Date:	20/08/2019	Sales Order:	NA	Document №:	SCR-0201	Revision:	A
Job Title:	Econoflex: single body #7000 196mm – O/A strength characteristics			Client:	Brownings		

Structural Calculation Report (SCR-0201_A)

Calculations have been performed in order to assess the overall strength characteristics of the Signcomp Econoflex flexible face sign system. Specifically, the single standard body #7000.

The calculations have been based on technical literature and drawings produced by Signcomp as well as additional simplified sketches produced by Image Technique as necessary for the purposes of calculation. Copies of the drawings referenced have been included on pages 5-7 of this report.

For the purposes of this report; namely to apply loading to the sign system for the purpose of assessing support requirements, the analysis conducted within has been based on signs with overall face dimensions of 3x3m, 5x5m and 5x3m. Wind-loading has been based on the wind pressure established by Signcomp when testing the plastic, Delrin 507, tension clips.

Wind-load

For the purpose of calculation, a resultant force created by wind effects, the wind-load, has been calculated according to BS-EN-1991-1-4:2005 and its National Annex to produce a resultant load equivalent to the pressure used by Signcomp for the purpose of testing the plastic, Delrin 507, tension clips. Additional windload values have been established for two sites and applied to the three sign sizes considered to show the variation in support requirements.

Self-Weight

A resultant force created by the combined weight of individual components, the dead load, has been calculated based on characteristic values in accordance with BS-EN-1991-1-1:2002 for the three sign sizes considered, however, only the calculation for the 3x3m Econoflex sign has been included within the report.

Structural Comments

Calculations have been performed in accordance with BS-EN-1999-1-1 and the respective National Annexes. Based on the results the following comments are provided.

Due to the amount of variability it is difficult to comment on Econoflex signs as a whole but the following can be assumed following the analysis conducted within this report.
Any Econoflex #7000 signcase, built to Signcomp guidelines upto and including an overall face size of 5x5m, has sufficient strength to support its own weight if supported from underneath, i.e. sign sitting on bottom edge, supported by a floor.

Variables. Depending on the number of back support sections used during the manufacture of the signcase, each will have varying capacity to accommodate the axial loads due to self-weight and bending moment and associated shear load created by wind acting normal to the face of the sign.

The loading induced on the sign due to wind effects will vary depending on the size of the sign and the variable parameters associated with determining the wind loading for any specific sign which include:

- Overall size and aspect ratio of the sign
- Altitude of the installation site
- Distance of the installation site to the shore
- Installation height above ground

The sufficiency, to accommodate loading, of any Econoflex sign is dependant on the way in which it is supported i.e. the location of fixing rails relative to the sign and the magnitude of loading induced due to wind. In order to assess the sufficiency of any specific single std. body #7000 Econoflex sign certain parameters need to be defined.
In order to apply loading to in-turn assess the sufficiency of specific Econoflex signs three differing overall sign sizes have been analysed using the same windload, equivalent to the test pressure adopted by Signcomp for the testing of the tension clips, to allow comparison of the fixing requirements due to variation in sign size. Differing wind-loads have then been applied to the three different signs to allow comparison of the fixing requirements due to variation in load.

Due to the number of variables some of which are identified above, for an economic design the requirements of the fixing rails should be calculated for each specific installation.

Although the specific detailing of any fixing rails is not covered within this report the positional requirements based on the specific load case are; it has been assumed for the purposes of this report, that the fixing rails are detailed such as to have sufficient capacity to accommodate the imposed loads, transferred by the sign.

The three different load cases are summarised below

Load case 1:
The windload, mentioned earlier in this report; equivalent to the test pressure adopted by Signcomp for the testing of the tension clips that retain the vinyl skin to the frame, is used and applied to an Econoflex sign with overall dimensions of 3x3m, based on a simplified overall signcase consisting of 2-N^{o} simplified side body cross-sections and 4-N^{o} back support cross-sections.

It can be seen, from the analysis, that a 3x3m std. single body Econoflex sign case would have sufficient integral strength to resist the imposed loads due to the effects of self-weight and wind loading if the sign case is supported on 2-N^{o} horizontal rails each inset 275mm from the overall height of the signcase.

Load case 2:
The windload, mentioned earlier in this report; equivalent to the test pressure adopted by Signcomp for the testing of the tension clips that retain the vinyl skin to the frame, is again used (for direct comparison purposes) and applied to an Econoflex sign with overall dimensions of 5x5m, based on a simplified overall signcase consisting of 2-N^{o} side body cross-sections and 10-N^{o} back support cross-sections, the calculation of the weight load is revised specifically for a 5x5m Econoflex #7000 sign case.

It can be seen, from the analysis, that a 5x5m std. single body Econoflex sign case would have sufficient integral strength to resist the imposed loads due to the effects of self-weight and wind loading if the sign case is supported on 2-Nº horizontal rails each inset 1,100mm from the overall height of the signcase with an additional horizontal rail positioned centrally, 3 rails required in total.

Load case 3:
The windload, mentioned earlier in this report; equivalent to the test pressure adopted by Signcomp for the testing of the tension clips that retain the vinyl skin to the frame, is again used (for direct comparison purposes) and applied to an Econoflex sign with overall dimensions of 5x3m, based on a simplified overall signcase consisting of 2-Nº side body cross-sections and 10-Nº back support cross-sections, the calculation of the weight load is revised specifically for a 5x3m Econoflex #7000 sign case.

It can be seen, from the analysis, that a 5x3m std. single body Econoflex sign case would have sufficient integral strength to resist the imposed loads due to the effects of self-weight and wind loading if the sign case is supported on 2-Nº horizontal rails each inset 500mm from the overall height of the signcase.

Load cases 1 to 3:
If vertical support rails are to be used the orientation of the signcase should be rotated through 90 degrees such that the vertical back supports are in a horizontal plane. The positional requirements of the support rails will be as stated albeit inset from the side faces of the overall signcase as opposed to the top/bottom.
The positional requirements suggested, above, are however only applicable for the particular sized sign under the windload determined, which is equivalent to the test pressure used by Econoflex for the testing of their tension clips. For each specific installation site this windload may be greater or lesser therefore changing the positional requirements and/or total number of support rails.

Comparison against different wind loads
Two different wind loads have been determined (subscripts a and b) one for a site in Bournemouth which uses a wind speed equivalent to that required to attain the Signcomp test pressure to show the difference in support requirements when shoreline distance is decreased to less than 1km. The second additional windload has been determined for a site in Liverpool, again at less than 1km to the shore, to show the difference in support requirements when wind speed is increased due to geographical location and the altitude of the site above sea level.

The table, overleaf, highlights the different support requirements suggested to ensure the signcases have sufficient strength to imposed loading.

Sign	Windload (kN, on loaded area)	Nº of rails	Rail inset	Nº of back supports	Utilisation of load capacity

3x3 (LC1)	$Q_{d,test,3x3}$ = 15.85kN	2	275	4	0.96
3x3 (a)	$Q_{d,a,3x3}$ = 16.97kN	2	325	4	0.98
3x3 (b)	$Q_{d,b,3x3}$ = 18.32kN	2	400	4	0.99
5x5 (LC2)	$Q_{d,test,5x5}$ = 30.18kN	3	1,100	10	0.96
5x5 (a)	$Q_{d,a,5x5}$ = 32.50kN	3	1,150	10	1.00
5x5 (b)	$Q_{d,b,5x5}$ = 34.69kN	3	1,250	10	0.98
5x3 (LC3)	$Q_{d,test,5x3}$ = 21.56kN	2	500	10	0.97
5x3 (a)	$Q_{d,a,5x3}$ = 22.87kN	2	550	10	0.98
5x3 (b)	$Q_{d,b,5x3}$ = 24.70kN	2	610	10	0.99

NOTE:

The maximum rail inset is limited by the strength of the cantilevered part/s of the signcase extending past the support rails. For all of the cases above this has not been exceeded but it is also the rational for the 3 sections required for the sufficient support of the 5x5m sign.

The maximum combined utilisation of load capacity, of the cantilevered part/s of the 5x5m sign was 0.77 (77%) under windload (b) where the cantilevered part of the signcase is 1.25m.

Summary:

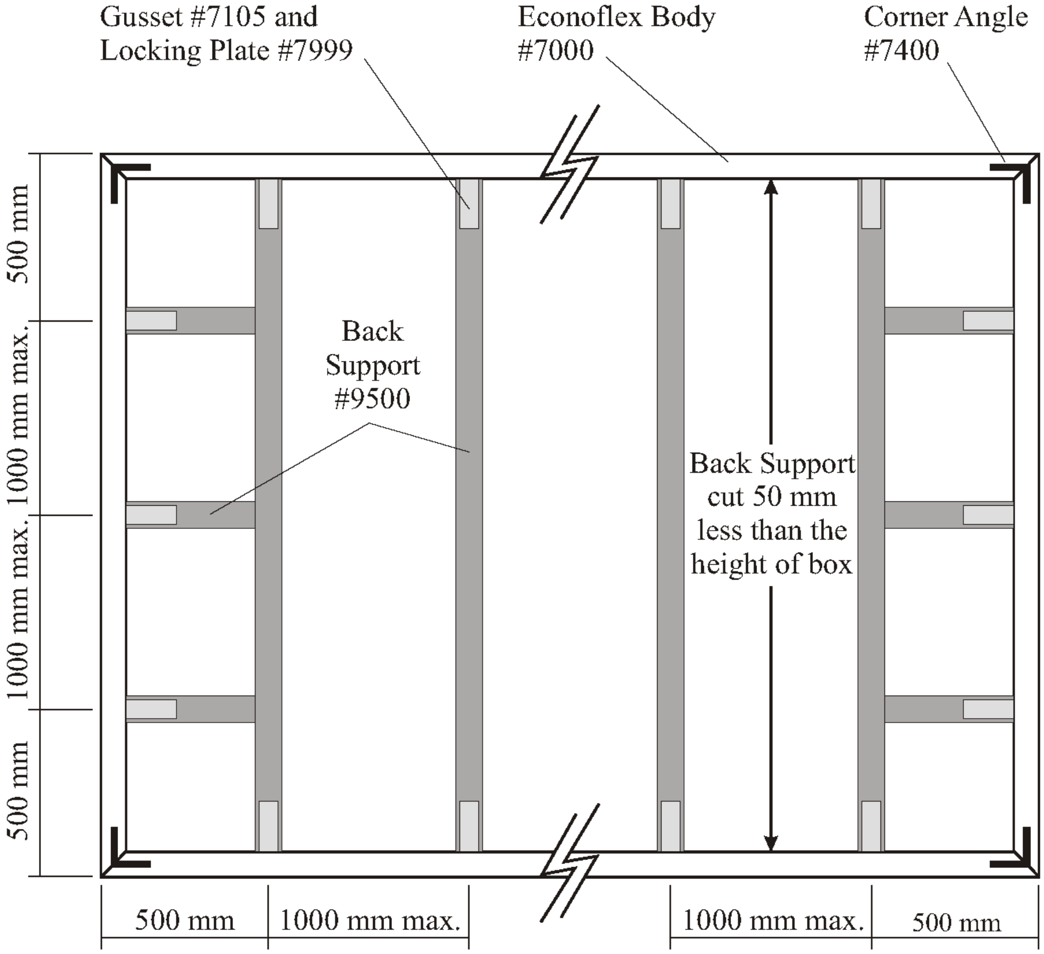
It is evident from the analysis conducted that due to the number of variables, even for the same sign size that the support requirements differ and thus for an economic and safe design the requirements should be determined on a sign/site specific basis.

Further work could be carried out to either create a worst-case load case i.e. for the most onerous combination of site variables for a catalogue of different sign sizes. This would prevent the need for re-calculation for specific sites/sizes but would result in the supports/sign being significantly 'over engineered' for the majority of cases.

The above could be refined with a number of load cases completed for each sign size with limits assigned to the outcome of each i.e. if sign is to be installed <u><</u>1km to the shore and limited to specific areas within Britain, at a height of upto 10m.

Econoflex Back Support #9500

Positioning of back support on Econoflex box.

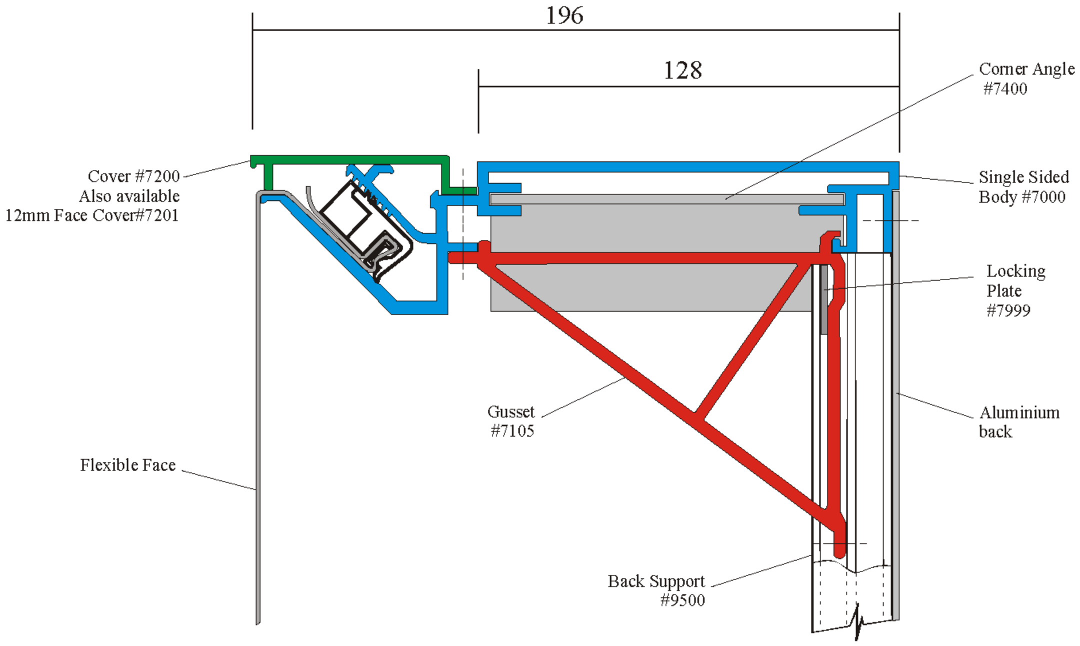


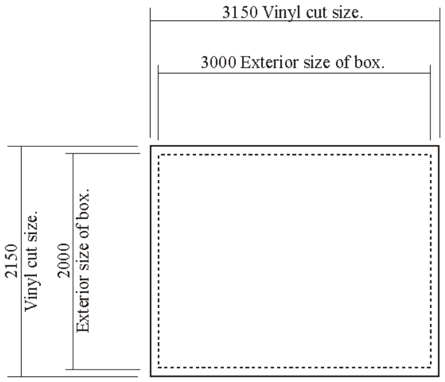
Vinyl cutting sizes

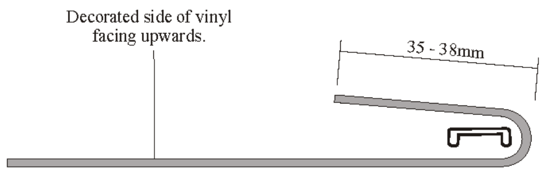
Add 150mm to the height and width (75mm on each side) of the finished size of the frame #7000 ie. For a frame that has overall measurements of 3000 x 2000mm, the vinyl should measure 3150 x 2150mm.

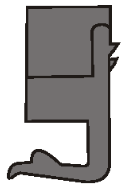
Econoflex Single Sided Body #7000 (196 mm).

Assembled frame and vinyl sizes.









Vinyl cutting sizes

Add 150mm to the height and width (75mm on each side) of the finished size of the frame #7000 ie. For a frame that has overall measurements of 3000 x 2000mm, the vinyl should measure 3150 x 2150mm.

SignComp™ Europe

TENSIONING SYSTEMS FOR FLEXIBLE VINYL SIGNS

I have attached the information that you requested regarding specification on the Aluminium, which of course is only as good or as strong as the finished assembly. As for the vinyl specification you will need to get that from the vinyl suppliers, I have however enclosed the specification of the Tension clip.

ALUMINIUM	*Aluminium tempered quality T6 = 6063* *EN 755-2 = 6060*	
TENSION CLIP	*Test pressure (Dynamic)*	*220 Kg/M2*
	ie : wind speed	*210 Kph*
	Maximum load per clip	*127 Kg*

Components are U.L certified made from plastic QMFZ2 Delrin 507.

If you need further information or samples, please do not hesitate in contacting me.

Yours sincerely,

John Gillam

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Tensioning Systems Industries Ltd Registered in England No. 3007574

1. Site Details

- No specific site details
- Windload ($Q_{d,test}$), determined below, is equivalent to a site with the following details:
  - Located 10km from south coast (not SE or SW) i.e. $V_{b,map}$=22m/s
  - Site altitude of 38m
  - Installation height 10m, exposure coeff. ($C_{e,z}$ = 2.5)
  - Country terrain
  - Insignificant orography

- Windload calculations (a), ($Q_{d,a}$), determined below, is equivalent to a site with the following details:
  - Located <1km from south coast (not SE or SW) i.e. $V_{b,map}$=22m/s (Bournemouth)
  - Site altitude of 36m
  - Installation height 10m, exposure coeff. ($C_{e,z}$ = 2.8)
  - Country terrain
  - Insignificant orography

- Windload calculations (b), ($Q_{d,b}$), determined below, is equivalent to a site with the following details:
  - Located <1km from north west coast i.e. $V_{b,map}$=23m/s (Liverpool)
  - Site altitude of 64m
  - Installation height 10m, exposure coeff. ($C_{e,z}$ = 2.8)
  - Country terrain
  - Insignificant orography

2. Windload calculations – Based on dynamic test pressure used by Signcomp for the testing of the tension clips.

References are to EN-1991-1-4 UNO

2.1. Windload, due to test pressure acting normal to front area of sign

$Q_{d,test} = W_{test} \cdot A_{ref}$

$$\mathbf{Q_{d,test,3x3} = 2,156 \times 7.35 = 15,846.60N = 15.85kN}$$
$$\mathbf{Q_{d,test,5x5} = 2,156 \times 14 = 30,184.0N = 30.18kN}$$
$$\mathbf{Q_{d,test,5x3} = 2,156 \times 10 = 21,560.0N = 21.56kN}$$

2.1.1. Test pressure, dynamic (W_{test})= 220kg/m^2 = 2,156.0N/m^2

2.1.2. Reference area, between support rails. Based on rails being inset 275mm from the O/A extent of the sign case

$A_{ref,3x3} = 3 \times (3 - 2 \times 0.275) = 7.35\text{m}^2$

$A_{ref,5x5} = 5 \times (5 - 2 \times 1.1) = 14\text{m}^2$

$A_{ref,5x3} = 5 \times (3 - 2 \times 0.5) = 10\text{m}^2$

Suitable rail insets for these signs have been found to be
3x3m = 275mm
5x5m = 1,100mm
5x3m = 500mm
to maintain sufficient strength, under the calculated windload

3. Windload calculations (a)

A windload calculation will be performed, below, to allow comparison with the above load to identify differences in support requirements for the 3 sign sizes considered.

3.1. Wind Velocity ($V_{b,Map}$)

$$\mathbf{V_{b,Map} = 22m/s}$$

Wind velocity - Figure NA.1 - UK National Annex.

3.2. Basic Wind Velocity (V_b)

$$V_b = C_{dir}.C_{Season}.V_{b,0}$$
$$V_b = 1 \times 1 \times 22.792$$
$$\mathbf{V_b = 22.792\ m/s}$$

Basic velocity – 4.2 Exp.4.1
$C_{dir} = 1$ – Note 2 of Expression 4.1 - BS EN 1991-1-4
$C_{Season} = 1$ – Note 3 of Expression 4.1 - BS EN 1991-1-4

3.2.1. Fundamental Basic Wind Velocity ($V_{b,0}$)

$$V_{b,0} = V_{b,Map}.C_{alt}$$
$$V_{b,0} = 22 \times 1.036$$
$$V_{b,0} = 22.792m/s$$

Fundamental basic velocity – NA.2.4 Exp.NA.1

3.2.1.1. Altitude Correction Factor (C_{alt})

$$C_{alt} = 1 + 0.001\,.A$$
$$C_{alt} = 1 + 0.001 \times 36$$
$$\mathbf{C_{alt} = 1.036}$$

Altitude correction - NA. 2.5 - UK NA & Fig. 6.1. - BS EN 1991-1-4.

3.3. Basic Velocity Pressure (q_b)

$$q_b = 0.5\rho.V_b{}^2$$
$$q_b = 0.5 \times 1.226 \times 22.792^2$$
$$\mathbf{q_b = 318.44N/m^2}$$

Basic pressure – 4.5(1) Exp.4.10
Air Density (ρ) = 1.226kg/m³ - NA.2.18

3.4. Peak Velocity Pressure (q_p)

$$q_p = C_{e(z)}.q_b$$
$$q_p = 2.8 \times 318.44$$
$$\mathbf{q_p = 891.63N/m^2}$$

Peak pressure – 4.5(1) Exp.4.8
$C_{e(z)} = 2.8$ – Fig. NA.7, using height z of 10m (centre of sign), <1km to shore.

3.5. Wind-force acting on loaded area, between fixing rails

$$F_W = C_SC_D.C_f.q_p.A$$

Wind-load – 5.3(2) Exp.5.3
Structural factor (C_SC_D) = 1 – 6.2(1)a)

Force coefficient C_f=1.8 – Expression 7.7 BS EN 1991-1-4 – True as b/h $\leq$1 (Choice of aerodynamic coefficient determined from 7.1.1)

Partial factors for actions
Variable actions (γ_Q)=1.5 table NA.A1.2(A) NA to BS EN1990

For a 3x3m sign

$$F_{W,3x3,a} = 1 \times 1.8 \times 891.63 \times 7.05$$
$$F_{W,3x3,a} = 11{,}314.75N\ (\text{characteristic value}) = F_k$$

$$Q_{d,3x3,a} = \gamma_Q.F_k = 1.5 \times 11{,}314.75$$
$$\mathbf{Q_{d,3x3,a} = 16,972.13N = 16.97kN}$$

For a 5x5m sign

$$F_{W,5x5,a} = 1 \times 1.8 \times 891.63 \times 13.5$$
$$F_{W,5x5,a} = 21{,}666.54N\ (\text{characteristic value}) = F_k$$

$$Q_{d,5x5,a} = \gamma_Q.F_k = 1.5 \times 21{,}666.54$$
$$\mathbf{Q_{d,5x5,a} = 32,499.82N = 32.50kN}$$

For a 5x3m sign

$$F_{W,5x3,a} = 1 \times 1.8 \times 891.63 \times 9.5$$
$$F_{W,5x3,a} = 15{,}246.83N\ (\text{characteristic value}) = F_k$$

$Q_{d,5x3,a} = \gamma_Q . F_k = 1.5 \times 15{,}246.83$

$\mathbf{Q_{d,5x3,a} = 22,870.24N = 22.87kN}$

3.5.1. Reference areas of signage (A_{OA})

$A_{ref,3x3,a} = 3 \times (3 - 2 \times 0.325) = 7.05m^2$

$A_{ref,5x5,a} = 5 \times (5 - 2 \times 1.150) = 13.5m^2$

$A_{ref,5x3,a} = 5 \times (3 - 2 \times 0.550) = 9.5m^2$

4. Windload calculations (b)

A windload calculation will be performed, below, to allow comparison with the above load to identify differences in support requirements for the 3 sign sizes considered.

4.1. Wind Velocity ($V_{b,Map}$)

$\mathbf{V_{b,Map} = 23m/s}$

4.2. Basic Wind Velocity (V_b)

$V_b = C_{dir} . C_{Season} . V_{b,0}$

$V_b = 1 \times 1 \times 24.472$

$\mathbf{V_b = 24.472\ m/s}$

4.2.1. Fundamental Basic Wind Velocity ($V_{b,0}$)

$V_{b,0} = V_{b,Map} . C_{alt}$

$V_{b,0} = 23 \times 1.064$

$V_{b,0} = 24.472m/s$

4.2.1.1. Altitude Correction Factor (C_{alt})

$C_{alt} = 1 + 0.001 . A$

$C_{alt} = 1 + 0.001 \times 64$

$\mathbf{C_{alt} = 1.064}$

4.3. Basic Velocity Pressure (q_b)

$q_b = 0.5\rho . {V_b}^2$

$q_b = 0.5 \times 1.226 \times 24.472^2$

$\mathbf{q_b = 367.11N/m^2}$

4.4. Peak Velocity Pressure (q_p)

$q_p = C_{e(z)} . q_b$

$q_p = 2.8 \times 367.113$

$\mathbf{q_p = 1,027.92N/m^2}$

4.5. Wind-force acting on loaded area, between fixing rails

$F_W = C_S C_D . C_f . q_p . A$

For a 3x3m sign

$F_{W,3x3,b} = 1 \times 1.8 \times 1{,}027.92 \times 6.6$

$F_{W,3x3,b} = 12{,}211.64N$ (characteristic value) $= F_k$

$Q_{d,3x3,b} = \gamma_Q . F_k = 1.5 \times 12{,}211.64$

$\mathbf{Q_{d,3x3,b} = 18,317.46N = 18.32kN}$

For a 5x5m sign

$F_{W,5x5,b} = 1 \times 1.8 \times 1{,}027.92 \times 12.5$

$F_{W,5x5,b} = 23{,}128.10N$ (characteristic value) $= F_k$

Suitable rail insets for these signs have been found to be
3x3m = 325mm
5x5m = 1,150mm
5x3m = 550mm
to maintain sufficient strength, under the calculated windload

Wind velocity - Figure NA.1 - UK National Annex.
Basic velocity – 4.2 Exp.4.1
C_{dir} = 1 – Note 2 of Expression 4.1 - BS EN 1991-1-4
C_{Season} = 1 – Note 3 of Expression 4.1 - BS EN 1991-1-4

Fundamental basic velocity – NA.2.4 Exp.NA.1

Altitude correction - NA. 2.5 - UK NA & Fig. 6.1. - BS EN 1991-1-4.

Basic pressure – 4.5(1) Exp.4.10
Air Density (ρ) = 1.226kg/m^3 - NA.2.18

Peak pressure – 4.5(1) Exp.4.8
$C_{e(z)}$ = 2.8 – Fig. NA.7, using height z of 10m (centre of sign), <1km to shore.

Wind-load – 5.3(2) Exp.5.3
Structural factor ($C_S C_D$) = 1 – 6.2(1)a)

Force coefficient C_f=1.8 – Expression 7.7 BS EN 1991-1-4 – True as b/h $\leq$1 (Choice of aerodynamic coefficient determined from 7.1.1)

Partial factors for actions
Variable actions (γ_Q)=1.5

$Q_{d,5x5,b} = \gamma_Q . F_k = 1.5 \times 23{,}128.1$
$\mathbf{Q_{d,5x5,b} = 34,692.15N = 34.69kN}$

For a 5x3m sign
$F_{W,5x3,b} = 1 \times 1.8 \times 1{,}027.92 \times 8.9$
$F_{W,5x3,b} = 16{,}467.21\text{N (characteristic value)} = F_k$

$Q_{d,5x3,b} = \gamma_Q . F_k = 1.5 \times 16{,}467.21$
$\mathbf{Q_{d,5x3,b} = 24,700.81N = 24.70kN}$

4.5.1. Reference areas of signage (A_{0A}), as previously determined
$A_{ref,3x3,b} = 3 \times (3 - 2 \times 0.375) = 6.6m^2$
$A_{ref,5x5,b} = 5 \times (5 - 2 \times 1.250) = 12.5m^2$
$A_{ref,5x3,b} = 5 \times (3 - 2 \times 0.610) = 8.9m^2$

table NA.A1.2(A) NA to BS EN1990

Suitable rail insets for these signs have been found to be
3x3m = 400mm
5x5m = 1,250mm
5x3m = 610mm
to maintain sufficient strength, under the calculated windload

5. Self -Weight

Overall weight of sign not including any support rails or framework.
$\mathbf{G_k = 117.26kg = 1,149.16N}$ **(characteristic value)**

The characteristic value, above, includes a 2.5% allowance for paint finish to signcase & adhesive tape/silicon for LED modules

Design value of overall weight load
$\mathbf{G_d = \gamma_G . G_k = 1.35 \times 1,149.16 = 1,551.36N\ (Design)}$

Partial factors for actions
Permanent actions
(γ_G)=1.35
table NA.A1.2(A) NA to BS EN1990

Main sections

5.1. Side body sections – #7000; std. 196mm

Material – Aluminium 6063 T6
Length – 1200cm (cumulative length)
CSA – 8.86cm² (CAD model, true section)
Volume = 10.63x10³cm³
Density – 2.7g/cm³ (Aalco datasheet, 6063T6 extrusions)
Weight/component = 28.69kg
Number of components – 1
Total weight = 28.69kg = 281.19N

5.2. Back support sections (vertical raceways) – #9500

Material – Aluminium 6063 T6
Length – 295cm (O/A height minus 5cm)
CSA – 2.63cm² (CAD model, true section)
Volume = 776.82cm³
Density – 2.7g/cm³ (Aalco datasheet, 6063T6 extrusions)
Weight/component = 2.10kg
Number of components – 6 (min. quantity of 4 as used within calcs +2 sections)
Total weight = 12.58kg = 123.33N

5.3. Gusset sections – #7105 (for std. single body)

Material – Aluminium 6063 T6
Length – 3.75cm

CSA – 10.19cm² (CAD model, true section)
Volume = 38.22cm³
Density – 2.7g/cm³ (Aalco datasheet, 6063T6 extrusions)
Weight/component = 0.10kg
Number of components – 15
Total weight = 1.55kg = 15.17N

5.4. Locking plates – #7999

Material – Aluminium 6063 T6
Volume = 8.75cm³ (Based on O/A size of 54x54x3)
Density – 2.7g/cm³ (Aalco datasheet, 6063T6 extrusions)
Weight/component = 0.02kg
Number of components – 15
Total weight = 0.35kg = 3.47N

5.5. Corner, angle, brackets – #7400

Material – Aluminium 6063 T6
Length – 11.2cm
CSA – 2.91cm² (CAD model, measured section)
Volume = 32.59cm³
Density – 2.7g/cm³ (Aalco datasheet, 6063T6 extrusions)
Weight/component = 0.09kg
Number of components – 4
Total weight = 0.35kg = 3.45N

5.6. Corner, angle, brackets – #7400

Material – Aluminium 6063 T6
Length – 11.2cm
CSA – 2.91cm² (CAD model, measured section)
Volume = 32.59cm³
Density – 2.7g/cm³ (Aalco datasheet, 6063T6 extrusions)
Weight/component = 0.09kg
Number of components – 4
Total weight = 0.35kg = 3.45N

5.7. Back supports (Horizontals at sides) – #9500

Material – Aluminium 6063 T6
Length – 45cm (based on outer vertical back supports being inset 500mm as per Signcomp guidelines)
CSA – 2.63cm² (CAD model, true section)
Volume = 118.50cm³
Density – 2.7g/cm³ (Aalco datasheet, 6063T6 extrusions)
Weight/component = 0.32kg
Number of components – 10 (2 additional sections per side above the min. recommended by Signcomp)
Total weight = 3.20kg = 31.35N

5.8. Inverted angle (Image panel jointing system)

Material – Aluminium 1050A H14
Length – 295cm (taken equal to the length of back support sections)
CSA – 0.75cm² (CAD model)
Volume = 221.04cm³
Density – 2.71g/cm³ (Aalco datasheet, 1050A H14 sheet)
Weight/component = 0.60kg
Number of components – 2 (2 panel joints across sign)

Total weight = 1.20kg = 11.74N

5.9. Bleed cover - #7200

Material – Aluminium 6063 T6
Length – 1200cm (taken equal to the cumulative length of side body sections)
CSA – 1.12cm^2 (CAD model)
Volume = 1.347x10^{3}cm^3
Density – 2.7g/cm^3 (Aalco datasheet, 6063T6 extrusions)
Weight/component = 3.64kg
Number of components – 1
Total weight = 3.64kg = 35.67N

5.10. Backing sheet

Material – Aluminium 1050A H14
Length – 300cm (taken to be full overall size of signcase)
CSA – 60cm^2 (CAD model)
Thickness – 2mm (Image use 1mm where possible)
Volume = 18.0x10^{3}cm^3
Density – 2.71g/cm^3 (Aalco datasheet, 6063T6 extrusions)
Weight/component = 48.78kg
Number of components – 1 (treated as 1 full sheet)
Total weight = 48.78kg = 478.04N

Total weight, main sections = 100.35kg = 983.42N

Fixings

5.11. Bleed cover screws – pan head #8x1/2”

Material – Stainless steel 18/8
Weight/component – 1.36g (weight, 100pcs = 136g)
Number = 120pcs (based on a conservative 100mm spacing)
Total weight = 0.163kg = 1.60N

5.12. Inverted angle screws – hex. head ST5.5x25mm

Material – Steel
Weight/component – 4.9g (weight, 1000pcs = 4.9kg)
Number = 59pcs (based on a conservative 100mm spacing)
Total weight = 0.289kg = 2.83N

5.13. Pop rivets – Ø4x20mm

Material – steel (conservative; Alu. Should be used)
Weight/component – 2.99g (weight, 100pcs = 299g)
Number, gussets = 45pcs (based on 3 per gusset)
Weight, gusset fixings = 0.135kg
Number, corner brackets = 32 (based on 4 per profile)
Weight, corner bracket fixings = 0.096kg
Number, backing sheet = 356 (based on conservative spacing of 100mm around perimeter, along vertical back supports and inverted angle sections)
Weight, back panel fixings = 1.064kg
Total weight = 1.295kg = 12.691N

Total weight, fixings = 1.75kg = 17.12N

Vinyl skin

5.14. Vinyl – MACal 9800 series

Face area = 9m^2
Weight/unit area – 600gsm (conservative estimate allowing for different types and double thickness)
Total weight = 5.40kg = 52.92N

5.15. Tension clips - #5360

Material – Delrin 507
Length – 6.5cm
CSA – 1.73cm^2 (CAD model)
Thickness – 2mm (Image use 1mm where possible
Volume = 11.23cm^3
Density – 1.4g/cm^3 (Matweb)
Weight/component = 15.72kg
Number of components – 120 (based on conservative 100mm spacing)
Total weight = 1.89kg = 18.49N

Total weight, vinyl skin = 7.29kg = 132,324.50N

Illumination

5.16. LED modules – Osram Box LED XS plus G15

Length – 26.10m
Weight/m – 0.14kg/m (Based on 855g for 6,083mm chain of specified LED, particularly heavy LED chosen)
Total weight = 3.67kg = 35.95N

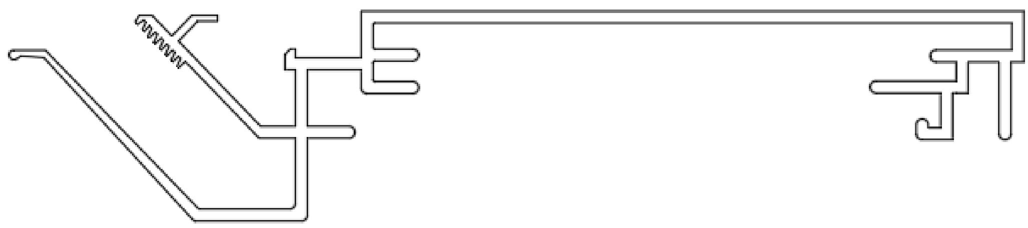
5.17. Power converters – Talex LCU60W

Weight/module = 0.45kg
Number of modules – 3No (based on that required for std. B&Q 3x3m flex)
Total weight = 1.35kg = 13.23N

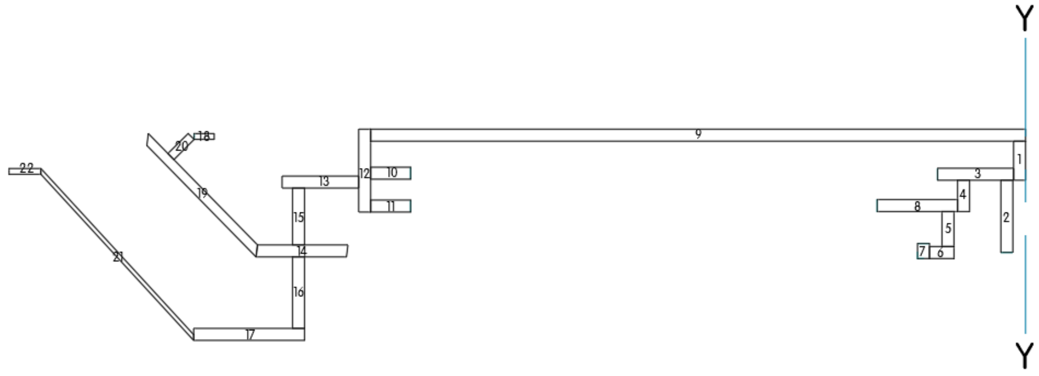
Total weight, illumination = 5.02kg = 49.18N

6. Side body sections

6.1. Figure below shows the true cross-section of the side body member



6.2. Figure below shows the cross-section of the side body section simplified to allow conservative calculation of the sectional properties



References are to BS EN-1999-1-1 UNO

6.3. Material properties, for 6063T6 extrusions

Proof strength (f_o)=160N/mm^2
Ultimate strength (f_u)=195N/mm^2
Elastic modulus (E)=70,000N/mm^2

Strengths – Aalco datasheet 6063T6 extrusions
Elastic mod. – 3.2.5(1)

6.4. Cross section classification, section subject to bending

Cross section classification - 6.1.4

The cross section will be classified considering the central, most slender web, about which the Elastic Neutral Axis is located; position of which is determined later in this report, is subject to a stress gradient i.e. in bending. This central web, shown as part 9 on the figure; above, will be treated as a flat internal part. Based on this the slenderness parameter (β) is given by

$$\beta = \eta\frac{b}{t} = 0.4\frac{123.4}{2.3} = 21.46\text{mm} < 27.5 \therefore \textbf{Class 3 section}$$

Slenderness parameter 6.1.4.3(1)

Where:
b=inside dimension of web part = 123.4mm
t=thickness of web part = 2.3mm

Class limits – internal part subject to compression

Class 1 limit: $\frac{\beta_1}{\beta} = 11$

$\therefore \beta_1 = 11 \times 1.25 = 13.75$

Class 2 limit: $\frac{\beta_2}{\beta} = 16$

$\therefore \beta_2 = 16 \times 1.25 = 20$

Class 3 limit: $\frac{\beta_3}{\beta} = 22$

$\therefore \beta_3 = 22 \times 1.25 = 27.5$

$$\varepsilon = \sqrt{250/f_o} = \sqrt{250/160} = 1.25$$

As the cross section is class 3 the sectional properties and resultant resistance to bending moment will be based on elastic properties.

6.5. Sectional properties, position of ENA from reference y-axis at extreme right-hand-side of section, viewed as shown in figure above.

Areas, individual areas of each part

Part	Area (mm²)
1	17.25
2	31.85
3	33.58
4	13.8
5	35.53
6	15.41
7	10.81
8	6.55
9	289.11
10	17.6
11	17.6
12	36.57
13	33.81
14	25.07
15	39.91
16	31.51
17	48.94
18	54.04
19	4.28
20	8.9
21	32.25
22	6.71
ΣA	811.08mm²

Individual centroids – of each part from reference y-axis, at right-hand-side of section

Part	Centroid, from ref. y (mm)
1	1.15
2	3.6
3	9.6
4	11.9
5	14.9
6	16.1
7	19.6
8	20.775
9	62.85
10	121.875
11	121.875
12	126.85
13	135.35
14	138.884
15	139.55
16	139.55
17	149.04
18	157.657
19	158.026
20	162.111
21	174.34
22	192.05

First/statical moment of areas (=Area x centroidal distance from y-axis)

Part	Moment of area (mm^3)
1	19.84
2	114.66
3	322.37
4	164.22
5	529.40
6	248.10
7	211.88
8	136.08
9	18,170.56
10	2,145.0
11	2,145.0
12	4,638.90
13	4,576.18
14	3,481.82
15	5,569.44
16	4,397.22
17	7,294.02
18	8,519.78
19	676.35
20	1,442.79
21	5,622.47
22	1,288.66
Σ	**71,714.73mm³**

Centroidal position of overall section, position of Elastic Neutral Axis from reference y-axis at right hand side of section

$$\mathbf{y_R}' = \frac{\mathbf{\Sigma}}{\mathbf{\Sigma A}}$$

$$\mathbf{y_R}' = \frac{\mathbf{71,714.73}}{\mathbf{811.08}} = \mathbf{88.42mm\ (from\ right)}$$

Or

$$\mathbf{y_L}' = \mathbf{h} - \mathbf{y_R}'$$

$$\mathbf{y_L}' = \mathbf{195.10} - \mathbf{88.42} = \mathbf{106.68mm\ (from\ left)}$$

Height of overall simplified cross section
h=195.10mm

6.6. Sectional properties, second moment of area about y-axis of the simplified side body cross section.

The simplified cross-section will now be split into an additional part, about the ENA, as shown in the figure, below.

Individual centroidal second moments of each part, about individual NA's

Part	I_{cy}(mm^4)
$I_{cy}(1)$	7.60
$I_{cy}(2)$	14.04
$I_{cy}(3)$	596.49
$I_{cy}(4)$	6.08

$I_{cy}(5)$	6.79
$I_{cy}(6)$	19.90
$I_{cy}(7)$	2.89
$I_{cy}(8)$	706.86
$I_{cy}(9)$	132,494.58
$I_{cy}(10)$	9,930.57
$I_{cy}(11)$	85.81
$I_{cy}(12)$	85.81
$I_{cy}(13)$	16.12
$I_{cy}(14)$	608.83
$I_{cy}(15)$	1,001.03
$I_{cy}(16)$	11.05
$I_{cy}(17)$	13.89
$I_{cy}(18)$	1,846.98
$I_{cy}(19)$	5.28
$I_{cu}(20)$	1,989.46
$I_{cu}(21)$	12.20
$I_{cu}(22)$	2,295.49
$I_{cy}(23)$	0.68

As parts 20, 21 & 23 are on inclined axis the second moments about there individual NA will be rotated normal to the ENA of the O/A section using the following transformation equations

$$I_{cu} = \frac{I_{cy} + I_{cz}}{2} + \frac{I_{cy} - I_{cz}}{2}\cos2\varphi - I_{cyz}\sin2\varphi$$

$$I_{cv} = \frac{I_{cy} + I_{cz}}{2} - \frac{I_{cy} - I_{cz}}{2}\cos2\varphi + I_{cyz}\sin2\varphi$$

$$I_{cuv} = \frac{I_{cy} + I_{cz}}{2}\sin2\varphi + I_{cyz}\cos2\varphi$$

Where I_{cy} & I_{cz} are 2nd moments about the individual axes & I_{cyz} the product of inertia.
I_{cu}, I_{cv} & I_{cuv} are the 2nd moments about the rotated axes u & v.
The product of inertia (I_{cyz}) for a rectangle is zero as y and z are symmetry axes.
Conservatively the min. 2nd moment values about the rotated axes will be used.

Part 20

$\varphi = 45.54^o$

$$I_{cy} = \frac{B.H^3}{12} = \frac{1.81 \times 29.92^3}{12} = 4{,}040.01\text{mm}^4$$

$$I_{cz} = \frac{H.B^3}{12} = \frac{29.92 \times 1.81^3}{12} = 14.78\text{mm}^4$$

$$I_{cu} = \frac{I_{cy} + I_{cz}}{2} + \frac{I_{cy} - I_{cz}}{2}\cos2\varphi - I_{cyz}\sin2\varphi$$

$$I_{cu} = \frac{4{,}040.01 + 14.78}{2} + \frac{4{,}040.01 - 14.78}{2}\cos(2 \times 45.45) - 0$$

$$\mathbf{I_{cu} = 1,989.46mm^4}$$

$$I_{cv} = \frac{I_{cy} + I_{cz}}{2} - \frac{I_{cy} - I_{cz}}{2}\cos2\varphi + I_{cyz}\sin2\varphi$$

$$I_{cv} = \frac{4{,}040.01 + 14.78}{2} - \frac{4{,}040.01 - 14.78}{2}\cos(2 \times 45.45) + 0$$

$$I_{cv} = 2{,}065.33\text{mm}^4$$

$$I_{cuv} = \frac{I_{cy} + I_{cz}}{2}\sin 2\varphi + I_{cyz}\cos 2\varphi$$

$$I_{cuv} = \frac{4{,}040.01 + 14.78}{2}\sin(2 \times 45.54) + 0$$

$$I_{cuv} = 2{,}012.25\text{mm}^4$$

Part 21

$\varphi = 45.18^o$

$$I_{cy} = \frac{B.H^3}{12} = \frac{1.63 \times 5.48^3}{12} = 22.35\text{mm}^4$$

$$I_{cz} = \frac{H.B^3}{12} = \frac{5.48 \times 1.63^3}{12} = 2.17\text{mm}^4$$

$$I_{cu} = \frac{I_{cy} + I_{cz}}{2} + \frac{I_{cy} - I_{cz}}{2}\cos 2\varphi - I_{cyz}\sin 2\varphi$$

$$I_{cu} = \frac{22.35 + 2.17}{2} + \frac{22.35 - 2.17}{2}\cos(2 \times 45.18) - 0$$

$$\mathbf{I_{cu} = 12.20mm^4}$$

$$I_{cv} = \frac{I_{cy} + I_{cz}}{2} - \frac{I_{cy} - I_{cz}}{2}\cos 2\varphi + I_{cyz}\sin 2\varphi$$

$$I_{cv} = \frac{22.35 + 2.17}{2} - \frac{22.35 - 2.17}{2}\cos(2 \times 45.18) + 0$$

$$I_{cv} = 12.32\text{mm}^4$$

$$I_{cuv} = \frac{I_{cy} + I_{cz}}{2}\sin 2\varphi + I_{cyz}\cos 2\varphi$$

$$I_{cuv} = \frac{22.35 + 2.17}{2}\sin(2 \times 45.18) + 0$$

$$I_{cuv} = 10.09\text{mm}^4$$

Part 22

$\varphi = 47.37^o$

$$I_{cy} = \frac{B.H^3}{12} = \frac{0.74 \times 43.29^3}{12} = 5{,}002.80\text{mm}^4$$

$$I_{cz} = \frac{H.B^3}{12} = \frac{43.29 \times 0.74^3}{12} = 1.46\text{mm}^4$$

$$I_{cu} = \frac{I_{cy} + I_{cz}}{2} + \frac{I_{cy} - I_{cz}}{2}\cos 2\varphi - I_{cyz}\sin 2\varphi$$

$$I_{cu} = \frac{5{,}002.8 + 1.46}{2} + \frac{5{,}002.8 - 1.46}{2}\cos(2 \times 47.37) - 0$$

$$\mathbf{I_{cu} = 2,295.49mm^4}$$

$$I_{cv} = \frac{I_{cy} + I_{cz}}{2} - \frac{I_{cy} - I_{cz}}{2}\cos 2\varphi + I_{cyz}\sin 2\varphi$$

$$I_{cv} = \frac{5{,}002.8 + 1.46}{2} - \frac{5{,}002.8 - 1.46}{2}\cos(2 \times 47.37) + 0$$

$$I_{cv} = 2{,}7080.77\text{mm}^4$$

$$I_{cuv} = \frac{I_{cy} + I_{cz}}{2}\sin 2\varphi + I_{cyz}\cos 2\varphi$$

$$I_{cuv} = \frac{5{,}002.8 + 1.46}{2}\sin(2 \times 47.37) + 0$$
$$I_{cuv} = 2{,}492.12\text{mm}^4$$

Distances from ENA to individual centroids

Part	Centroid, from ENA (mm)
1	87.27
2	84.82
3	78.82
4	76.52
5	73.52
6	72.32
7	68.82
8	67.645
9	44.21
10	18.64
11	33.455
12	33.455
13	38.43
14	46.93
15	50.464
16	51.13
17	53.13
18	60.62
19	69.237
20	69.606
21	73.691
22	85.92
23	103.63

Centroidal 2nd moment of area of overall compound section about the ENA, see figure below

The second moment of area of the overall simplified composite section will be determined using the following equation:

$$I_{cy}(OA) = \Sigma\left(I_{cy}(i) + A(i).d(i)^2\right)$$

where: i=part numbers 1 to 23

$$\mathbf{I_{cy}(OA) = 2,825,894.45mm^4}$$

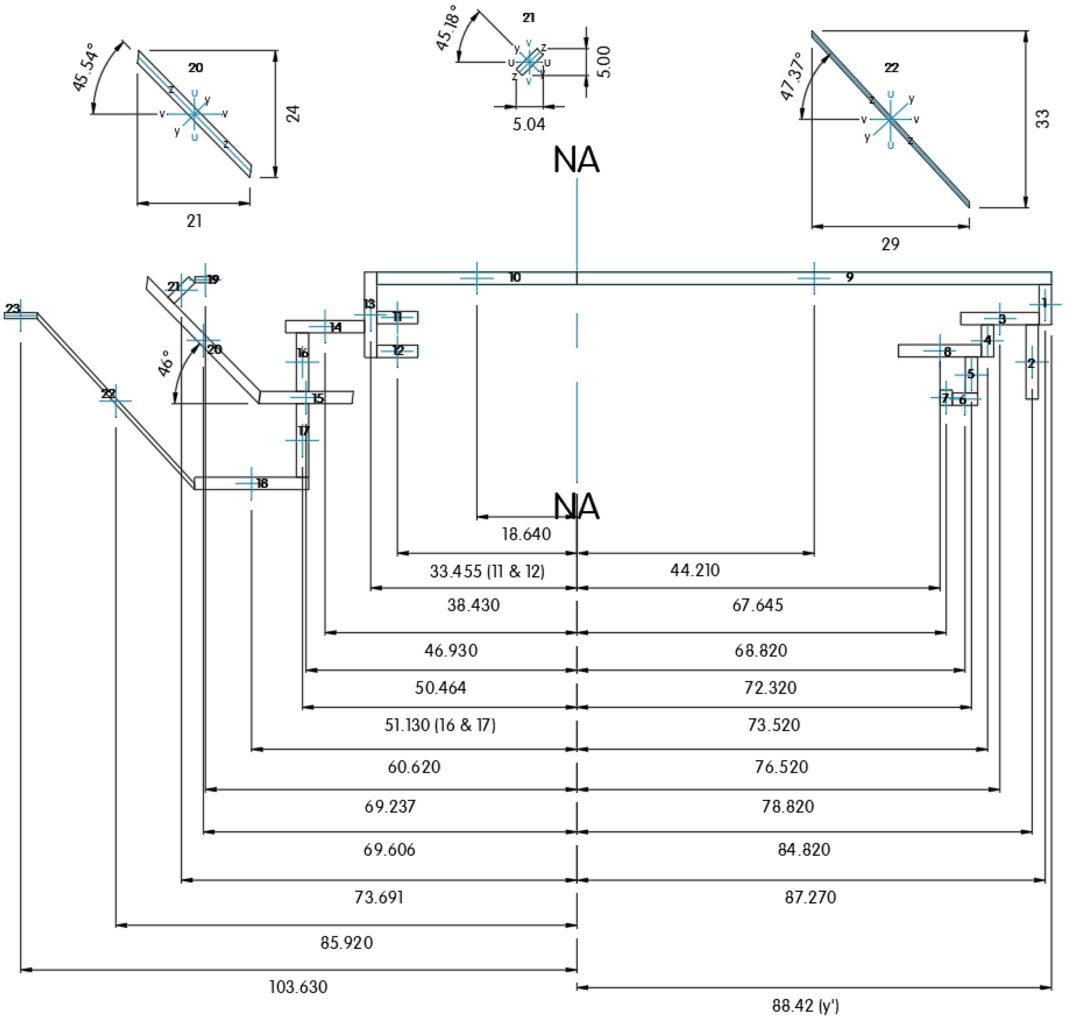
6.7. Sectional properties, elastic section modulus

The minimum elastic section modulus, which will in turn be used to determine the sections resistance to bending moment will be found using the following equation.

$$W_{el,y,min} = \frac{I_{cy}(OA)}{y_L{}'}$$

$$W_{el,y,min} = \frac{2{,}825{,}894.45}{106.68} = 26{,}498.15\text{mm}^3$$

6.8. Figure below shows the simplified cross-section divided into 23 parts about the Elastic Neutral Axis



6.9. Resistance to bending moment, provided by the side body sections

The design resistance for bending about one principle axis of a cross section (M_{Rd}) is given by the lesser of:

$M_{u,Rd} = W_{net}.f_u/\gamma_{M2}$

$M_{u,Rd} = 26{,}489.15 \times 195/1.25$

$M_{u,Rd} = 3{,}390{,}611.82\text{Nmm} = 3.39\text{kNm}$

$M_{o,Rd} = \alpha.W_{el}.f_o/\gamma_{M1}$

$M_{o,Rd} = 1.0 \times 26{,}489.15 \times 160/1.1$

$M_{o,Rd} = 3{,}852{,}967.97\text{Nmm} = 3.85\text{kNm}$

The resistance of the O/A sign case to bending about any axis is provided by 2No side body sections, therefore the overall resistance to bending provided by the side body sections is:

$\mathbf{\Sigma M_{Rd} = 2.M_{u,Rd} = 6,781,223.63Nmm}$

$M_{u,Rd}$ – 6.2.5.1(2)Eq(6.24)

Partial factors (γ_{M1} & γ_{M2}) – NA6.1.3(1)

γ_{M1}=1.1

γ_{M2}=1.25

$M_{o,Rd}$ – 6.2.5.1(2)Eq(6.25)

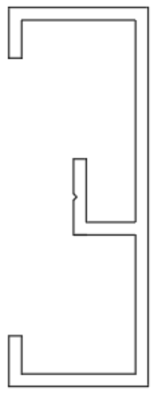
6.10. Shear resistance

The resistance to shear loading may be limited by the susceptibility of the slenderest web to shear buckling. This

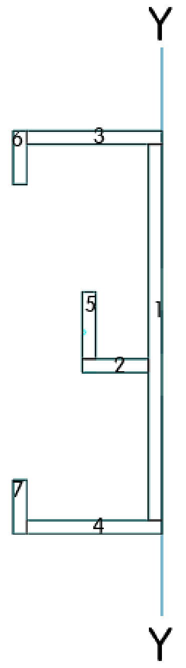
susceptibility is defined by the parameter β, where β=b/t and b is the shorter of the side dimensions. For all edge conditions the plate (web) is classified as slender or non-slender as follows: $\beta \le 39\varepsilon$ non − slender plate $\beta > 39\varepsilon$ slender plate where: $\varepsilon = 1.25$ as determined earlier $\therefore 39\varepsilon = 48.75$ b=123.4mm t=2.3 $\therefore \beta = 53.65 > 48.75 \therefore$ Plate (web) is slender As the web has been classified as slender the shear resistance will more than likely be limited by shear buckling of the web part of the section.	6.5.5(2)
Shear buckling check – resistance to shear buckling $V_{Rd} = \frac{\nu_1 . b . t . f_o}{(\sqrt{3} . \gamma_{M1})}$ where: $\nu_1 = 17 . t . \varepsilon . \sqrt{k_\tau / b}$ but not more than $\nu_1 = k_\tau \frac{430 . t^2 . \varepsilon^2}{b^2}$ and $\nu_1 \le 1.0$ $k_\tau = 5.34 + 4.0 \times (b/a)^2$ if $a/b \ge 1$ a=1000mm (taken as maximum distance between back supports) $\frac{a}{b} = \frac{1000}{123.4} = 8.104 > 1 \therefore$ Eq. for k_τ is valid $k_\tau = 5.34 + 4.0 \times (123.4/1000)^2 = 5.401$ ν_1 is therefore the lesser of $\nu_1 = 17 \times 2.3 \times 1.25 \times \sqrt{5.401/123.4} = 10.225$ $\nu_1 = 5.401 \times \frac{430 \times 2.3^2 \times 1.25^2}{123.4^2} = 1.261$ $\nu_1 = 1.0 > 1.261 > 10.225 \therefore \boldsymbol{\nu_1 = 1.0}$ $\therefore V_{Rd} = \frac{1.0 \times 123.4 \times 2.3 \times 160}{(\sqrt{3} \times 1.1)}$ $\mathbf{V_{Rd} = 24,998.04N = 25.0kN}$	6.5.5(2)Eq(6.89)

7. Back support sections

7.1. Figure below shows the true shape of the cross section



7.2. Figure below shows the cross-section of the Back/Rear Support section simplified to allow conservative calculation of the sectional properties



References are to BS EN-1999-1-1 UNO

7.3. Material properties, for 6063T6 extrusions

Proof strength (f_o)=160N/mm^2
Ultimate strength (f_u)=195N/mm^2
Elastic modulus (E)=70,000N/mm^2

Strengths – Aalco datasheet 6063T6 extrusions
Elastic mod. – 3.2.5(1)

7.4. Cross section classification, section subject to bending

Cross section classification - 6.1.4

The cross section will be classified considering the central, most slender flange, is subject to compression with no stress gradient. This central flange, shown as part 5 on the figure; above, will be treated as a flat outstand part. Based on this the slenderness parameter (β) is given by

$$\beta = \frac{b}{t} = \frac{10}{1.5} = 6.67\text{mm} < 7.5 \therefore \textbf{Class 3 section}$$

Where:
b=inside dimension of web part = 10mm

Slenderness parameter 6.1.4.3(1)

t=thickness of flange part = 1.5mm

Class limits – internal part subject to compression

Class 1 limit: $\frac{\beta_1}{\beta} = 3$

$\therefore \beta_1 = 11 \times 1.25 = 3.75$

Class 2 limit: $\frac{\beta_2}{\beta} = 4.5$

$\therefore \beta_2 = 16 \times 1.25 = 5.63$

Class 3 limit: $\frac{\beta_3}{\beta} = 6$

$\therefore \beta_3 = 22 \times 1.25 = 7.5$

$\varepsilon = \sqrt{250/f_o} = \sqrt{250/160} = 1.25$

As the cross section is class 3 the sectional properties and resultant resistance to bending moment will be based on elastic properties.

7.5. Sectional properties, position of ENA from reference y-axis at extreme right-hand-side of section, viewed as shown in figure above.

Areas, individual areas of each part

Part	Area (mm^2)
1	112
2	19.58
3	40
4	40
5	20
6	16
7	16
ΣA	**263.58mm²**

Individual centroids – of each part from reference y-axis, at right-hand-side of section

Part	Centroid, from ref. y (mm)
1	1
2	6.895
3	10
4	10
5	10.79
6	21
7	21

First/statical moment of areas (=Area x centroidal distance from y-axis)

Part	Moment of area (mm^3)
1	112
2	135
3	400
4	400
5	215.8

6	336
7	336
Σ	**1,934.80mm³**

Centroidal position of overall section, position of Elastic Neutral Axis from reference y-axis at right hand side of section

$$y_R' = \frac{\Sigma}{\Sigma A}$$

$$y_R' = \frac{1,934.80}{263.58} = 7.34\text{mm (from right)}$$

Or

$$y_L' = h - y_R'$$

$$y_L' = 22 - 7.34 = 14.66\text{mm (from left)}$$

Height of overall simplified cross section
h=22mm

7.6. Sectional properties, second moment of area about y-axis of the simplified side body cross section.

Individual centroidal second moments of each part, about individual NA's

Part	$I_{cy}(mm^4)$
$I_{cy}(1)$	37.33
$I_{cy}(2)$	156.39
$I_{cy}(3)$	1,333.33
$I_{cy}(4)$	1,333.33
$I_{cy}(5)$	6.67
$I_{cy}(6)$	5.33
$I_{cy}(7)$	2.89

Distances from ENA to individual centroids

Part	Centroid, from ENA (mm)
1	6.34
2	0.445
3	2.66
4	2.66
5	3.45
6	13.66
7	13.66

Centroidal 2nd moment of area of overall compound section about the ENA, see figure below

The second moment of area of the overall simplified composite section will be determined using the following equation:

$$I_{cy}(OA) = \Sigma\left(I_{cy}(i) + A(i).d(i)^2\right)$$

where: i=part numbers 1 to 7

$$\mathbf{I_{cy}(OA) = 14,158.66mm^4}$$

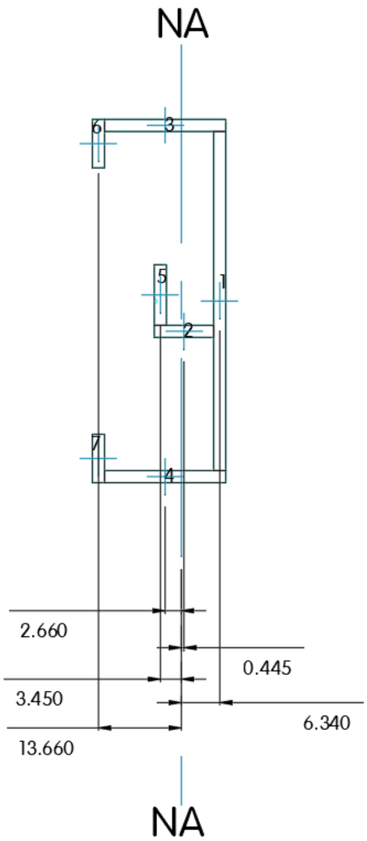
7.7. Sectional properties, elastic section modulus

The minimum elastic section modulus, which will in turn be used to determine the sections resistance to bending moment will be found using the following equation.

$$W_{el,y,min} = \frac{I_{cy}(OA)}{y_L{}'}$$

$$W_{el,y,min} = \frac{14{,}158.66}{14.66} = 965.83mm^3$$

7.8. Figure below shows the simplified cross-section divided into 7 parts about the Elastic Neutral Axis

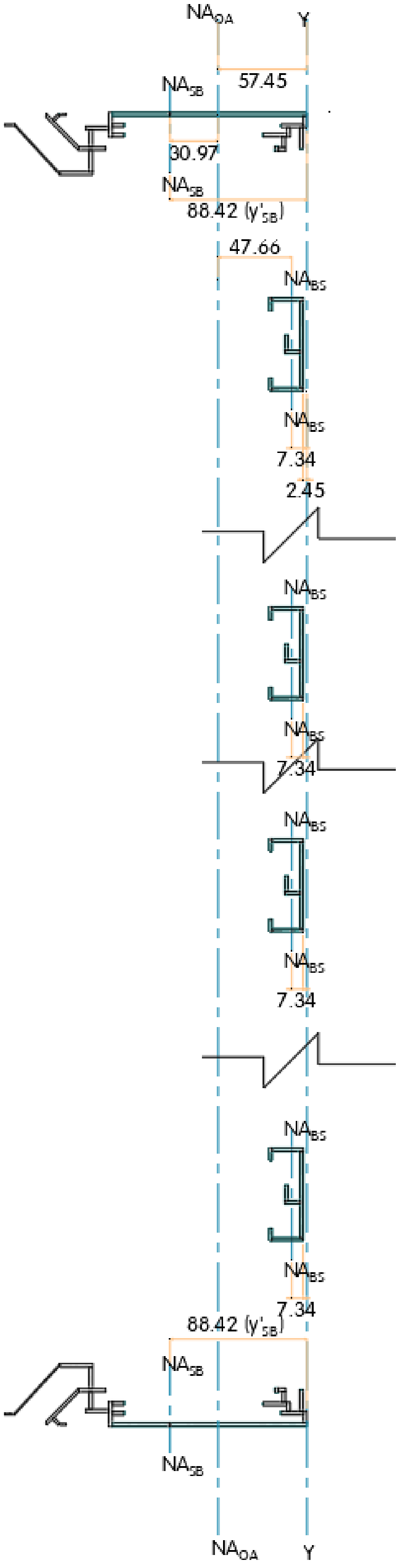


8. O/A signcase

Horizontal bending i.e. if the signcase is supported on horizontal rails. The resistance to bending will be increased, depending on the number and due to the contribution of the back/Rear Support sections.

The contribution provided by the back/Rear support sections to the horizontal bending resistance will be determined considering 2No Side Supports and 4No Rear Supports as a compound section, as shown in the figure below.
This arrangement for a 3x3m Econoflex sign uses the minimum amount of 4-Nº back/Rear Support sections as recommended by Signcomp. In reality there would more than likely be 6 to accommodate the joints in the back panel.

8.1. Figure showing the simplified overall signcase as a compound section to account for the resistance to bending provided by the Rear Support sections.



NA$_{OA}$
Y
57.45
NA$_{SB}$
30.97
NA$_{SB}$
88.42 (y'$_{SB}$)
47.66
NA$_{BS}$
NA$_{BS}$
7.34
2.45
NA$_{BS}$
NA$_{BS}$
7.34
NA$_{BS}$
NA$_{BS}$
7.34
NA$_{BS}$
NA$_{BS}$
7.34
88.42 (y'$_{SB}$)
NA$_{SB}$
NA$_{SB}$
NA$_{OA}$
Y

References are to BS EN-1999-1-1 UNO

8.2. Material properties, for 6063T6 extrusions

Proof strength (f_o)=160N/mm²
Ultimate strength (f_u)=195N/mm²
Elastic modulus (E)=70,000N/mm²

Strengths – Aalco datasheet 6063T6 extrusions
Elastic mod. – 3.2.5(1)

8.3. Cross section classification

The individual sections i.e. the Side Body sections and the Rear Support sections have been classified previously as class 3 sections.

8.4. Sectional properties, position of ENA from reference y-axis at extreme right-hand-side of section, viewed as shown in figure above.

Areas, individual areas of each part

Part	Area (mm²)
SB1	811.08
SB2	811.08
RS1	263.58
RS2	263.58
RS3	263.58
RS4	263.58
ΣA	**2,676.48mm²**

SB = Side Body
RS = Back/Rear Support

Individual centroids – of each section from reference y-axis, at right-hand-side of simplified O/A signcase

Part	Centroid, from ref. y (mm)
SB1	88.42
SB2	88.42
RS1	9.79
RS2	9.79
RS3	9.79
RS4	9.79

First/statical moment of areas (=Area x centroidal distance from y-axis)

Part	Moment of area (mm³)
SB1	71,714.73
SB2	71,714.73
RS1	2,580.58
RS2	2,580.58
RS3	2,580.58
RS4	2,580.58
Σ	**153,751.76mm³**

Centroidal position of overall section, position of Elastic Neutral Axis from reference y-axis at right hand side of section

$$y_R' = \frac{\Sigma}{\Sigma A}$$

$$y_R' = \frac{153,751.76}{2,676.48} = 57.45\text{mm (from right)}$$

Or

$\mathbf{y_L}' = \mathbf{h} - \mathbf{y_R}'$

$\mathbf{y_L}' = \mathbf{195.10} - \mathbf{57.45} = \mathbf{137.65mm\ (from\ left)}$

Height of overall simplified cross section
h=195.10mm

8.5. Sectional properties, second moment of area about y-axis of the simplified side body cross section.

Individual centroidal second moments of each section, about individual NA's

Part	$I_{cy}(mm^4)$
I_{cy}(SB1)	2,825,894.45
I_{cy}(SB2)	2,825,894.45
I_{cy}(RS1)	14,158.66
I_{cy}(RS2)	14,158.66
I_{cy}(RS3)	14,158.66
I_{cy}(RS4)	14,158.66
I_{cy}(RS5)	14,158.66

Distances from ENA to individual centroids

Part	Centroid, from ENA (mm)
SB1	6.34
SB2	0.445
RS1	2.66
RS2	2.66
RS3	3.45
RS4	13.66

Centroidal 2nd moment of area of overall compound section about the ENA, see figure below

The second moment of area of the overall simplified signcase will be determined using the following equation:

$I_{cy}(OA) = \Sigma\left(I_{cy}(i) + A(i).d(i)^2\right)$

where: i=cross sections SB1-SB2, RS1-RS4

$\mathbf{I_{cy}(OA) = 9,659,165.70mm^4}$

8.6. Sectional properties, elastic section modulus

The minimum elastic section modulus, which will in turn be used to determine the sections resistance to bending moment, will be found using the following equation:

$$W_{el,y,min} = \frac{I_{cy}(OA)}{y_L'}$$

$$W_{el,y,min} = \frac{9,659,165.70}{137.65} = 70,169.64mm^3$$

8.7. Resistance to bending moment, of the overall simplified signcase.

The design resistance for bending about one principle axis of a cross section (M_{Rd}) is given by the lesser of:

$M_{u,Rd} = W_{net}.f_u/\gamma_{M2}$

$M_{u,Rd} = 70,169.64 \times 195/1.25$

$M_{u,Rd}$ – 6.2.5.1(2)Eq(6.24)

Partial factors (γ_{M1} & γ_{M2}) – NA6.1.3(1)

γ_{M1}=1.1

$M_{u,Rd} = 10{,}946{,}463.65\text{Nmm} = 10.95\text{kNm}$

$\gamma_{M2}=1.25$

$M_{o,Rd} = \alpha.W_{el}.f_o/\gamma_{M1}$
$M_{o,Rd} = 1.0 \times 70{,}169.64 \times 160/1.1$
$\mathbf{M_{o,Rd} = 10{,}206{,}492.91Nmm = 10.21kNm}$

$M_{o,Rd}$ – 6.2.5.1(2)Eq(6.25)

9. Example load cases to determine wind load and the associated effects on the signcase.

References are to BS EN 1999-1-1 UNO

In order to assess the sufficiency of any specific single std. body Econoflex sign certain parameters need to be defined.

The ability of the signcase to accommodate external loading from effects due to the wind is largely influenced by the way in which it is supported i.e. the location of fixing rails.
Although the specific detailing of any fixing rails is not covered within this report the positional requirements based on the specific load case are; it has been assumed for the purposes of this report, that the fixing rails are detailed such as to have sufficient capacity to accommodate the imposed loads.

There are many variable parameters associated with determining the wind loading for any specific sign which include:

- Overall size and aspect ratio of the sign
- Altitude of the installation site
- Distance of the installation site to the shore
- Installation height above ground
- Position on building

Due to the number of variables some of which are identified above, for an economic design the requirements of the fixing rails should be calculated for each specific installation.

10. Load case (1)

The windload, determined earlier in this report; equivalent to the test pressure adopted by Signcomp for the testing of the tension clips that retain the vinyl skin to the frame, will be used and applied to an Econoflex sign with overall dimensions of 3x3m, based on the simplified overall signcase analysed previously; the size used for the calculation of the weight load, also determined earlier.

10.1. Design moment, load case (1)

Acting about the centre of the signcase due to wind effects acting on the front face and assuming the signcase is simply supported between fixing rails, horizontal or vertical, inset 275mm from the signcase.

$$M_{Ed} = \frac{Q_{d,test}(3x3).L}{4}$$

$$M_{Ed} = \frac{15{,}846.60 \times 2{,}450}{4}$$

$\mathbf{M_{Ed}(1) = 9{,}706{,}042.50Nmm = 9.71kNm}$
where:
$Q_{d,test} = 15{,}846.60\text{N} = 15.84\text{kN}$
$L = 2{,}450\text{mm}$ (if supports are inset 275mm)

10.2. Resistance to shear loading

Will be taken as that previously determined for the side body sections:
$\mathbf{V_{Rd} = 24,998.04N = 25.0kN}$

Shear load, due to wind and weight.
Vertical shear due to weight, considering signcase being supported from vertical rails (worst case) with horizontal shear due to wind acting on front face of sign

$$V_{Ed} = \frac{(Q_{d,test} + N_{Ed})}{4}$$

$$\mathbf{V_{Ed}} = \frac{(15{,}846.60 + 1{,}149.16)}{4} = \mathbf{4,349.49N = 4.35kN}$$

For value of N_{Ed} see assessment of effects due to weight, below

$$\frac{V_{Ed}}{V_{Rd}} \leq 1.0$$

$$\frac{\mathbf{V_{Ed}}}{\mathbf{V_{Rd}}} = \mathbf{0.17 \therefore therefore\ sufficient}$$

As the above value is less than 0.5 no reduction in bending moment due to shear force needs to be made.

Effect of shear force on bending moment resistance – 6.2.8(2)

Shear load, due to wind and weight acting on cantilevered overhang
Vertical shear due to weight, considering signcase being supported from vertical rails (worst case) with horizontal shear due to wind acting on front face of overhang

$$V_{Ed} = \frac{(Q_{d,test,canti} + G_{d,canti})}{2}$$

$$V_{Ed} = \frac{(1{,}778.70 + 345.15)}{2} = 1{,}061.92N = 1.06kN$$

$$\frac{V_{Ed}}{V_{Rd}} \leq 1.0$$

$$\frac{V_{Ed}}{V_{Rd}} = 0.04 \therefore \text{ sufficient}$$

10.3. Resistance to bending moment

The resistance of a 3x3m std. single body Econoflex sign, based on the simplified cross-section/s with the minimum 4 back/Rear Support sections has been previously determined as:
$\mathbf{M_{Rd} = 10,206,492.91Nmm = 10.21kNm}$

Utilisation of bending moment resistance

$$\frac{M_{Ed}}{M_{Rd}} \leq 1.0$$

$$\frac{M_{Ed}}{M_{Rd}} = \frac{9.71}{10.21} = 0.95 < 1 \therefore \text{sufficient}$$

It can therefore be concluded that the 3x3m std. Econoflex sign should be supported on horizontal fixing rails inset 250mm from the top/bottom of the overall sign.

10.4. Effects due to self-weight

The self-weight of the sign will induce an axial load acting vertically through the signcase sections. In addition, if the signcase was supported

The resistance to buckling, caused by the self-weight of the sign will conservatively be based on that of the simplified O/A signcase containing 4-No back/Rear support sections.	
Cross section classification Assuming the slenderest flange of the side body section (the part treated as a web for the assessment of bending effects due to wind) about which the ENA is located is subject to compression. This central flange will be treated as a flat internal part and based on the above statement the slenderness β is given by	Cross section classification - 6.1.4
$\beta = \frac{b}{t} = \frac{123.4}{2.3} = 53.65mm > 27.5 \therefore$ **Class 4 section** **Where:** b=inside dimension of web part = 123.4mm t=thickness of flange part = 2.3mm	Slenderness parameter 6.1.4.3(1)
Class limits – internal part subject to compression Class 1 limit: $\frac{\beta_1}{\beta} = 11$ $\therefore \beta_1 = 11 \times 1.25 = 13.75$ Class 2 limit: $\frac{\beta_2}{\beta} = 16$ $\therefore \beta_2 = 16 \times 1.25 = 20$ Class 3 limit: $\frac{\beta_3}{\beta} = 22$ $\therefore \beta_3 = 22 \times 1.25 = 27.5$ $\varepsilon = \sqrt{250/f_o} = \sqrt{250/160} = 1.25$	
As the cross-section is class 4 allowance needs to be made to account for local buckling. This will be achieved by applying a local buckling factor (ρ_c) to factor down the thickness of the class 4 part. $\rho_c = \frac{C_1}{(\beta/\varepsilon)} - \frac{C_2}{(\beta/\varepsilon)^2}$ $\rho_c = \frac{32}{(53.65/1.25)} - \frac{220}{(53.65/1.25)^2} = 0.626$	Local buckling factor 6.1.5(2)Eq(6.12)
Reduced thickness $\rho_c.t = 2.3 \times 0.626 = 1.44mm$	
Buckling resistance It is assumed that there is sufficient restraint to cross sections to mitigate the effects of Lateral-Torsional buckling, therefore the resistance to buckling will be based on that for flexural buckling only A compression member shall be verified against flexural buckling as follows: $\frac{N_{Ed}}{N_{b,Rd}} \leq 1.0$ **The design buckling resistance** will be determined using:	Buckling resistance criteria

$$N_{b,Rd} = \frac{k.X.A_{eff}.f_o}{\gamma_{M1}}$$

6.3.1.1(1)Eq(6.48)

where:

$k = 1$ as no welds

$$X = \frac{1}{\Phi + \sqrt{\Phi^2 - \lambda'^2}} = \frac{1}{0.766 + \sqrt{0.766^2 - 0.650^2}} = 0.853$$

Buckling resistance 6.3.1.1(2)Eq(6.49)

$A_{eff} = 1{,}955.80mm^2$

Reduction factor

$$\Phi = 0.5\left(1 + \alpha(\lambda' - \lambda'_0) + \lambda'^2\right)$$

$$\Phi = 0.5(1 + 0.2(0.650 - 0.1) + 0.650^2) = 0.766$$

Effective area A_{eff} attained from CAD by reducing thickness of cross sections to 1.44mm (2-Nº side body + 4-Nº back support)

Non-dimensional slenderness

$$\lambda' = \sqrt{\frac{A_{eff}.f_o}{N_{cr}}} = \sqrt{\frac{1{,}955.80 \times 160}{741{,}472.23}} = 0.650$$

$\lambda'_0=0.10$ – table 6.6

$\alpha=0.20$ – table 6.6

Critical elastic buckling load

$$N_{cr} = \frac{\pi^2.E.I_{zz}}{L_{cr}^2} = \frac{\pi^2 \times 70{,}000 \times 9{,}659{,}165.70}{3{,}000}$$

$N_{cr} = 741{,}472.23N$

Non-dim. Slenderness 6.3.1.2(1)Eq(6.51)

Second moment of area about weak axis of simplified overall signcase, with 4-Nº Rear Supports. Value previously determined.

$I_{cz} = 9{,}659{,}165.70mm^4$

Buckling length (L_{cr}) taken as entire signcase length

$$\therefore N_{b,Rd} = \frac{1 \times 0.853 \times 1{,}955.80 \times 160}{1.1}$$

$$\mathbf{N_{b,Rd} = 242{,}770.56N = 242.77kN}$$

Axial load due to weight.

$$\mathbf{N_{Ed} = G_{d,OA} = 1{,}551.36N = 1.55kN}$$

Weight of the cantilevered part of the signcase, due to the inset fixing rails

$N_{Ed,canti} = G_{d,canti} = 345.15N$

For 3x3m signcase with rails inset 275mm

$$\mathbf{\frac{N_{Ed}}{N_{b,Rd}} = \frac{1.55}{242.77} = 0.01 < 1.0 \therefore sufficient}$$

10.5. Interaction of combined effects

To allow for the interaction of bending moment (M_{Ed}), shear load (V_{Ed}); allowance made to moment resistance if necessary, and the axial force (N_{Ed}) a conservative approach of summing the utilisation of the capacity of each effect will be taken.

$$\mathbf{\frac{N_{Ed}}{N_{b,Rd}} + \frac{M_{Ed}}{M_{Rd}} \leq 1.0}$$

$$\mathbf{0.01 + 0.95 \leq 0.96 \therefore sufficient}$$

10.6. Summary – load case (1)

It can be seen, from the analysis above, that a 3x3m std. single body Econoflex sign case would have sufficient integral strength to resist the imposed loads due to the effects of self-weight and wind loading if the sign case is supported on 2-Nº horizontal rails each inset 275mm from the overall height of the signcase.
If vertical support rails are to be used the orientation of the signcase should be rotated through 90 degrees such that the vertical back supports are in a horizontal plane.
This is however only applicable for the windload determined, which is equivalent to the test pressure used by Econoflex for the testing of their tension clips. For each specific installation site this windload may be greater or lesser therefore changing the positional requirements and/or total number of support rails.

11. Load case (2)

The windload, determined earlier in this report; equivalent to the test pressure adopted by Signcomp for the testing of the tension clips that retain the vinyl skin to the frame, will again be used (for direct comparison purposes) and applied to an Econoflex sign with overall dimensions of 5x5m, based on a simplified overall signcase containing 10-Nº back/Rear Support sections, analysed following the same procedure as previously completed for the 3x3m signcase with 4-Nº back supports; the calculation of the weight load has also been revised specifically for a 5x5m signcase.

11.1. Design moment, load case (2)

Acting about the centre of the signcase due to wind effects acting on the front face and assuming the signcase is simply supported between fixing rails, horizontal or vertical, inset 1,100mm from the signcase.

$$M_{Ed} = \frac{Q_{d,test}(5x5).L}{4}$$

$$M_{Ed} = \frac{30{,}184 \times 1{,}400}{4}$$

$$\mathbf{M_{Ed}(2) = 10{,}564{,}400.0Nmm = 10.56kNm}$$

where:

$Q_{d,test} = 30{,}184.0N = 30.18kN$

$L = 1{,}400mm$ (if supports are inset 1,100mm with additional at centre; 3-off rails total)

11.2. Resistance to shear loading

Will be taken as that previously determined for the side body sections:

$$\mathbf{V_{Rd} = 24{,}998.04N = 25.0kN}$$

Shear load, per section, due to wind and weight.

Vertical shear due to weight, considering signcase being supported from vertical rails (worst case) with horizontal shear due to wind acting on front face of sign

$$V_{Ed} = \frac{(Q_{d,test} + N_{Ed})}{4}$$

$$\mathbf{V_{Ed}} = \frac{(30{,}184.0 + 3{,}873.31)}{4} = \mathbf{8{,}514.33N = 8.51kN}$$

$$\frac{V_{Ed}}{V_{Rd}} \leq 1.0$$

$$\frac{\mathbf{V_{Ed}}}{\mathbf{V_{Rd}}} = \mathbf{0.34 \therefore therefore\ sufficient}$$

As the above value is less than 0.5 no reduction in bending moment due to shear force needs to be made.

For value of N_{Ed} see assessment of effects due to weight, below

Shear load, due to wind and weight acting on cantilevered overhang

Vertical shear due to weight, considering signcase being supported from vertical rails (worst case) with horizontal shear due to wind acting on front face of overhang

$$V_{Ed} = \frac{(Q_{d,test,canti} + G_{d,canti})}{2}$$

$$V_{Ed} = \frac{(12{,}936.0 + 1{,}182.06)}{2} = 6{,}520.03N = 6.52kN$$

$$\frac{V_{Ed}}{V_{Rd}} \leq 1.0$$

$$\frac{V_{Ed}}{V_{Rd}} = 0.26 \therefore \text{ sufficient}$$

Effect of shear force on bending moment resistance – 6.2.8(2)

11.3. Resistance to bending moment

The resistance of a 5x5m std. single body Econoflex sign, based on the simplified cross-section/s with 10 back/Rear Support sections has been determined, following the same procedure used to determine that for the simplified signcase with 4 Back Support sections, as:

$$\mathbf{M_{Rd} = 11{,}236{,}990.27Nmm = 11.24kNm}$$

Utilisation of bending moment resistance

$$\frac{M_{Ed}}{M_{Rd}} \leq 1.0$$

$$\frac{\mathbf{M_{Ed}}}{\mathbf{M_{Rd}}} = \frac{\mathbf{10.56}}{\mathbf{11.24}} = \mathbf{0.94} < 1 \therefore \text{ sufficient}$$

It can therefore be concluded that the 5x5m std. Econoflex sign should be supported on horizontal fixing rails inset 1,100mm from the top/bottom of the overall sign.

Bending moment resistance of cantilever.

Due to the distance of the overhang, the inset distance, being substantial for the 5x5m sign the resistance to the bending moment created by wind acting of the area of the overhang will be checked.

Design moment, acting on cantilever

$$M_{Ed,canti} = Q_{d,test,canti}.(L/2)$$

$$M_{Ed,canti} = 11{,}858.0 \times (1{,}100/2)$$

$$M_{Ed,canti} = 6{,}521{,}900.0Nmm = 6.52kNm$$

Utilisation of bending moment resistance, cantilever

$$\frac{M_{Ed,canti}}{M_{Rd}} \leq 1.0$$

Windload on cantilever ($Q_{d,test,canti}$) – determined using test pressure (W_{test})

$$\frac{M_{Ed,canti}}{M_{Rd}} = \frac{6.52}{11.24} = 0.58 < 1 \therefore \text{sufficient}$$

for the area overhanging each support rail

It can therefore be concluded that the 1,100mm overhang of the 5x5m std. Econoflex sign with 10No rear supports has sufficient strength in bending to resist the imposed windload.

11.4. Effects due to self-weight

The resistance to buckling, caused by the self-weight of the sign will conservatively be based on that of the simplified O/A signcase containing 4-No back/Rear support sections.

Cross section classification

Class 4 section, as previously classified

Reduced thickness, to account for local buckling in class 4 sections

$\rho_c.t = 2.3 \times 0.626 = 1.44\text{mm, as before}$

Buckling resistance

It is assumed that there is sufficient restraint to cross sections to mitigate the effects of Lateral-Torsional buckling, therefore the resistance to buckling will be based on that for flexural buckling only

A compression member shall be verified against flexural buckling as follows:

$$\frac{N_{Ed}}{N_{b,Rd}} \leq 1.0$$

The design buckling resistance will be determined using:

$$N_{b,Rd} = \frac{k.X.A_{eff}.f_o}{\gamma_{M1}}$$

Buckling resistance criteria 6.3.1.1(1)Eq(6.48)

where:

$k = 1$ as no welds

$$X = \frac{1}{\Phi + \sqrt{\Phi^2 - \lambda'^2}} = \frac{1}{1.695 + \sqrt{1.695^2 - 1.456^2}} = 0.39$$

Buckling resistance 6.3.1.1(2)Eq(6.49)

$A_{eff} = 3{,}535.78\text{mm}^2$

Effective area A_{eff} attained from CAD by reducing thickness of cross sections to 1.44mm (2-N° side body + 10-N° back support)

Reduction factor

$$\Phi = 0.5\left(1 + \alpha(\lambda' - \lambda'_0) + \lambda'^2\right)$$

$$\Phi = 0.5(1 + 0.2(1.456 - 0.1) + 1.456^2) = 1.695$$

Non-dimensional slenderness

$$\lambda' = \sqrt{\frac{A_{eff}.f_o}{N_{cr}}} = \sqrt{\frac{3{,}535.78 \times 160}{266{,}930.0}} = 1.456$$

λ'_0=0.10 – table 6.6

α=0.20 – table 6.6

Critical elastic buckling load

$$N_{cr} = \frac{\pi^2.E.I_{zz}}{L_{cr}^2} = \frac{\pi^2 \times 70{,}000 \times 9{,}659{,}165.70}{5000}$$

$N_{cr} = 266{,}930.0\text{N}$

Non-dim. Slenderness 6.3.1.2(1)Eq(6.51)

Second moment of area about weak axis of simplified O/A signcase, with 4-No rear supports. Value previously determined.
$I_{cz} = 9{,}659{,}165.70\text{mm}^4$

$$\therefore N_{b,Rd} = \frac{1 \times 0.39 \times 3{,}535.78 \times 160}{1.1}$$
$$\mathbf{N_{b,Rd} = 200,589.27N = 200.59kN}$$

Buckling length (L_{cr}) taken as entire signcase length

Axial load due to weight.
$$\mathbf{N_{Ed} = G_{d,OA} = 3,873.31N = 3.87kN}$$

Weight of the cantilevered part of the signcase, due to the inset fixing rails
$N_{Ed,canti} = G_{d,canti} = 1{,}240.93\text{N}$
For 5x5m signcase with rails inset 1,200mm

$$\mathbf{\frac{N_{Ed}}{N_{b,Rd}} = \frac{3.87}{200.59} = 0.02 < 1.0 \therefore sufficient}$$

11.5. Interaction of combined effects

To allow for the interaction of bending moment (M_{Ed}), shear load (V_{Ed}); allowance made to moment resistance if necessary, and the axial force (N_{Ed}) a conservative approach of summing the utilisation of the capacity of each effect will be taken.

$$\mathbf{\frac{N_{Ed}}{N_{b,Rd}} + \frac{M_{Ed}}{M_{Rd}} \leq 1.0}$$
$$\mathbf{0.02 + 0.94 \leq 0.96 \therefore sufficient}$$

11.6. Summary – load case 2

It can be seen, from the analysis above, that a 5x5m std. single body Econoflex sign case would have sufficient integral strength to resist the imposed loads due to the effects of self-weight and wind loading if the sign case is supported on 2-N° horizontal rails each inset 1,100mm from the overall height of the signcase with an additional 1-N° horizontal rail positioned centrally.
If vertical support rails are to be used the orientation of the signcase should be rotated through 90 degrees such that the vertical back supports lie in a horizontal plane.
This is however only applicable for the windload determined, which is equivalent to the test pressure used by Econoflex for the testing of their tension clips. For each specific installation site this windload may be greater or lesser therefore changing the positional requirements and/or total number of support rails.

12. Load case (3)

The windload, determined earlier in this report; equivalent to the test pressure adopted by Signcomp for the testing of the tension clips that retain the vinyl skin to the frame, will again be used (for direct comparison purposes) and applied to an Econoflex sign with overall dimensions of 5x3m, based on a simplified overall signcase containing 10-Nº back/Rear Support sections, analysed following the same procedure as previously completed for the 3x3m signcase with 4-Nº back supports; the calculation of the weight load has also been revised specifically for a 5x3m signcase.

12.1. Design moment, load case (3)

Acting about the centre of the signcase due to wind effects acting on the front face and assuming the signcase is simply supported between fixing rails, horizontal or vertical, inset 1,100mm from the signcase.

$$M_{Ed} = \frac{Q_{d,test}(5x3).L}{4}$$

$$M_{Ed} = \frac{21{,}560.0 \times 2{,}000}{4}$$

$$\mathbf{M_{Ed}(3) = 10,780,000.0Nmm = 10.78kNm}$$

where:

$Q_{d,test} = 21{,}560.0\text{N} = 21.56\text{kN}$

$L = 2{,}000\text{mm}$ (if supports are inset 500mm)

12.2. Resistance to shear loading

Will be taken as that previously determined for the side body sections:

$$\mathbf{V_{Rd} = 24,998.04N = 25.0kN}$$

Shear load, per section, due to wind and weight.

Vertical shear due to weight, considering signcase being supported from vertical rails (worst case) with horizontal shear due to wind acting on front face of sign

$$V_{Ed} = \frac{(Q_{d,test} + N_{Ed})}{4}$$

$$\mathbf{V_{Ed}} = \frac{(21{,}560.0 + 1{,}825.79)}{4} = \mathbf{6,006.20N = 6.01kN}$$

For value of N_{Ed} see assessment of effects due to weight, below

$$\frac{V_{Ed}}{V_{Rd}} \leq 1.0$$

$$\frac{\mathbf{V_{Ed}}}{\mathbf{V_{Rd}}} = \mathbf{0.24 \therefore therefore\ sufficient}$$

As the above value is less than 0.5 no reduction in bending moment due to shear force needs to be made.

Effect of shear force on bending moment resistance – 6.2.8(2)

Shear load, due to wind and weight acting on cantilevered overhang

Vertical shear due to weight, considering signcase being supported from vertical rails (worst case) with horizontal shear due to wind acting on front face of overhang

$$V_{Ed} = \frac{(Q_{d,test,canti} + G_{d,canti})}{2}$$

$$V_{Ed} = \frac{(5{,}390.0 + 666.80)}{2} = 3{,}028.40\text{N} = 3.03\text{kN}$$

Windload on cantilever ($Q_{d,test,canti}$) – determined using test pressure (W_{test}) for the area overhanging each support rail

$$\frac{V_{Ed}}{V_{Rd}} \leq 1.0$$

$$\frac{V_{Ed}}{V_{Rd}} = 0.12 \therefore \text{ sufficient}$$

12.3. Resistance to bending moment

The resistance of a 5x3m std. single body Econoflex sign, based on the simplified cross-section/s with 10 back/Rear Support sections has been determined, following the same procedure used to determine that for the simplified signcase with 4 Back Support sections, as:

$\mathbf{M_{Rd} = 11,236,990.27Nmm = 11.24kNm}$

Utilisation of bending moment resistance

$$\frac{M_{Ed}}{M_{Rd}} \leq 1.0$$

$$\frac{\mathbf{M_{Ed}}}{\mathbf{M_{Rd}}} = \frac{\mathbf{10.78}}{\mathbf{11.24}} = \mathbf{0.96} < 1 \therefore \text{sufficient}$$

It can therefore be concluded that the 5x3m std. Econoflex sign should be supported on horizontal fixing rails inset 500mm from the top/bottom of the overall sign.

12.4. Effects due to self-weight

The resistance to buckling, caused by the self-weight of the sign will conservatively be based on that of the simplified O/A signcase containing 4-No back/Rear support sections.

Cross section classification

Class 4 section, as previously classified

Reduced thickness, to account for local buckling in class 4 sections

$\rho_c.t = 2.3 \times 0.626 = 1.44\text{mm, as before}$

Buckling resistance

It is assumed that there is sufficient restraint to cross sections to mitigate the effects of Lateral-Torsional buckling, therefore the resistance to buckling will be based on that for flexural buckling only

A compression member shall be verified against flexural buckling as follows:

$$\frac{N_{Ed}}{N_{b,Rd}} \leq 1.0$$

Buckling resistance criteria 6.3.1.1(1)Eq(6.48)

The design buckling resistance will be determined using:

$$N_{b,Rd} = \frac{k.X.A_{eff}.f_o}{\gamma_{M1}}$$

Buckling resistance 6.3.1.1(2)Eq(6.49)

where:

k = 1 as no welds

$$X = \frac{1}{\Phi + \sqrt{\Phi^2 - \lambda'^2}} = \frac{1}{1.695 + \sqrt{1.695^2 - 1.456^2}} = 0.39$$

$A_{eff} = 3,535.78\text{mm}^2$

Effective area A_{eff} attained from CAD by reducing thickness of cross sections to 1.44mm (2-Nº side body + 10-Nº back support)

Reduction factor

$$\Phi = 0.5\left(1 + \alpha(\lambda' - \lambda'_0) + \lambda'^2\right)$$

$$\Phi = 0.5(1 + 0.2(1.456 - 0.1) + 1.456^2) = 1.695$$

λ'_0=0.10 – table 6.6

α=0.20 – table 6.6

Non-dimensional slenderness

$$\lambda' = \sqrt{\frac{A_{eff}.f_o}{N_{cr}}} = \sqrt{\frac{3{,}535.78 \times 160}{266{,}930.0}} = 1.456$$

Non-dim. Slenderness 6.3.1.2(1)Eq(6.51)

Critical elastic buckling load

$$N_{cr} = \frac{\pi^2.E.I_{zz}}{{L_{cr}}^2} = \frac{\pi^2 \times 70{,}000 \times 9{,}659{,}165.70}{5000}$$

$$N_{cr} = 266{,}930.0\text{N}$$

Buckling length (L_{cr}) taken as entire signcase length

Second moment of area about weak axis of simplified O/A signcase, with 4-No rear supports. Value previously determined.

$$I_{cz} = 9{,}659{,}165.70\text{mm}^4$$

$$\therefore N_{b,Rd} = \frac{1 \times 0.39 \times 3{,}535.78 \times 160}{1.1}$$

$$\mathbf{N_{b,Rd} = 200{,}589.27N = 200.59kN}$$

Axial load due to weight.

$$\mathbf{N_{Ed} = G_{d,OA} = 2{,}464.82N = 2.46kN}$$

Weight of the cantilevered part of the signcase, due to the inset fixing rails

$$N_{Ed,canti} = G_{d,canti} = 666.80\text{N}$$

For 5x3m signcase with rails inset 500mm

$$\mathbf{\frac{N_{Ed}}{N_{b,Rd}} = \frac{2.46}{200.59} = 0.01 < 1.0 \therefore sufficient}$$

12.5. Interaction of combined effects

To allow for the interaction of bending moment (M_{Ed}), shear load (V_{Ed}); allowance made to moment resistance if necessary, and the axial force (N_{Ed}) a conservative approach of summing the utilisation of the capacity of each effect will be taken.

$$\mathbf{\frac{N_{Ed}}{N_{b,Rd}} + \frac{M_{Ed}}{M_{Rd}} \leq 1.0}$$

$$\mathbf{0.01 + 0.96 \leq 0.97 \therefore sufficient}$$

12.6. Summary – load case 3

It can be seen, from the analysis above, that a 5x3m std. single body Econoflex sign case would have sufficient integral strength to resist the imposed loads due to the effects of self-weight and wind loading if the sign case is supported on 2-N° horizontal rails each inset 500mm from the overall height of the signcase.

If vertical support rails are to be used the orientation of the signcase should be rotated through 90 degrees such that the vertical back supports lie in a horizontal plane.

This is however only applicable for the windload determined, which is equivalent to the test pressure used by Econoflex for the testing of their tension clips. For each specific installation site this windload may be greater or lesser therefore changing

the positional requirements and/or total number of support rails.	