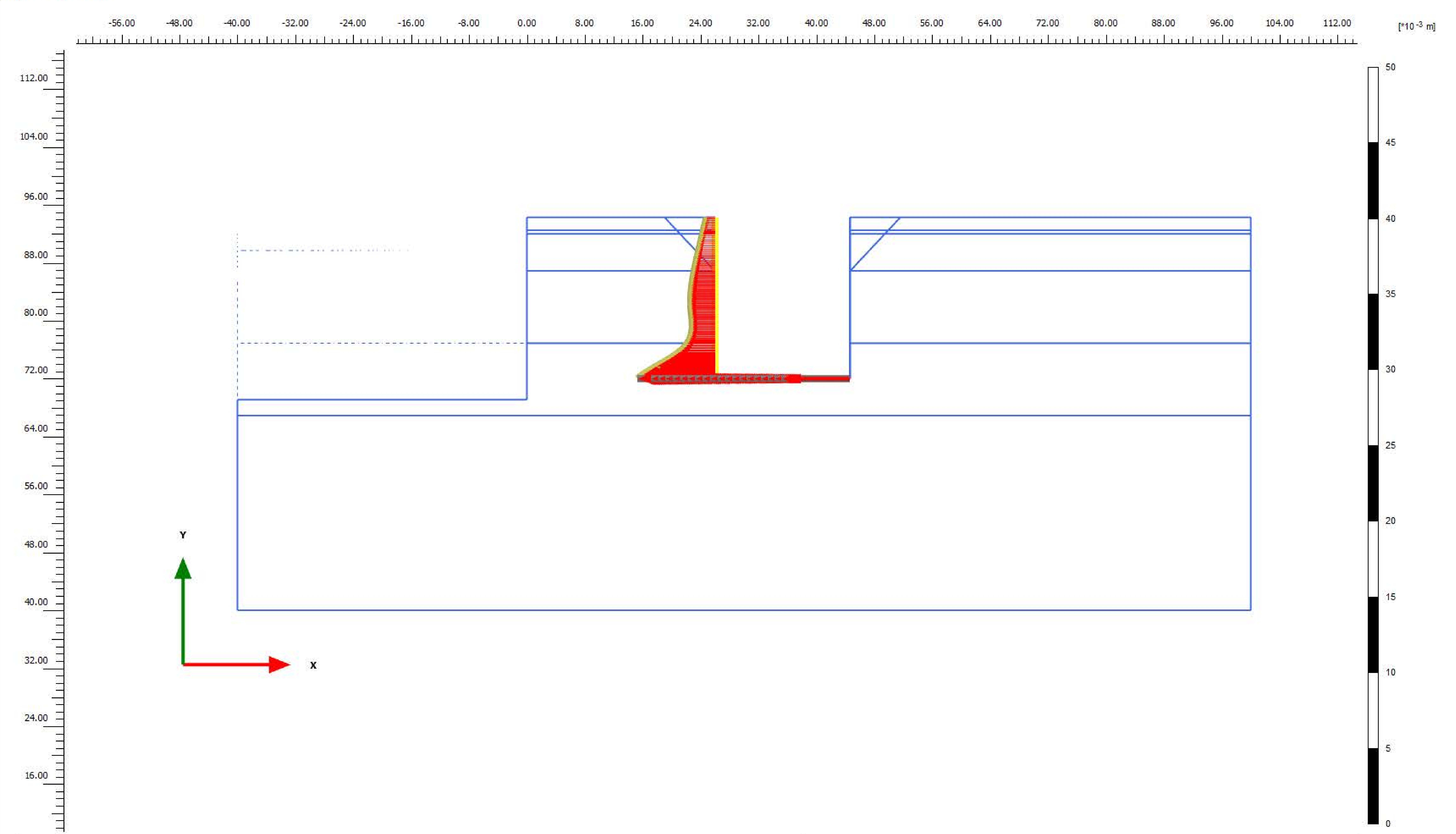
| | | | |
|---|---|---|---|
| Project description<br>E24724.G06.Rev 4 Castle Hill Development – 50%vs | | | Date<br>4/05/2022 |
| Project filename<br>E24724.G06.Rev4 Castle Hill Proposed Development – ... | Step<br>31 | Company<br>EI Australia | |




**Total displacements |u| (scaled up $1.00 \times 10^3$ times)**

Maximum value = $7.115 \times 10^{-3}$ m (Element 53 at Node 10196)

| | | | |
|---|---|---|---|
| *Project description* E24724.G06.Rev 4 Castle Hill Development – 50%vs | | | *Date* 4/05/2022 |
| *Project filename* E24724.G06.Rev4 Castle Hill Proposed Development – ... | *Step* 31 | *Company* EI Australia | |



**Total displacements $u_x$ (scaled up $2.00*10^3$ times)**

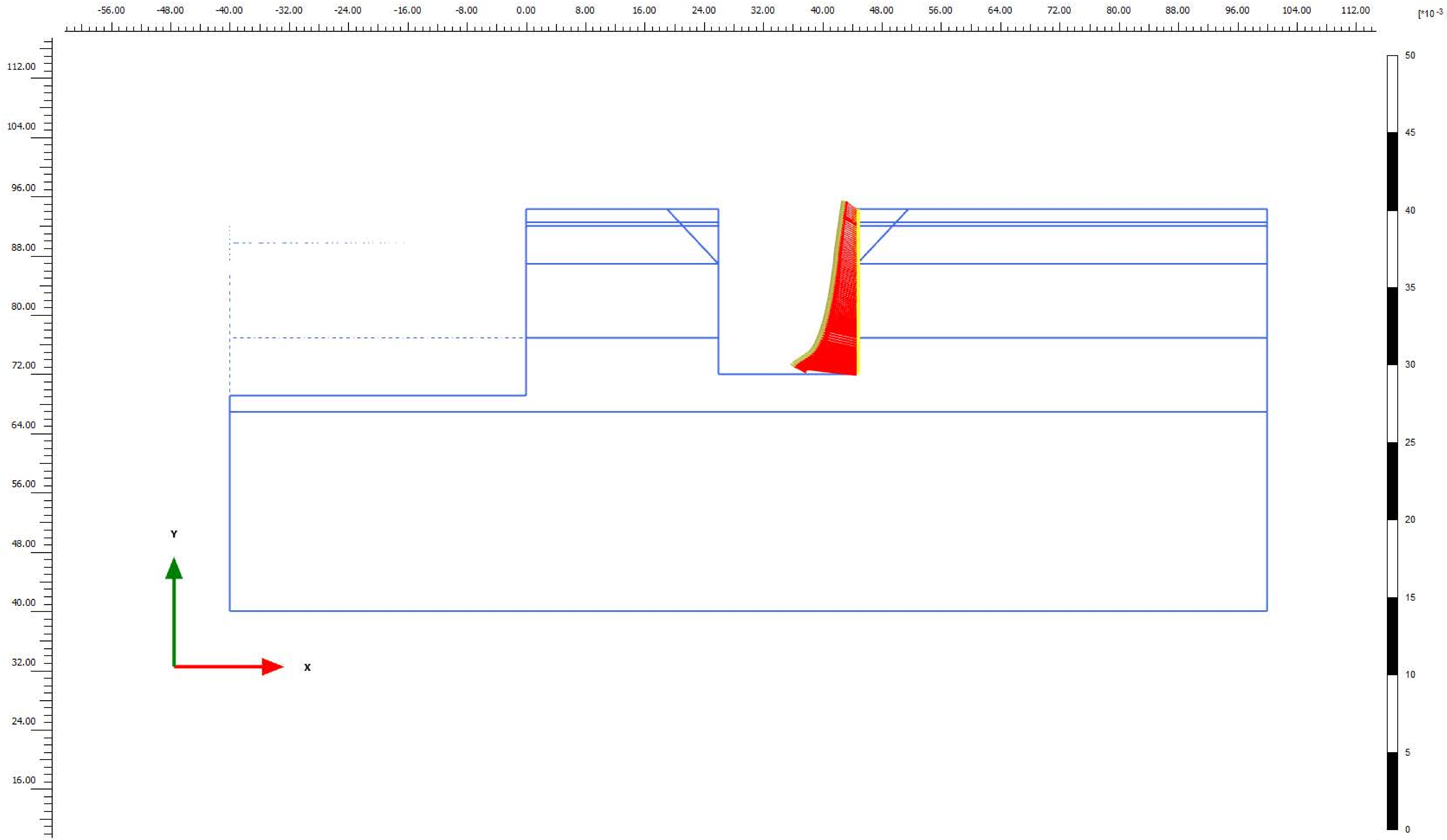
Maximum value = $-0.6019*10^{-3}$ m (Element 4 at Node 20515)

Minimum value = $-5.376*10^{-3}$ m (Element 53 at Node 10196)

| Project description | Date |
|---|---|
| E24724.G06.Rev 4 Castle Hill Development – 50%vs | 4/05/2022 |

| Project filename | Step | Company |
|---|---|---|
| E24724.G06.Rev4 Castle Hill Proposed Development – ... | 31 | EI Australia |

Output Version 21.1.0.479



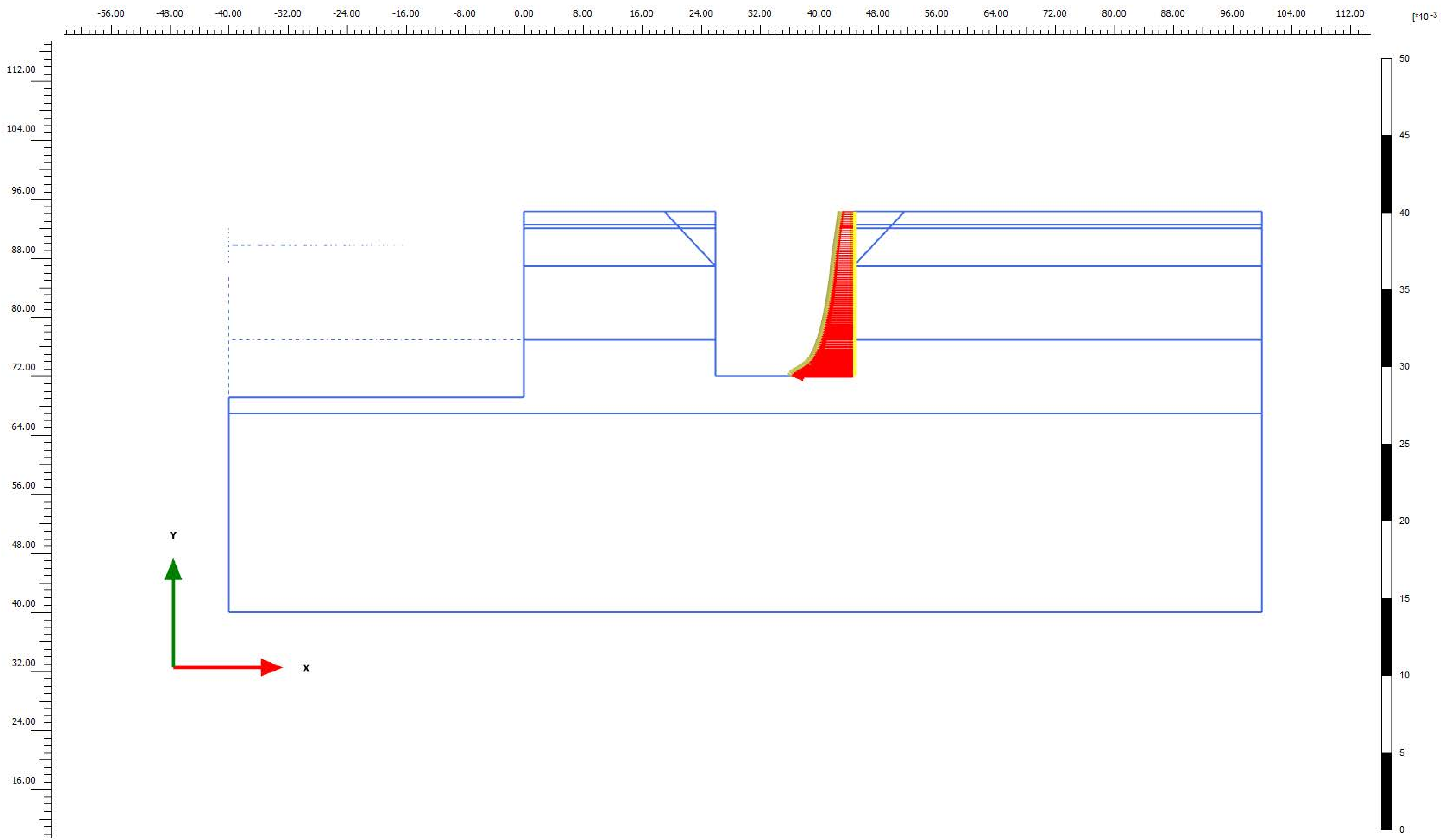

**Total displacements |u| (scaled up $2.00 \times 10^{3}$ times)**

Maximum value = $4.308 \times 10^{-3}$ m (Element 57 at Node 11888)

| Project description | Date |
|---|---|
| E24724.G06.Rev 4 Castle Hill Development – 50%vs | 4/05/2022 |

| Project filename | Step | Company |
|---|---|---|
| E24724.G06.Rev4 Castle Hill Proposed Development – ... | 31 | EI Australia |

Output Version 21.1.0.479




**Total displacements $u_x$ (scaled up $2.00*10^3$ times)**

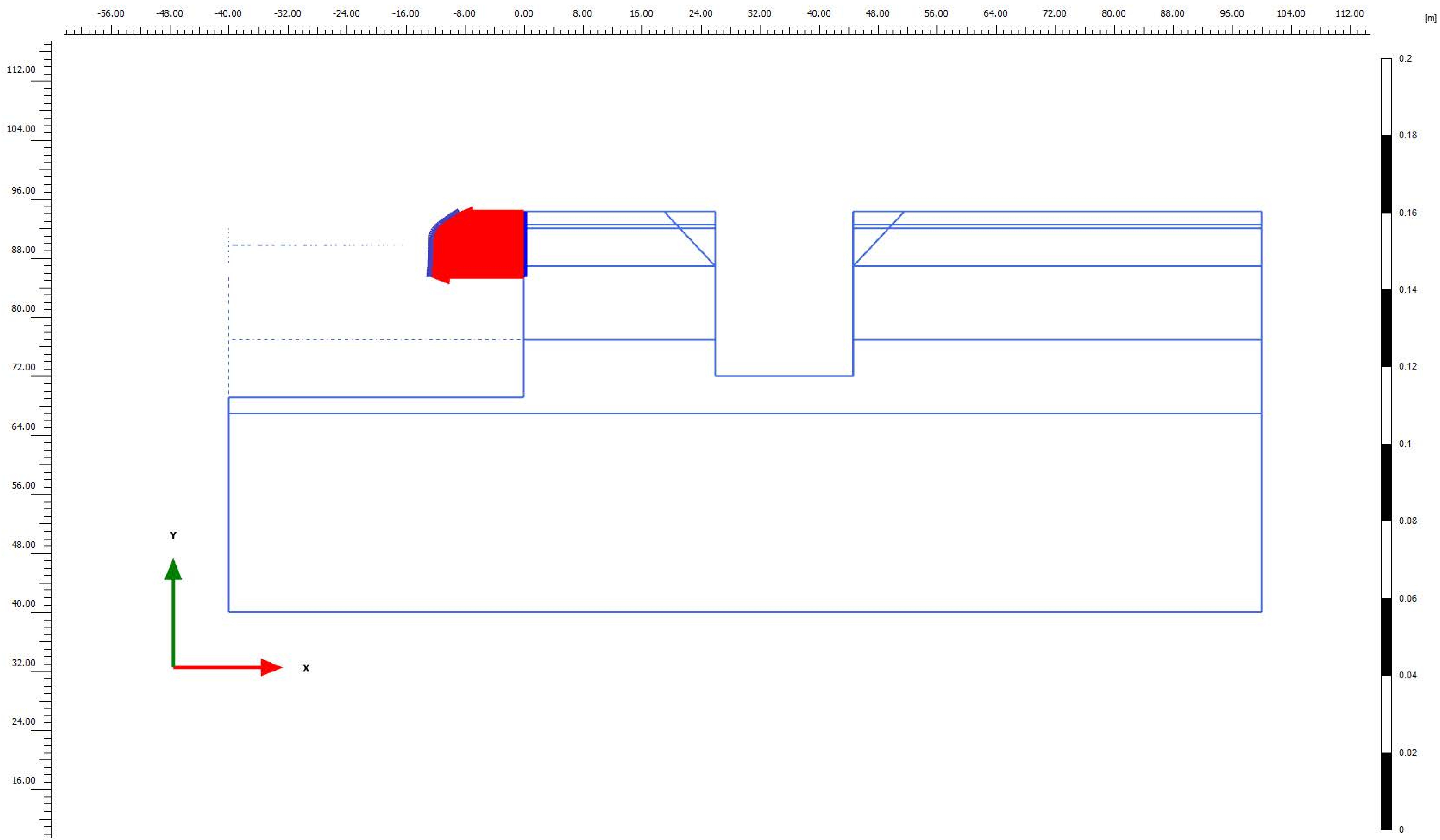
Maximum value = $-0.8014*10^{-3}$ m (Element 6 at Node 24499)

Minimum value = $-4.280*10^{-3}$ m (Element 57 at Node 11888)

| Project description | Date |
|---|---|
| E24724.G06.Rev 4 Castle Hill Development – 50%vs | 4/05/2022 |

| Project filename | Step | Company |
|---|---|---|
| E24724.G06.Rev4 Castle Hill Proposed Development – ... | 31 | EI Australia |

Output Version 21.1.0.479




**Total displacements $u_x$ (scaled up 500 times)**

Maximum value = -0.01738 m (Element 1 at Node 3070)

Minimum value = -0.02545 m (Element 28 at Node 7537)

| | | | |
|---|---|---|---|
| Project description<br>E24724.G06.Rev 4 Castle Hill Development – 50%vs | | | Date<br>4/05/2022 |
| Project filename<br>E24724.G06.Rev4 Castle Hill Proposed Development – ... | Step<br>31 | Company<br>EI Australia | |

# APPENDIX B

## Important Information

# Important Information

## SCOPE OF SERVICES

The geotechnical report ("the report") has been prepared in accordance with the scope of services as set out in the contract, or as otherwise agreed, between the Client And EI Australia ("EI"). The scope of work may have been limited by a range of factors such as time, budget, access and/or site disturbance constraints.

## RELIANCE ON DATA

EI has relied on data provided by the Client and other individuals and organizations, to prepare the report. Such data may include surveys, analyses, designs, maps and plans. EI has not verified the accuracy or completeness of the data except as stated in the report. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations ("conclusions") are based in whole or part on the data, EI will not be liable in relation to incorrect conclusions should any data, information or condition be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to EI.

## GEOTECHNICAL ENGINEERING

Geotechnical engineering is based extensively on judgment and opinion. It is far less exact than other engineering disciplines. Geotechnical engineering reports are prepared for a specific client, for a specific project and to meet specific needs, and may not be adequate for other clients or other purposes (e.g. a report prepared for a consulting civil engineer may not be adequate for a construction contractor). The report should not be used for other than its intended purpose without seeking additional geotechnical advice. Also, unless further geotechnical advice is obtained, the report cannot be used where the nature and/or details of the proposed development are changed.

## LIMITATIONS OF SITE INVESTIGATION

The investigation programme undertaken is a professional estimate of the scope of investigation required to provide a general profile of subsurface conditions. The data derived from the site investigation programme and subsequent laboratory testing are extrapolated across the site to form an inferred geological model, and an engineering opinion is rendered about overall subsurface conditions and their likely behaviour with regard to the proposed development. Despite investigation, the actual conditions at the site might differ from those inferred to exist, since no subsurface exploration program, no matter how comprehensive, can reveal all subsurface details and anomalies. The engineering logs are the subjective interpretation of subsurface conditions at a particular location and time, made by trained personnel. The actual interface between materials may be more gradual or abrupt than a report indicates.

## SUBSURFACE CONDITIONS ARE TIME DEPENDENT

Subsurface conditions can be modified by changing natural forces or man-made influences. The report is based on conditions that existed at the time of subsurface exploration. Construction operations adjacent to the site, and natural events such as floods, or ground water fluctuations, may also affect subsurface conditions, and thus the continuing adequacy of a geotechnical report. EI should be kept appraised of any such events, and should be consulted to determine if any additional tests are necessary.

## VERIFICATION OF SITE CONDITIONS

Where ground conditions encountered at the site differ significantly from those anticipated in the report, either due to natural variability of subsurface conditions or construction activities, it is a condition of the report that EI be notified of any variations and be provided with an opportunity to review the recommendations of this report. Recognition of change of soil and rock conditions requires experience and it is recommended that a suitably experienced geotechnical engineer be engaged to visit the site with sufficient frequency to detect if conditions have changed significantly.

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## REPORT FOR BENEFIT OF CLIENT

The report has been prepared for the benefit of the Client and no other party. EI assumes no responsibility and will not be liable to any other person or organisation for or in relation to any matter dealt with or conclusions expressed in the report, or for any loss or damage suffered by any other person or organisation arising from matters dealt with or conclusions expressed in the report (including without limitation matters arising from any negligent act or omission of EI or for any loss or damage suffered by any other party relying upon the matters dealt with or conclusions expressed in the report). Other parties should not rely upon the report or the accuracy or completeness of any conclusions and should make their own inquiries and obtain independent advice in relation to such matters.

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EI will not be liable to update or revise the report to take into account any events or emergent circumstances or fact occurring or becoming apparent after the date of the report.