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opta2e.xls TOOL FOR THE DESIGN OF SUPPORTS FOR VERTICAL SIGNS

Users manual

1. **The designer fills in the location and the size of each sign and general requirements for the supports**
2. **Opta2e.xls computes the loads and the flexural resistance required according to EN 12899-1**
3. **The contractor or the manufacturer fills in the type and the flexural resistance and stiffness of each support**
4. **Opta2e_eng.xls compares the required value with the offered one**
5. **Then the file can be used in building the road**
6. **Finally the file is given for the maintenance organisation**

The file Opta2e.xls (or a later version 3, 4 …) is available in www.tiehallinto.fi/tlohje (3.3 Mb)

	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	ADDRESS AND TYPE											SIGN'S GEOMETRY					
2	Road		Dist.	Loca-	Visibil-	Type	Id-code					Sign's Dimensions			Sign's Position		
4	No. &	Sup-	from	tion of	ity Di-	of	(Road		Coordinates (m) if Needed						Vertic.	Horiz.	Δh_{centre}
5	Quality	port's	Begin-	Sign	rection	Sup-	Traffic	Additional				Height	Growth	Width	Distan.	Distan.	
6	Requir.	No.	ning	l/c/r	of Sign	port	Degr.)	Information	x	y	z	a (m)	Factor	b (m)	c (m)	d (m)	(m)
7	Vt 0, Supports are impact safe (NE 100;2 or HE or LE 100;3) or borderline cases unless marked by S (= Stiff), all supports are purely pipe or truss structure, ply																
8																	
9	Vt 0, Su	1	340	r								3,00	1,00	2,40	1,80	4,00	1,00
10	Vt 0, Su	2	678	l		S		safety barrier				4,50	1,00	2,40	1,80	4,00	1,00
11	Vt 0, Su	3	720	r								2,00	1,00	2,40	1,80	4,00	1,00
12	Vt 0, Su	4	1123	l								1,60	1,00	1,20	2,00	2,50	0,60
13	Vt 0, Su	5	1123	r	from left							1,60	1,00	1,20	2,00	2,50	0,60
14	Vt 0, Su	6	1340	r								2,80	1,00	1,80	2,00	4,00	0,90
15																	
16																	
17	Vt 0, Su	7	1570	l								4,70	1,00	2,60	1,80	4,00	0,20
18												0,00	1,00	0,00	0,00	0,00	0,00
19	Vt 0, Su	4ve	1123	l								1,60	1,00	1,20	2,20	2,50	0,60
20	Vt 0, Su	5ve	1123	r	from left							1,60	1,00	1,20	2,20	2,50	0,60
21												0,00	1,00	0,00	0,00	0,00	0,00
22												0,00	1,00	0,00	0,00	0,00	0,00
23	Pt 00 000, Supports are stiff, otherwise as on the main road																
24																	
25	Pt 00 0	101	30	l								1,20	1,00	2,00	1,70	2,50	-0,10
26												0,00	1,00	0,00	0,00	0,00	0,00
27	Pt 00 0	101ve	30	l								1,20	1,00	2,00	1,90	2,50	-0,10
28												0,00	1,00	0,00	0,00	0,00	0,00
29												0,00	1,00	0,00	0,00	0,00	0,00
30												0,00	1,00	0,00	0,00	0,00	0,00
31																	

AC	AD	AF	AO	BF	BG	DP	DQ	DR	DS	DT	DU	DV
CONDITIONS				FORCES AND MOMENTS					REQUIREMENT			
Allowable Deformations		Terrain Cate-gorry	Snow Clear. Speed	Wind (kN,m) (posts combin.)		Snow Clearance (kN,m) (posts combined)			Larger Load (wind/snow) Multiplied by γ_Q=1,5 (kN,m) (posts combined)			EI (posts comb.)
				Shear	Bend.	Shear	Bend.	Tors.				
mm/m	°/m	(wind)	(km/h)	H	M	H	M	M_T	H_d	M_d	M_{Td}	(kNm^2)
wood or aluminium signs												
25	0,29	2	60	5,0	20,9	5,1	15,2	1,5	7,7	31,3	2,3	765,9
25	0,29	2	60	8,1	40,5	5,1	15,2	1,5	12,2	60,7	2,3	1809,5
25	0,29	2	60	3,1	11,6	5,1	15,2	1,5	7,7	22,9	2,3	364,1
25	0,29	2	60	1,2	4,0	3,1	8,2	0,4	4,7	12,3	0,6	111,5
25	0,29	2	60	1,2	4,0	3,1	8,2	0,4	4,7	12,3	0,6	111,5
25	0,29	2	60	3,5	14,8	3,5	10,2	0,6	5,3	22,1	0,9	537,3
25	0,29	2	60	8,9	38,2	5,2	11,2	1,8	13,3	57,3	2,7	1524,3
25	0,29	2	60	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
25	0,29	2	60	1,3	4,3	2,3	5,8	0,2	3,4	8,8	0,3	126,7
25	0,29	2	60	1,3	4,3	2,3	5,8	0,2	3,4	8,8	0,3	126,7
25	0,29	2	60	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
25	0,29	2	60	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
25	0,29	2	50	1,5	3,2	4,6	8,6	1,0	6,9	12,9	1,5	58,7
25	0,29	2	60	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
25	0,29	2	50	1,5	3,5	3,7	7,1	0,8	5,6	10,6	1,2	69,4
25	0,29	2	60	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
25	0,29	2	60	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
25	0,29	2	60	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0

1 USERS MANUAL

1.1 Computer-aided design, general guidelines

Opening

Opta1i.xls is a calculation sheet created with the Microsoft Excel 97 spreadsheet program to facilitate the design of support construction for standard shape sign faces and traffic signs. Subsequent revisions are numbered as Opta2i and so forth. When opening a file, the program asks if its macros are to be activated, unless the user has deleted the query from the program's settings. The query is a security precaution against viruses possibly transmitted through macros. The calculation sheet has been checked using several anti-virus programs. If the user however disables the macros, the program functions normally except that the checking of graphical source data cannot be performed.

There are two versions of the form: the 1-page Opta1p.xls, containing up to 42 traffic signs and the 3-page Opta1i, capable of holding up to 126 signs. If projects require greater quantities, additional files must be created. Each support construction may contain a maximum of five posts. The distances between posts in support construction are often standardised.

Calculation sheets are provided on an “as is” basis without a warranty of any kind. The user is responsible for results produced by using the sheets.

Forms

The calculation sheet has six forms: Design, Offer Request, Capacity, Installation, Standard Shape Sign Face and Principle Drawing.

Forms’ headers and footers

Forms have a header and footer. The header indicates the road district, the name of the project, the title of the list of equipment and the page number. The footer indicates the directory path, the name of the file and form as well as the date of creation, revision and printing dates. Because files have not yet been named, their designations must be planned carefully. The date of creation and revision dates are entered into the footer manually, while the printing date prints out automatically.

Schematic drawing

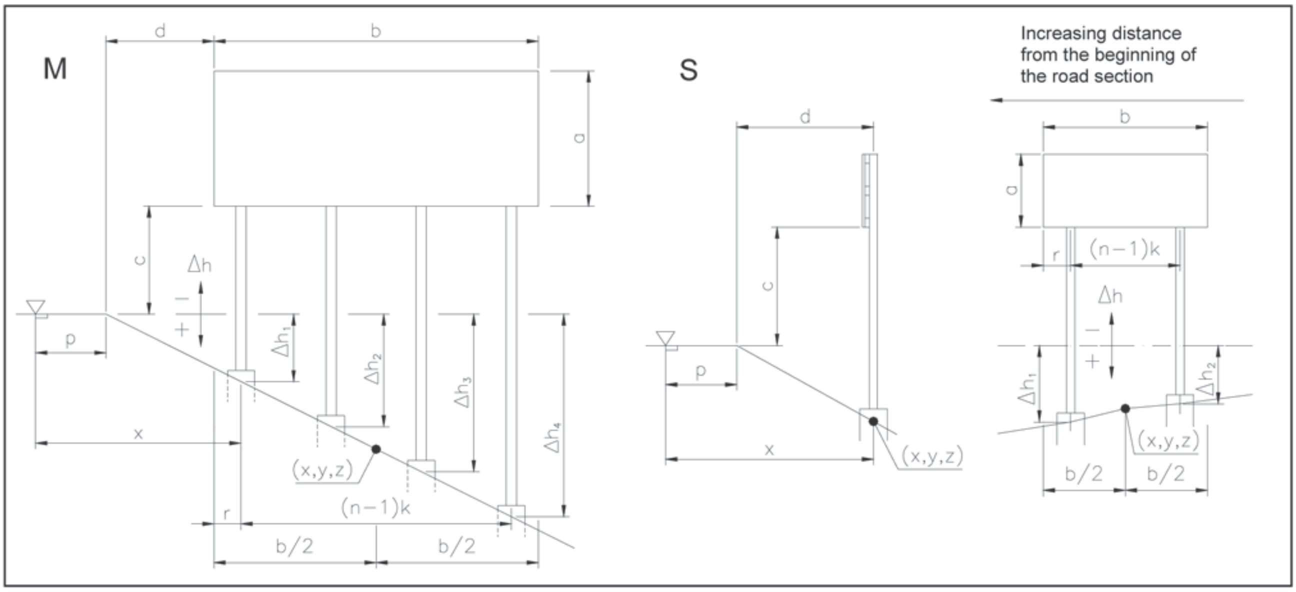


Figure 1. Dimensions used in calculations. On the left a case in which the sign has been placed perpendicular to the road (main road sign = M). On the right a case in which the sign has been placed parallel to the road (side-road sign = S).

The symbols for the dimensions entered as source data are shown in *Figure 1*. The person filling out the form shall ensure that the given dimensions are accurate and that the entered construction is geometrically consistent. The checking of the construction's dimensions can be performed with the Principle Drawing form. Clicking the Picture button at the upper left edge of the form updates the Principle Drawing according to the active row. The Principle Drawing is not updated automatically when dimensions are altered, only after the Picture button has been clicked.

Transmission of files

The calculation sheet and its printouts are utilised throughout the entire course of the project: from designer through the main contractor to the manufacturers of support construction and further on to those performing installation works. The sequential order of the forms in the calculation is Design, Order Request, Capacity and Installation. A simplified procedure can also be used for the design of support construction for standard shape sign faces: the Standard Shape Sign Face form that is a condensed version of the forms at the starting end. If the size of a file requiring transmission is too large, separate project-specific agreements can be made regarding procedures for the transmission of partial files. This can be implemented, for example, if each party has a complete version of the calculation sheet without the entered values, and the transmitted files contain only the form into which values have been entered in each phase. The necessary information from the transmitted files can then be copied to the complete calculation sheet. The sizes of Excel files requiring transfer can further be reduced if the data entered into the form is copied as a separate file during the transfer; compression software also reduces transmitted files' sizes.

Project name and table date

The name of the project, file directory and date of creation are entered into the header and footer. The file name and printing date are printed automatically.

Filling out of forms

Locking protects cells not requiring data. Repetitive data in forms is entered automatically into subsequent forms' equivalent rows and it is not necessary to enter the same information repeatedly. Although the copy function may be employed when filling out forms, <u>the cut-paste technique may not be used; this ensures that the cells' reciprocal references will remain in their original form</u>. Row numbering is visible on the left side of the page. Space is provided on the lower edge of each page (except the Principle Drawing) for the user's comments; references can be made regarding, for example, poor foundation conditions.

Settings

Excel's iteration function is required for frame references (Tools/Options/Calculation menus: check iteration box)

Printing

A default printing area is assumed for all the forms' pages. If desired, the printing area can be adjusted using normal Excel commands.

1.2 Design form

The road designer fills out this form, specifically those columns whose titles are tinted pale yellow. In this instruction the sections in question are marked in **boldface**.

Based on the data provided, the calculation sheet computes the forces and moments acting on the post located in the centre of the sign as characteristic value of live loads separately for wind and the dynamic load from snow clearance. The results of the calculation yield the serviceability limit state's bending stiffness requirement EI for the sign's centrally located post. The forces and moments in the ultimate limit state are displayed in the maximum loading columns multiplied by the load factor γ_q = 1,5.

Address data B – L do not affect loading.

B. Road number and quality requirements. The road number, as well as the sign's and post's quality requirements (for example the sign's film type and passive safety class under vehicle impact), are entered into the chart's blank title rows for this column, where the type symbols in column G are also explained. The data in this column is copied into the calculation rows' corresponding cells under the same heading. The value entered into this column is visible in its entirety only in the title rows; only the prefix is visible in the calculation rows. Copying is necessary if the order of the rows is altered subsequently, for example when preparing bills of quantities.

C. Support's number (maximum 5 characters).

Support's address, sections D - F. Extracted from the road design programme or entered manually.

D. Distance from the beginning of the road section or the survey line (m), 5 characters.

E. Location of sign in road's cross section profile viewed in direction of increasing distance from the beginning of the road section: l = left, r = right, c = centre.

F. Visibility direction of sign: Locations of signs visible from the side-road and from the left on the main road are marked from s-r (= side-road) or from left.

G. Type of support. Various quality requirements can be provided under the same title by using common type symbols (for example S1, S2 etc.) The type symbols' content is explained in column A: Road number and quality requirements.

H. For signs stacked one above the other the upper sign's data is entered into column I. The support's identification code required by the Road Traffic Decree is entered into this column.

I. Additional information regarding the sign or support, for example mention of a sign's two-sidedness. The quantity of sign faces is entered into this column. The quantity is given as a sum for two-sided signs.

Coordinates (m) sections J – L

J. Support's x-coordinate. Centre of sign.

K. Support's y-coordinate. Centre of sign.

L. Support's z-coordinate. Slope's surface at centre of sign.

Sign's geometry (m) sections M – Q

M. a: Height of sign in metres. For multiple signs' supports the signs' combined height is entered. Standard shape sign faces are changed to rectangles according to *Table 2*.

N. Growth factor if allowance is to be made for increasing the sign's surface area upwards. Growth factor = $A_{future}/A_{existing}$ (≥1), default value = 1,0.

O. b: Width of sign in metres. Standard shape sign faces are changed to rectangles according to *Table 2*.

P. c: Height (m) of sign's lower edge from road surface (from edge of slope).

Q. d: Horizontal distance (m) of sign's front edge from side of road. If this is subsequently altered, Δh_{centre} must also be updated.

R. Δh_{centre} (m). Height (m) of centre post's base from road surface (from edge of slope) = height difference between coordinate point and road surface. If the slope's surface is above the road's surface the dimension is negative.

S. Post's thickness = 0,1 b, however 90…400 mm. Hidden.

T. Permeability factor, default ϕ = 1 (impermeable). See Offer Request form, section EX.

U. Aerodynamic coefficient of post, default C_f/ψ_d= 0,8. See Offer Request form, section EY.

Conditions, sections AC - AO

AC. Support construction's allowable deflection (mm/m) caused by wind. 25 mm/m (default value).

AD. Support construction's allowable twisting rotation (Ú/m) caused by wind. 0,29 Ú/m (default value).

AF. Terrain category matching conditions where structure is located, See Section 2.2. The default value is terrain category 2 = open, but not coastal. Terrain category 1 is used when the support is located near a large lake, open field or along the seashore. Altered as required.

AO. Road's maximum snow clearance speed 50 or 60 km/h. The default value is 60 km/h. In built-up areas 50 km/h is selected.

Wind load (kN,m), sections BF and BG. Calculated by program (supports combined).

BF. H. Horizontal load (kN) in serviceability limit state caused by wind load (shear force at base of post).

BG. M. Value of bending moment (kNm) at base of post in serviceability limit state caused by wind load.

Value (kN,m) from dynamic load from snow clearance acting on sign's support construction, sections DP, DQ and DR. Calculated by program (supports combined).

DP. H. Horizontal load value (kN) in serviceability limit state.

DQ. M. Bending moment (kNm) at base of post in serviceability limit state.

DR. M_T. Torsion moment (kNm) at base of post in serviceability limit state.

Larger load (kN,m) from wind and dynamic snow load multiplied by the load factor γ_q = 1,5 , sections DS, DT and DU. Calculated by program (supports combined).

DS. H_d. Largest horizontal load at base of post (multiplied by 1,5).

DT. M_d. Largest moment at base of post (multiplied by 1,5).

DU. M_{Td}. Largest torsion moment at base of post (multiplied by 1,5).

DV. EI. Support construction's required bending stiffness (kNm^2) in serviceability limit state.

Because at this stage a central position is assumed for the post, the values for the torsion moment M_T caused by wind and the torsion stiffness requirement GI_T = 0 and thus not displayed.

1.3 Offer Request form

The manufacturer of the support construction or subcontractor submitting an offer to the main contractor fills out this form, specifically those columns whose titles are tinted pale yellow. In this instruction the sections in question are marked in **boldface**.

The REQUIRED section displays the support construction's required properties, as well as the force and moment actions acting on it and stiffness requirements, copied from the Design form. The proposed support construction's properties and resistances are entered into the SELECTED section.

Additionally there are sections on the right side of the form to facilitate the selection of support construction: Required for a single post and unlocked cells for the user's own formulas. Next to the SELECTED columns is a narrow column for performing a comparison between a single support's required and selected capacities.

REQUIRED, sections B – R and EN - EQ. Data transferred automatically from Design form.

Section B. In the title's lower rows the name of the product is entered after the word SELECTED.

Sections B - R. Copied from Design form.

Sections EN - EP. Larger bending moment caused by wind and dynamic load from snow clearance multiplied by the load factor 1,5. See Design form, sections DS - DU.

Section EQ. EI. See Design form, section DV.

SELECTED, sections ER – EZ and FA - FD

ER. Product type. Type of support construction product selected for location, for example P114,3×2,0 or specific manufacturer's own product name.

ES. Additional product properties. Selected support construction's additional properties. Characteristics such as the sign's material, if it varies sign-specifically, are entered into this column.

Posts (m) sections ET – EY

ET. Quantity of posts; the default value of 1 is replaced by the actual quantity of posts. When this section is filled out, sections FL – FO should be kept visible.

EW. b_{post}. Width of single post; the default value is replaced the actual thickness, the pipe's diameter for round pipes, or the construction's overall width for trusses.

EX. Permeability factor ϕ; the default value 1,0 is replaced an actual value (<1,0), when it is a question of a truss support.

EY. Aerodynamic coefficient c_f/ψ_λ the default of 0,8 is replaced with a value from *Table 2* when the support is not round or b_{post} < 80 mm.

Force and moment resistance (kN,m) per single support post (Ultimate limit state capacity) sections EZ – FB. When these sections are filled sections FL – FO should be kept visible.

EZ. Entering of selected support's shear force capacity H_u (kN) in ultimate limit state (= resistance divided by material's partial safety coefficient according to Eurocodes). If one support is offered H_u must be greater or equal to H. If two supports are offered $H_u \geq H / 1{,}8 \ldots 2$ etc.

FA. Entering of selected support's bending moment capacity M_u (kNm) in ultimate limit state (= resistance divided by material's partial safety coefficient according to Eurocodes).

FB. Entering of selected support's torsion moment capacity M_{Tu} (kNm) in ultimate limit state (= resistance divided by material's partial safety coefficient according to Eurocodes).

Stiffnesses (kNm^2), sections FC and FD. When these sections are filled sections FL – FO should be kept visible.

FC. Entering of selected support's bending stiffness EI in serviceability limit state.

FD. Entering of selected support's torsion stiffness GI_T in serviceability limit state.

REQUIRED FOR SINGLE POST

In columns FL - FN a preliminary calculation is made for the distribution of actions on a single post when more than one (n) support is selected. The load acting on a single support is not M/n, H/n or ?/n; the divisor is a figure roughly according to *Table 1*.

Maximum load γ_q = 1,5 (kN,m), sections FL – FN.

FL. H_d Maximum value of horizontal load acting on single post in ultimate limit state at base of post.

FM. M_d Maximum value of bending moment acting on single post in ultimate limit at base of post.

FN. M_{Td} Maximum value of torsion moment acting on single post in ultimate limit state at base of post.

FO. EI. Required bending stiffness for single post.

BLANK COLUMNS

The structural engineer or provider of an offer can use these columns to create spreadsheet formulas that automatically propose a suitable support on behalf of the party submitting the offer. The columns can also be used for cost calculations. Because these columns do not print, the selected product must be copied into column B.

The narrow column next to the SELECTED columns displays a question mark (?) character if the preliminary calculation yields a lower capacity for the selected support than is required. A more precise calculation taking the supports' more exact lengths into account is performed using the Capacity form.

Table 1. Divisors dependent on the quantity of posts enabling the results obtained for a single centrally positioned post to be applied to the requirements for construction with multiple supports.

No. of posts	Wind load		Dynamic load from snow clearance		Stiffness
	H	M	H	M	EI
2	1,8	1,7	2,0	1,8	1,6
3	2,5	2,4	1,8	1,7	2,2
4	3,2	3,1	1,6	1,6	2,8
5	3,9	3,8	1,4	1,5	3,2

Table 2. Coefficient c_f/ψ_λ typical values for various types of post construction. B = width of profile parallel to the sign, H = width of other face, t = profile's wall thickness.

Construction	c_f/ψ_λ
Square profile	
B/t < 14	1,05 … 1,30
14 ≤B/t < 25	1,30 … 1,60
B/t ≥ 25	1,60 … 1,90
Rectangular profile where H/B = 2 (1	
B/t < 14	0,85 … 1,05
14 ≤B/t < 25	1,05 … 1,25
B/t ≥ 25	1,25 … 1,50
Round pipe profile	
∅ 60 mm	1,20
∅ 90 mm … ∅ 160 mm	0,80
Round bar space truss	1,60 … 1,85

The rectangular profile's c_f/ψ_λ value decreases as the aspect ratio increases. If the matter is not studied in greater detail the square profile's values such as H/B < 2 comparable to the B/t ratio, as well as values such as H/B ≥ 2 according to the aspect ratio H/B = 2, can be used.

1.4 Capacity form

The structural engineer fills out this form, entering the exact lengths of posts for signs with multiple supports and distances for installation personnel. The form also checks stiffness requirements. In simple construction the Capacity form is not important. Those columns in the form whose titles are tinted pale yellow are filled out. In this instruction the sections in question are marked in **boldface**.

The form is divided into three parts: SELECTED, REQUIRED and SELECTED/REQUIRED. The SELECTED section specifies each post's exact Δh dimensions as well as the posts' locations (dimensions r and k). Based on the data provided, the program calculates the final post-specific force and moment resistances, as well as stiffnesses, required for the support construction and displays them in the REQUIRED columns. The results obtained are compared to the support construction properties provided in the Offer Request form, and this is displayed in the SELECTED/REQUIRED section. If the results of the comparison yield an excessively large capacity shortfall, the form's right side displays a question mark (?) character for the rows in question.

GENERAL INFORMATION

Sections B – F, See Design form. Data transferred automatically.

SELECTED

Posts (m) according to actual construction

R. **Δh_1 Height of first post's base from road surface; the default value is Δh_{centre}. The figure is negative if the base is above the road.**

S. **Δh_2 Height of second post's base height from road surface; the default value Δh_1 if $n \geq 2$, otherwise it is 0. The dimension is updated according to the slope gradient depending on the actual construction.**

T. **Δh_3 such as S.**

U. **Δh_4 such as S.**

V. **Δh_5 such as S.**

W. **n. Posts' quantity copied from the Order Request form.**

X. **r. Distance of sign's edge from centreline of first post, default value b/2 where n = 1, otherwise 0,2 m.**

Y. **k. Posts' centre-to-centre distance, default value = 0 where n = 1, otherwise (b-2r)/(n-1).**

Capacity data HA - HC are copied from the Order Request form.

Stiffnesses (kNm^2) sections HD and HE are copied from the Order Request form.

REQUIRED

Loads, sections HF - HH are copied from the Order request form.

Stiffnesses (kNm^2), sections HI and HJ are copied from the Order Request form.

SELECTED / REQUIRED

The program states a capacity shortfall as a percentage (%) in columns HS–HW. If the selected construction's capacity is sufficient, a dash (–) appears in the cell.

HS. $((H_d - H_u) / H_d) \times 100$ %.

HT. $((M - M_u) / Hd) \times 100$ %.

HU. $((M_u - M_{Tu}) / M_u) \times 100$ %.

HV. EI. Selected post's bending stiffness compared to the required. If the selected construction's capacity is sufficient, a dash (–) appears in the cell.

HW. GI_T. Selected post's torsion stiffness compared to the required. If the selected construction's capacity is sufficient, a dash (–) appears in the cell.

If any part of the selected construction's required capacity indicates a shortfall exceeding 10 %, a question mark (?) character is displayed on the right edge of the form. In that case higher-performance properties for posts must be entered into the Order Request form. A precondition for the final selection of posts is that no question mark (?) characters can appear on any part of the Capacity form.

1.5 Installation form

The structural engineer fills out this form, specifically those columns whose titles are tinted pale yellow. The form is filled out for installation personnel and it also functions as an as-built list for maintenance personnel. In this instruction the sections in question are marked in **boldface**.

Sections B – L, See Design form, sections B - L. Data transferred automatically.

Sections M – Q, Sign's geometry, See Design form, sections M - Q. Data transferred automatically.

Sections R – Y, posts (m), See Capacity form, sections R - Y. Data transferred automatically.

If necessary, auxiliary dimensions can be entered in sections AB and AC.

AB. p. Distance of edge of slope (m) from border line of road. When the sign is located in the centre of the road's cross section profile, p is given from the same edge as d.

AC. x. Distance (m) of first post (on road side) from border line of road. If a value is not provided specifically, the program calculates its values using p, d and r.

AD. Product type. See Order Request form, section ER. Data transferred automatically.

AE. Additional product property. See Order Request form, section ES. Data transferred automatically.

Sections AF – AH, force and moment resistance (kN,m). See Order Request form, sections EZ - FB. Data transferred automatically.

Sections AI and AJ stiffnesses (kNm^2). See Order Request form, sections FC and FD. Data transferred automatically.

The form's command lines are diagrams depicting the symbols used for the Sign Geometry, Posts and Auxiliary Dimensions sections as well as for the location of coordinate points. The drawing on the left depicts a sign that is perpendicular to the road (main road sign). The drawing on the right presents a case in which the sign is located parallel to the road (side-road sign).

1.6 Standard Shape Sign Face form

The road designer fills out this form's REQUIRED columns and the main contractor or his designated consultant fills out the SELECTED columns, in both cases those columns whose titles are tinted pale yellow. In this instruction the sections in question are marked in **boldface**.

The Standard Shape Sign Face form replaces the Design, Order Request, Capacity and Installation forms. It can be used alternatively for standard shape sign faces (see Table 3) instead of the forms in question. The form is divided into two parts: REQUIRED and SELECTED. Additionally there is a narrow column on the right side of the form for performing a comparison between the required moment capacity M_d and the capacity M_u of the selected construction.

Address data B – L do not affect loading.

REQUIRED

B. Road No. and quality requirements. The road number, as well as the sign's and supports' quality requirements (for example the sign's film type and passive safety class under vehicle impact), are entered into this column's blank title rows, where the type symbols in column F are also explained. The data in this column is copied to the calculation rows' equivalent cells under the same heading. The value fed into this column can be seen in its entirety only in the title rows; only the prefix is visible in the calculation rows. Copying is necessary if the order of the rows is altered subsequently, for example when preparing bills of quantities.

C. Support's number (maximum 5 characters).

Support's address, Sections D - F. Extracted from the road design programme or entered manually.

D. Distance to survey line or edge of road (m), 5 characters.

E. Location of sign in road's cross section profile viewed in direction of increasing distance from road section: l = left, r = right, c = centre.

F. Visibility direction of sign: Locations of signs visible from the side-road and from the left on the main road are marked from s-r (= side-road) or from left.

G. Type of support. Various quality requirements can be provided under the same title by using common type symbols (for example S1, S2 etc.) The content of type symbols is explained in column A: Road number and quality requirements.

H. For signs stacked one above the other the upper sign's data is entered into column I. The support's identification code required by the Road Traffic Decree is entered into this column.

I. Additional information regarding the sign or support, for example mention of a sign's two-sidedness. The quantity of sign faces is entered into this column. The quantity is given as a sum for two-sided signs.

Coordinates (m) sections J – L

J. Support's x-coordinate. Centre of sign.
K. Support's y-coordinate. Centre of sign
L. Support's z-coordinate. Slope's surface at centre of sign.

Sign’s geometry (m) sections M – Q

J. a. Height of sign in metres according to Table 3.

K. b. Width of sign in metres according to Table 3.

P. c. Height (m) of sign’s lower edge from road surface (from edge of slope).

Q. d. Horizontal distance (m) of sign’s front edge from edge of slope. When the sign is located in the centre of the road’s cross section profile, the values for the shorter distance are given.

R. Δh_{centre} (m) Height (m) of centre post’s base from road surface (from edge of slope) = height difference between the coordinate point and the road surface. If the slope’s surface is above the road’s surface the dimension is negative.

Auxiliary dimensions (m), sections Z and AA

Z. p. Distance (m) of edge of slope from border line of road. When the sign is located in the centre of the road’s cross section profile, p is given from the same edge as d.

AA. x. Distance (m) of first post (on road side) from border line of road. If a value is not provided specifically, the program calculates its valuesusing p, d and r.

AG. Terrain category where the structure is located, see Annex 1. The default value generally used is terrain category 2 = open but not coastal. Terrain category 1 is used when the support is located near a large lake, open field or along the seashore.

AP. Road’s maximum snow clearance speed 50 or 60 km/h. The default value is 60 km/h. In built-up areas 50 km/h is selected.

Moments (kNm) sections BH, DR and DU

BH. M_{wind}. Value of bending moment (kNm) from wind load acting on sign’s support construction in serviceability limit state at base of post.

DR. M_{snow}. Value of bending moment (kNm) from dynamic load from snow clearance acting on sign’s support construction in serviceability limit state at base of post.

DU. M_d Maximum value of bending moment (kNm) acting on support construction at base of post in ultimate limit state = larger bending moment caused by wind and dynamic load from snow clearance multiplied by the factor 1,5.

SELECTED, sections DX – DZ, EA and EB

DX. Product type. Type of support construction product selected for location, for example P88,9$\times$2,0.

DY. Additional product property. Selected support construction’s additional properties. This column displays characteristics such as the sign’s material if it varies sign-specifically.

Post (m) sections DZ – EB

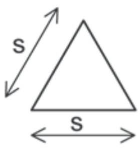
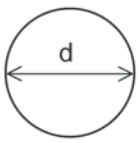
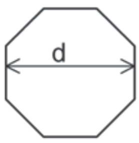
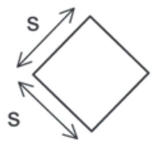
DZ. b_{post}. Post's diameter (m), default value = 0,09 m.

EA. c_f/ψ_λ. Construction's aerodynamic coefficient: default value of 0,8 for ∅88,9…114 mm pipe. The equivalent factor for a ∅60,3 pipe is 1,2.

EB. M_u Post's bending moment capacity (kNm) in ultimate limit state (= resistance divided by material's partial safety coefficient according to Eurocodes), the default value for a ∅88,9 ×2,0 S355J2 pipe's resistance is 3,7 kNm (the equivalent factor for a ∅60,3×2,0 S355J2 pipe is 1,7 kNm).

Next to the SELECTED columns is a narrow column for performing a comparison between a single support's required and selected capacities. If the capacity of the selected construction is less than required, the columns display question mark (?) characters for the rows in question. A precondition for the final selection of posts is that no question mark (?) characters can appear on any part of the form. Only the bending moment's values are calculated for standard shape sign face construction because they exert a greater dimensional effect on the support construction. If the intent is to also define other forces and moments as well as stiffness requirements, the Design, Order Request, Capacity and Installation Forms must be used.

Table 3. Standard shape sign faces' reduced dimensions. When using two signs stacked one on top of the other, the signs' height is the sum of the "a" dimensions and the width is the larger "b" dimension. Additional signs are not taken into account when specifying the sign's dimensions.

Symbol	Size	s/d (m)	a (m)	b (m)
	large	1,350	0,900	0,900
	normal	0,900	0,600	0,600
	small	0,600	0,400	0,400
	large	0,900	0,900	0,900
	normal	0,640	0,600	0,600
	small	0,400	0,400	0,400
	large	0,900	0,900	0,900
	normal	0,600	0,600	0,600
	large	0,900	0,900	0,900
	normal	0,600	0,600	0,600
	small	0,400	0,400	0,400

1.7 Principle Drawing form

The Principle Drawing form is used to verify the geometry of the entered source data. In all four of the previously described forms, the Picture button is located at the form's upper left edge. When the button is pressed, the active row's general information about the support, the sign's geometry and posts' location data is copied to the Principle Drawing form, where the data in question is visible at the upper part of the form; the program then draws a simple model of the construction based on this information. The drawing prints out at the scale of 1:100. The Principle Drawing is not updated automatically when support-related data changes unless the Picture button is pressed. If the macros are not activated when the calculation sheet is opened, the Picture button will not function. The Principle Drawing can also be drawn by entering the required information into the table at the upper part of the form, even though the macros have not been activated. Data entered into the Principle Drawing form is not copied to other forms.

B. Road No. and quality requirements. Road number, the sign's and supports' quality requirements as well as explanation of the type column's symbols.

C. Support's No. Support's number.

Support's address, sections D – F.

D. Distance from the beginning of the road section or the survey line (m), 5 characters.

E. Location of sign in road's cross section profile viewed in direction of increasing distance from the beginning of the road section: l = left, r = right, c = centre.

F. Visibility direction of sign: Locations of signs visible from the side-road and from the left on the main road are marked from s-r (= side-road) or from left.

G. Type of support. Type symbols, for example S1, S2 etc. for support structures with similar properties.

H. Sign's identification code required by the Road Traffic Decree.

I. Additional information. Further information regarding the sign or support, for example the number of signs.

Coordinates, sections J – L

J. Support's x-coordinate.

K. Support's y-coordinate.

L. Support's z-coordinate

Sign's geometry (m) sections M - Q

M. a Height of sign in metres.

O. b Width of sign in metres.

P. c Height of sign's lower edge from road surface.

Q. d Horizontal distance of sign's front edge from edge of slope.

Posts (m) sections R - Y

R. Δh_1 Height of first post's footing from road surface.
S. Δh_2 Height of second post's footing from road surface.
T. Δh_3 Height of third post's footing from road surface.
U. Δh_4 Height of fourth post's footing from road surface.
V. Δh_5 Height of fifth post's footing from road surface.
W. n Quantity of posts.
X. r Distance from centreline of first post to edge of sign.
Y. k Distance between posts.

2 CALCULATION PRINCIPLES FOR STANDARD SHAPE SIGN FACES AND TRAFFIC SIGNS

General

Calculations of support construction for standard shape sign faces and traffic signs are performed according to various EN standards:

SFS-ENV 1991-1 Eurocode 1: Basis of design and actions on structures
Part 1: Basis of design

SFS-ENV 1991-2-4 Eurocode 1: Basis of design and actions on structures
Parts 2-4: Actions on structures. Wind actions.

prEN 12899-1 Road equipment – Fixed, vertical road traffic signs,
Part 1: Signs

Calculation results are independent of the materials used in construction; for that reason norms governing specific materials have not been used in this instruction. When selecting construction based on calculation the results obtained, the Eurocodes prepared for materials must be used, for example:

SFS-ENV 1993-1-1 Eurocode 3: Design of steel structures.
Part 1-1: General rules and rules for buildings

ENV 1995-1-1 Eurocode 5: Design of timber structures
Part 1-1: General rules and rules for buildings

The dimensional values used in calculations are shown in *Figure 2*. It is however assumed that the wind loads and dynamic loads from snow clearance acting on signs and their support construction do not occur simultaneously. It is also generally assumed that the dead weight of the construction exerts no significant effect on the dimensioning of support construction for traffic signs, nor is it taken into account here. If significant stresses however act on the selected construction owing to its dead weight, they must be taken into account separately.

When defining post-specific actions for multi-support construction it is assumed that the sign is divided into the sections which border lines lays in the middle of the two post next to each other. The torsion calculation is performed only for single-support construction. When entering a growth factor describing an increase of the sign's surface area, the sign's height “a” multiplied by a growth factor is used in calculations.

Forces and moments are calculated at the base of the post where the maximum values for the shear/horizontal force H (kN), as well as its consequential bending moment M (kNm) and torsion moment M_T (kNm) parallel to the road, are achieved. The maximum values are displayed in the ultimate limit state (H_d, M_d and M_{Td}) by using a load factor of γ_q = 1,5 for service live loads. The values of forces and moments are so-called extreme values; they are not necessarily derived from the same loading conditions nor are their magnitudes as large for all posts. The calculation is based on the assumption that, in multi-post construction as well, all posts (except for their lengths) are identical. The forces and moments derived can be used for the selection of posts as well as footings. When calculating the allowable deformations acting on the posts' stiffnesses (EI, GI_T), deflection and twisting rotation from wind are examined in the serviceability limit state at the post's highest point. The deformation caused by the dynamic load from snow clearance is not taken into account because the loading is only momentary, nor is there any appreciable effect on the sign's readability. If characteristic values derived from the serviceability limit state are used when calculating footings, the values provided by the calculation program must be divided by the appropriate load factor.

The calculation is based on a statically determined cantilevered beam construction with standard stiffnesses. The calculation of forces and moments will have no effect if the selected post's stiffness changes as a function of length. If however the selected post's force and moment capacities decrease from the base of the post upwards, the portion of the construction being measured may behave differently than at the base of the post. In that case the construction's resistance must be demonstrated separately. Changing the stiffnesses will affect the magnitude of deformations. The construction's deformation stiffness must be demonstrated separately if the stiffnesses of the selected posts throughout their entire construction fail to exceed the values provided by the calculation program.

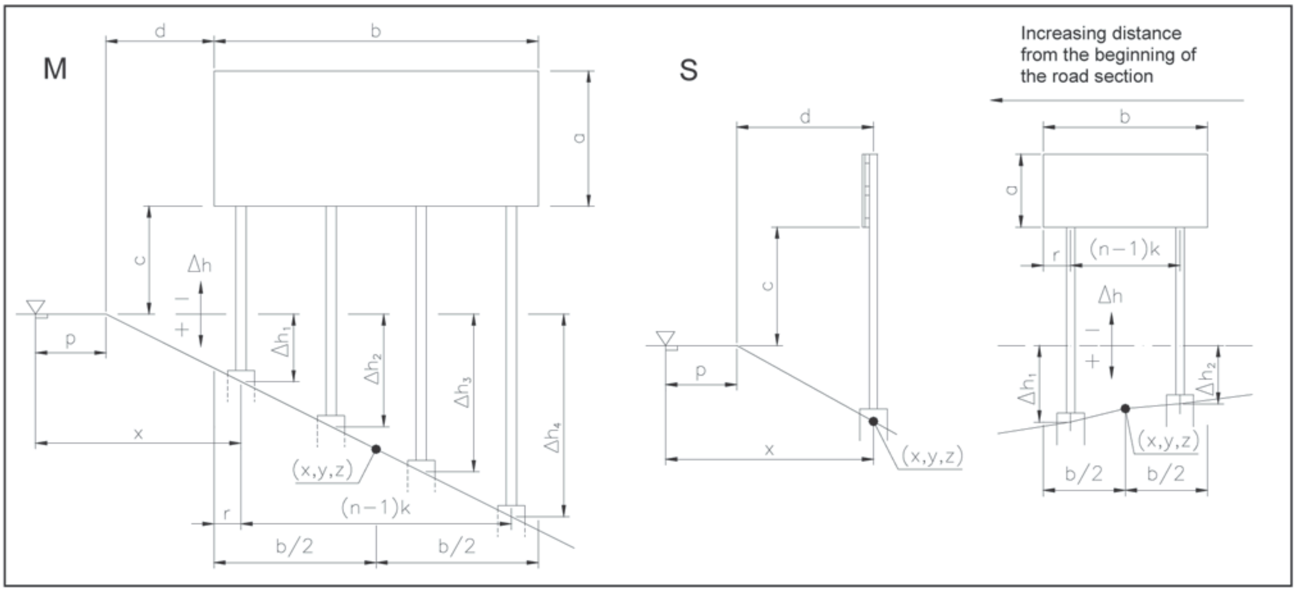
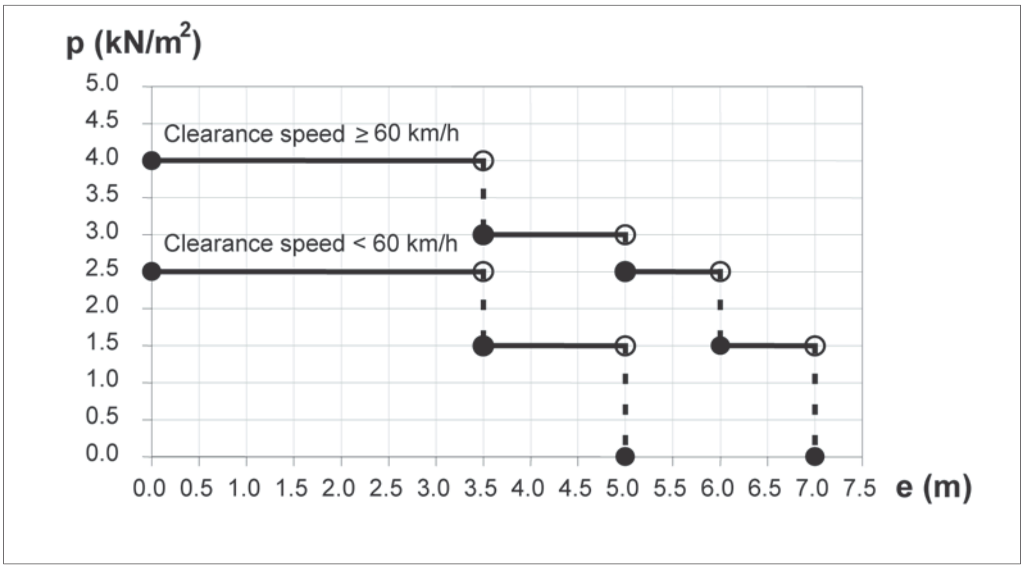


Figure 2. Dimensions used in calculations. On the left a case in which the sign has been placed perpendicular to the road (main road sign = M). On the right a case in which the sign has been placed parallel to the road (side-road sign = S).

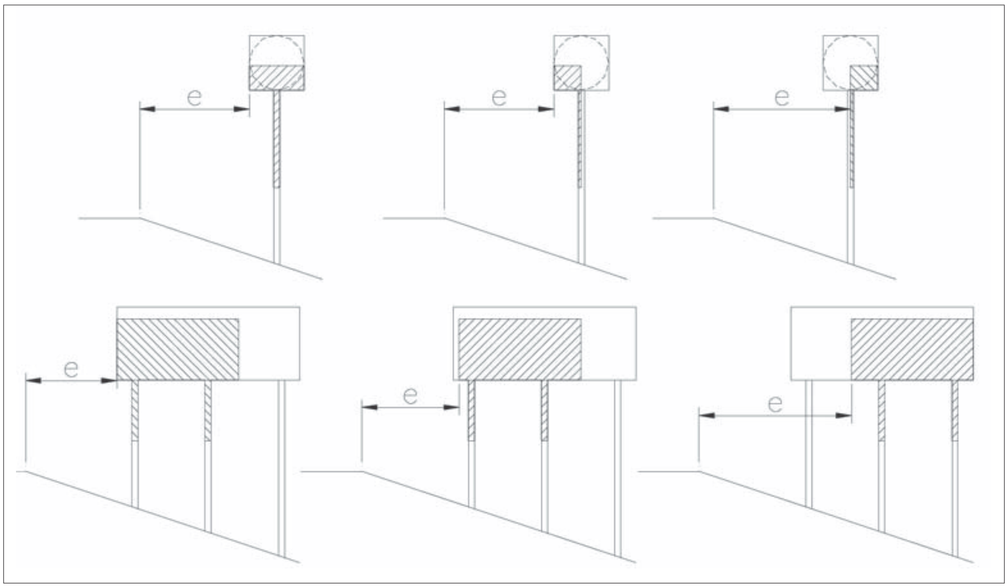
Dynamic load from snow clearance

Figure 3. Magnitude of dynamic load from snow clearance's intensity as a function of distance for standard shape sign faces and traffic signs. A lower loading value can be used for the intensity at transitional points.



The dynamic snow load acts on a maximum area of 2,0×2,0 m^2 whose upper edge is a maximum of 2,5 m from the surface of the road and whose lower edge is at its lowest at the level of the road surface. If a more specific calculation is desired, the dynamic load from snow clearance acting on an area of the sign smaller than its maximum surface area is studied. The intensity of the load depends on the distance e from the edge of the road's slope to the area of the sign face upon which the load is acting according to *Figure 3*. The dynamic load from snow clearance affects the construction's projected surfaces facing the dynamic load from snow clearance as for wind loading. Several different types of loading conditions (See *Figure 4*) are studied to find more specific situations. In areas where the snow clearance speed is low (< 60 km/h), a lower value for the dynamic load from snow clearance can be used.

Figure 4. Example of load situations studied when calculating dynamic loads from snow clearance.



Allowable deformations

The limiting of deformations is based on factors such as the readability of the sign in windy conditions as well as the damping of vibrations. The given allowable deformation enables the required stiffnesses EI and GI_T (kNm^2) to be calculated for the support construction. The allowable deflection is given as a function of the post's unit of length (mm/m). The results yield the required bending stiffness EI that is the incidence of the modulus of elasticity E (kN/m^2) describing the post's material characteristics and the moment of inertia I (m^4) describing cross-sectional properties. The required torsion stiffness GI_v for a sign with a single support where the post is eccentric with respect to the sign is obtained from the allowable value of twisting rotation (°/m) provided as a function of the post's unit of length. The torsion stiffness is the incidence of the shear modulus G (kN/m^2) describing material characteristics and the twisting moment of inertia I_T (m^4) describing cross-sectional properties.

Allowable deformations resulting from momentary deflections and twisting rotation caused by wind are divided into several different classes. The boundary values compliant with EN standards are 100, 50, 25, 10, 5 or 2 mm/m deflection. The EN standards' allowable boundary values for twisting rotation are 1,15; 0,57; 0,29; 0,11; 0,06 and 0,02 °/m. The Finnish Road Administration normally requires compliance with the values 25 mm/m and 0,29 °/m for standard shape sign faces and traffic signs. The torsion stiffness is measured only for large signs with single supports where the post is particularly eccentric with respect to the sign.

Previous numbers:

1. Break-away lighting columns, current practice in Finland in 1993
2. Foundations of luminare supports. The effect of backfill on the strains in foundations.
3. The need of space for snow remover from carriageways in Finland.
4. Acoustic performance of simple board and plywood fences.
5. Break-away lighting columns, current practice in Finland in 1996
6. Break-away lighting columns, current practice in Finland in 1998
7. The effect of openings on the insertion loss of noise barriers
8. Improving roadside safety on old roads
9. Break-away lighting columns in Finland, years 2001

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	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	AC	AD	AF	AO	BF	BG	DP	DQ	DR	DS	DT	DU	DV
1	ADDRESS AND TYPE											SIGN'S GEOMETRY						CONDITIONS				FORCES AND MOMENTS					REQUIREMENT			
2	Road		Dist.	Loca-	Visibil-	Type	Id-code					Sign's Dimensions			Sign's Position					Terrain	Snow	Wind (kN,m)		Snow Clearance (kN,m)			Larger Load (wind/snow)			EI
4	No. &	Sup-	from	tion of	ity Di-	of	(Road		Coordinates (m) if Needed						Vertic.	Horiz.	Δh_{centre}	Allowable		Cate-	Clear.	(posts combin.)		(posts combined)			Multiplied by γ_q=1,5 (kN,m)			(posts
5	Quality	port's	Begin-	Sign	rection	Sup-	Traffic	Additional				Height	Growth	Width	Distan.	Distan.		Deformations		gorry	Speed	Shear	Bend.	Shear	Bend.	Tors.	(posts combined)			comb.)
6	Requir.	No.	ning	l/c/r	of Sign	port	Degr.)	Information	x	y	z	a (m)	Factor	b (m)	c (m)	d (m)	(m)	mm/m	°/m	(wind)	(km/h)	H	M	H	M	M_T	H_d	M_d	M_{Td}	(kNm^2)
7	Vt 0, Supports are impact safe (NE 100;2 or HE or LE 100;3) or borderline cases unless marked by S (= Stiff), all supports are purely pipe or truss structure, plywood or aluminium signs																													
8																														
9	Vt 0, Su	1	340	r								3,00	1,00	2,40	1,80	4,00	1,00	25	0,29	2	60	5,0	20,9	5,1	15,2	1,5	7,7	31,3	2,3	765,9
10	Vt 0, Su	2	678	l		S		safety barrier				4,50	1,00	2,40	1,80	4,00	1,00	25	0,29	2	60	8,1	40,5	5,1	15,2	1,5	12,2	60,7	2,3	1809,5
11	Vt 0, Su	3	720	r								2,00	1,00	2,40	1,80	4,00	1,00	25	0,29	2	60	3,1	11,6	5,1	15,2	1,5	7,7	22,9	2,3	364,1
12	Vt 0, Su	4	1123	l								1,60	1,00	1,20	2,00	2,50	0,60	25	0,29	2	60	1,2	4,0	3,1	8,2	0,4	4,7	12,3	0,6	111,5
13	Vt 0, Su	5	1123	r	from left							1,60	1,00	1,20	2,00	2,50	0,60	25	0,29	2	60	1,2	4,0	3,1	8,2	0,4	4,7	12,3	0,6	111,5
14	Vt 0, Su	6	1340	r								2,80	1,00	1,80	2,00	4,00	0,90	25	0,29	2	60	3,5	14,8	3,5	10,2	0,6	5,3	22,1	0,9	537,3
15																														
16																														
17	Vt 0, Su	7	1570	l								4,70	1,00	2,60	1,80	4,00	0,20	25	0,29	2	60	8,9	38,2	5,2	11,2	1,8	13,3	57,3	2,7	1524,3
18												0,00	1,00	0,00	0,00	0,00	0,00	25	0,29	2	60	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
19	Vt 0, Su	4ve	1123	l								1,60	1,00	1,20	2,20	2,50	0,60	25	0,29	2	60	1,3	4,3	2,3	5,8	0,2	3,4	8,8	0,3	126,7
20	Vt 0, Su	5ve	1123	r	from left							1,60	1,00	1,20	2,20	2,50	0,60	25	0,29	2	60	1,3	4,3	2,3	5,8	0,2	3,4	8,8	0,3	126,7
21												0,00	1,00	0,00	0,00	0,00	0,00	25	0,29	2	60	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
22												0,00	1,00	0,00	0,00	0,00	0,00	25	0,29	2	60	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
23	Pt 00 000, Supports are stiff, otherwise as on the main road																													
24																														
25	Pt 00 0	101	30	l								1,20	1,00	2,00	1,70	2,50	-0,10	25	0,29	2	50	1,5	3,2	4,6	8,6	1,0	6,9	12,9	1,5	58,7
26												0,00	1,00	0,00	0,00	0,00	0,00	25	0,29	2	60	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
27	Pt 00 0	101ve	30	l								1,20	1,00	2,00	1,90	2,50	-0,10	25	0,29	2	50	1,5	3,5	3,7	7,1	0,8	5,6	10,6	1,2	69,4
28												0,00	1,00	0,00	0,00	0,00	0,00	25	0,29	2	60	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
29												0,00	1,00	0,00	0,00	0,00	0,00	25	0,29	2	60	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
30												0,00	1,00	0,00	0,00	0,00	0,00	25	0,29	2	60	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
31																														
32																														
33												0,00	1,00	0,00	0,00	0,00	0,00	25	0,29	2	60	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
34												0,00	1,00	0,00	0,00	0,00	0,00	25	0,29	2	60	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
35												0,00	1,00	0,00	0,00	0,00	0,00	25	0,29	2	60	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
36												0,00	1,00	0,00	0,00	0,00	0,00	25	0,29	2	60	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
37												0,00	1,00	0,00	0,00	0,00	0,00	25	0,29	2	60	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
38												0,00	1,00	0,00	0,00	0,00	0,00	25	0,29	2	60	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
39																														
40																														
41												0,00	1,00	0,00	0,00	0,00	0,00	25	0,29	2	60	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
42												0,00	1,00	0,00	0,00	0,00	0,00	25	0,29	2	60	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
43												0,00	1,00	0,00	0,00	0,00	0,00	25	0,29	2	60	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
44												0,00	1,00	0,00	0,00	0,00	0,00	25	0,29	2	60	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
45												0,00	1,00	0,00	0,00	0,00	0,00	25	0,29	2	60	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
46												0,00	1,00	0,00	0,00	0,00	0,00	25	0,29	2	60	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
47																														
48																														
49												0,00	1,00	0,00	0,00	0,00	0,00	25	0,29	2	60	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
50												0,00	1,00	0,00	0,00	0,00	0,00	25	0,29	2	60	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
51												0,00	1,00	0,00	0,00	0,00	0,00	25	0,29	2	60	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
52												0,00	1,00	0,00	0,00	0,00	0,00	25	0,29	2	60	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
53												0,00	1,00	0,00	0,00	0,00	0,00	25	0,29	2	60	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
54												0,00	1,00	0,00	0,00	0,00	0,00	25	0,29	2	60	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
55																														
56																														
57												0,00	1,00	0,00	0,00	0,00	0,00	25	0,29	2	60	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
58												0,00	1,00	0,00	0,00	0,00	0,00	25	0,29	2	60	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
59												0,00	1,00	0,00	0,00	0,00	0,00	25	0,29	2	60	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
60												0,00	1,00	0,00	0,00	0,00	0,00	25	0,29	2	60	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
61												0,00	1,00	0,00	0,00	0,00	0,00	25	0,29	2	60	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
62												0,00	1,00	0,00	0,00	0,00	0,00	25	0,29	2	60	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
63	Additional Information:																													
64																														
65	Road number and the quality requirements of the road's traffic sign supports have been written into the cells B7 & B23. From there it has been copied to the column's B other cells, whose rows has traffic sign information. Additional information can also be written into this box.																													
66																														
67																														
68	The manufacturer of the supports has already managed to add his own support structure versions 4ve, 5ve and 101ve after testing suitable pipe dimensions in Offer Request form.																													