GENERAL WORK SPECIFICATION

ROAD SIGNS – GWS

TENDER SPECIFICATION

MAY 2011

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1 GENERAL

The works specification contains specific descriptions of the manufacturing, supply and mounting of road signs, including road sign equipment, mounting equipment and foundations.

Common descriptions are shown in *Common to Road Equipment – GWS*, to which reference is made.

1.1 Scope

The work specification applies to all material and equipment used in connection with vertical marking in the road network.

1.2 Definitions

1.2.1 Sign
Traffic technical term for a structure which includes both sign(s) and pole(s).

1.2.2 Plate
Sign plate including sign foil.

1.2.3 Pole
The overall term for pole and post.

1.2.4 Pole with offset sign
Term for pole, where the centre line of the signs located offset in relation to the centre line of the pole, often referred to as gallows post.

1.2.5 Sign gantry
The overall term for a construction which supports a sign located above the carriageway area.

1.2.6 Edge profile
Profile used for bracing of a sign plate along the outer edges of the sign plate.

1.2.7 Bracing profile
Profile used for bracing of sign plates. Also used together with section profiles for joining several sign plates into large sign plates.

1.2.8 Section profile
Profile used for joining several sign plates together with bracing profiles.

1.2.9 Fittings
Device for mounting of sign plates onto pole(s).

1.2.10 Protective edge
Product or manufacturing process intended to protect the edge of the sign and reduce the degree of severity of personal injury in the event of physical contact with the edge of the sign.

1.2.11 Sign plate
Surfacing to support the sign foil is most often made of aluminium.

1.2.12 Sign foil
Material applied to sign plate as the final surface of the sign.

1.2.13 Transilluminated island bollard (traffic bollard) (TTB)
Full or partial transilluminated object placed to warn drivers against obstacles on the road.

1.2.13.1 Type 1 TTB
TTB that also contains one or more road signs or plane surfaces as an alternative.

1.2.13.2 Type 2 TTB
TTB that also carries one or more road signs.

1.2.14 Marker post
White post which clearly marks out the course of carriageway edges. Pole is erected at the verge or fitted on safety barrier and has a yellow reflector when placed in the right-hand side of the road and a white reflector when placed in left-hand side of the road relative to the direction of travel.

1.2.15 Traffic island bollard
Yellow bollard located on a traffic island – often a secondary traffic island – to emphasize the island.

1.2.16 Stele
Vertically narrow column used as a supplement to traffic calming measures and restricted access or indication of areas in which access for cars are not welcome under normal circumstances.

1.2.17 Bollard
Vertically wide column used as a supplement to traffic calming measures and restricted access or indication of areas in which cars are not welcome under normal circumstances.

1.2.18 Reflector
Object designed to reflect light.

1.3 Standards/Instructions

DS 475	Code of practice for trenching of underground pipes and cables
DS/EN 1990-0	Eurocode 0: Basis of structural design
DS/EN 04/01/1991	Eurocode 1: Actions on structures – Part 1-4: General actions – Wind actions
DS/EN 05/01/1993	Eurocode 3: Design of steel structures – Part 1-5: Plated structural elements
DS/EN 1997-1	Eurocode 7: Geotechnical design – Part 1: General rules

DS/EN 12767	Passive safety of stands for road equipment – Requirements, classification and test methods
DS/EN 12899-1	Fixed, vertical road traffic signs – Part 1: Fixed signs
DS/EN 12899-2	Fixed, vertical road traffic signs – Part 2: Transilluminated traffic bollards (TTB)
DS/EN 12899-3	Fixed, vertical road traffic signs – Part 3: Delineator posts and retroreflectors
DS/EN 14991	Precast concrete products – foundation elements

1.4 CE marking

CE marking of road equipment, road signs shall be performed in accordance with the instructions in DS/EN 12899 and prefabricated foundations in accordance with the instructions in DS/EN 14991.

1.5 Lifespan

See *Common to Road Equipment – GWS*.

2 MATERIALS

2.1 Steel

See *Common to Road Equipment – GWS*.

2.2 Aluminium

See *Common to Road Equipment – GWS*.

2.3 Timber

See *Common to Road Equipment – GWS*.

2.4 Fibre-reinforced polymer composite

See *Common to Road Equipment – GWS*.

2.5 Plastics

Marker posts shall be made of a plastic type which, with the specified dimensions, provides adequate strength and durability to:

- Comply with WL 2 (6.4.1.1) in DS/EN 12899-3
- Pass the dynamic impact test (6.4.1.3) in DS/EN 12899-3
- Pass the natural weathering test (6.4.2.4) in DS/EN 12899-3.

Marker posts can be made of polyethylene or similar plastics.

These strength and durability requirements also apply to steles and bollards made of polyethylene or similar plastics.

2.6 Concrete

See *Common to Road Equipment – GWS*.

2.7 Bolts, etc.

Threads of foundation bolts to be hot-dip galvanised shall be undercut, as stated in DS/EN ISO 10684, with regard to hot-dip galvanising. Alternatively, threads shall be brushed immediately after the hot-dip galvanising procedure.

Nuts for assembling of signs shall be supplied in accordance with DS/EN ISO 10511 with a nylon ring.

Pop rivets for assembling of signs shall be made of an aluminium alloy with an aluminium pin or steel pin.

2.8 Surface dressing

See *Common to Road Equipment – GWS*.

2.8.1 Hot-dip galvanising

Buried poles/stands for mounting of minor road signs are permitted without an increased zinc layer or other supplementary corrosion protection.

2.8.2 Anodising

See *Common to Road Equipment – GWS*.

2.8.3 Pickling

See *Common to Road Equipment – GWS*.

2.8.4 Coating

See *Common to Road Equipment – GWS*.

2.8.5 Powder coating

See *Common to Road Equipment – GWS*.

2.9 Tolerances

2.9.1 Steel

See *Common to Road Equipment – GWS*.

2.9.2 Aluminium

See *Common to Road Equipment – GWS*.

2.9.3 Timber

See *Common to Road Equipment – GWS*.

2.9.4 Fibre-reinforced polymer composite

See *Common to Road Equipment – GWS*.

2.9.5 Plastics
Normal trading tolerance.

2.9.6 Concrete
See *Common to Road Equipment – GWS*.

2.9.7 Manufacturing of marker posts
The external dimensions of the marker post may vary by a maximum of 2% as specified on Figure 8 (section 0), which approximately corresponds to tolerance ± 2.0 mm on the main lengths and ± 0.5 mm on the other dimensions. The distance measured from the surface of a marker post to a straightedge located in the longitudinal direction of the marker post shall not exceed 3 mm.

2.9.8 Bolts, etc.
Tolerances on bolts shall not exceed the "medium" class according to ISO 965 and product grade A or B according to DS/EN ISO 4759.

The hole diameter in bolt templates shall not exceed bolt diameter + 1.0 mm. Hole pitch between bolts shall not vary by more than ± 1.0 mm.

2.9.9 Location of posts/poles
In the event of the use of 3 or more posts/poles for the same sign, differences in their deviations at sign level shall not exceed 2.0‰ (0.20%) of the distance between the outermost posts/poles.

In the event of the use of two or more posts/poles, any deviation from the horizontal level, which consists of the top of the posts or poles, shall be deviated by no more than ± 10 mm after adjustment of the mutual heights of the posts/poles.

2.9.10 Foundations
The location of the foundation in the plane shall not deviate by more than ± 10 mm.
Foundations in paved areas shall not deviate by more than -0/+10 mm in height.
Foundations outside of paved areas shall not deviate by more than ± 10 mm in height.

Foundations for the same construction shall be located mutually to each other (measured between the bolt groups of the foundations) by:
- in the plane ± 10 mm
- in the height ± 10 mm.

The tolerance of location of reinforcing bars and embedded items are:
- Bolt location, mutually horizontal $\delta = \pm 1$ mm
- Bolt location, mutually vertical $\delta = \pm 3$ mm
- Bolt location, vertical $\delta = \pm 20$ mm
- Distance between reinforcing bars $\delta = \pm 30$ mm
- Concrete cover $\delta = -5$ mm.

3 EXECUTION

3.1 Steel

See *Common to Road Equipment – GWS*.

3.2 Aluminium

See *Common to Road Equipment – GWS*.

3.3 Timber

See *Common to Road Equipment – GWS*.

3.4 Fibre-reinforced polymer composite

See *Common to Road Equipment – GWS*.

3.5 Plastics

(Currently no comments).

3.6 Concrete

See *Common to Road Equipment – GWS*.

3.7 Hot-dip galvanising

See *Common to Road Equipment – GWS*.

3.8 Anodising

See *Common to Road Equipment – GWS*.

3.9 Pickling

See *Common to Road Equipment – GWS*.

3.10 Coating

See *Common to Road Equipment – GWS*.

3.11 Powder coating

See *Common to Road Equipment – GWS*.

3.12 Torque

As part of the delivery, the post and pole supplier shall forward rules and regulations for tightening of bolts in frangible and cutting joints, including information on torque moment.

Similarly, the post or pole supplier shall indicate torque of tightening the mounting brackets.

3.13 Flexible poles

Where the use of flexible poles is prescribed, poles shall meet the requirements set out in accordance with DS/EN 12767. This shall appear from the CE marking.

3.14 Signs

Sign colours, text and symbols as well as other design shall be applied and made as stated in the road standards for road signs and direction signs.

Text and symbols shall be located as shown in the detailed drawings of the individual signs.

3.14.1 Sign fronts

3.14.1.1 Colour coordinates and luminance factors

Colour coordinates of sign foils of type 1 shall lie within the range specified by the corner points which are specified in table 18 of DS/EN 12899-1:2007 with the use of class B1 for luminance factors.

Colour coordinates of sign foils of type 2 shall lie within the range specified by the corner points which are specified in table 18 of DS/EN 12899-1:2007 with the use of class B2 for luminance factors.

Colour coordinates for sign foils of types 3, 4 and 5 shall be within the range specified by the corner points, which are specified in Figure 1 and the value of luminance factors shall as a minimum and as a maximum, respectively, be as indicated in Figure 2.

Colour coordinates of sign foils of types 3, 4 and 5 are equal to the colour coordinates indicated in class CR1 in DS/EN 12899-1:2007. Luminance factor requirements for sign foils of type 3 are equal to the requirements indicated for class CR1 sign foil, table 3 in DS/EN 12899-1:2007, while luminance factor requirements for sign foils of types 4 and 5 are equal to the requirements indicated for class CR1, table 4 of DS/EN 12899-1:2007. Excepted from this are the requirements for the colour black, which are not found in the aforesaid requirements in DS/EN 12899-1:2007 see Figure 1 and Figure *2*.

Colour	Point 1		Point 2		Point 3		Point 4	
	x	y	x	y	x	y	x	y
black	(0.385)	0.355	(0.300)	0.270	0.260	0.310	0.345	0.395

Figure 1 Colour coordinate limits for sign foils of types 3, 4 and 5.

Colour	Material type 3		Material of types 4 and 5	
	minimum	maximum	minimum	maximum
black		(0.03)		0.03

Figure 2 Luminance factors for sign foils of types 3, 4 and 5.

3.14.1.2 Coefficient for retro-reflection, material types 3, 4 and 5

Sign foil coefficient for retro-reflection shall at least comply with the
Figure *3* to Figure 5 specified values when the measurements are made, as specified in annex A. This requirement also applies to signs covered in overlay foil.

For serigraphic parts of the sign, the retro-reflection coefficient shall be at least 70% of values specified in
Figure *3* to Figure 5.

Divergence α	Angle of incidence β	White	Yellow	Orange	Red	Green	Blue	Brown
0.33°	5° 15° 30°	43 42 38	30 29 26	22 21 19	8.6 8.4 7.5	6.0 5.8 5.2	2.6 2.5 2.2	1.3 1.2 1.1
0.5°	5° 15° 30°	25 24 21	17 16 14	13 12 11	4.9 4.7 4.2	3.4 3.3 2.9	1.4 1.4 1.2	0.7 0.7 0.6
1.0°	5° 15° 30°	9.3 9.0 8.1	6.5 6.3 5.6	4.7 4.5 4.1	1.8 1.8 1.6	1.3 1.2 1.1	0.5 0.5 0.4	0.2 0.2 0.2
1.5°	5° 15° 30°	5.4 5.2 4.7	3.7 3.6 3.3	2.7 1.8 2.4	1.0 1.0 0.9	0.7 0.7 0.6	0.3 0.3 0.2	0.1 0.1 0.1
2.0°	5° 15° 30°	4.2 4.1 3.6	2.9 2.8 2.5	2.1 2.1 1.8	0.8 0.8 0.7	0.5 0.5 0.5	0.2 0.2 0.2	0.1 0.1 0.1
	40°	3.2[1)]	2.2[1)]	1.6[1)]	0.6[1)]	0.4[1)]	0.2[1)]	0.1[1)]

[1)] These requirements may be made applicable to signs, the necessary location of which is such that they need to be read at a large angle. This may, for example, be the case for arrow signs at roundabouts.

Figure 3 Minimum values for the coefficient for retro-reflection in (cd/lux)/m^2 for sign foil of type 3.

Divergence α	Angle of incidence β	White	Yellow	Orange	Red	Green	Blue	Brown
0.33°	5°	72	50	36	14	10	4.3	2.1
	15°	70	49	35	14	9.8	4.2	2.1
	30°	63	44	32	12	8.8	3.7	1.8
0.5°	5°	40	28	20	8.1	5.7	2.4	1.2
	15°	39	27	20	7.9	5.5	2.3	1.1
	30°	35	24	18	7.7	4.9	2.1	1.0
1.0°	5°	15	10	7.5	3.1	2.1	0.9	0.4
	15°	15	10	7.5	3.0	2.1	0.9	0.4
	30°	13	9.4	6.5	2.7	1.8	0.8	0.4
1.5°	5°	9.0	6.3	4.5	1.8	1.2	0.5	0.2
	15°	8.6	6.0	4.3	1.7	1.2	0.5	0.2
	30°	7.8	5.4	3.9	1.5	1.0	0.4	0.2

Divergence α	Angle of incidence β	White	Yellow	Orange	Red	Green	Blue	Brown
0.2°	5°	359	250	178	71	50	21	10
	15°	348	243	174	69	48	20	10
0.33°	5°	144	101	72	28	20	8.6	4.3
	15°	140	98	70	28	19	8.4	4.2
0.5°	5°	82	57	41	16	11	4.9	2.4
	15°	79	55	40	15	11	4.7	2.3
1.0°	5°	31	21	16	6.2	4.3	1.8	0.9
	15°	30	21	15	6.0	4.2	1.8	0.9

Figure 4 Minimum values for the coefficient for retro-reflection in (cd/lux) /m^2 for sign foil of type 4.
Figure 5 Minimum values for the coefficient for retro-reflection in (cd/lux)/m^2 for sign foil of type 5.

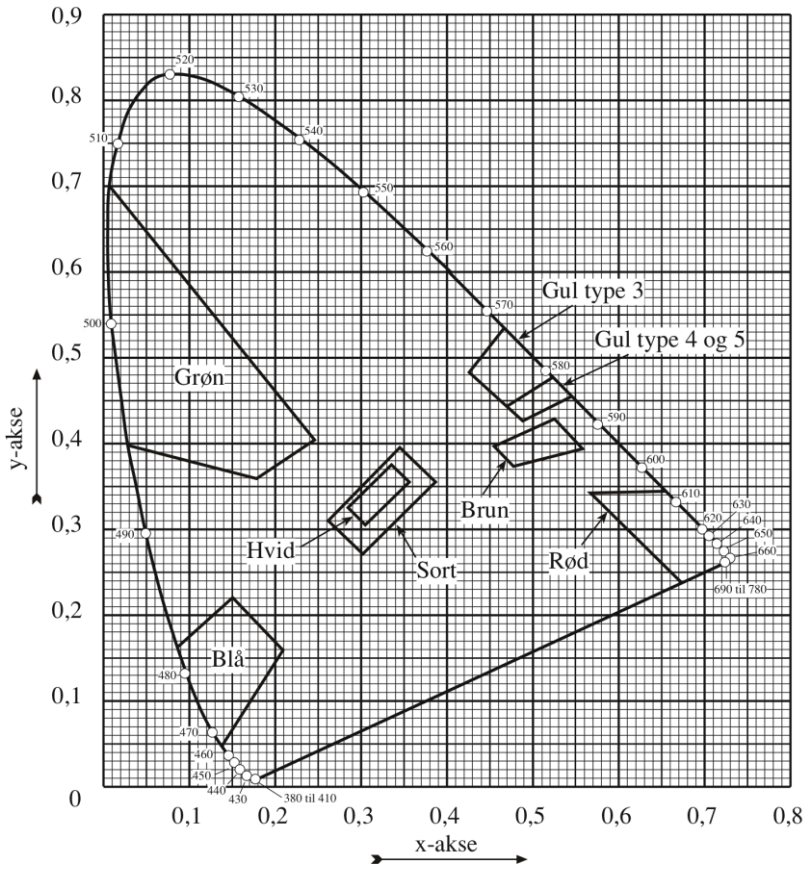

Figure 6 Colour triangle with the colour ranges specified for sign foils of types 3, 4 and 5 have been marked.

3.14.2 From inside illuminated signs

Inside illuminated signs shall comply with the following medium luminance, luminance contrast and symmetry.

The medium luminance shall be least 40, 30, 8, 6 and 4 cd/m^2 for the colours of white, yellow, green, red and blue. The luminance contrast is for dark colours measured by the ratio of luminance of contrast colour (white or yellow) and the luminance of the relevant dark colour (green, red or blue), and shall be in the interval 5 to 15. Regularity is measured by the ratio of the lowest and the highest luminance of the background and shall be at least 1/6.

The requirements are set out in DS/EN 12899-1:2007, table 19 class L1 and table 20 and also table 21 class U2.

The lamp shall have good colour rendering properties with a colour rendering index of at least 50.

3.14.3 Externally illuminated signs

Externally illuminated signs shall be class E3 signs in accordance with table 22 in DS/EN 12899-1:2007.

Where lighting only serves to ensure the sign legibility, an average illuminance strength equivalent at least to class E1 in accordance with table 22 in DS/EN 12899-1:2007 shall be used.

For road signs, small direction signs as well as edge marking and delineators with small dimensions, lighting shall have a symmetry equivalent to class SC3 in accordance with table 23 in DS/EN 12899-1:2007.

For signs with large dimensions, lighting shall have a symmetry equivalent to class SC2 in accordance with table 23 in DS/EN 12899-1:2007.

When determining the minimum illuminance strength, items on the sign surface which are more than 0.25 m from the nearest text, may be disregarded.

Average illuminance strength and symmetry may be calculated and measured by using the methods shown in section 7.4.1.4 in DS/EN 12899-1:2007.

The light source shall have a colour rendering index Ra of at least 50.

Fixtures for illumination of road signs shall be completely screened near horizontal in directions parallel with the road or nearby road or rail sections.

3.14.4 Sign backs

For surface of sign backs (without text or symbols), light grey, RAL no. 7000 shall be used. Foil or varnish may be used as surface finish. The sign back shall be diffusely reflective.

If text or symbols need to be applied to the sign backs, the application shall be in accordance with the description found in section 0.

3.14.5 Foil joints

Foil on individual signs or sign sections with heights up to 1.2 m shall be applied without joints.

Joints in foil used for letters, numbers and pictograms are only permitted if required to allow for a proper location of section joints.

Foil joints in frames made of foil can only be permitted at the frame corners.

Foil joints in diagrams and arrows made of foil are permitted at the points of transition between the branches of the diagrams/arrows.

3.14.6 Methods for application and varnishing

3.14.6.1 Reflective sign base

A reflective base (type 3, 4 and 5) is established by applying foil on an aluminium plate.

An area with foil of types 4 or 5 on a sign covered in foil of type 3 is established by applying foil on foil. An area with foil of type 5 on a sign covered in foil of type 4 is also established by applying foil on foil.

3.14.6.2 Reflective sign edge

A reflective sign edge is established by using transparent silk screen prints or by applying reflective foil (types 3, 4 or 5).

3.14.6.3 Non-reflective sign edge or base

A non-reflective sign edge or base is established by stove enamelling, opaque (all-covering) silk screen prints or by applying non-reflective foil (type 2).

3.14.6.4 Text and symbols

Text and symbols are established by using by transparent silk screen prints, overlay foil or by applying reflective foil. Non-reflective text and symbols are established by using opaque silk screen prints or by applying non-reflective foil.

3.14.7 Surface dressing

Film, colours and varnishes shall be used in accordance with the supplier's instructions.

3.14.8 Repair of foil damage

Repair work must not be visible if viewed from a distance of 10 m from the sign standard.

3.14.8.1 Damage to silk screen prints

Minor damage to silk screen prints, meaning surface flaws or other scratch marks resulting from damage in transit or handling of less than 50 mm^2 or a surface flaw width of less than 1 mm and a maximum length of 100 mm are repaired by applying the same type of varnish and colour on the damaged areas.

3.14.8.2 Air pockets

Air pockets in overlay foil and anti-dim foil are punctured and pressed into place using a rubber hand roller. Air pockets of less than 4 mm^2 shall not be punctured. If air pockets are found between the base foil and the sign plate, the sign must be scrapped.

3.14.8.3 Delamination

Delamination shall not exceed the area depicted in light grey in Figure 7.

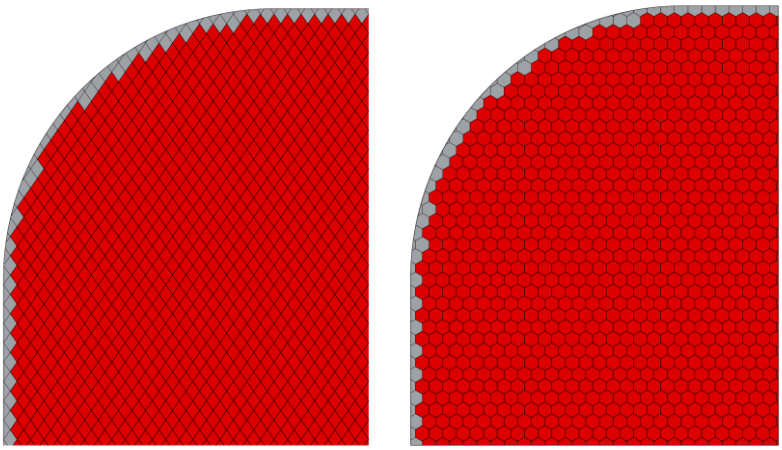

Figure 7 Delamination of the cut cells in a typical circular cut-out section is shown in light grey for a diamond and a hexagonal cell structure, respectively.

3.14.9 Bolt heads, etc.

If they go through the sign front, bolt heads, rivets and washers shall be coloured in the colour of the sign on the relevant spot.

3.14.10 Gusset plates

Aluminium gusset plates shall be coloured in the same colour as the sign back.

3.14.11 Division

Division of large signs into sections and the location of gusset plates shall be in accordance with the detail drawings of the individual signs, or in accordance with proposals made by the contractor as presented to the to the client for approval.

Only the joints depicted in the drawing are permitted in edge, section and bracing profiles.

However, plate joints are not permitted on double-sided arrow signs.

3.14.12 Drain holes

An adequate number of 6 mm drain holes are drilled in signs mounted with the use of edge, bracing and joint profiles or signs with closed edges to ensure that water cannot collect in the profiles or the edge. The distance between the holes shall be ≤ 1.00 m.

3.14.13 Rolling/clamped of profile groove

If the sign is mounted using an edge profile, the profile groove shall be rolled or clamped following mounting of the sign to ensure that the plate is completely secured. Rolling or clamping is, however, only required until about 150 mm before the corners. Foil used on the sign shall cover an area large enough to be secured by the rolled or clamped profile groove.

The sign plate is considered to be properly secured if a 100 mm long arbitrary item is cut out of the edge profile, and the sign plate is not loosed from the edge profile groove if the sign plate and the edge profile are subjected to a light pull.

The force of rolling/squeezing shall be adjusted to ensure that the foil is not damaged, while at the same time ensuring that the profile groove is only as wide after squeezing as will allow the sign plate to remain secured in the groove.

No sporadic "slips" of more than approx. 1/10 mm (corresponding to the thickness of an A4 size sheet 80 g paper) are permitted after rolling/squeezing. Such "slips" are only permitted in areas where foil overlaps. In these areas, a minor "slip" is permitted between the sign plate and the profile groove over a stretch of 50 mm before and after the foil overlap. The "slip" must not be greater than the extra foil thickness in the area in question.

3.14.14 Cover plates

Before fabrication of cover plates for mounting on existing signs, measurements of the existing sign with respect to location of text, route number boxes, etc. shall be made.

After the measurement is made, the final plate size(s) shall be determined, taking the plate sectioning into consideration.

Cover plates to be mounted on existing signs are designed using a plate thickness of 1 to 2 mm depending on the plate field size. The cover plate backs shall be stove enamelled with grey base. Together with cover plates, dyed 5 mm pop rivets with a clamping length corresponding to the total sheet thickness + 2 × foil thickness shall be supplied in a number large enough to be able to secure the plate edges every 250 mm. The pop rivets shall be inserted with a centre line located 10 mm from the edge of the plate.

In addition, coloured pop rivets shall be supplied in a number corresponding to the number of pop rivets covered by the cover plates on the existing sign, which at least corresponds with the total number of pop rivets covered by the cover plates at joint and bracing profiles, for example. The clamping length of these pop rivets shall correspond to the total plate thickness + 2 × foil thickness + thickness of flange on bracing or section profiles.

Existing pop rivets shall be drilled out, and, at the drilled out pop rivets, the cover plate shall be transpierced using a 666 mm drill, and subsequently, 66 mm pop rivets shall be fitted.

Colouring of the pop rivets shall match the colour of the location of the cover plate.

3.15 Marker posts

Marker posts, N 41, shall be made of a plastic material with a nominal wall thickness of 3 mm and a minimum wall thickness of 2.0 mm measured along a random cross section in the marker post. In the sharp edges at recesses made for reflective foil or a reflective plate, kilometre plates and fluorescent tape are permitted, provided, however, that the metal thickness is no less than 1 mm.

Marker posts shall be made with external dimensions and appearance as described in "Executive Order no. 783 of 6 July 2006 - Executive Order on the Use of Road Markings, Signs and Signals, Figure 1" (see also Figure 8). Recesses shall be made to allow for the fitting of fluorescent bands, reflective plates and kilometre plate, so the surfaces of the individual items are at level with or just below the marker post sides after fitting.

If reflective material and fluorescent tape are stuck directly onto the plastic material, documentation shall be provided demonstrating that no air pockets are found between the foil and the plastic due to emissions within a test period of at least 2 years.

Instead, a thin aluminium sheet (of about 0.5 mm) may be used as base plate for the reflective material, which will subsequently be secured to the marker post. Sheets with white and yellow reflective material and kilometre plates are secured to the marker post at the corners of the plates. The fluorescent edging strips are attached to the marker post at the centre of the reflective strip and at the centre of the flat construction sides as well as at the centre of the rounded front edge of the post.

If plastic rivets are used for the attachment process, these rivets shall be included in 2-year test required in accordance with DS/EN 12899-3 for "Natural Weathering" in connection with the application for the CE mark. The durability requirements applying to the marker post also apply to plastic rivets.

Marker posts shall be manufactured in a white colour corresponding to RAL no. 9003.
Marker post shall comply with the requirements set out in DS/EN ISO 12899-3.

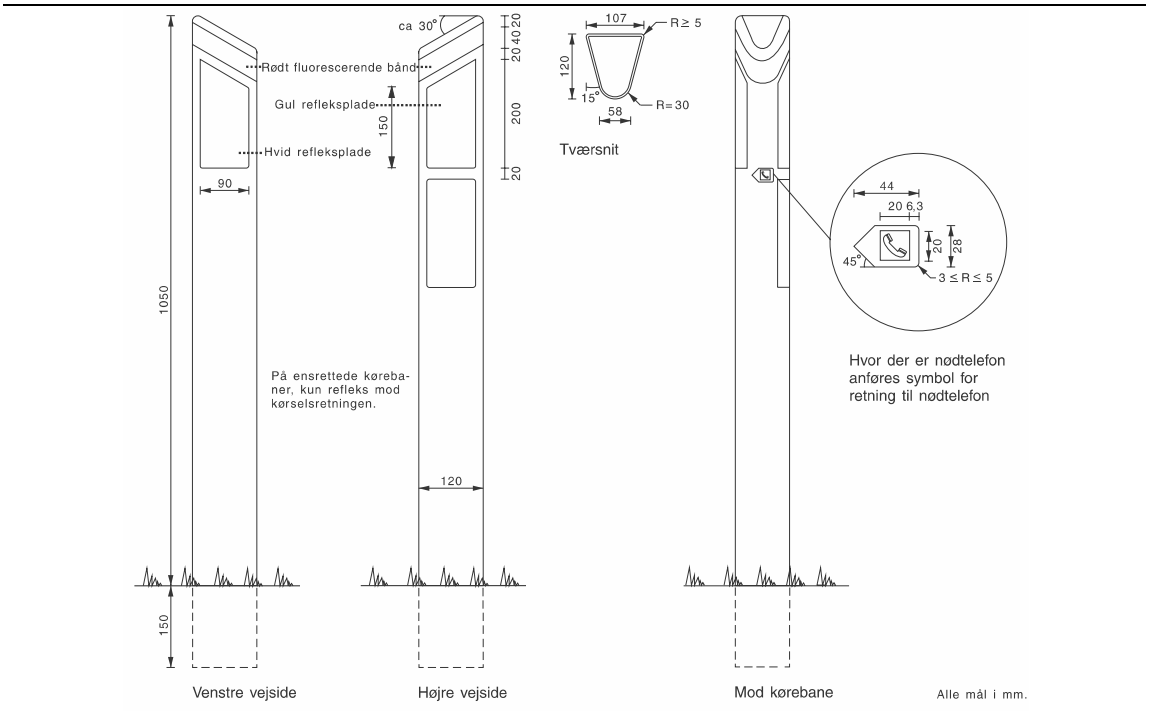

Figure 8 Marker post erected along verges. Foundation not shown.

3.16 Traffic island bollard

Traffic island bollards shall be made with the external dimensions and appearance described in "Executive Order no. 783 of 6 July 2006 - Executive Order on the Use of Road Markings, Signs and Signals, Figure 3" (see also Figure 9). For internally illuminated traffic island bollards, this corresponds to type 2 TTB in DS/EN 12899-2.

Traffic island bollards shall be made of such material or in such a way that they do not expose road users to special risk in the event of collision. The traffic island bollards shall be uniformly illuminated or reflective all the way round from the base up to a height which shall not be more than 100 mm below the upper top of the traffic island bollard.

If reflective material or other material are stuck directly onto traffic island bollards made of plastics, documentation shall be provided demonstrating that no air pockets are found between the foil and the plastic due to emissions within a test period of at least 2 years. Traffic island bollards with air pockets contained between the traffic island bollard and the foil shall be replaced within the warranty period.

Internally illuminated traffic island bollards shall comply with the requirements set out in DS/EN 12899-2.

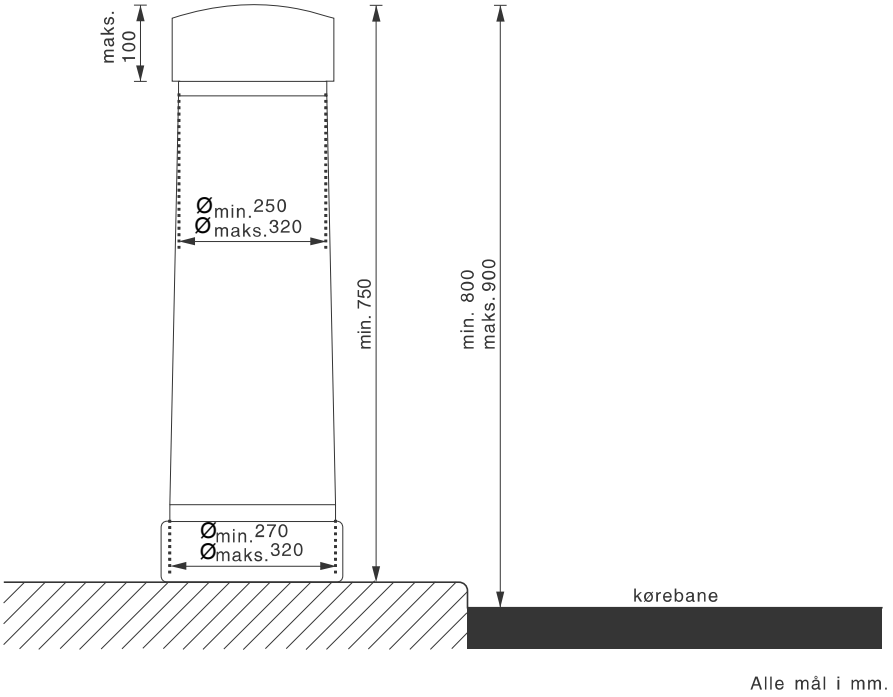

Figure 9 Traffic island bollards.

3.17 Steles

Steles shall be made with the external dimensions and appearance that can be contained within the dimensions shown in Figure 10. The stele must not have any sharp edges or other projections that may pose a danger in the event of close contact. All corners and edges shall therefore, be rounded with a minimum radius of 5 mm.

Steles shall be made of materials which in terms of construction and method of operation are suitable for the specific purpose, and are designed so as not to expose road users to special risk in the event of collision, see classification set out in DS/EN 12767.
Steles shall, if required, be designed to be demountable.

If reflective or other material are stuck directly on steles made of plastics, documentation shall be provided demonstrating that no air pockets are found between the foil and the plastic due to emissions within a test period of at least 2 years.

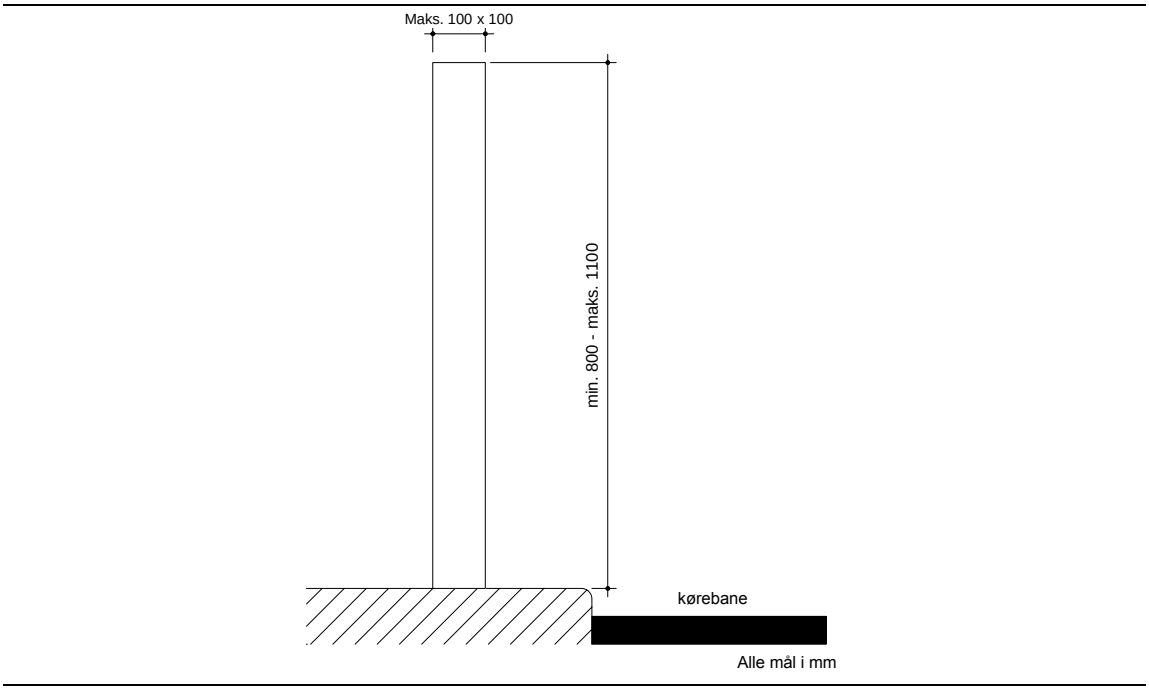

Figure 10 Stele.

3.18 Bollards

Bollards shall be made with external dimensions and appearance that can be contained within the dimensions shown in Figure 11. Bollards must not have any sharp edges or other projections that may pose a danger in the event of close contact. All corners and edges shall therefore, be rounded with a minimum radius of 5 mm.

Bollards shall be made of materials which in terms of construction and method of operation are suitable for the specific purpose.

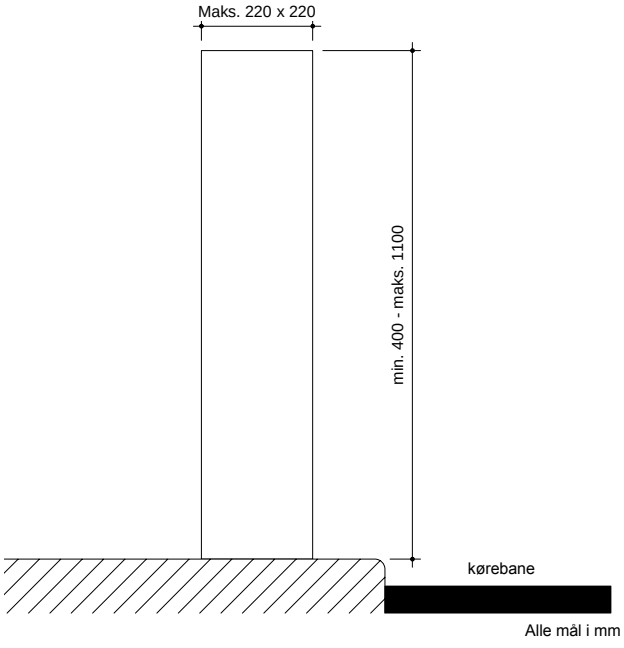

Figure 11 Bollard.

Bollards shall, if required, be designed to be demountable, or as a height adjustable type, which can be buried completely at ground level.

If reflective material or other materials are stuck directly on bollards made of plastics, documentation demonstrating that no air pockets are found between the foil and the plastic due to emissions within a test period of at least 2 years shall be provided.

3.19 Labelling

3.19.1 Signs

All signs shall be marked on the back of the sign (bottom right corner) by engraving the name of the manufacturer and the month of manufacturing. The type height shall be at least 10 mm. For single-sided signs, the marking shall be legible after mounting.

Single-sided signs ≥ 1 m^2 shall, in addition to engraving in the sign plate, be marked using a visible label, which shall also contain the name or logo of the manufacturer and the month and year of manufacturing. The label shall be stock onto the sign back near the engraving.

The label shall be legible from the ground.
The label size is shown in Figure 12.

Type of sign	Label size h x w (mm)	Type height (mm)
General road signs	20 x 40	5
Direction, position or indication signs	40 x 75	10
Overhead signs	75 x 120	20

Figure 12 Label size.

The label shall be printed on transparent foil in black or white type.

Example of design of label is shown in the "Mounting and verification guidance" for road signs.

3.19.2 Marker posts

Marker posts shall be marked with the manufacturing year and month together with the logo of the manufacturer.

3.19.3 Traffic island bollards

Traffic island bollard shall be marked with the manufacturing year and month together with the logo of the manufacturer.

3.19.4 Steles

Steles shall be marked with the manufacturing year and month together with the logo of the manufacturer.

3.19.5 Bollards

Bollards shall be marked with the manufacturing year and month together with the logo of the manufacturer.

3.20 Welding

3.20.1 Steel

Manufacturing of stationary, vertical traffic signs are subject to the provisions set out in DS/EN 12899-1. Execution of other structures is subject to the provisions set out in DS/EN 1090-1 and DS/EN 1090-2.

3.20.2 Aluminium

Manufacturing of stationary, vertical traffic signs are subject to the provisions set out in DS/EN 12899-1. Execution of other structures is subject to the provisions set out in DS/EN 1090-1 and DS/EN 1090-3.

3.21 Cable Trenches

Cable trenches shall primarily be located in the pole alignment and follow the road layout.

Execution of cable trenches is subject to the provisions set out in DS/EN 475.

Two different cable trench depths may be applied:

1. Cable Trenches shall have a depth and width allowing for the cables to be laid between 0.70 m and 0.80 m below ground level. The bottom of the cable trench shall be levelled evenly, and at least 0.05 m of gravel shall be laid out. When cables are laid out, 0.10 m of gravel shall be laid on top.

   Marker tape shall be laid out approx. 0.20 m above the cable. Red marker tape shall be used, marked with the words "heavy current" or similar text that includes the words "heavy current".

   Cable Trenches shall be filled in layers (about 0.20 m) with suitable excavated material or suitable external filling and shall be compacted at optimum moisture content.

2. Cable trenches shall have a depth and width that allow for the cables to be laid out between 0.40 and 0.50 m below ground level. The bottom of the cable trenches shall be levelled evenly, and at least 0.05 m of gravel must be laid out. When cables are laid out, 0.10 m of gravel shall be laid on top.

   Marking plates (plastic cover) should be laid out approx. 0.10 m above the cable. Red marking tape (plastic cover) shall be used, marked with the words "heavy current" or similar text including the words "heavy current".

   Cable trenches shall be filled in layers (about 0.20 m) with suitable excavated material or suitable external filling and shall be compacted at optimum moisture content.

3.21.1 Underpasses/crossings

Pipes in cable trenches and for sub-compression by way of underdrilling shall be PE pipes, PN 10.

The internal pipe diameter shall be a minimum of 40 mm and at least 50% larger than the cable or cable harness diameter.

Carriageway areas on major roads may be crossed by way of sub-compression using directional drilling with pipes at least 0.70 m below the carriageway or by way of the laying out of pipes in cable trenches. The road administration's acceptance of method shall be obtained before execution of such work.

Minor roads or other less busy areas may be crossed by way of sub-compression or the laying out of pipes in cable trenches. The road administration's acceptance of method shall be obtained before it is implemented.

3.22 Electrical work

Electrical work shall be carried out by an authorised electrician in accordance with provisions set out in the Danish Heavy Current Regulations. It is the Contractor's responsibility to register the lighting system with the network operators, if specific provisions shall be complied with, and if permission for connection to the network shall be obtained.

3.22.1 Cables in ground

Cables in ground shall comply with the rules and standards of the Danish Heavy Current Regulations for cables laid in ground and in cable ducts.

If an aluminium cable with solid conductors (4x16 mm^2) is chosen, the cable shall be manageable and suitable for installation at temperatures of -5°C.

Cables must not contain PVC.

Under carriageway areas, cables shall be laid out in cable ducts. Cables must not be collected in the ground. Cable supplier instructions shall be followed with respect to tension in conductors, bending radius and laying of cables at low temperatures.

Cables running parallel will be laid in a shared cable trench at a minimum distance corresponding to 2 $\times$ largest cable diameter.

If several cables are laid in the same duct, a correction factor shall be used, see part, clause 523.4.3.1 of the Danish Heavy Current Regulations.

3.22.2 Fixture cables

Fixture cables shall as a minimum be 1.5 mm^2 plastic cap cables of the H05Vv-F type.

Ignition cables shall be installed inside a pole without fixation, but with sufficient additional length to ensure that the cable dead weight does not cause tension in the terminals of the pole insert/fuse link.

From each fixture at the top of a mast, a fixture cable will be laid until the point of the pole insert/fuse link. The cable is held in the fixture cable stress relief terminal and placed in the pole in hanging position.

The fixture cable is relieved in the pole insert/fuse link.

When pole inserts/fuse links are used, the fixture cable is given a downturned loop (drip cap) to prevent seeping water from running into the terminal element.

Where cables are entered at the top of the pole insert/fuse link, sealing with a suitable joint sealant shall be established to prevent penetration of water.

All cables must be relieved of tension.

Fixture cables shall be secured by means of pieces of foam to the extent necessary, so that they do not thrust against the inside of the pole in windy conditions.

3.22.3 Cables in ducts

The cables sheaths must not be damaged and shall be lubricated using a lubricant that has been approved by the cable manufacturer in connection with tension.

For heavy tension and if there is doubt as to compliance with the permitted tension capacity, the tension capacity shall be checked using a dynamometer.

3.22.4 Sign portal illumination

Sign portal illumination includes installation and adjustment of projectors, including screening at floodlight poles.

3.23 Foundation

Foundation includes earthwork relating to excavation for the purpose of setting up posts/poles, including excavation for casting and establishment of concrete foundations.

Foundations of sign portals, posts/poles and posts with offset signs shall be established before the manufacturing of the structures is begun, as any adjustments to allow for terrain variations, cables, pipelines etc., may have led to a changed foundation location.

3.23.1 Excavations

Following identification of pipes and cables at and around the excavation site, the location of the excavation may be adjusted in relation to the cross-section longitudinal direction of the road, if excavation is not deemed to be possible without causing damage to the identified pipes and cables. Adjustment or removal of pipes shall be agreed with the supervision.

If, in connection with excavation for the purpose of establishing a foundation, unforeseen objects or poor soil conditions are identified, for example in the form of mud, peat, postglacial clay, topsoil, clean loose sand or a water table above the lower edge of the foundation, the client shall immediately be informed and precautions will be agreed.

Excavated materials of various qualities (gravel material/raw soil) shall be kept separate for the purpose of the later filling.

Flagstones or paving stones shall be dug up with care if they are intended for reuse.

In places where there are cables or pipes, excavation shall be made by hand until the cables and pipes are properly secured.

By excavation for in situ cast foundations, the remaining soil must be left intact along the excavation sides with no slipping of soil. Where this requirement is not met, casting against a mould is necessary.

If excavation leaves a hole larger than the foundation planned, the foundation shall be increased in size in accordance with further consultation with the client, or casting against a mould shall be executed.

The client shall have the opportunity to inspect the excavation before commencement of concreting.

3.23.2 Temporary ground water lowering

If the water table is located above foundation level for the foundations, temporary groundwater lowering shall be executed according to agreement with the supervision, so that dry foundation work may be carried out.

Ground water lowering can be executed with the aid of a pump sump or a well point installation.

In connection with the establishment of pump systems, a sufficient number of hoses shall be included in the calculation between tips and pumps and to an exit hose for the disposal of pumped water.
Similarly, an adequate number of electrical systems shall be included in the calculation of pump operation ((depending on conditions, also for emergency power systems for the protection of the continuous day-to-day operation of the pumps).

Pumped water, which will be drained off, must not contain suspended materials.

3.23.3 Mould

Moulds shall be so rigid that quality requirements for geometry and surfaces are complied with.

When the form is oiled, reinforcing bars and embedded items must not be polluted.

All visible edges must chamfered. The chamfer shall be carried out as a 20 mm right-angled triangle.

All mould surfaces of untreated wood shall be watered thoroughly before casting, so that swelling of wood during casting does not cause deterioration of the concrete surface layer.

Immediately before casting, the shape must be cleaned and free water must be removed.

The Contractor shall visually inspect the moulds before casting. The visual verification shall include at least mould geometry, application of slip agent, recesses, mould density, clean-up and watering.

By in situ cast foundations, the plinth will always be cast against mould. At least 0.20 m of the foundations shall always be cast against form. If the soil does not have enough strength or cohesion to stand with vertical sides during excavation and subsequent casting, the sides shall be cast against a mould according to agreement with the client.

Surface shuttering shall be performed immediately outside the plinth in order to prevent heaving of concrete by casting of plinth.

3.23.4 Reinforcement, embedded items, etc.

The Contractor shall on receipt check that type and dimension of the delivered reinforcement are correct and after mounting of reinforcement and embedded items check that dimensions, measurements and tolerances, etc. have been complied with.
Reinforcement with rust spots D or worse according to DS/EN ISO 8501-1 may not be used.

Any loose rust on the reinforcement shall be removed by mechanical cleaning or similar before casting.

Reinforcement, which is polluted with mortar or concrete laitance, shall be cleaned, so the collar is clearly visible before embedding. Reinforcing bars contaminated by oil or mould oil may not be used before degreasing has been made.

The Contractor shall ensure that the correct location of reinforcement and embedded items can be achieved.

The reinforcement and the location of the foundation bolts, including the thickness of the concrete cover, shall be checked before casting. There must be no electrical contact between the reinforcement and the embedded bolts.

Ducts should be placed in the foundation as shown in the drawings. Ducts shall be maintained, so that they do not offset during casting, and pipe ends must be plugged against the ingress casting silt and ground.

A bolt template shall be used for fixing of the foundation bolts during concreting. Bolt threads that are not to be embedded shall be protected against concrete with tape or the like. The template is to be maintained until the concrete has hardened, so that specified tolerances are complied with. After removal of a template, the bolts must be fitted with the specified washers and nuts.

3.23.5 Foundation bolts, sheaths and templates

Foundation bolts and sheaths are mounted in such a way and deep enough to result in flowing in bolt before bolts or sheaths are pulled out of the foundation. A template shall be used for keeping foundation bolts or sheaths in place at the top during concreting to ensure the correct distance between them.

Holes in mounting frames, mounting bands and casting templates must not be more than 1 mm larger than the corresponding foundation bolts.

3.23.6 Ducts

Foundations which are used for traffic lighting or illuminated signs shall be provided with two 50 mm PE-ducts for introduction of electrical cables. The PE pipes are placed in the foundation so that the horizontal part of the pipes ends centrally between the foundation bolts. The horizontal part of the pipes shall be located so that the centre line is approx. 0.70 m below finally levelled ground level. Bending radius in the centre line between vertical and horizontal shall be no less than 250 mm.

The pipes shall be secured so they are not closed using concrete during concreting.

Due to the risk of frost damage, it must be ensured that water cannot accumulate in the pipes in the operational phase.

3.23.7 Concreting

Below the foundations, a blinding of 50 mm is concreted.

Concreting shall be carried out as soon as possible after the excavation and the associated clean-up of loose soil, water, etc. has been completed.

The concrete shall not be contaminated with soil falling down during concreting.

Covers shall be at least 50 mm.

Construction joints are not permitted.

The concrete is concreted in layers of 300-400 mm and compacted by vibration.

The foundation top excluding the plinth is completed 0.20 m below ground level and with a slope of 50 mm per meter. The top is smoothed into a plane and even surface free of potholes, burrs, sharp-edged holes and accumulated laitance.

Plinth shall be cast against a smooth mould with triangular strips along all edges. The plinth surface shall slope approx. 50 mm on all sides exiting the centre of the plinth.

After demoulding, all exposed concrete surfaces will be reviewed, and all burrs shall be cut off, and all moulding wounds and separated materials shall be repaired. Casting marks on visible foundations shall be chiselled off carefully.

All visible surfaces are smoothed into a plane and even surface.

Repairs of non-compliant surfaces may only be carried out according to the client's acceptance.

3.23.8 Prefabricated foundations

Prefabricated foundations can be used on the following conditions:

- Foundations shall be placed in soil-moist concrete or a level thin layer and compacted sand layer
- If there are embedded separate "discs", these may not be in contact with the reinforcement of the foundations
- Excavations for foundations shall have such a width that compression of the backfill can be carried out by a machine
- Compression of backfill shall comply with compression requirements for earth work, i.e. a 98% and 100% standard proctor, respectively.

3.24 Fill and restoration

Filling shall be made with excavated frictional material. The client may require that only some of the excavated materials are reused.

Soil, which is not suitable as backfilling material, must be disposed of/is exposed.

Filling shall be carried out in layers of no more than 0.20 m, and each layer shall to be compacted carefully with mechanical compression or the like.

Restoration of grass planted areas shall be made with a grass seed mix subject to prior acceptance by the client.

Paved areas, such as tiles, paving stone and asphalt, as well as unpaved areas, such as grass, shall be generally restored to the same condition as they were in when the work was commenced.

Top-soil covered areas shall be cleaned of stone > 30 mm and levelled.

All affected areas, including paved areas, shall be restored to the same appearance and condition as before the commencement of the works.

3.24.1 Surplus excavated material

In pursuance of the Act on Contaminated Soil, applicable from 1 January 2000, all soil from public roads is deemed as contaminated. Reference is made to the WEA notification no. 04.4.16 .

Surplus excavated material from excavation for foundations is to be considered as road soil. Road soil is defined as road support as well as soil and filling materials located between road side and road boundary.

Road soil, which will be cleared, shall be installed in a temporary storage. The location of surplus excavated material shall be agreed with the supervision.

The Contractor shall dispose all surplus excavated material. Executive Order no. 1427 of 4 December 2009 and Executive Order no. 1479 of 12 December 2007.

3.25 Mounting

3.25.1 Erection of poles/posts

Poles/posts bolted on a foundation shall be equipped with a foot plate, which must be perpendicular on the centre line of the post.

Poles/posts are adjusted in weight. If there is more than one post, these posts shall also flush horizontally before nuts are tightened to the required torque.

The deviation of poles/posts from plumb line may not exceed h x 0.002, where h is the height of the pole above ground level.

3.25.2 Grouting of base plates

If grouting of base plates is performed, such grouting shall be carried out as specified in the drawings or after pole supplier instructions.

3.25.3 Placing of signs

To prevent disturbing reflections, the signs should generally be turned approximately 3-5 degrees away from the norm to the road at the point of mounting, so that the norm to the sign surface falls outside the carriageway (to the right of the viewer), see Figure 13.

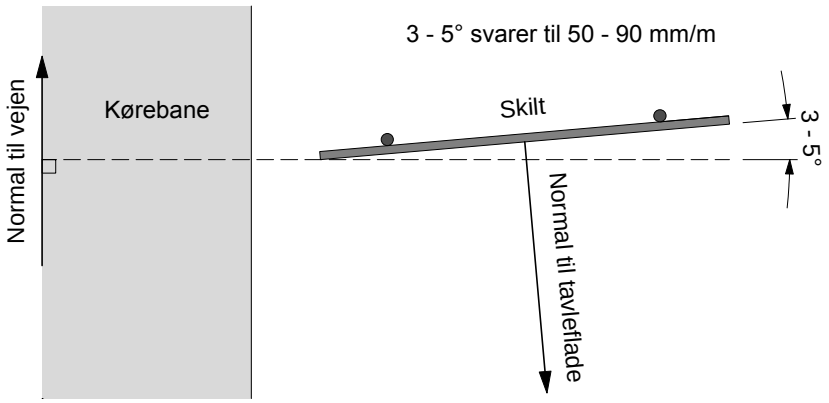

Figure 13 Location of the sign in relation to the carriageway.

For small and less detached signs which are spaced out in the same post, the signs shall be located with a distance of approx. 20 mm from one another, see Figure 14 . For small and small signs mounted in frame constructions such as curved hollow sections, pole with offset sign (gallows post) or pipe gallows, the dimensions stated for the construction type apply, see *Design, manufacturing and installation of road signs*.

Where more large signs are mounted on the same construction, they will normally be located with a distance of 50 mm, see Figure 15 . In certain cases, however, it may be necessary to increase the space between the signs due to the location of fixings. The distance must, however, never be greater than 100 mm.

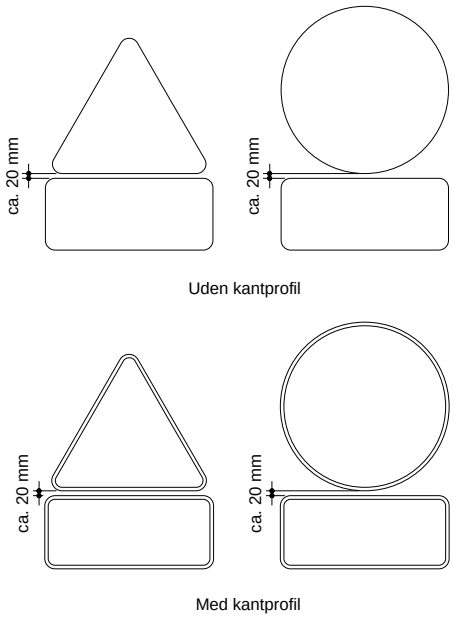

Figure 14 Distance between small detached signs which are spaced out on the same structure.

The signs normal location in the cross section is stated in the respective marking rules. Special conditions shall be taken into consideration at the site of mounting, such as sight conditions and the requirements for distances to fixed objects as set out in the road standards for Urban Traffic Areas and safety barrier.

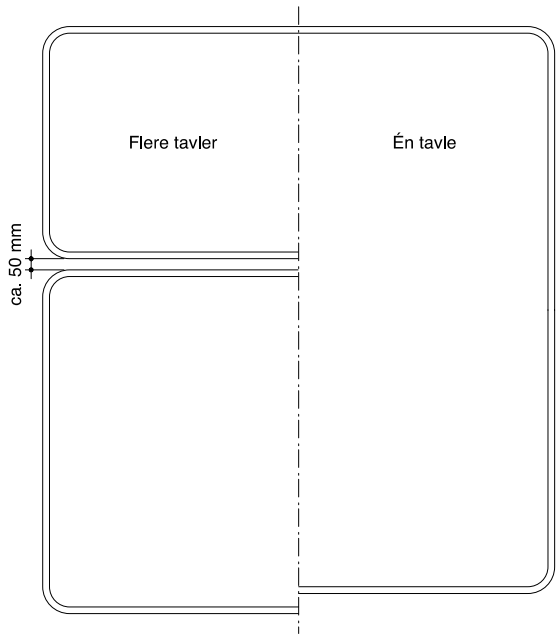

Figure 15 Distance between large signs which are mounted on the same structure.

The tops of signs shall always be horizontal regardless of grade of ground level and carriageway.

3.25.4 Changes to existing signs

See section 0.

3.25.5 Covering of signs

Full or partial covering of signs shall be made with a material which is opaque under all conditions, and which does not damage the surface of the sign.

Method for masking of signs shall be submitted to the client for approval. Acceptance does not relieve the Contractor of the responsibility regarding damage to the posts caused by covering.

3.26 Transportation

During transport and storage of equipment, the delivery shall be treated in a way ensuring that it is not damaged. This applies in particular to the surface dressing. Use of steel link chains is therefore not permissible.

For total transport, it shall be ensured that the individual parts are laid and/or wrapped in such a way that they cannot damage each other during the transport.

If, in the course of transport and mounting of signs damage is found, these must be registered with the aim of a later replacement of sign or repair depending on the extent and nature of the damage, see also section 0 for repair.

4 VERIFICATION, TESTING AND CORRECTION

4.1 Steel

See *Common to Road Equipment – GWS*.

4.2 Aluminium

See *Common to Road Equipment – GWS*.

4.3 Timber

See *Common to Road Equipment – GWS*.

4.4 Fibre-reinforced polymer composite

See *Common to Road Equipment – GWS*.

4.5 Plastics

On receipt, the Contractor shall check that the requirements set out in *Common to Road Equipment – GWS* are complied with if the plastic material is exposed to sunlight and/or outdoor weather effects.

4.6 Concrete

See *Common to Road Equipment – GWS*.

4.7 Hot-dip galvanising

See *Common to Road Equipment – GWS*.

4.8 Anodising

See *Common to Road Equipment – GWS*.

4.9 Pickling

See *Common to Road Equipment – GWS*.

4.10 Coating

See *Common to Road Equipment – GWS*.

4.11 Powder coating

See *Common to Road Equipment – GWS*.

4.12 Torque

See *Common to Road Equipment – GWS*.

4.13 Welding

4.13.1 Steel

The provisions of DS/EN 12899-1 are applicable for the production of stationary, vertical traffic signs.

4.13.2 Aluminium

The provisions of DS/EN 12899-1 are applicable for the production of stationary, vertical traffic signs.

4.14 Signs

4.14.1 Colours and foil

There must be no colour differences between the same sign constructions, which are visible when the sign is viewed in clear sunlight or in the dark, when the signs are illuminated, if observed from a distance of 10 m. Reflector foil shall be matched.

4.14.2 Visual verification at manufacturing

If, in the course of laying of foil(s) or a subsequent varnishing sign front scratches, air pockets, wrinkling or other accidental damage to foil or painting are detected, such damage shall be recorded with a view to rejection or repair depending on the extent and nature of the damage and type, see also section 0 on repair.

4.14.3 Visual verification on the expiry outlet

On the expiry outlet, visual verification of the sign must be carried out. It shall be checked:

- that there are no spots where retro-reflection by car lights differ significantly from the other surface or from a new material of the same type
- that there are no spots where the colour seen in daylight differs significantly from the other surface or from a new material of the same type
- that letters or symbols have not been bleached so that they appear significantly different from those in the new state.

4.14.4 Verification at expiry of the warranty

If it cannot be determined by means of visual verification whether the warranty for a sign is complied with, a measurement of coefficient for retro-reflection, colour coordinates and contrast between symbol and background shall be performed. It must be able to document:

- that the coefficient for retro-reflection at a divergence $\alpha = 0.33°$ and the angle of entry $\beta = 5°$ is at least 80% of the replacement requirements set out in
- Figure *3*, Figure 4 and Figure 5. This way, the value specified in Figure 16 is met to the effect that
- the relationship between the smallest and the largest coefficient for retro-reflection by a divergence $\alpha = 0.33°$ and the angle of entry $\beta = 5°$ within a solid colour area is no less than 0.6
- colour coordinates in daylight are within the areas specified in section0
- contrast ratio in daylight between symbols, clarity and the like in relation to the background is at least 1:2.

Type	White	Yellow*	Red*	Green*	Blue*	Brown*
3	34	24	6.6	4.8	2.0	1.0
4	57	40	11	8.0	3.4	1.7
5	115	81	22	16	6.8	3.4
* for serigraphic parts, however, only 70% of the specified values						

Figure 16 Minimum requirements for the coefficient for retro-reflection at divergence $\alpha = 0.33°$ and angle of entry $\beta = 5°$.

4.15 Marker posts

The Contractor shall check that marker posts colour corresponds to RAL no. 9003, and that reflector strips, reflective material, plates and kilometre plates are fixed to the marker post, as prescribed.

Marker posts with contained air pockets between marker post and foil shall be replaced within the warranty period.

4.16 Traffic island bollard

The Contractor shall check that reflector bands and reflective material are fixed to traffic island bollard, as prescribed.

4.17 Steles

The Contractor shall check that reflector bands and reflective material are fixed to the stele, as prescribed.

If the stele is detachable, it should be checked that this feature works as specified.

Steles with contained air pockets between stele and foil shall be replaced within the warranty period.

4.18 Bollards

The Contractor shall check that the reflector band and reflective material are fixed to the bollard, as specified.

If the bollard is detachable or raise/lower the type, it shall be checked that the function works as specified.

Bollards with contained air pockets between stele and foil shall be replaced within the warranty period.

4.19 Cable Trenches

The depth of the cable trench shall be subject to control measurement, and it shall be checked that cable duct level is even, and that at least 0.05 m of gravel is laid prior to laying out cables. After cabling it shall be checked whether gravel has been laid out approx. 0.10 m above the cables. It

shall be checked whether marker tape is laid out approx. 0.20 m above cable or marking plates approx. 0.10 m above cable depending on the planting depth, see portion0 .

4.20 Electrical work

The Contractor shall by checking of own work ensure that all cables and wires are safely fixed and relieved of tension.

In addition, the Contractor shall ensure that the plant is fully functional.

4.21 Location of posts/poles

Location of posts/poles shall be checked according section 0 .

4.22 Foundations

For each foundation, the Contractor shall check that the requirements for tolerances for the location have been met; see section0. For in situ cast foundations, the requirement for control of tolerances also applies to the location of reinforcing bars and embedded items.

The final levels of foundation tops and any distances between foundations shall be surveyed, and deviations from design drawings shall be submitted to the supervision, so that column and beam lengths as well may be adjusted before the manufacturing of their commencement.

4.23 Fill and restoration

It shall be checked whether compression of filling material is at least as good as the surrounding mass of soil so that settlement of filling material do not occur at a later date. It shall be checked whether re-establishment bears the cost of areas corresponding to the same condition as the surrounding areas.

4.24 Mounting

If damage is found in connection with installation, these shall be registered with the aim of a later replacement of damaged parts or repair depending on the extent and species.

5 DOCUMENTATION

5.1 Components with CE marking

As of 1 January 2013, all road signs covered by the provisions of DS/EN 12899 shall be CE marked. After that date, new road signs without a valid CE marking may not to be used. Pre manufactured concrete foundations shall be CE marked after DS/EN 14991.

Documentation of CE marking shall be submitted to the client.

5.2 Devices that do not carry the CE mark

See *Common to Road Equipment – GWS*.

5.3 Operation and maintenance

See *Common to Road Equipment – GWS*.

6 DIMENSIONING

Road signs shall be designed in accordance with the standards and guidelines set out. Any deviations from these standards and guidelines are subject to the acceptance of the Employer.

Any construction and/or structural element shall be documented by either calculation or testing.

6.1 Safety

As safety factors (partial coefficients) the following shall be used:

- Wind load 1.35
- Dynamic snow load 1.35
- Point load 1.0
- Dead weight 1.1

As partial coefficients of materials the following shall be used:

- Steel 1.05
- Aluminium 1.15
- Timber 1.35
- Composite materials 1.50
- Plastic 1.80

As shape factors for wind actions the following shall be used:

- Sign surfaces set up outside the carriageway area 1.2
- Sign surfaces set up above the carriageway area 1.6

Shape factors for other structural elements are determined in accordance with the instructions in DS/EN 1991-1-4.

Dimensioning will be in accordance with DS/EN 1990.

Stainless steel is dimensioned as steel.

6.2 Loads

6.2.1 Wind load

Wind loading shall be calculated in accordance with the instructions in DS/EN 1991-1-4. Wind speed 24 m/s shall be used as reference. In areas in Jutland with sites located less than 25 km from the North Sea and the Ringkøbing Fjord, the reference speed of 27 m/s shall be used.

Road signs exclusive sign portals shall be designed for a 25 years design period.

Sign portals shall be designed for a 50-year design period.

Normally, site category II is used as design basis. On moorland plains, at lakes and other similar flat stretches of land, site category I shall be used, and near the sea and coastal areas exposed from open sea, site category 0 shall be used as design basis.

In the area where switch is made from one site category to the other, interpolation may be made in connection with dimensioning, as described in DS/EN 1991-1-4.

As a starting point, site category II shall be used.

If dimensioning according to the classes set out in DS/EN 12899-1, table 8, is to be applied, the values in Figure 17 may be used as a guide. The wind classes in Figure 17 do not apply to overhead signs.

Distance from ground level to centre of the sign Site category I	Wind load class
< 1.75 m	WL2 (0.60 kN/m^2)
< 5.40 m	WL3 (0.80 kN/m^2)
< 9.15 m	WL4 (0.90 kN/m^2)
< 15.00 m	WL5 (1.00 kN/m^2)

Distance from ground level to centre of the sign Site category II	Wind load class
< 4.00 m	WL2 (0.60 kN/m^2)
< 10.90 m	WL3 (0.80 kN/m^2)
< 17.40 m	WL4 (0.90 kN/m^2)

Figure 17 Wind load classes according to DS/EN 12899-1:2007.

Wind loadings to the individual classes in Figure 17 are without partial coefficients and form factors. The specified distance from ground level to the centre of the sign is based on a 25 years design period.

For the calculation of deformations, a 1-year design period for wind load shall be used (not applicable to sign portals). For the calculation of deformation for overhead signs, a 25-year design period for wind load shall be used.

At torsion affected structures, a horizontal eccentricity of 10% of the wind load shall be calculated.

6.2.2 Snow load

Dimensioning for snow loads is subject to DS/EN 12899-1.

Choice of class is determined on the basis of the following:

- Distance from pavement or snow removal limit to the nearest sign edge (d), see Figure 18
- Speed of snow removal vehicles (for the majority of roads, the snow removal speed is less than or equal to 60 km/h).

The entire structure including foundation shall be dimensioned by the horizontal impact of the snow load.

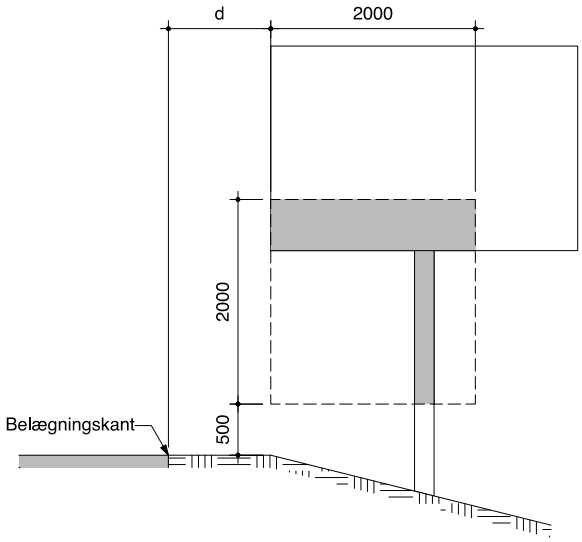

Figure 18 The part of the structure which is located in the selected field of 2000 x 2000 mm shall be subjected to a maximum load from the snow load, see Figure 19.

Distance	Speed of removal vehicle	
m	≤ 60 km/h	> 60 km/h
d < 3.5	2.5 kN/m^{2} = DSL 2	4.0 kN/m^{2} = DSL 4
3.5 ≤ d < 5.0	1.5 kN/m^{2} = DSL 1	3.0 kN/m^{2} = DSL 3
5.0 ≤ d < 6.0	-	2.5 kN/m^{2} = DSL 2
6.0 ≤ d < 7.0	-	1.5 kN/m^{2} = DSL 1

Figure 19 Values for snow load pressure according to DS/EN 12899-1:2007, table 9.

6.2.3 Point load

Requirement for dimensioning of point load shall only be used for signs which can be expected to be subject to vandalism. The point load classes are defined in DS/EN 12899-1:2007, table 10.

In the dimensioning of the actual point load, the other loads shall not be included in the calculation.

6.3 Deformations

All loads in connection with deformation requirements are characteristic and apply in their installed state.

6.3.1 Temporary deformations, bending

The maximum permissible temporary deformation for equipment exposed to bending in accordance with DS/EN 12899-1:2007, table 11, is as follows:

- Steel structures class TDB3
- Other structures class TDB4.

6.3.2 Temporary deformations, torsion

The maximum permissible temporary deformation for equipment exposed to torsion in accordance with DS/EN 12899-1:2007, table 12, is as follows:

- Steel structures class TDT3
- Other structures class TDT4.

6.3.3 Permanent deformations

No permanent deformation of plant/equipment is permitted other than slippage between bolted or riveted joints, until bearing contact is obtained. For construction of a physical test, the theoretical contribution of slippage in joints to the measured permanent deformation shall appear.

6.4 Calculation

6.4.1 General

Stationary, vertical traffic signs shall be calculated in accordance with the instructions in DS/EN 12899-1.

Calculations of other structures shall be made in accordance with the electricity theory and shall be documented by means of a calculation report, which, as a minimum, shall contain the following:

- Calculation assumptions
- Specification including drawings of all structural elements
- Calculation model
- Calculation of critical sections and joints
- Calculation of deflection
- Comparison of the results with claim/specifications.

6.4.2 Steel

Steel structures shall be calculated in accordance with DS/EN 1993-1-1 and DS/EN 1993-1-5 for plated structures.

6.4.3 Aluminium

Design of aluminium structures shall be calculated in accordance with DS/EN 1999-1-1.

6.4.4 Timber

Design of timber structures shall be calculated in accordance with DS/EN 1995-1-1.

6.4.5 Fibre-reinforced composite materials

Structures of fibre-reinforced composite material shall be calculated in accordance with Structural Design of Polymer composites - EUROCOMP Design Code and Handbook.

6.4.6 Plastics

Calculations shall be carried out in accordance with elasticity or plasticity theory depending on the application for plastic material with reference to relevant standards. Method of calculation shall be submitted to the client's acceptance.

6.4.7 Concrete

Concrete structures shall be calculated in accordance with DS/EN 1992-1-1.

6.4.8 Foundation

Foundations shall be designed according to DS/EN 1997-1.

It is permitted that foundations for or foundation of road signs installed on the side of the road are dimensioned in accordance with the guidelines set out in Bulletin No. 12 from the Danish Geotechnical Institute published in 1963, or in similar literature on the use of active and passive earth pressure.

In the design of foundations for road signs, which shall be mounted above road cadastral and by the use of active and passive earth pressure, it shall be taken into account that the foundations and, thus, also the columns may obtain a less angular rotation before the passive earth pressure is developed. The partial coefficient on the moving load (wind load) shall therefore be increased from 1.35 to 1.5 in the calculation of this type of foundations.

In the calculation of foundation, soil and groundwater conditions at the site of mounting shall be used as a basis.

As a starting point, it shall be assumed that the groundwater is below foundation level.

The following values for soil parameters shall be used in the calculation:

- Effective angle of friction φ' = 32°
- Density soil γ_j = 18 kN/m^3.

Partial coefficient for angle of friction: γ_φ = 1.25. The partial coefficient applies to tan φ'.

6.5 Testing

Testing can be carried out in exceptional cases instead of a calculation.

The test report shall contain at least the following points:

- Calculation of loads for use in the testing
- Specification including drawings of all parts with an indication of which parts to be tested
- Specification of test display
- Specification of methods for the registration of test results
- Comparison of test results with claims/specifications.

The client reserves the right to accept the test report before delivery of the structure takes place.

6.6 Documentation

Upon request to that effect, calculations and test reports shall be submitted to the client.

The client reserves the right to accept calculation reports before the contract is accepted as compliant.

The client reserves the right to accept the prepared test reports before the contract is accepted as compliant.

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