Windloads Generated by Siemens Helios and Similar Traffic Signal Heads: Data and Methodology

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ABSTRACT AND INTRODUCTION

The wind loads imposed by traffic signal heads on their supporting structures have hitherto been uncertain, as signal heads are of irregular shape and installed in a multitude of configurations. Accurate determination of wind loads has become increasingly important as signal heads are now frequently fitted onto poles with door openings, which are generally less strong than traditional poles. In order to reduce uncertainty Siemens tested a variety of signal head configurations in the University of Southampton's RJ Mitchell wind tunnel. Wind tunnel test results are tabulated in terms of 'Specific Force' and 'Specific Torque', which when multiplied by wind pressure give figures for force and torque respectively. As testing all potential signal head combinations would have required a very large number of wind tunnel runs, representative configurations only were tested. Values of SF and ST for untested configurations were extrapolated from the wind tunnel data. The derivation of the extrapolated data is given in every case. The data and methodology set out in this document can be easily incorporated into a spreadsheet to assess support structure requirements. It is considered that SF and ST values given herein for Siemens Helios signal heads can be used with confidence for other manufacturers' products, as signal heads are broadly similar in shape and size for a given configuration.

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1 PURPOSE

To outline the methodology and values to be used when determining the loads imposed on support structures by Siemens Helios traffic signal heads and signal heads of similar geometry.

2 REFERENCE DOCUMENTS

No.	Reference	Title	Author/ Contact	Located
1	667/AS/46618/004	Wind Tunnel Test Report	Paul Weston	Meridian

3 ISSUE STATUS

Issue 1	First issue	22/04/2013
Issue 2	Minor corrections between tables	23/05/2017

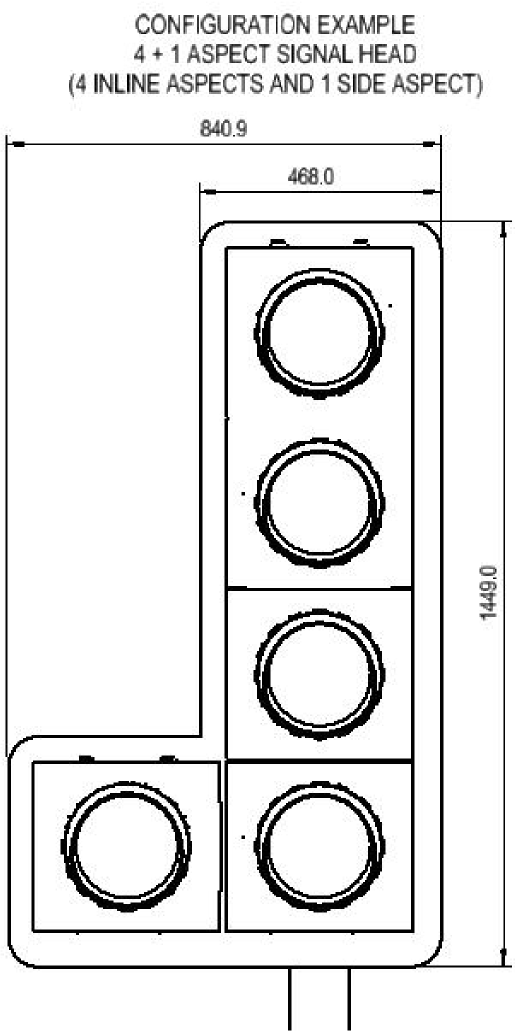
4 NOTES

Related files are archived in Meridian

5 OVERVIEW

Results from Siemens' wind tunnel testing (Ref 1) are extrapolated to give values of SF and ST for common combinations of signal heads. The method by which these figures are derived is outlined for each case.

Figure 1 - Typical Siemens Helios Signal Head



6 SPECIFIC FORCE AND SPECIFIC TORQUE

The results are presented in terms of Specific Force (SF) and Specific Torque (ST).

6.1 SPECIFIC FORCE

Specific Force is defined as the force generated by the component of interest per unit wind pressure. The units are m^2.

6.2 SPECIFIC TORQUE

Specific Torque is defined as the torque generated by the component of interest per unit wind pressure. The units are m^3.

6.3 APPLYING SPECIFIC FORCE

The Force (F) generated by a component is assessed by multiplying the Specific Force by the Dynamic Wind Pressure. The units are N.

$$F\ (N) = SF \cdot W$$

6.4 APPLYING SPECIFIC TORQUE

The Torque (T) generated by a component is assessed by multiplying the Specific Torque by the Dynamic Wind Pressure. The units are Nm.

$$T\ (Nm) = ST \cdot W$$

7 WIND LOADINGS FOR COMMON INSTALLATION CONFIGURATIONS

7.1 SF AND ST VALUES FOR SIGNAL HEAD CONFIGURATIONS

Values for commonly encountered signal head configurations are given in Table 1 below.

Table 1 - SF and ST for Signal Head Combinations

Case	Table	Configuration	SF (m^2)	ST (m^3)
1	17	No Equipment Fitted	0	0
2	18	1x3	0.64	0.14
3	19	2x3	0.94	0.21
4	20	3x3	1.77	0.31
5	21	4x3	1.77	0.31
6	22	1x4	0.87	0.16
7	23	2x4	1.28	0.24
8	24	3x4	2.41	0.35
9	25	4x4	2.41	0.35
10	26	1x(3+1)	0.86	0.22
11	27	2x(3+1)	1.26	0.33
12	28	3x(3+1)	2.37	0.49
13	29	1x3 + (3+1)	1.16	0.29
14	30	2x3 + (3+1)	1.99	0.39
15	31	3x3 + (3+1)	1.99	0.39
16	32	1x4 + (3+1)	1.28	0.33
17	33	2x4 + (3+1)	2.41	0.41
18	34	3x4 + (3+1)	2.41	0.41
19	35	1x3 + 1x4	1.28	0.24
20	36	1x3 + 2x4	2.41	0.35
21	37	1x3 + 3x4	2.41	0.35
22	38	1x4 + 2x3	2.00	0.33
23	39	1x4 + 3x3	2.00	0.33
24	40	1x(4+1)	1.08	0.26
25	41	1x(3+2)	1.21	0.33

7.2 ADDITIONAL ASPECTS AND ALTERNATIVE CONFIGURATIONS

In the event that a particular configuration of signal heads is not covered by the instances shown in Table 1, the following values may be used for each additional aspect:

Additional in line aspects:

$$SF = 0.22\ m^2$$
$$ST = 0.05\ m^3$$

Additional side mounted aspects:

$$SF = 0.35\ m^2$$
$$ST = 0.11\ m^3$$

7.3 SIGNAL POLE FORCES

The Specific Force generated by 114.3 mm diameter signal poles may be taken as:

$$SF_{\text{114 mm dia pole}} = 0.11\ m^2/\text{metre length of pole}$$

7.4 SIGNAL POLE SHIELDING

In some configurations the signal heads shield the pole from the effects of the wind. In these cases the reduction in moment from the shielded length of pole should be taken into account when calculating the overall moment.

7.5 ADDITIONAL EQUIPMENT

Individual engineers should exercise their judgement when assessing the loads generated by additional pole mounted equipment such as cameras. As a general rule it is suggested that the following drag coefficient with respect to frontal area is assumed:

$$C_{d\ \text{additional equipment}} = 1.3$$

7.6 LONG COWLS

If the values given in Table 3 are compared with those in Table 7 it can be seen that long cowls generate considerable extra torque. Where long cowls are fitted it is suggested that the following correction is applied for those signal heads where they are fitted:

$$ST_{\text{long cowls}} = 2.6 \times ST_{\text{secondary cowls}}$$

7.7 EXTENSION BRACKETS

At present Siemens does not recommend that extension brackets are fitted to passively safe poles.

8 EXAMPLE CALCULATION

Data

Pole diameter	114.3 mm
Pole height	4.2 m above ground
Signal heads	2x3 aspects
Do signal heads shield pole?	No
Wind pressure	600 Pa

Force due to Pole
From 6.3, SF = 0.11 m^2/m
Force due to Pole = 4.2 x 0.11 x 600 = 277.2 N

Force due to Signal Heads
From Table 1, SF = 0.94 m^2
Force due to signal head = 0.94 x 600 = 564 N

Torque due to Signal Heads
From Table 1, ST = 0.21 m^3
Torque due to signal head = 0.21 x 600 = 126 Nm

APPENDIX 1 - WIND TUNNEL RESULTS SUMMARY

Results are presented in terms of Specific Force and Specific Torque for a number of different configurations.

SIGNAL HEAD SF AND ST

Table 2 - 4 In Line Aspects Secondary Cowls

Specific Force (m^2)	0.87
Specific Torque (m^3)	0.16

Table 3 - 3 In Line Aspects Secondary Cowls

Specific Force (m^2)	0.64
Specific Torque (m^3)	0.14

Table 4 - 3 In Line Aspects No Cowls

Specific Force (m^2)	0.59
Specific Torque (m^3)	0.16

Table 5 - 3 In Line Aspects Grilles

Specific Force (m^2)	0.46
Specific Torque (m^3)	0.20

Table 6 - 3 In Line Aspects 380 mm Long Cowls

Specific Force (m^2)	0.68
Specific Torque (m^3)	0.36

Table 7 - 3 In Line Aspects 420 mm Long Cowls

Specific Force (m^2)	0.68
Specific Torque (m^3)	0.36

Table 8 - 2 In Line Aspects Ped Cowls

Specific Force (m^2)	0.33
Specific Torque (m^3)	0.07

Table 9 - 3 In Line + 1 Side Aspects Secondary Cowls

Specific Force (m^2)	0.86
Specific Torque (m^3)	0.22

Table 10 - 3 In Line + 2 Side Aspects Secondary Cowls

Specific Force (m^2)	1.21
Specific Torque (m^3)	0.33

Table 11 - 4 In Line + 1 Side Aspect

Specific Force (m^2)	1.08
Specific Torque (m^3)	0.26

Table 12 - 3 In Line Aspects on Short (300 mm) Extension Arm

Specific Force (m^2)	0.74
Specific Torque (m^3)	0.24

Table 13 - 3 In Line Aspects on Long (600 mm) Extension Arm

Specific Force (m^2)	0.70
Specific Torque (m^3)	0.30

Table 14- 2 x 3 In Line Aspects

Specific Force (m^2)	0.94
Specific Torque (m^3)	0.21

Table 15 - 4 x 3 In Line Aspects

Specific Force (m^2)	1.77
Specific Torque (m^3)	0.31

POLE FORCE

Table 16 - Pole Results (114.3 mm diameter pole)

	114.3 mm Diameter Pole
Cd Pole	0.93
Specific Force per metre of pole (m)	0.11

APPENDIX 2 - DERIVATION OF FIGURES FOR ST AND SF FOR COMMON SIGNAL HEAD COMBINATIONS

Nomenclature
Signal heads are classified by the number of heads x number of aspects.
For example “1x3” signifies one signal head with three aspects mounted in-line, and “2x4” signifies two signal heads each with four aspects mounted in line. “1x(3+1)” indicates that there is one signal head with three in line aspects, and one side mounted aspect.

Table 17 - No Equipment Fitted

Parameter	Value	Derivation
SF (m^2)	0	Pole loads only
ST (m^3)	0	Pole loads only

Table 18 - 1x3

Parameter	Value	Derivation
SF (m^2)	0.64	Taken from Table 3
ST (m^3)	0.14	Taken from Table 3

Table 19 - 2x3

Parameter	Value	Derivation
SF (m^2)	0.94	Taken from Table 14
ST (m^3)	0.21	Taken from Table 14

Table 20 - 3x3

Parameter	Value	Derivation
SF (m^2)	1.77	Taken directly from Table 15, as in some wind orientations projected area is the same as for the 4x3 case
ST (m^3)	0.31	Taken directly from Table 15, as in some wind orientations projected area is the same as for the 4x3 case

Table 21 - 4x3

Parameter	Value	Derivation
SF (m^2)	1.77	Taken directly from Table 15
ST (m^3)	0.31	Taken directly from Table 15

Table 22 - 1x4

Parameter	Value	Derivation
SF (m^2)	0.87	Taken directly from Table 2
ST (m^3)	0.16	Taken directly from Table 2

Table 23 - 2x4

Parameter	Value	Derivation
SF (m^2)	1.28	Value for 2x3 is taken from Table 14, and multiplied by 1.36, the ratio between the SF values for 1x4 (Table 2) and 1x3 (Table 3)
ST (m^3)	0.24	Value for 2x3 is taken from Table 14, and multiplied by 1.14, the ratio between the ST values for 1x4 (Table 2) and 1x3 (Table 3)

Table 24 - 3x4

Parameter	Value	Derivation
SF (m^2)	2.41	Value for 4x3 taken from Table 15, as in some wind orientations projected area is the same as 4 head configuration. Multiplied by 1.36, the ratio between the SF values for 1x4 (Table 2) and 1x3 (Table 3)
ST (m^3)	0.35	Value for 4x3 taken from Table 15, as in some wind orientations projected area is the same as for the 4 head configuration, and multiplied by 1.14, the ratio between the ST values for 1x4 (Table 2) and 1x3 (Table 3)

Table 25 - 4x4

Parameter	Value	Derivation
SF (m^2)	2.41	Value for 4x3 is taken from Table 15, and multiplied by 1.4, the ratio between the SF values for 1x4 (Table 2) and 1x3 (Table 3)
ST (m^3)	0.35	Value for 4x3 is taken from Table 15, and multiplied by 1.1, the ratio between the ST values for 1x4 (Table 2) and 1x3 (Table 3)

Table 26 - 1x(3+1)

Parameter	Value	Derivation
SF (m^2)	0.86	Taken from Table 9
ST (m^3)	0.22	Taken from Table 9

Table 27 - 2x(3+1)

Parameter	Value	Derivation
SF (m^2)	1.26	Value for 1x(3x1) taken from Table 9, and multiplied by 1.47, the ratio between the SF values for 1x3 (Table 3) and 2x3 (Table 14)
ST (m^3)	0.33	Value for 1x(3x1) taken from Table 9, and multiplied by 1.5, the ratio between the ST values for 1x3 (Table 3) and 2x3 (Table 14)

Table 28 - 3x(3+1)

Parameter	Value	Derivation
SF (m^2)	2.37	Value for 2x(3x1) taken from Table 27, and multiplied by 1.88, the ratio between the SF for 2x3 (Table 14) and 3x3 (Table 20)
ST (m^3)	0.49	Value for 2x(3x1) taken from Table 27, and multiplied by 1.48, the ratio between the ST for 2x3 (Table 14) and 3x3 (Table 20)

Table 29 - 1x3+(3+1)

Parameter	Value	Derivation
SF (m^2)	1.16	Sum of values for 2x3 (Table 14) + value for 1x(3+1) (Table 9) - value for 1x3 (Table 3) ie to get SF for a single additional aspect
ST (m^3)	0.29	Sum of values for 2x3 (Table 14) + value for 1x(3+1) (Table 9) - value for 1x3 (Table 3) ie to get ST for a single additional aspect

Table 30 - 2x3+(3+1)

Parameter	Value	Derivation
SF (m^2)	1.99	Sum of values for 3x3 (Table 20) + value for 1x(3+1) (Table 9) - value for 1x3 (Table 3) ie to get SF for a single additional aspect
ST (m^3)	0.39	Sum of values for 2x3 (Table 20) + value for 1x(3+1) (Table 9) - value for 1x3 (Table 3) ie to get ST for a single additional aspect

Table 31 - 3x3+(3+1)

Parameter	Value	Derivation
SF (m^2)	1.99	Sum of values for 3x3 (Table 20) + value for 1x(3+1) (Table 9) - value for 1x3 (Table 3) ie to get SF for a single additional aspect
ST (m^3)	0.39	Sum of values for 2x3 (Table 20) + value for 1x(3+1) (Table 9) - value for 1x3 (Table 3) ie to get ST for a single additional aspect

Table 32 - 1x4+(3+1)

Parameter	Value	Derivation
SF (m^2)	1.28	Taken from Table 23
ST (m^3)	0.33	Taken from Table 27

Table 33 - 2x4+(3+1)

Parameter	Value	Derivation
SF (m^2)	2.41	Taken from Table 24
ST (m^3)	0.41	Add difference between 1x(3+1) (Table 9) and 1x4 (Table 2) to value for 3x4 (Table 24) = 0.06 + 0.35

Table 34 - 3x4+(3+1)

Parameter	Value	Derivation
SF (m^2)	2.41	Assume same value as 2x4+(3+1) (Table 33)
ST (m^3)	0.41	Assume same value as 2x4+(3+1) (Table 33)

Table 35 - 1x3+1x4

Parameter	Value	Derivation
SF (m^2)	1.28	Assume same value as for 2x4 (Table 23)
ST (m^3)	0.24	Assume same value as for 2x4 (Table 23)

Table 36 - 1x3+2x4

Parameter	Value	Derivation
SF (m^2)	2.41	Assume same value as for 3x4 (Table 24)
ST (m^3)	0.35	Assume same value as for 3x4 (Table 24)

Table 37 - 1x3+3x4

Parameter	Value	Derivation
SF (m^2)	2.41	Assume same value as for 4x4 (Table 25)
ST (m^3)	0.35	Assume same value as for 4x4 (Table 25)

Table 38 - 1x4+2x3

Parameter	Value	Derivation
SF (m^2)	2.00	Assume same value as 3x3+((1x4)-(1x3)) = 1.77+(0.87-0.64) (Tables 20, 22 and 18)
ST (m^3)	0.33	Assume same value as 3x3+((1x4)-(1x3)) = 0.31+(0.16-0.14) (Tables 20, 22 and 18)

Table 39 - 1x4+3x3

Parameter	Value	Derivation
SF (m^2)	2.00	Assume same value as for 1x4+2x3 (Table 38)
ST (m^3)	0.33	Assume same value as for 1x4+2x3 (Table 38)

Table 40 - 1x(4+1)

Parameter	Value	Derivation
SF (m^2)	1.08	From Table 11
ST (m^3)	0.26	From Table 11

Table 41 - 1x(3+2)

Parameter	Value	Derivation
SF (m^2)	1.21	From Table 11
ST (m^3)	0.33	From Table 11

POLE FORCE

Table 42 - Pole Results (114.3 mm diameter pole)

	114.3 mm Diameter Pole
SF per metre of pole (m^2)	0.11