NORTHROP

Level 11, 345 George Street, Sydney NSW 2000

T (02) 9241 4188 E sydney@northrop.com.au

ABN 81 094 433 100

September 04, 2020

SY201496-SL01-A

**Gareth Bird**
Ethos Urban
173 Sussex St
Sydney NSW 2000

Dear Gareth,

**RE: Rail Signage Site 01**

**Woolloomooloo – Bridge Mounted**

**Structural Feasibility Statement**

Northrop Engineers have been engaged to undertake a desktop review to assess the feasibility of installing a new cantilevered signage to the northern side of the existing rail viaduct structure that bridges over Palmer Street and the Eastern Distributor at Woolloomooloo.

The assessment was done based on the available as-built structural drawings provided by Sydney Trains;

- As-built structural drawings numbered:
  - 50311A, 50312B, 50315A, 50316A, 50313A, 50314A, 50310A, 50224A (dated March 1977), 50167D, 50193D (dated May 1973), E.S.-B66 (undated), CV0137326A (dated 26 November 2004), CV0278212A (dated 6 February 2008) - we understand this does not constitute a full set of structural drawings
- Northrop does not have access to the full set of as-built structural drawings

As per the *Preliminary Assessment* document provided by Ethos Urban dated 22 June 2020, the type of signage is not determined, however it is proposed to be angled off the existing structure to more squarely face back towards the direction of vehicle travel. In order to enable maximum exposure to south-bound traffic, the proposed angle of the signage is 45 degrees.

As per the *Site Plan & General Arrangement* provided by Ethos Urban dated 7 July 2020, the type of signage is an LED screen, with dimensions of 12400mm x 3200mm. The screen dead loads have not yet been provided by Ethos Urban, however, based on our prior experience with this type of signage they are typically in the order of 55 kg/m$^2$. Based on the above, the overall weight of the *LED signage* is approximately 2.5 tonnes. This weight excludes additional fixings / supporting steelwork, access walkways etc.

## Site Description

The site is located at Woolloomooloo at the intersection of the viaduct servicing the Sydney Trains T4 South Coast Line and the Eastern Distributor. These two transport routes intersect at approximately 45 degrees. See below for Google Maps screenshot showing arrangements.

The proposed signage location is on the northern side of the viaduct over the eastern trafficable lanes of the Eastern Distributor. The signage is proposed to face north (pointed towards the traffic traveling south) and to align the signage with the direction of traffic travel the signage will need to be fixed to the viaduct at a 45 degree angle with the eastern end cantilevering approximately 13m north of the viaduct.

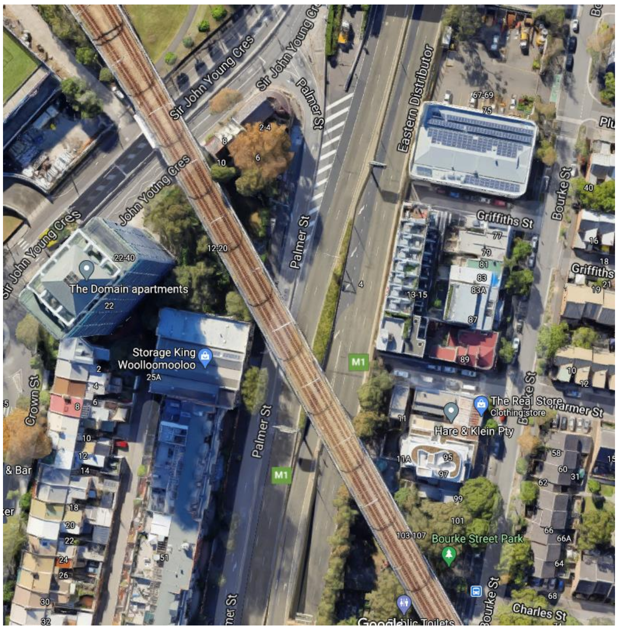


*Figure: Google Maps screenshot showing viaduct*

*and Eastern Distributor at Woolloomooloo*

We do not anticipate that there will be any height / clearance issues above the roadway as the proposed signage does not extend below the height of the existing viaduct.

## Structural Description

The existing structure was constructed in circa 1970. It consists of conventionally reinforced concrete box girder sections spanning between concrete piers on piled foundations. The viaduct supports two suspended railway tracks which is part of the passenger rail line between Martin Place and Kings Cross underground stations. The length of the span of the viaduct with the proposed signage is approximately 42m, with the eastern pier adjacent the Eastern Distributor and the western pier between the Eastern Distributor and the Palmer Street exit road at Woolloomooloo.

Also included as part of the structure are cantilevered balustrades to the sides of the viaduct, which from an assessment of the available as-built drawings consist of blockwork with steelwork fixings at the bottom.

Northrop assumes that the design live loads are approximately equivalent to the design loads in the bridge code AS5100. The available as-built drawings do not confirm the design live loads. For the purposes of our assessment, we have assumed that the design live loads are equivalent to current standard rail loading for passenger trains (type 300LA) which is approximately 22 tonnes per linear metre for each track. Refer to AS5100 clause 9.2 for loading conditions. Note that ultimate state design for rail loading includes relatively high load and dynamic factors, and that the train line has tracks in both directions.

**Structural Modeling**

It was assumed that the signage structure would fix to the viaduct at an fixing point on the eastern side of the sign and to a cantilevered steel truss on the western side, and that the signage weight would be distributed equally between these two supports. As the weight of the signage was approximately 2.5 tonnes, a load of 1.25 tonnes was placed at either end. This is shown as 13 kilonewtons in the model and in the figures below.

An indicative steel truss was modeled in the finite element analysis software ETabs to determine the reactions on the viaduct from the cantilevered signage. See below for diagrams of this model showing loading.

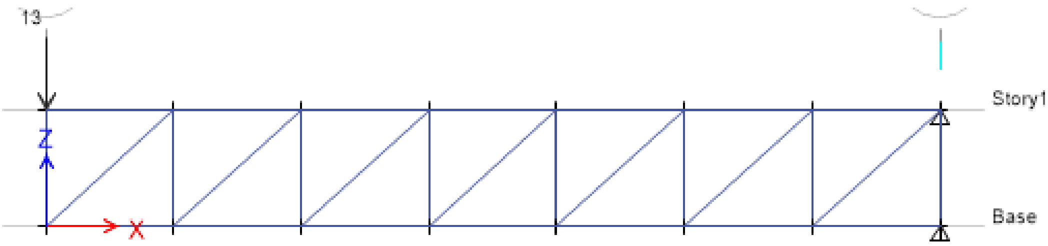


*Figure: Cantilevered steel truss – general arrangements and signage load*

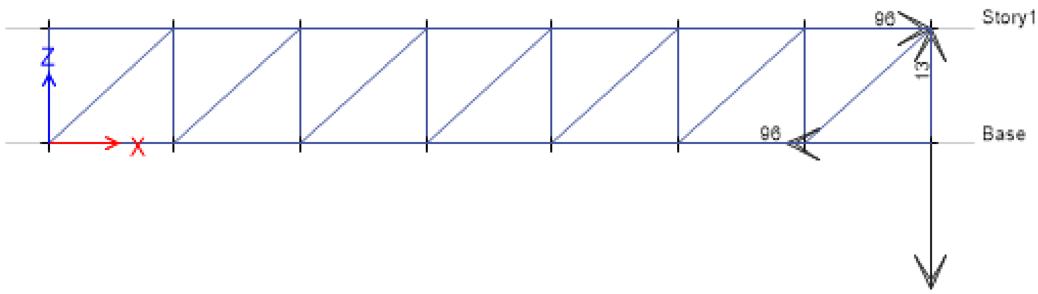


*Figure: Cantilevered steel truss – reactions from signage onto viaduct*

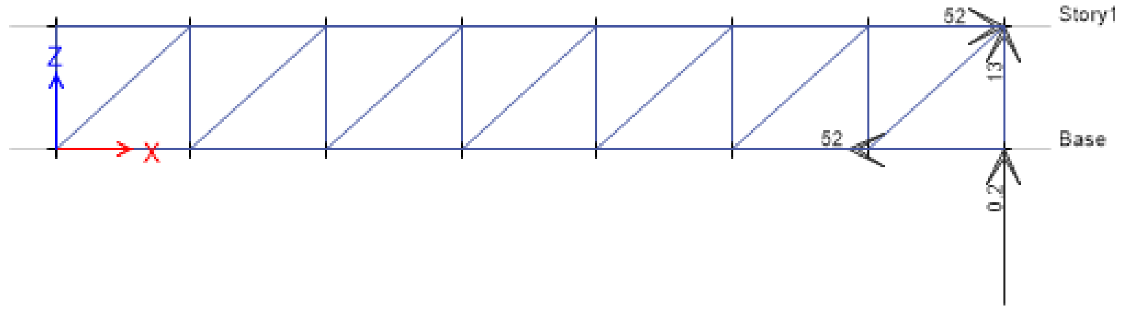


*Figure: Cantilevered steel truss – reactions from steel self-weight onto viaduct*

The approximate weight of the cantilevered truss steelwork will be in the order of 1.3 tonnes. This weight is indictive only and is subject to further engineering design and confirmation of the support requirements for signage framing (access walkways etc). Additional steelwork may be required for bracing, fixings to the concrete, to support the LED screens etc.

The viaduct structure was modeled in the finite element analysis software Eabs. The viaduct was idealized as shell elements for the webs and flanges of the boxed sections and assumed to act as a simply supported span between adjacent piers. The assumption that the viaduct is simply supported is conservative and should be confirmed during detailed design. The stresses in the concrete member stresses were assessed for the self-weight case and with the imposed loads from the signage.

**Feasibility of Additional Loading**

Supports

When considering the case of dead loads (i.e. self-weight) with the proposed signage loads, the analysis shows that there will be no net vertical tension forces acting on the pin steel supports at the tops of the piers. This indicates that the overturning from the weight of the signage will not result in an uplift load on the opposite support. As these reactions are acting in the same direction (i.e. downwards), this does not change the existing support condition and is structurally acceptable.

Given the geometry of the existing balustrades, the new signage is not expected to attract significant additional wind loads to the structure and we consider the existing supports to be structurally adequate.

Due to the small increase in seismic mass from the signage (approximately 1%) we do not anticipate significant additional forces applied to the supports during a seismic event and we consider the existing supports to be structurally adequate.

See below for figures of the support reactions.

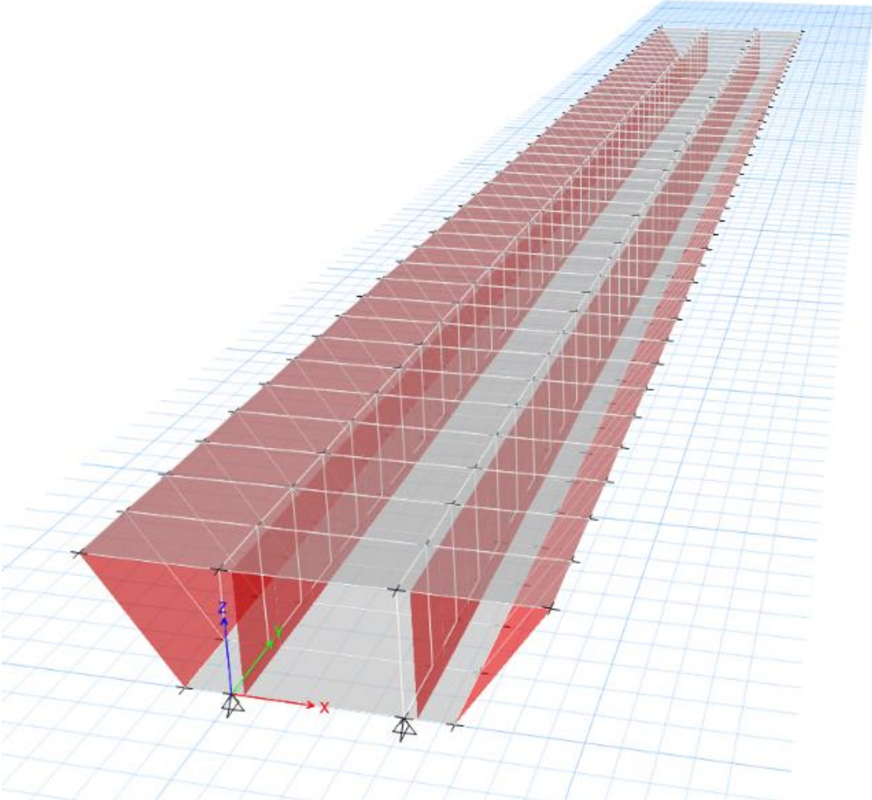


*Figure: Viaduct Model – 3D view general arrangements*

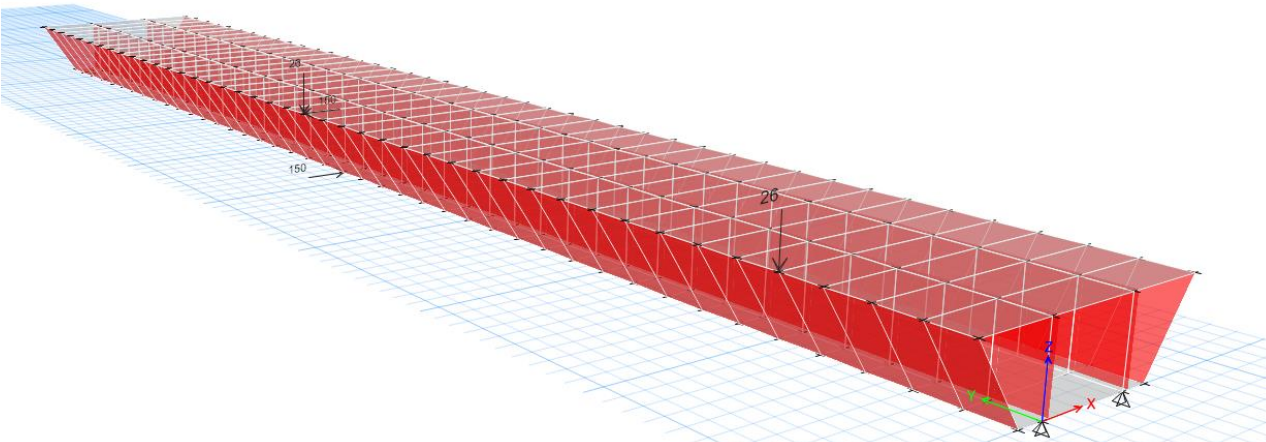


*Figure: Viaduct Model – 3D view with signage loads*

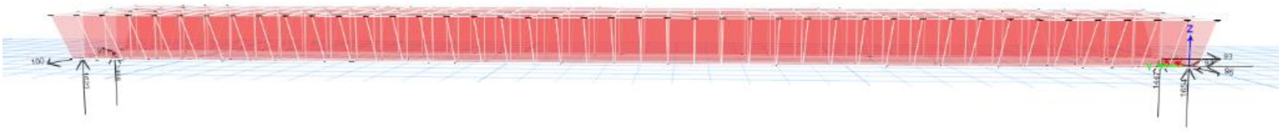

*Figure: Viaduct Model – 3D view viaduct reactions*

Viaduct internal forces and actions

The analysis of the viaduct with the proposed signage shows that the addition of the signage increases the stresses in the top and bottom chord by approximately 1%, which matches the increase in weight. For the dead load (self-weight) case, the stress in the bottom chord is 9 MPa (tension) and the stress in the top chord is 9 MPa (compression). For the SDL (superimposed dead load of the signage) case, the stress in the bottom chord is 0.1 MPa (tension) and the stress in the top chord is 0.1 MPa (compression).

Additional vertical deflections due to the signage weight will be in the order of 0.1mm on the northern side of the viaduct, which is not considered structurally significant.

Our analysis did not continue to consider the impact of additional dead loads (e.g. rail track ballast weight) or live loads as the design actions from these additional loads would only decrease the comparative impact of the signage. The total load on the viaduct from the (unfactored) rail loads alone is approximately 1850 tonnes, making the signage load insignificant in comparison.

The results at this preliminary stage of analysis satisfied us that there was no need to continue with a live load analysis.

Considerations for fixing to the viaduct

Subject to further design stage engineering analysis, the approximate weight of the cantilevered truss is in the order of 1300kg. Northrop expects that to achieve similar design results to that outlined above, the final tonnage of steel would need to be similar to this weight.

The steelwork designed to support the signage will need to be designed with the following considerations;

- Cantilevered steelwork will need to be stiff enough to limit vertical deflections and to maintain the assumption that the height / clearance above the roadway will not be an issue
- Fixings to the viaduct;
    - The forces at the connection points to the viaduct concrete walls were in the order of forces appropriate for chemical anchors, however Northrop notes that chemical anchors are not recommended for connections under constant tension
    - Designer is to confirm the design loads and suitability of chemical anchors in constant tension

- Alternate connection detailing could also be appropriate, such as drilling through the concrete and install bearing plates to the inside of the box section walls, although Northrop has not investigated the feasibility of access to these internal spaces

Structural Assessment

Northrop have not undertaken detailed analysis of the bridge structure above that shown above, however in our professional opinion we anticipate the load increase from the signage will be allowable considering the capacity of the existing structure. On this basis we do not anticipate any adverse actions from the addition of the signage weight and support structures.

Based on the results from comparing the viaduct self-weight with the signage loads, we consider that the increase in weight and stresses within the concrete members will not significantly impact the performance of the existing structure.

From the results of this feasibility analysis, Northrop considers the viaduct able to support the signage loads, subject to design stage engineering confirmation.

**Recommendations**

Based on our understanding of the structure to date and the above discussed loads, we see no reason why the existing bridge could not support the additional loads imposed by a new sign fixed at 45 degrees as proposed in the documentation from Ethos Urban. This assessment is subject to further engineering design and Northrop makes the following recommendations;

- Site investigations will be required prior to detailed design including concrete scanning to determine reinforcement quantum and location.
- Condition assessments will be required to determine the existing condition of the viaduct structure, and to confirm that the assumptions made for the feasibility report are valid
- Further structural engineering needs to be undertaken for complete engineering analysis of the existing structure and design of the proposed sign framing and connections.

This letter is intended to provide structural feasibility advice only and does not constitute a structural engineering approval. Signage details are yet to be determined, and further work is required to provide structural analysis and approval for construction.

Yours faithfully,

**Brendan Blake**
Structural Engineer
BE (Civil), Dip Eng Prac

**Aaron Hughes**
Principal | Sydney Structural Section Manager
BE Civil Hons. (Structures)

ON BEHALF OF NORTHROP CONSULTING ENGINEERS

# APPENDIX – ANALYSIS RESULTS

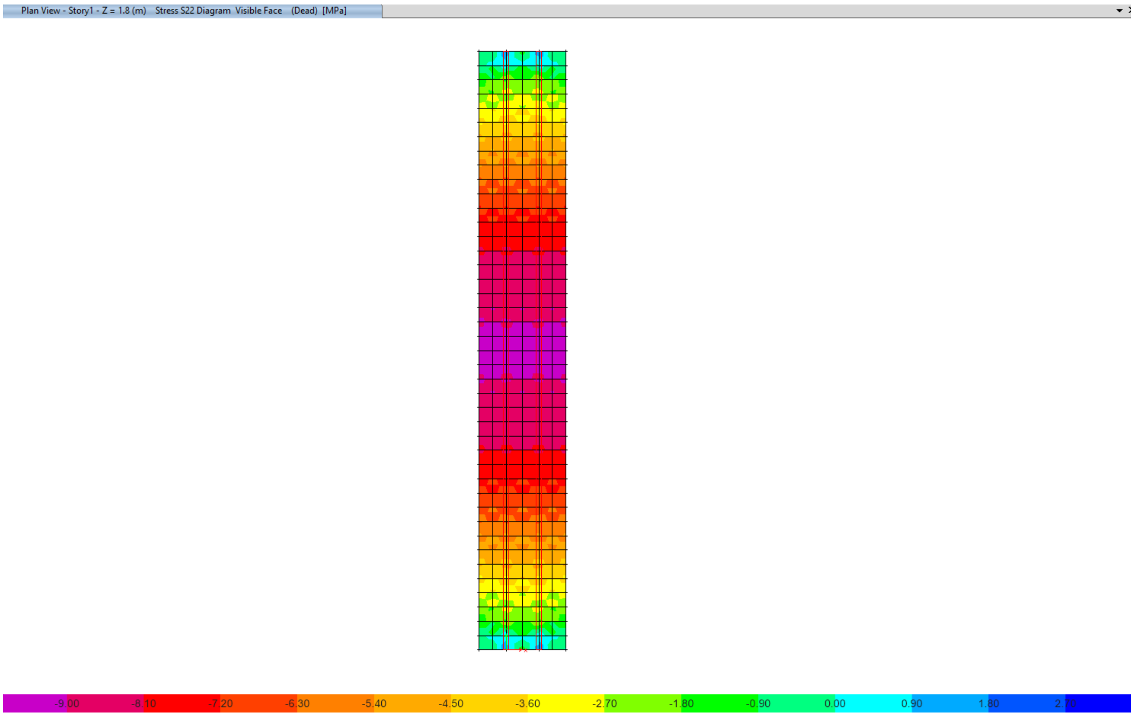


*Figure: Viaduct Model Results – Top flange axial stress for dead loads*

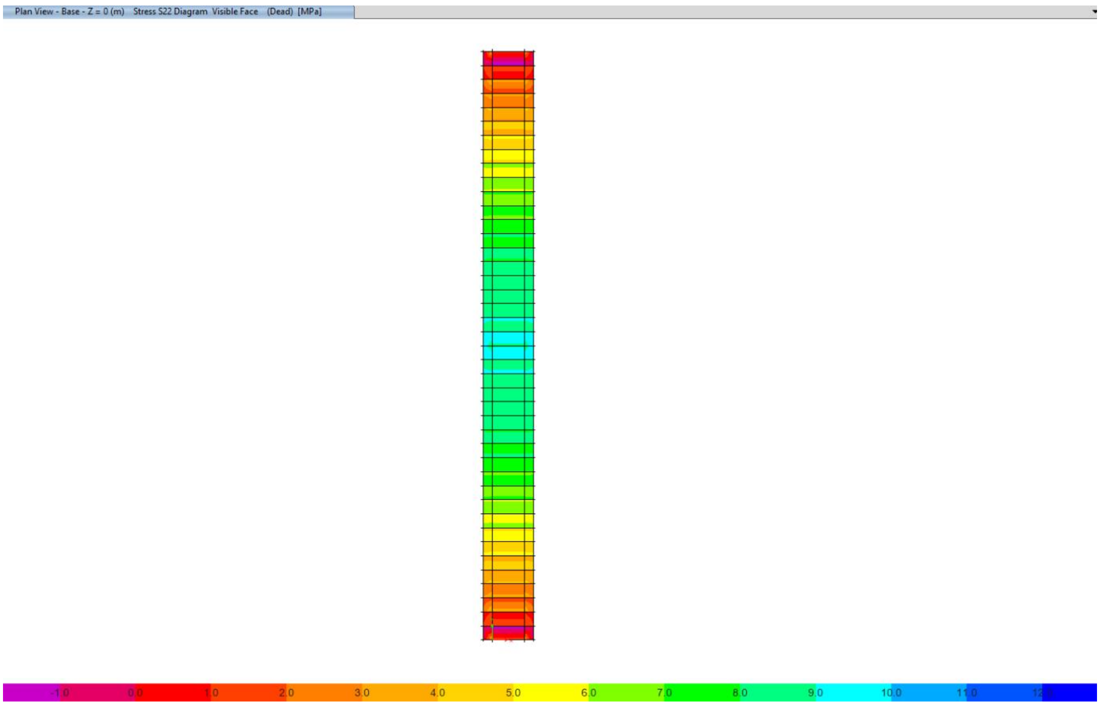


*Figure: Viaduct Model Results – Bottom flange axial stress for dead loads*

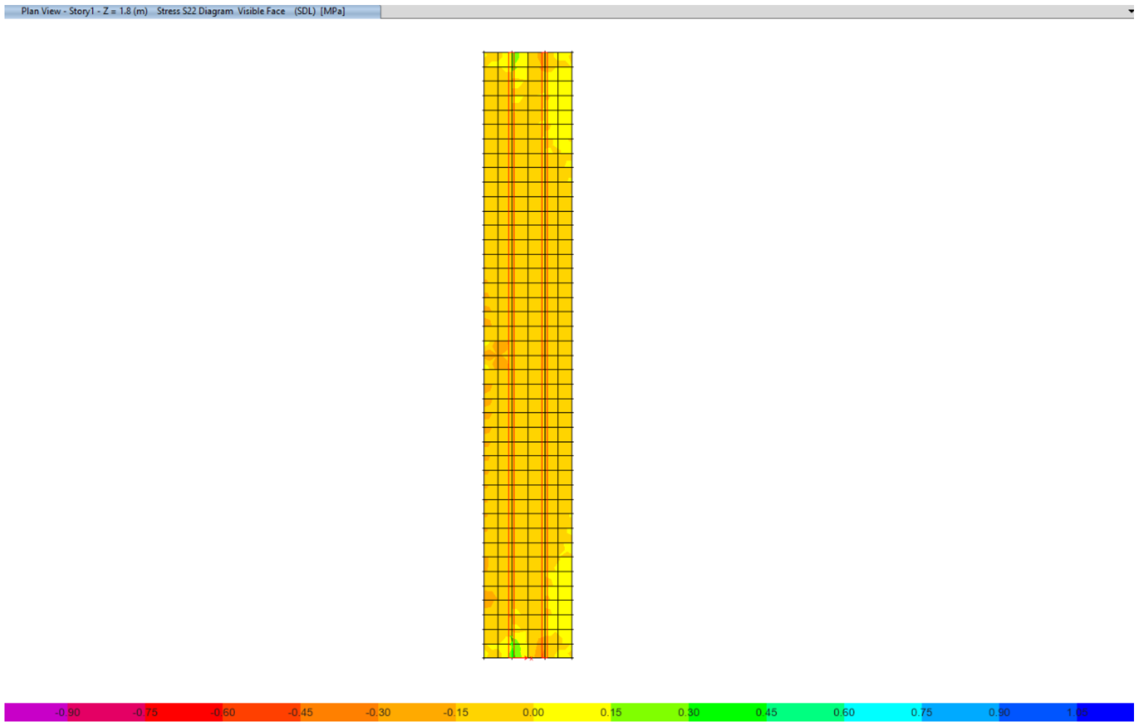


*Figure: Viaduct Model Results – Top flange axial stress for signage only*

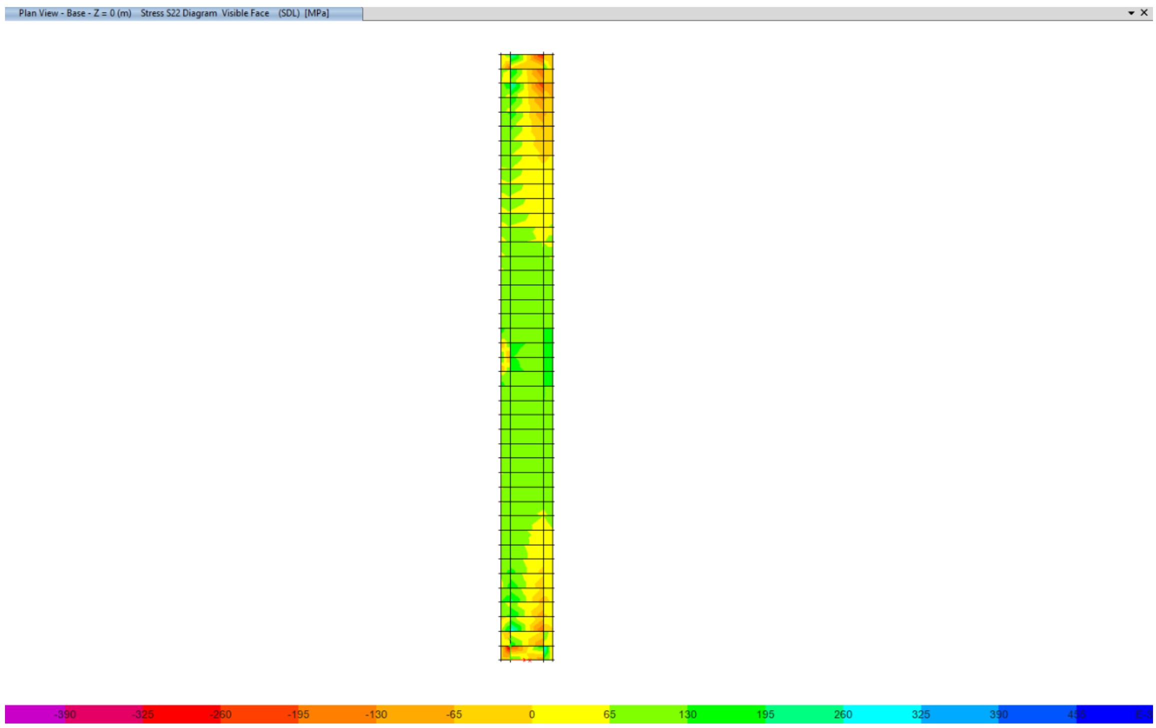


*Figure: Viaduct Model Results – Bottom flange axial stress for signage only*