

**GUIDELINES FOR ROAD DESIGN,
CONSTRUCTION, MAINTENANCE AND
SUPERVISION**

Volume I: DESIGNING

Section 2: DESIGNING BRIDGES

DESIGN GUIDELINES (DG 1.2.3)

Part 3: RAILINGS AND BARRIERS ON BRIDGES

INTRODUCTION

Railings and barriers are an essential constitutive part of bridge equipment to protect pedestrians, cyclists and vehicles crossing the bridge as well as to protect the space below the bridge.

Moreover, railings and barriers are significant architectural elements influencing the aesthetic appearance of bridges.

Railings and fences shall be designed in such a way that uniformity is achieved before as well as on the bridge regarding the purpose, structure, material and appearance, what essentially influences the traffic safety.

The best solution of a railing and/or a barrier is achieved when a driver does not perceive the moment he commences to drive across the bridge. This is particularly significant for shorter bridges.

Uniform solutions of railings and barriers shall be worked out for certain road routes.

Together with the design guidelines DG 1.2.1 and DG 1.2.2, the present design guidelines DG 1.2.3 represents a structural integrity with regard to the design of railings and barriers.

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1. SUBJECT OF DESIGN GUIDELINES

The intention of the present design guideline is to define in a systematic and an up-to-date manner the solutions of railings and barriers on bridges by their sense, clearance, dimensions, and material.

The design guideline gives integral information to designers, contractors and clients, and prevents eventual unsuitable solutions of railings and barriers

2. REFERENCE REGULATIONS

- Steel safety barriers JUS U.S4.104 and JUS U.S4.110
- Slovenian standard TSC 07.102 Edge beams, kerbs and walkways on bridges, 2001
- RAS-L Guidelines for road equipment, 1995 (*Richtlinien für die Anlagen von Straßen*)
- RAS-Q 96 Guidelines for road equipment, 1996 (*Richtlinien für die Anlagen von Straßen*).

3. EXPLANATION OF TERMS

Metal railing for pedestrians is a bridge equipment element that protects pedestrians against falling from the bridge.

Steel safety barrier is a bridge equipment element that protects vehicles against falling from the bridge.

Concrete safety barrier is a bridge equipment element that protects vehicles against falling from the bridge.

Noise barrier protects the area along the bridge from noise caused by vehicles on the bridge.

Protective barrier is a bridge element that protects the motorway/highway below the bridge.

Protective mesh is a filling element of the protective barrier.

Buffer is a formed elastic steel plate being the basic element of steel safety barriers.

Spacer is a steel safety barrier element that absorbs a portion of the vehicle impact force at the transition from the buffer to the pillar.

Pillar is a steel safety barrier element that takes the vehicle impact force and transfers it to the bridge structure.

Railing expansion joint is a part of the railing structure that enables temperature expansion of the railing elements.

Handrail is an element of steel railings or steel safety barriers that retains pedestrians on the bridge.

Railing filling element is a vertical element located between the handrail and the lower tube of the railing.

Anchoring of railing or safety barrier enables taking and transferring of horizontal force from the handrail or buffer via banister or pillar to the bridge structure.

Anchor plate is a constructive element of anchoring the pillars of steel safety barriers into the concrete.

Anchors are constructive elements of anchoring the pillars of steel safety barriers into the concrete.

4. GENERAL INSTRUCTIONS

4.1 The design of railings and barriers depends on their purpose, position in the bridge cross-section, and material.

4.2 With respect to their purpose the following types of railings and barriers can be distinguished:

- Railings for pedestrians;
- Barriers for vehicles and pedestrians;
- Barriers for vehicles and maintenance crew;
- Barriers for vehicles;
- Noise and wind barriers.

4.3 With regard to their position on the bridge load bearing structure the following types of railings and barriers can be distinguished:

- Railings and barriers on bridge edge beams for protection of pedestrians or of both pedestrians and vehicles;
- Railings and barriers on walkways at traffic lanes for protection of vehicles as well as for protection of pedestrians from vehicles;
- Railings and barriers in the motorway central reserve for protection of vehicles and maintenance labour;

- Railings at edges of maintenance stairways.
- 4.4** With respect to the material the following types of railings and barriers can be distinguished:
- Metal railings and barriers (steel, stainless steel, aluminium);
 - Reinforced concrete railings and barriers;
 - Wooden railings and barriers;
 - Stone railings and barriers.
- 4.5** On motorway bridges as well as new bridges on main and regional roads, exclusively metal and reinforced concrete railings and barriers are used. Stone or wooden railings and barriers are recommended for urban bridges, for older bridges to be repaired, and in special landscaping conditions.
- 4.6** The design and application of stone and wooden railings and barriers conditioned by the bridge structure and the landscape architecture have plenty of particularities thus not being subject of the present design standard. In our opinion, any uniformity of railings and barriers would restrict the creativity and possibility of designing of each individual case. An essential condition for stone and wooden railings and barriers is, among others, to ensure safety and protection of both pedestrians and vehicles.
- 4.7** For railings and barriers for all purposes and of all materials the following shall be specified in the design:
- Purpose and position of the railing/barrier with regard to effective areas in the bridge cross-section;
 - Length of the railing/barrier on the bridge;
 - Solution of the railing/barrier ends and of connection of the railing/barrier on the bridge with that on the road respectively;
 - Railing/barrier height;
 - Method of railing/barrier anchoring.
- 4.8** The purpose and position of the railing or barrier are defined in the characteristic cross-section of a bridge and indicated in the DG 1.2.2 which comprises solutions of edge beams, kerbs and walkways with types and positions of railings and barriers in accordance with the DG 1.2.1 referring to the clear profiles and widths of road bridges.
- 4.9** The structure of railing or barrier shall be simple for fabrication, installation, maintenance, and replacement.
- 4.10** The length of a railing/barrier is generally equal to the bridge length including the length of parallel wing walls. Are on a bridge oblique or rectangular wings, the length of the railing/barrier is greater than that of the bridge. It is determined with regard to the height of the fill at bridge, to the length of the access ramps, and to the solutions of the railing/barrier on the road next to the bridge.
- 4.11** The solution of the barrier ends essentially influences the traffic safety and depends on the purpose and position of the barrier as well as on the solution of the barrier on roads next to the bridge. Both the barrier on the bridge and on the road shall be harmonized in plan and height. For the motorways it is desirably that also the barrier type is harmonized in view of its purpose, material and design solution (steel safety barrier or concrete safety barrier continue on the bridge as well).
- 4.12** The method of anchoring or the connection of the railing/barrier with the bridge load bearing capacity is essential for the safety of vehicles and pedestrians on the bridge as well as below it.
- 4.13** The height of all types of railings and barriers shall not be below the specified value. In special conditions greater heights are possible (urban bridges, high viaducts, a total protection of the environment from overturning of vehicles such as tank lorries, multi-story bridges, out-of-level crossings).
- 4.14** The proposed and worked-out structures of metal railings for pedestrians, steel safety barriers, concrete safety barriers and protective barriers are up-to-date, modified and approved in the practice. The solutions are adapted to available materials, fabrication, installation, protection, maintenance, and replacement. Designers and contractors are free to offer different solutions, however only

within the requirements and dimensional restraints given in the present design guideline DG 1.2.3.

- 4.15** In case of illuminated bridges it is mandatory to harmonize the solution of the railing with the solution of the public lighting posts. The latter can be placed and anchored in the plane of the outer railing for pedestrians or in the plane of the inner protective barriers. It is also possible to place and anchor the posts on the widened parts of the edge beams out of the plane of the pedestrian railing. The selection of the most appropriate solution depends on the length and purpose of the particular bridge, on the height and arrangement of the posts, on the required illumination, on the solution of the lighting on the road next to the bridge as well as on the regional and town planning conditions.
- 4.16** Noise or wind barriers can be installed on road bridges. Their necessity, height and position shall be specified in the road design.
- 4.17** The materials for standard railings and barriers (steel, concrete, steel reinforcement, protective coating, etc.) shall fulfil the requirements of valid regulations and codes.
- 4.18** No reduction of dimensions of standard railings and barriers as well as of their elements, which might affect the safety and bearing capacity, is permitted.
- 4.19** All non-standard types of railings and barriers shall be verified by appropriate design calculations.
- 4.20** The drawings of railings and barriers shall, among others, comprise the plan and the longitudinal section of the particular bridge, including the railings/barriers and the arrangement of expansion joints. The latter depend on the position of the bridge expansion joints, on the railing expansion length, on the railing type, and on the length of the railing prefabricated elements.

5. METAL RAILINGS FOR PEDESTRIANS

5.1 Introduction

- 5.1.1** In the figures 5.2 – 5.4 design solutions, dimensions and details of some common standardized metal railings for pedestrians are presented.
- 5.1.2** In the upper part of the figures, a portion of the bridge cross-section is presented indicating the position of the railings for pedestrians, which depends on the solution of the edge beams in accordance with the DG 1.2.2.
- 5.1.3** All pedestrian railings are 1.10 m high and consist of tubular or rectangular metal profiles and vertical or vertical and horizontal filling elements.
- 5.1.4** The railing for maintenance crew shown in the figure 5.4 is 1.0 m high and made of horizontal filling elements. It is intended for a safe approach of the labour onto the bridge as well as to the bridge surrounding.
- 5.1.5** In the figure 5.5 three details of railing anchoring are presented. The details A and B have an equal conical opening of Φ 17 cm on top and of 22 cm depth. The opening is reinforced with a spiral. In the edge beam concrete openings are made. After completion of the railing anchoring, those openings are filled up with concrete, whereas the upper layer of approx. 2 cm with epoxy mortar.
- 5.1.6** To enable dewatering of the hole for anchoring the railing banisters in accordance with the detail A, a pipe of Φ 18 mm is foreseen. Such a detail is applied in case that the railing is not carried through in the same construction season than the edge beams.
- 5.1.7** The detail D does not comprise any dewatering pipe. In the part of the banister above the edge beam, an opening of Φ 20 mm is left serving for draining the condensed water from the tubular handrail. It is also possible to fill up the banisters with concrete, whereas the openings for draining the condensed water are left on top of the banisters.

Anchoring of banisters of the metal railing according to the detail C foresees that the anchor plate is extremely accurately built-in during concreting of the edge beams. After completion of railing building-in, a weld of 4 mm thickness is executed on the joint banister – anchor plate.

5.1.8 In the figure 5.6, details of a metal railing made of tubes or rectangular profiles are presented. The detail A shows a joint of two railings. The internal part of the tube of minimum length of 50 mm serves to carry through a quality butt weld. In the detail B, the railing expansion joint is located next to the banister. The internal profile of minimum length of 150 mm is welded to one part of the railing only.

5.1.9 In the figure 5.7, a standardized detail of anchoring the public lighting post is shown. The required space for anchoring is obtained by widening the edge beam by 35 cm at the length of $50 + 2 \times 35$ cm. The position of the posts does not coincide with the railing banisters, which is favourable. The diameter (number) and the length of anchors are particularly dependent on the height of the posts and shall be determined in the design calculation.

5.1.10 In accordance with the British Standard BS 5493, hot dip galvanizing should ensure a quality corrosion protection in polluted or coastal atmosphere for a period of at least five years. The following conditions shall be fulfilled:

- Thorough leaching and neutralization;
- Hot dip galvanizing in a thickness of 85 μm ;
- Access of melted zinc to all surfaces shall be ensured;
- Extremely careful transportation and installation;
- No welding after galvanizing is allowed.

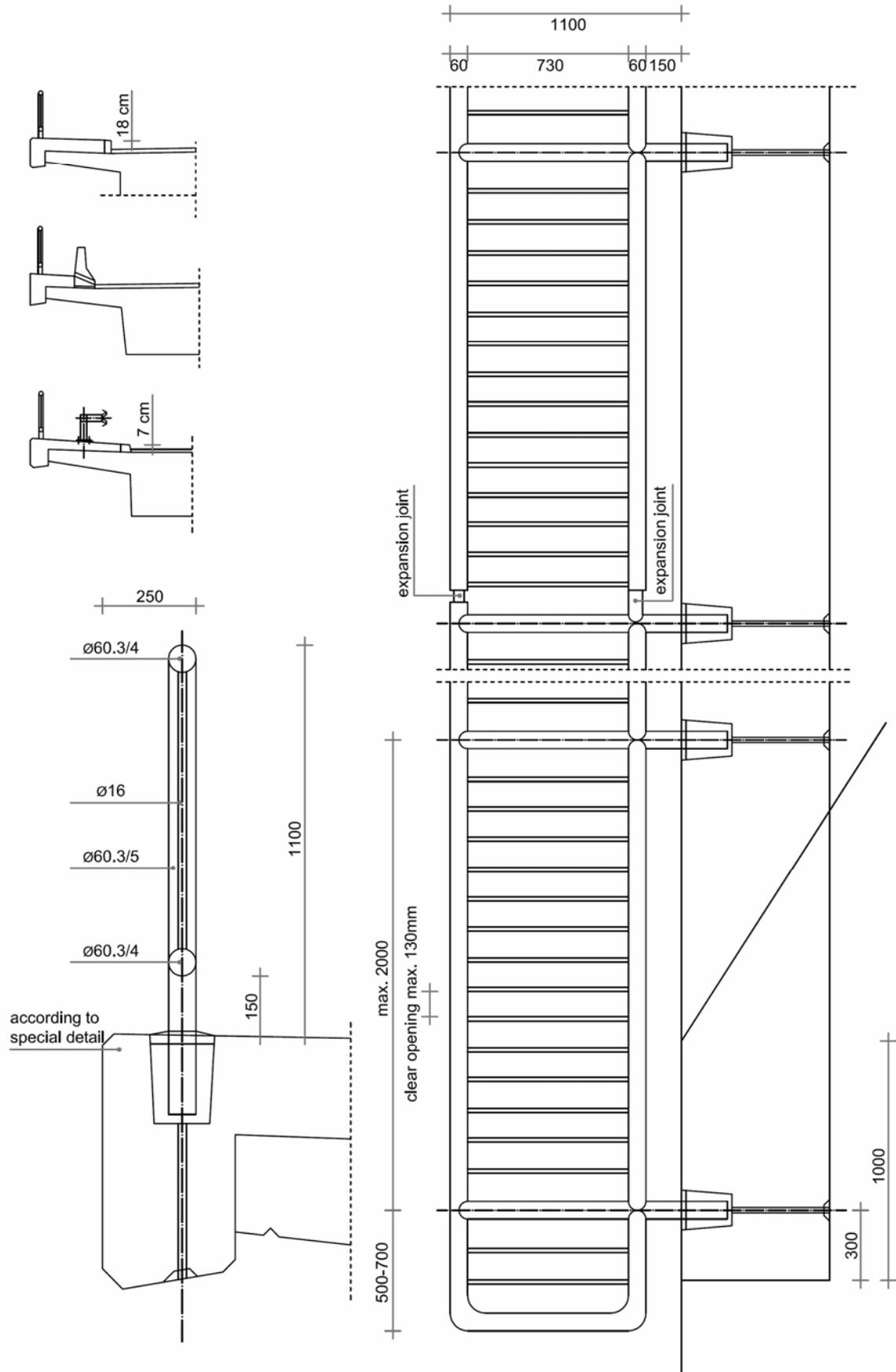
5.1.11 Alternatively to the hot dip galvanizing procedure, a quality corrosion protection can be achieved by application of protective paint coats. This is particularly recommendable in cases when field welding is foreseen and when damages of the zinc coat cannot be avoided during the transportation and installation. Paint coats are also advantageous because

the client can select any colour shade of the final coat.

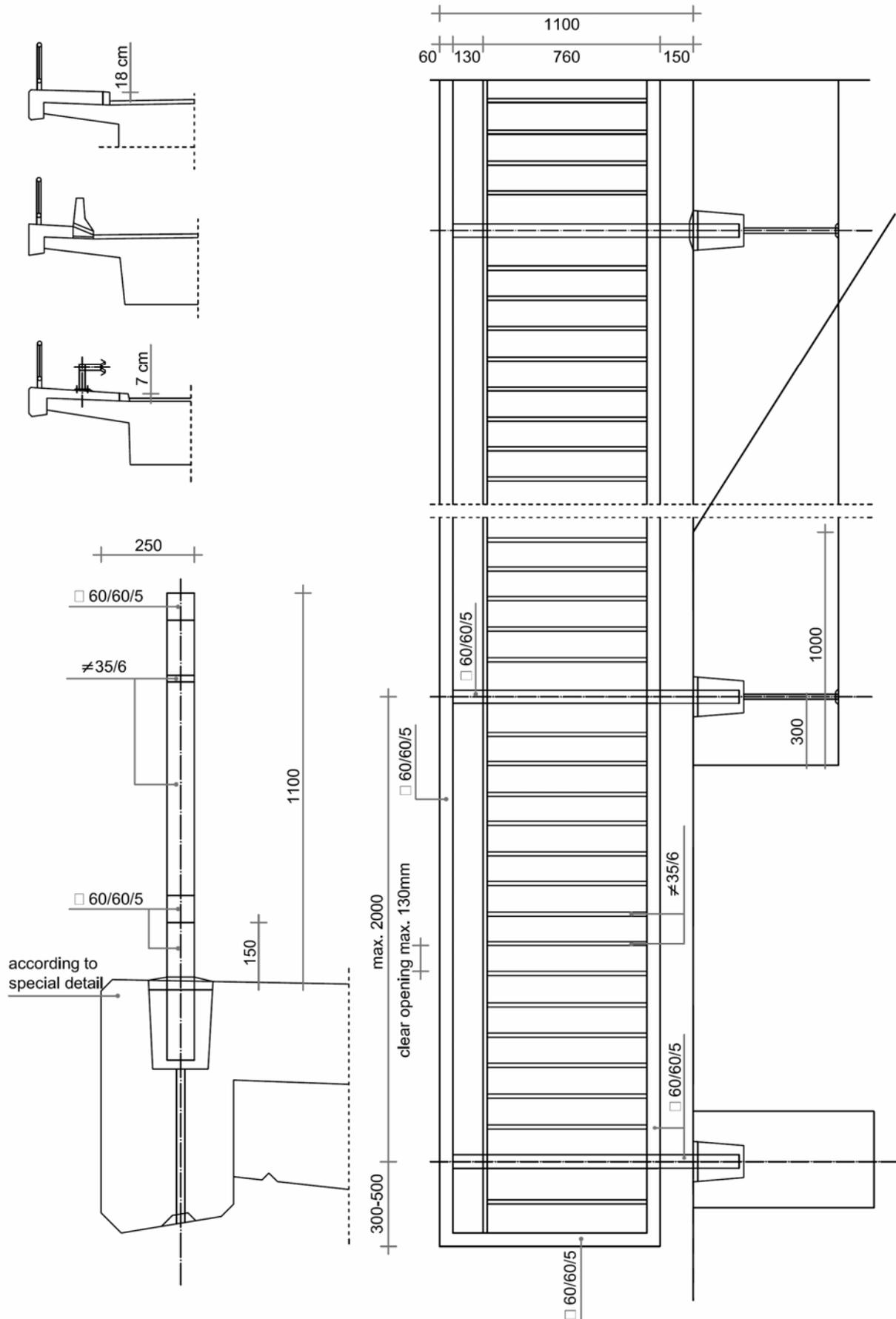
5.1.12 Corrosion protection system recommended for steel railings in polluted or coastal atmosphere for a period of minimum five years up to the first maintenance is the following:

- In the workshop: blast cleaning to minimum degree of SA 2,5 in accordance with the SIS 055900, 1 x epoxy priming coat in a minimum dry film thickness of 75 μm , 1 x epoxy intermediate coat with the MIOX-pigment in a minimum dry film thickness of 125 μm ;
- After installation on site: touching-up of all damaged and welded areas with the same paint coats and in the same minimum thicknesses than in the workshop; application of a polyurethane top coat of the specified colour shade and in a minimum dry film thickness of 50 μm .

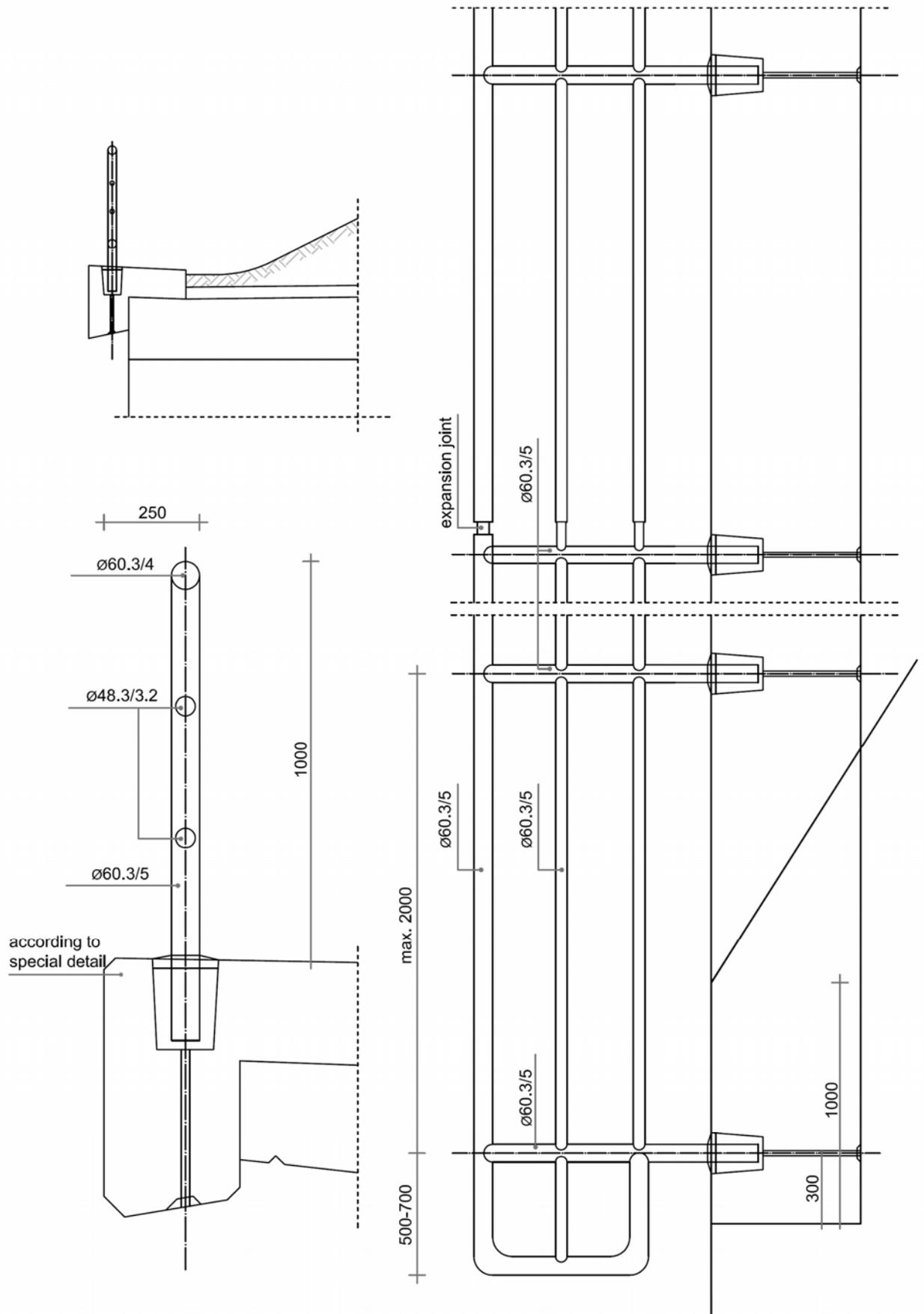
5.2 Tubular railing with vertical filling elements



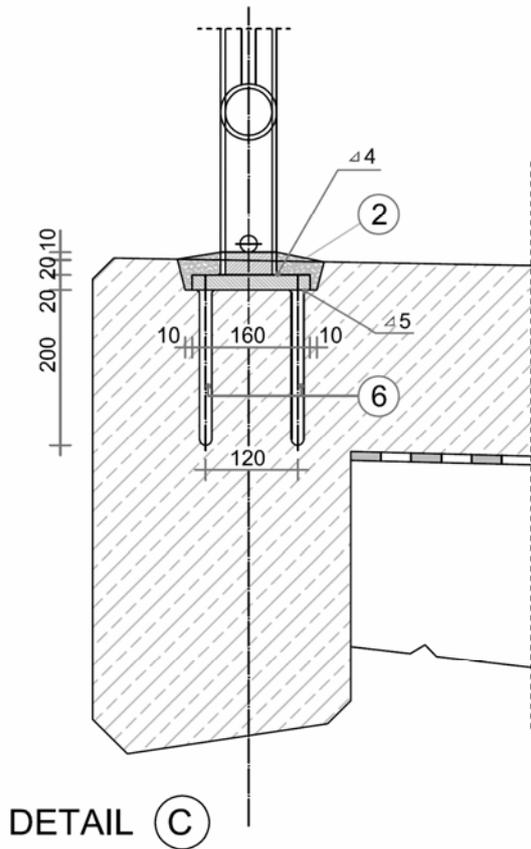
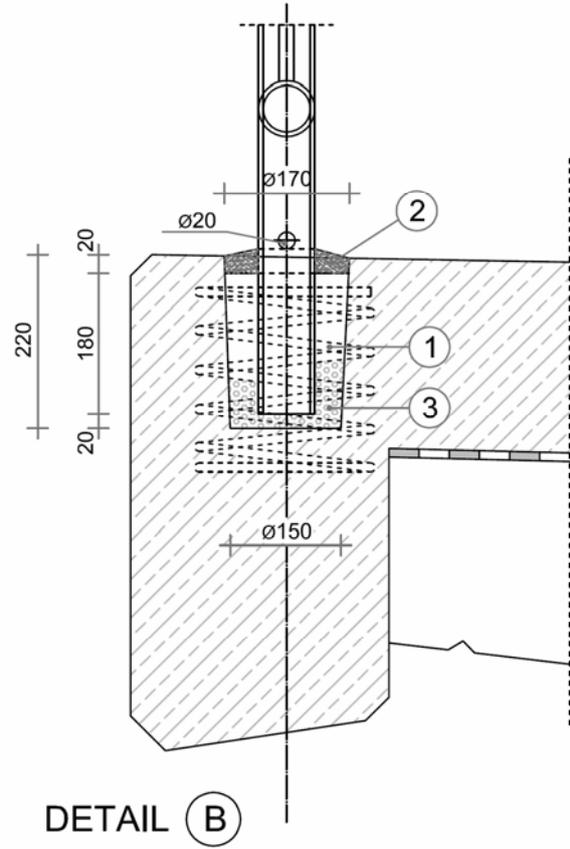
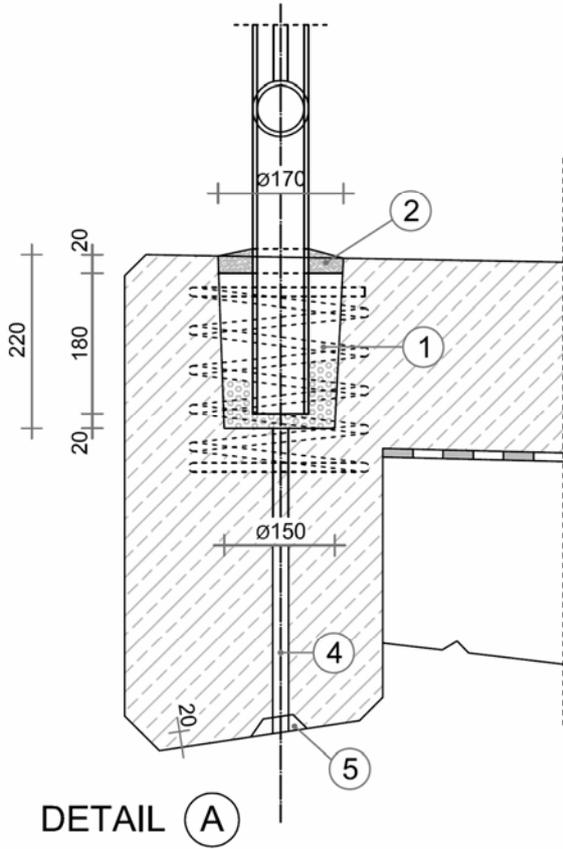
5.3 Railing with rectangular vertical and horizontal elements



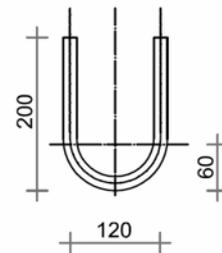
5.4 Tubular railing on bridges below fills



5.5 Detail of banister anchoring

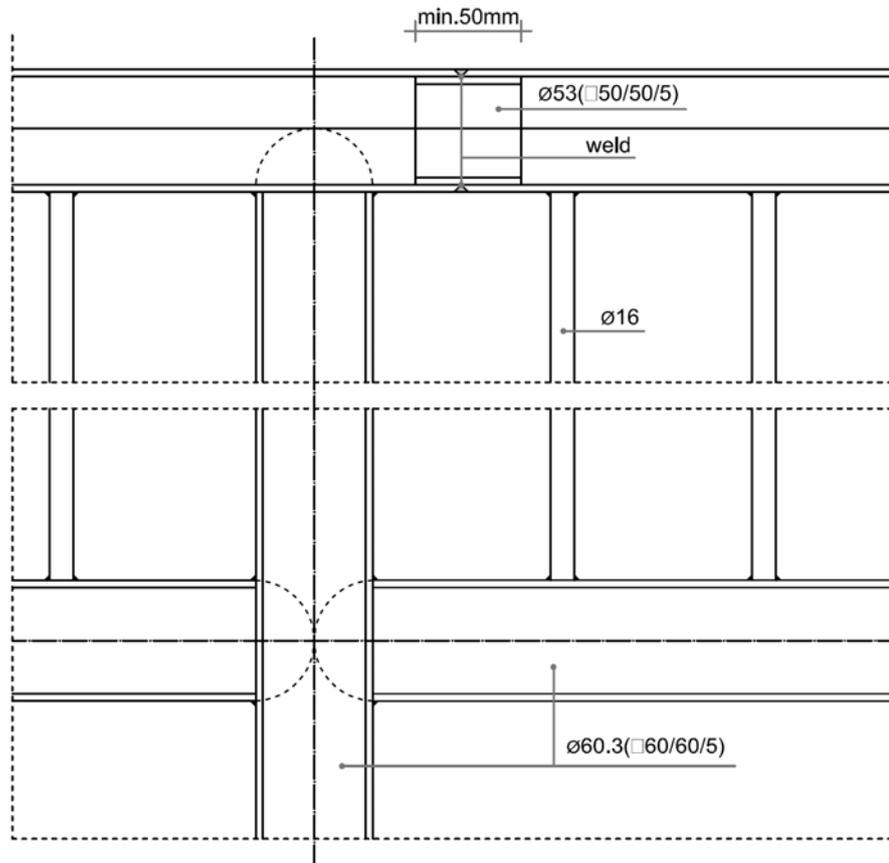


- ① Spiral reinforcement built-in in edge beam
 $\varnothing 10$, GA, D=250, s=50, L=225mm
- ② Epoxy mortar
- ③ Filling concrete
- ④ Dewatering pipe $\varnothing 18$
- ⑤ Groove $\varnothing 80/20$ mm
- ⑥ Anchors 2 $\varnothing 16$, l=460mm

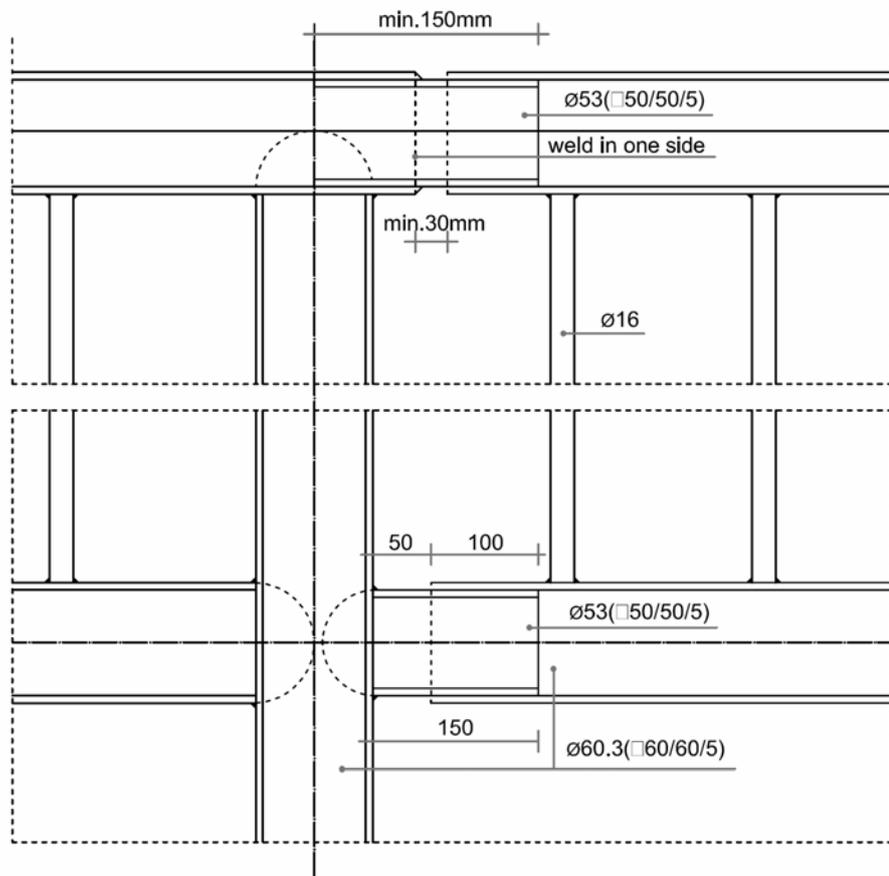


5.6 Expansion joint detail and connections of railing elements

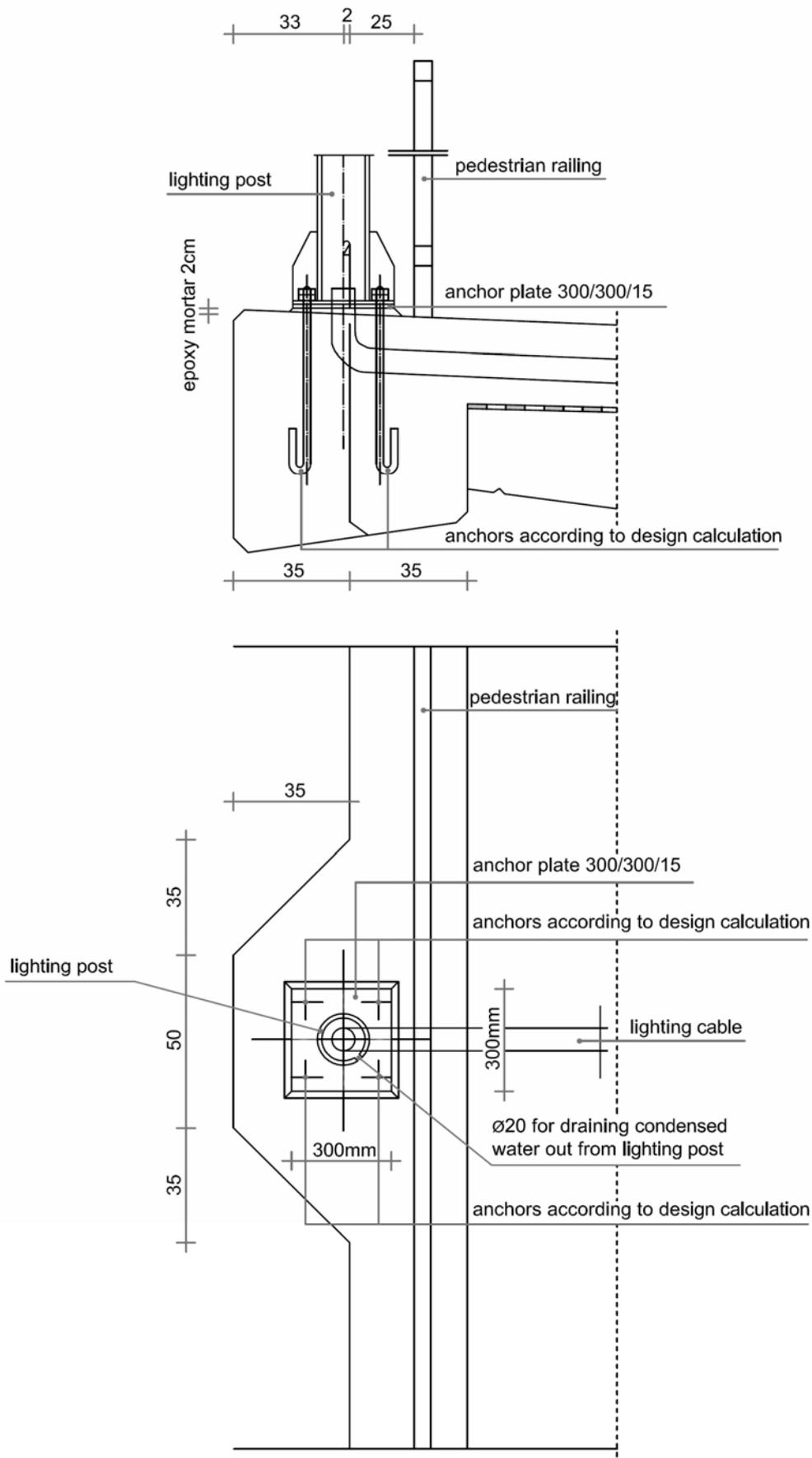
DETAIL A
Connection



DETAIL B
Expansion
joint



5.7 Detail of public lighting post anchoring



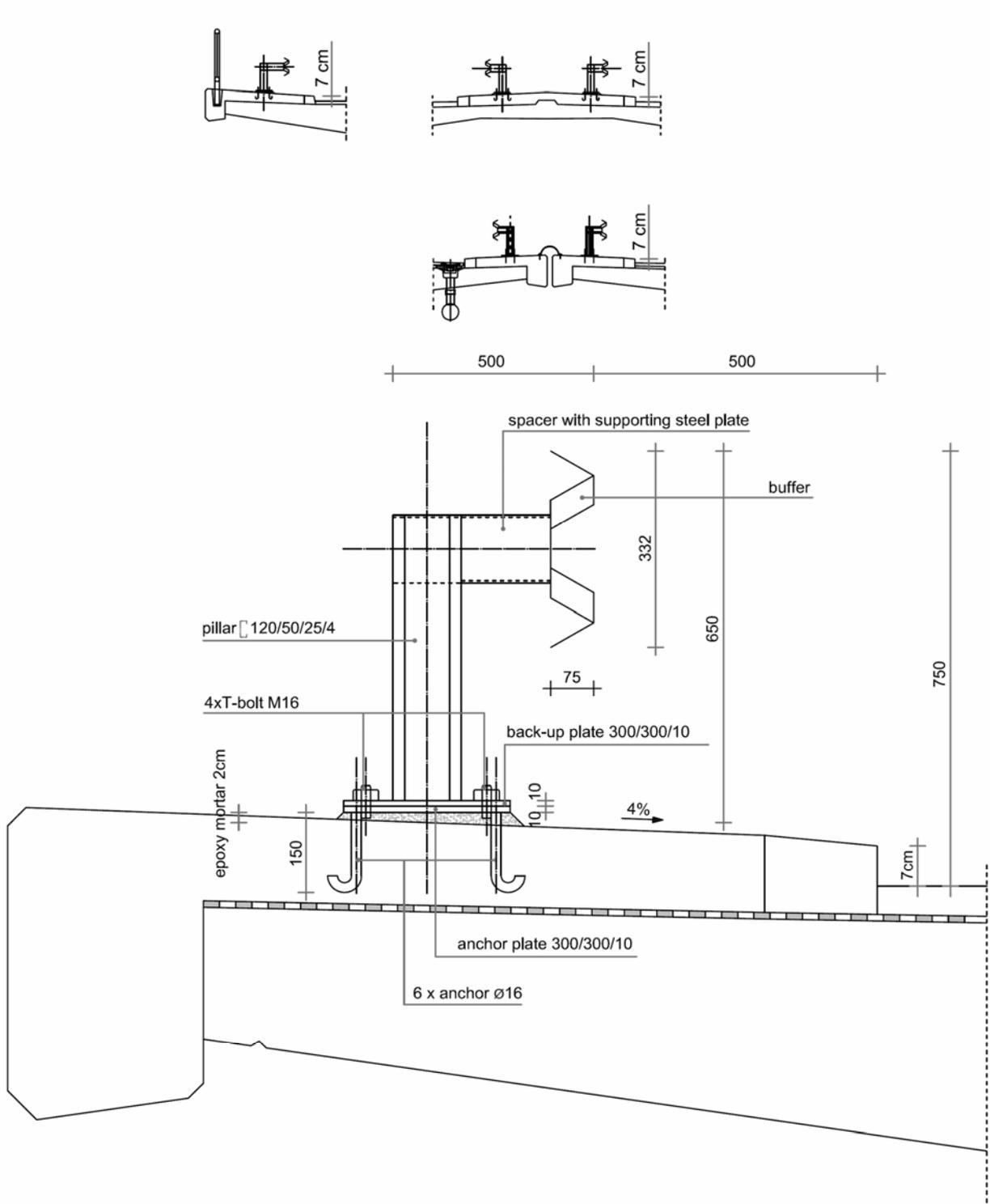
6. STEEL SAFETY BARRIERS

6.1 Introduction

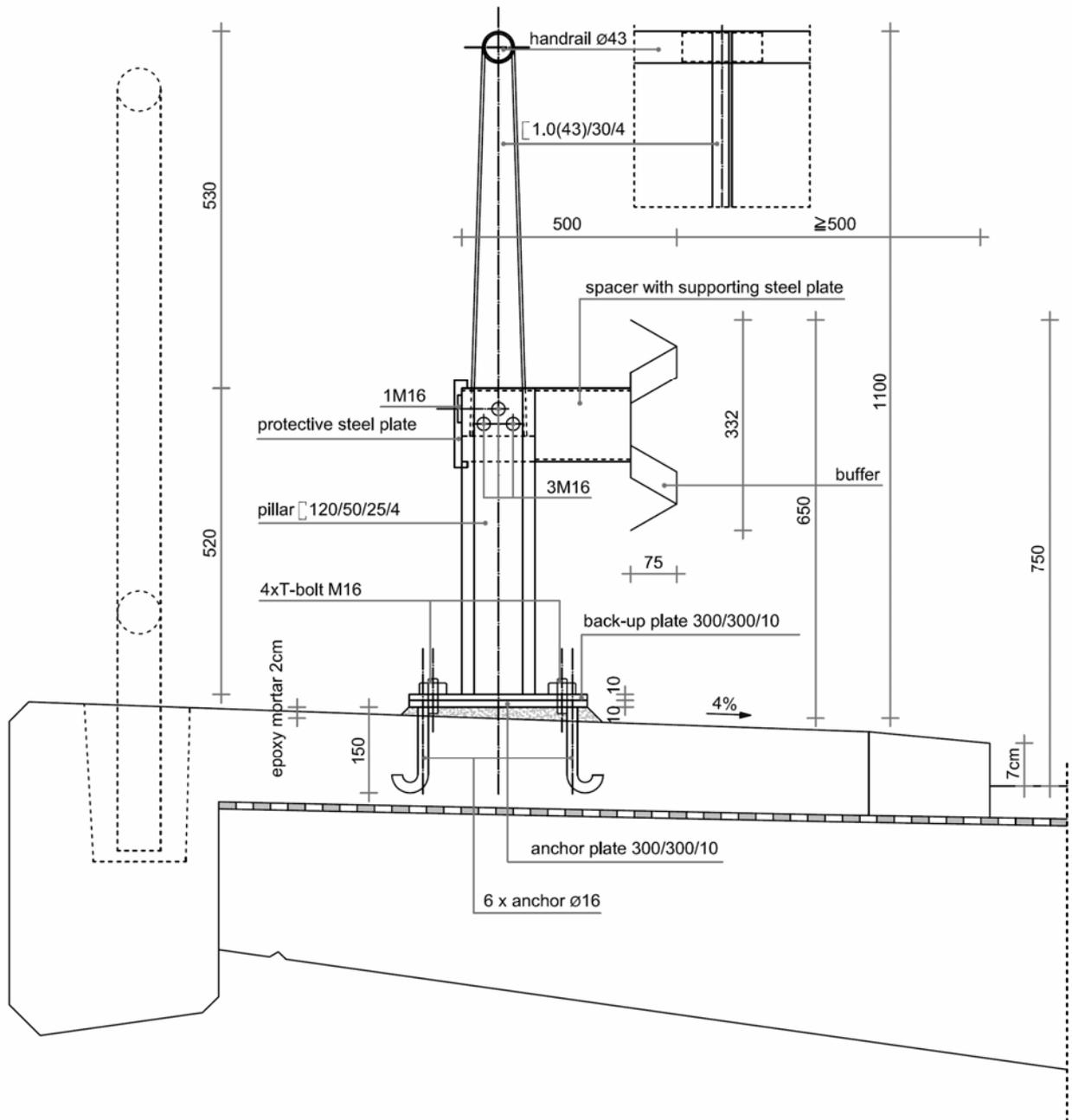
- 6.1.1** Steel safety barriers serve especially for protection of vehicles on the edge parts of bridges or on the motorway central reserves, all in accordance with the solutions of edge beams, kerbs and walkways presented in the DG 1.2.2.
- 6.1.2** Before the steel safety barriers were extensively introduced to roads and road bridges, theoretical and practical investigations had been carried through serving to optimize and adjust the solutions as well as to confirm their effectiveness and safety.
- 6.1.3** In the upper part of the figures, a portion of the bridge cross-section is presented indicating the position of the barriers/railings, all in accordance with the solutions given in the DG 1.2.2.
- 6.1.4** A steel safety barrier consists of a buffer, pillars, a spacer with supporting steel plate, an anchor plate, and anchor bolts with nuts.
- 6.1.5** Steel safety barriers are generally placed in such a way that the buffer upper edge is approx. 75 cm above the carriageway edge level. The same height of the safety barrier on the carriageway edge is also kept on the bridge at tolerances of ± 3 cm. As the carriageway is on the bridge with a raised edge beam, the height difference between the buffer upper edge and the edge beam surface amounts to 65 cm.
- 6.1.6** The length of buffer elements amounts to 4,200 mm. The joints are located at spacing of 4,000 mm. The overlapping length is 200 mm thus preventing an opening of the barrier. The connection on these joints shall be strong enough to ensure the load transfer from the buffer to the neighbouring pillars in case of a failure of the particular pillar. In this case, the buffer transfers the vehicle impact force as a link chain to other pillars. For connections bolts with lens-shaped heads shall only be used.
- 6.1.7** The spacing of adjacent pillars of a steel safety barrier amounts to 4.0 m (2.0 m) on roads, 2.0 m on transitions from roads to bridges, and 1.333 m (1.334 m) on bridges. The spacing of steel safety barrier pillars on bridges is shown in the figure 6.5.
- 6.1.8** For a simultaneous protection of both vehicles and pedestrians on bridge edges, a typified steel safety barrier is raised by an additional element consisting of pillar extensions and a handrail. In this way not only vehicles but also the maintenance crew and a minor number of pedestrians are protected on shorter bridges.
- 6.1.9** In the figure 6.2 a single steel safety barrier on the walkway of the outer edge or on the motorway central reserve is shown. The buffer top is 650 mm above the anchoring level. A standardized spacer with a supporting steel plate gives a barrier width of 360 mm (335 mm) being common for the Slovenian roads. Spacers of an increased width of 500 mm used e.g. in Germany are possible as well. The consequence of such solution is an increased bridge width therefore it is not applied in Slovenia. A steel safety barrier pillar is a cold-formed profile of 120/50/25. The wall thickness of those pillars shall not be smaller than 4 mm to enable the execution of a weld of 3 mm thickness at the contact with the anchor plate.
- 6.1.10** In the figure 6.3 a single steel safety barrier with extended pillars and a handrail for pedestrians is shown. The total height of such raised barrier amounts to 110 cm, which is the height of other pedestrian railings as well. Different solutions of extended pillars and of handrails are possible. A standardized solution in figure 6.3 presents C-shaped pillars made of cold-formed steel plate of 4 mm thickness with clamps of 43 mm radius on top. The handrail is a tube of $\Phi 42 \times 4$ mm, which has to be equipped with expansion joints. Each pillar extension is fixed to the appurtenant pillar by means of three bolts M16.

- 6.1.11** In the figure 6.4 a two-sided steel safety barrier is presented located in a 2.0 m wide central reserve of a motorway. For this safety barrier type, two different lengths of buffers are foreseen: 500 mm towards the free edge beam and 360 mm towards the edge beam and kerb where the barrier is anchored.
- 6.1.12** In the figure 6.6, a detail is shown where anchoring of steel safety barrier pillars is carried through by means of steel back-up plates and steel anchor plates of 300 x 300 x 10 mm as well as of four anchors M16. A levelling epoxy mortar of an area of 350 x 350 mm and of a variable thickness of 10-50 mm serves, among others, for ensuring the pillar verticality.
- 6.1.13** The anchoring of steel safety barrier pillars is presented in two ways:
- An exact building-in of anchoring elements during or before concreting of the edge beams;
 - A subsequent anchoring into already completed edge beams.
- 6.1.14** An exact building-in of anchoring elements of the steel safety barrier pillars during concreting of the edge beams is shown in the figures 6.2, 6.3, and 6.4. During concreting an anchor plate of 300 x 300 x 10 mm is fixed by means of six anchors of $\Phi 16$. The pillar verticality is achieved by pouring of an epoxy mortar of variable thickness of 1 – 4 cm.
- 6.1.15** A subsequent anchoring of steel safety barrier pillars shall be carried through according to the following procedure:
- Drilling of holes in the concrete perpendicularly to the edge beam surface;
 - Filling-up of holes with an injecting epoxy compound up to 1/3 of the height;
 - Inserting of bolts into the holes; coating of concrete surface below the anchor plate
 - with the epoxy compound pressed-out (the applied epoxy coating serves as a
 - priming coat to ensure adhesion);
 - Application of epoxy mortar by the help of a steel frame;
- Placing of a plastic washer followed by placing of the anchor plate with a pillar;
 - Adjusting of pillars;
 - After the mortar has hardened, tightening of bolts and filling-up of the holes in the
 - anchor plate with epoxy compound.
- 6.1.16** Other methods of the subsequent anchoring of steel safety barrier pillars are feasible as well depending on manufacturers' typified procedures. However, the latter shall be approved by the designer and by the client's engineer.
- 6.1.17** After fabrication and prior to transportation, all the steel safety barrier elements shall be protected from corrosion by hot dip galvanizing.
- 6.1.18** In accordance with the British Standard BS 5493, hot dip galvanizing should ensure a quality corrosion protection in polluted or coastal atmosphere for a period of at least five years. The following conditions shall be fulfilled:
- Thorough leaching and neutralization;
 - Hot dip galvanizing in a thickness of 85 μm ;
 - Access of melted zinc to all surfaces shall be ensured;
 - Extremely careful transportation and installation;
 - No welding after galvanizing is allowed.
- 6.1.19** All elements, connections and joints of steel safety barriers shall have an approximately equivalent resistance to vehicle impacts (buffer, pillar, connection of pillar with anchor plate, connection of anchor plate with anchors, and anchors themselves).
- 6.1.20** Steel safety barriers shall be installed in such a way that a perfect geometrical accordance in two planes as well as an adequate aesthetical appearance is achieved.
- 6.1.21** Some new steel safety barrier types developed and already introduced abroad will be applied in Slovenia not until reliable positive experience regarding their advantages, in particular their safety is gained.

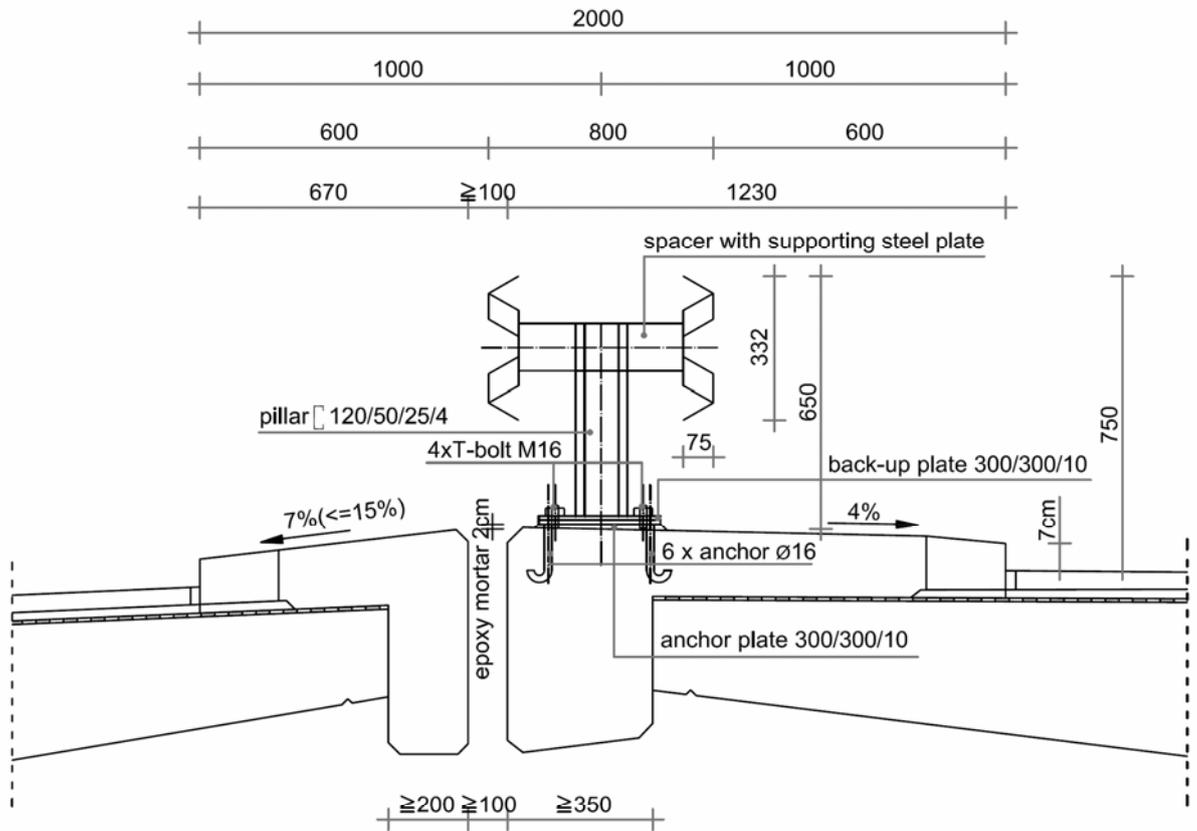
6.2 Single steel safety barrier for vehicles



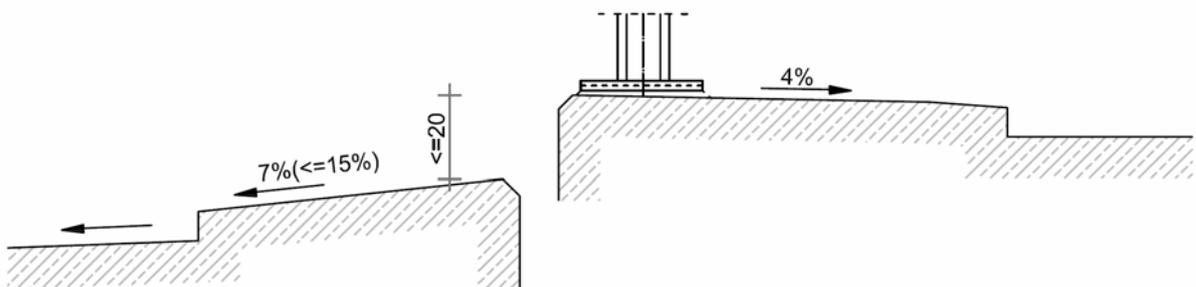
6.3 Single steel safety barrier with pedestrian handrail and protective steel plate for cyclists



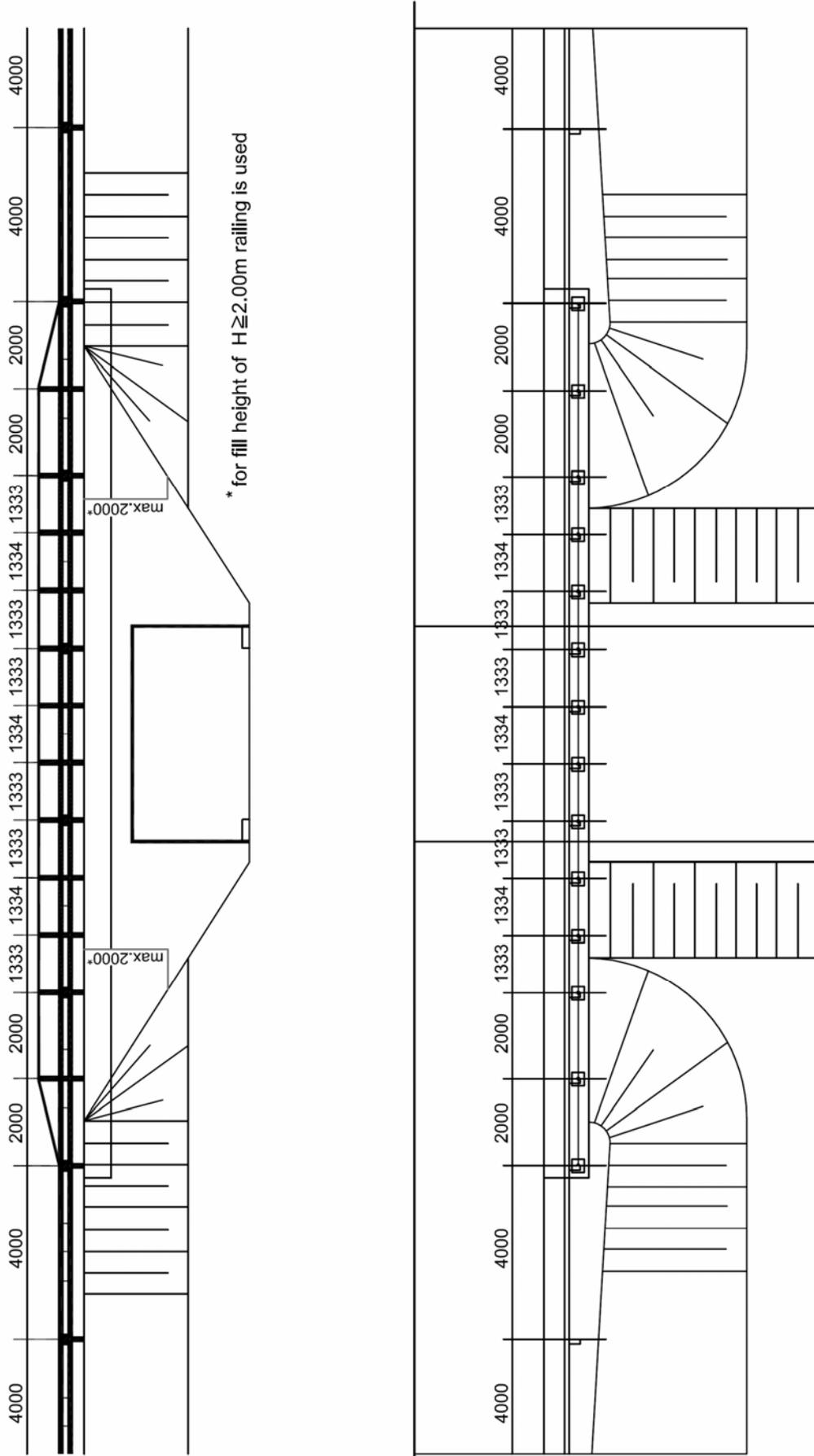
6.4 Two-sided steel safety barrier in central reserve of 2.0 m width



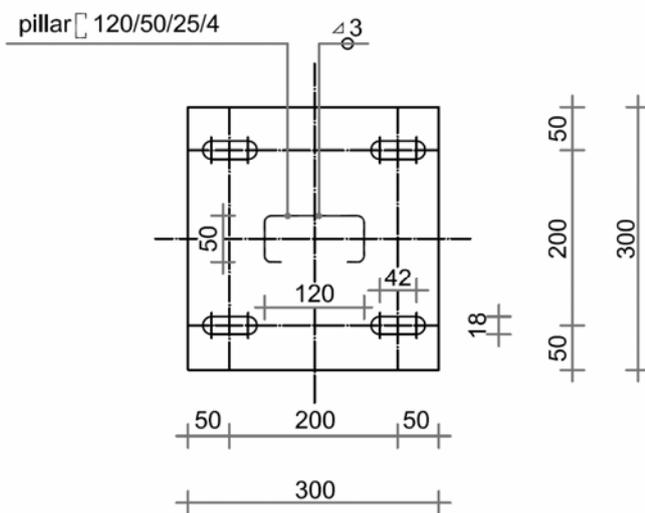
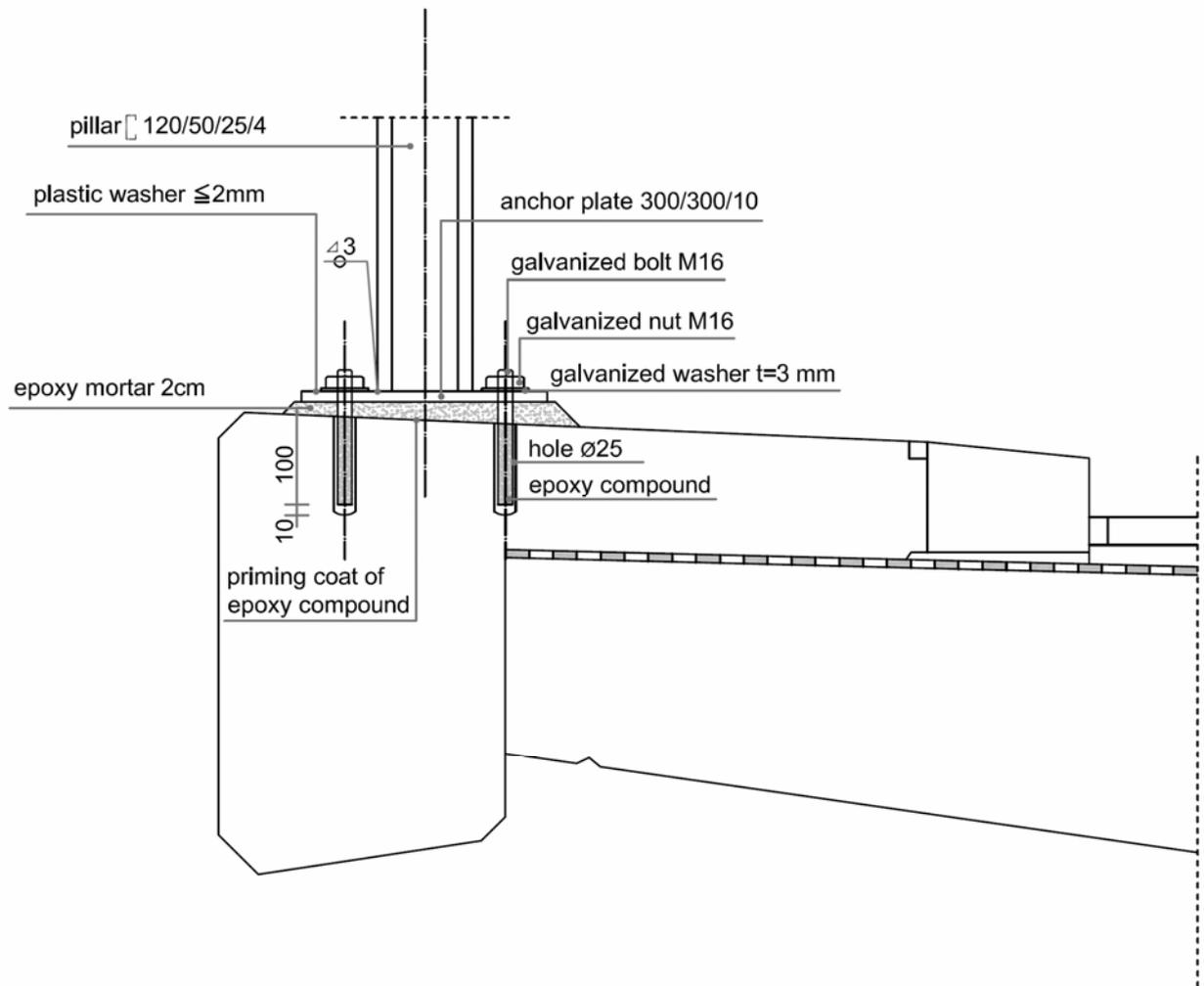
Alternative with height jump 20cm



6.5 Spacing of steel safety barrier pillars



6.6 Anchoring of steel safety barrier pillars



7. CONCRETE SAFETY BARRIERS

7.1 Introduction

7.1.1 Concrete safety barriers serve especially for protection of vehicles on the edge parts of bridges or on the motorway central reserves, all in accordance with the solutions of edge beams, kerbs and walkways presented in the DG 1.2.2.

7.1.2 In the upper part of the figures, a portion of the bridge cross-section is presented indicating the position of the barriers for vehicles and railings for pedestrians, all in accordance with the solutions given in the DG 1.2.2.

7.1.3 Good experience as well as both theoretical and practical investigations contributed to a mass application of concrete safety barriers on motorways and road bridges in the last 25 years. Concrete safety barriers offer one of the most reliable protections from falling of vehicles from bridges. Depending on the height and the anchoring method a perfect protection of all vehicle types from falling from a bridge can be achieved.

7.1.4 Concrete safety barriers represent a continuation of tradition of massive stone or concrete parapets on the bridge edges. Vehicles have been protected from falling-off only by the mass of those parapets. The fundamental advantage of a concrete safety barrier is the shape of its surface being inclined at different angles to the carriageway. The first gentle inclination of approx. 54° starts 8 cm above the asphalt part, followed by the second steeper inclination of approx. 85° ending on the top of the barrier.

7.1.5 In the present design standard only those concrete safety barriers are treated that refer to bridges. Some basic elements and conditions to be taken into consideration when foreseeing concrete safety barriers on road bridges are indicated.

7.1.6 By their position in the transverse direction of road bridges the following concrete safety barriers can be distinguished:

- Concrete safety barriers placed onto the road bridge outer edges (figures 7.2, 7.3);
- Concrete safety barriers placed at a distance of 0.5 m from the edge of traffic lanes
- at maintenance walkways (figure 7.4).

7.1.7 By the fabrication method the following concrete safety barriers can be distinguished:

- Semi-prefabricated concrete safety barriers;
- Monolithic concrete safety barriers.

7.1.8 In the concrete safety barrier design the following shall be defined:

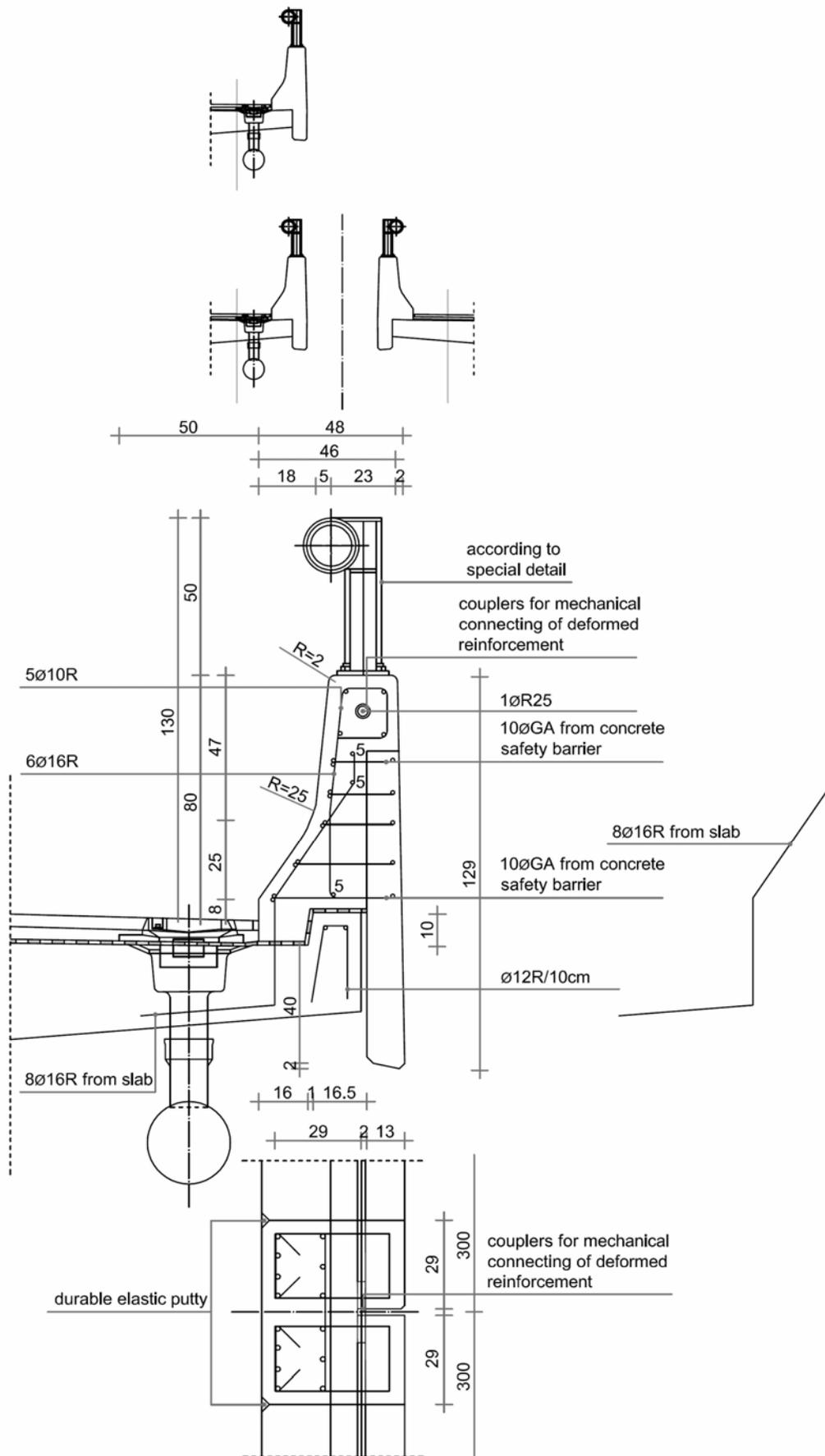
- Position of the concrete safety barrier in the bridge cross-section;
- Method of concrete safety barrier fabrication;
- Length of the concrete safety barrier on the bridge;
- Solution of the barrier ends and of the connection between the bridge barrier and the
- road barrier respectively;
- Safety barrier height;
- Method of barrier anchoring.

7.1.9 The design guidelines DG 1.2.1, DG 1.2.2, and DG 1.2.3 entirely define the position and purpose of concrete safety barriers on bridges. The distance between the barrier and the carriageway edge amounts to at least 0.5 m.

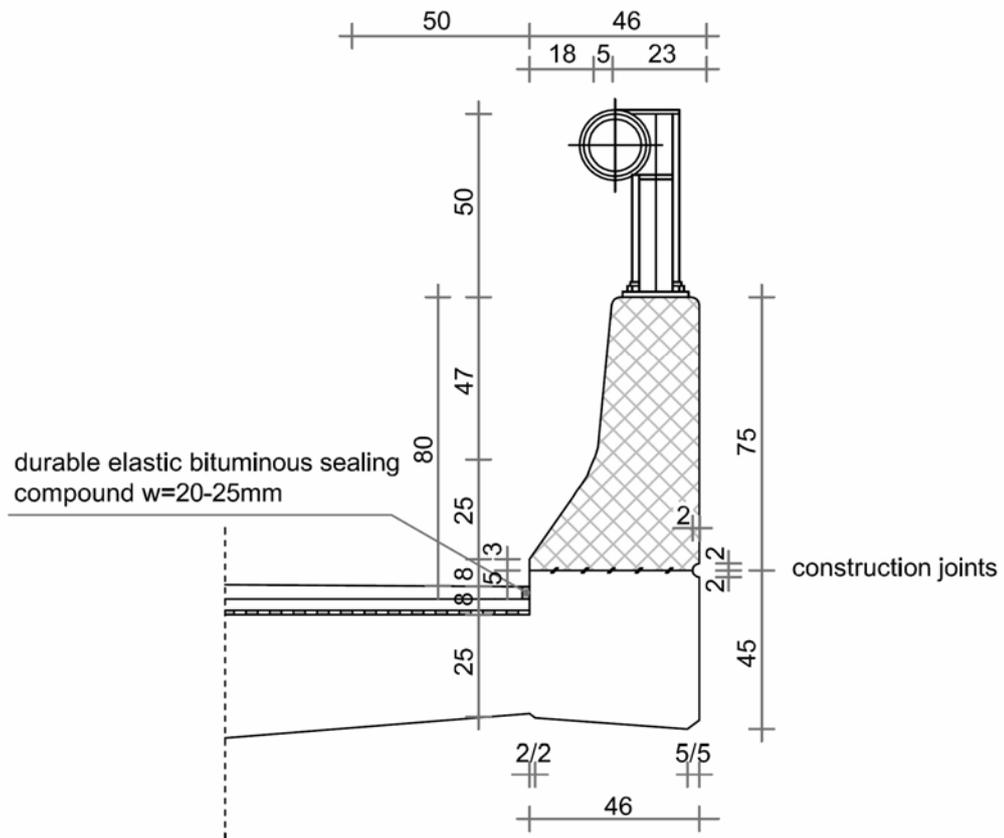
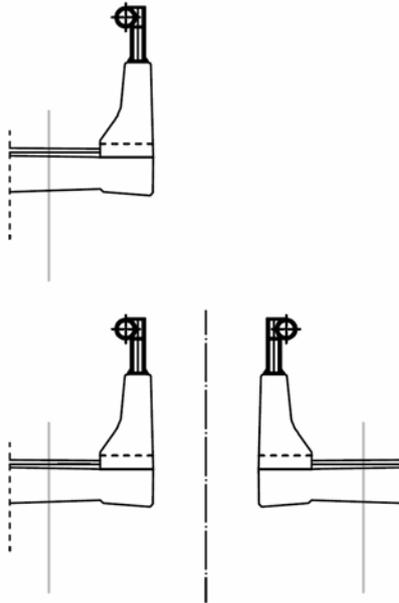
7.1.10 The method of fabrication of the concrete safety barriers on bridges is generally adapted to the method of fabrication of the barriers on the road next to bridge. It is essential to preserve the fundamental principle: material, method of fabrication, type, position and height of concrete safety barriers shall not be changed on shorter bridges, as this is the least disturbing to drivers and surroundings.

- 7.1.11** The length of a concrete safety barrier is generally equal to the bridge length including the length of wing walls. It is adapted to the length of standardized pre-cast elements of concrete safety barriers.
- 7.1.12** The solution of connection between the bridge safety barrier and the road safety barrier as well as the barrier ends (when it does not proceed on the road), are shown in the figure 7.6.
- 7.1.13** Expansion joints in the barrier shall be foreseen on the same locations, as the bridge expansion joints are built-in. Details of the barrier expansion joints are indicated in the design guidelines DG 1.2.7. However, they shall be worked out for each particular bridge. Their solution shall be harmonized with that of the bridge expansion joint.
- 7.1.14** The height of the concrete part of the concrete safety barrier on bridges is limited to 80 cm (82 cm). An increase of the height up to 110 cm can be achieved by steel handrail in accordance with the detail shown in the figure 7.5.
- 7.1.15** In the bridge longitudinal direction a concrete safety barrier is placed in such a way that the barrier upper edge is parallel to the bridge vertical alignment. In the transverse direction with respect to the bridge, safety barriers are always placed vertically.
- 7.1.16** The way of concrete safety barrier anchoring shall be conformable to the barrier fabrication method. In the figures 7.2 and 7.3 anchoring methods approved in practice are presented.
- 7.1.17** To increase the resistance to the vehicle impact, individual barrier elements including buffers are interconnected into a chain.
- 7.1.18** The concrete used for fabrication of concrete safety barriers shall fulfil the following EN 206-1:2000.
- 7.1.19** The visible surfaces of concrete safety barriers shall be even, smooth and compact, without unevenness or damages that can reduce the freeze and salt resistance. The latter can be ensured subsequently by application of protective coating.
- 7.1.20** In the figure 7.2 a detailed cross-section of the outer semi-prefabricated concrete safety barrier of 80 cm (110 cm) height is shown. The barrier anchoring is carried through by means of the anchor reinforcement $8 \Phi 16 R$ built-in into the both carriageway slab cantilevers in a width of 2×30 cm.
- 7.1.21** In the figure 7.3 a cross-section of the outer monolithic concrete safety barrier of 80 cm (110 cm) height is presented. The connection of the safety barrier with the carriageway slab is ensured by means of two reinforcement items: $\Phi 12 R/40$ cm from the slab front and $\Phi 12 R/20$ cm from the slab upper edge comes out. The formwork for execution of monolithic concrete safety barrier is generally movable. The quality of the joints is high, whereas the quality of the visible concrete surfaces might become unsatisfactory.
- 7.1.22** In the figure 7.4 a cross-section of the inner pre-cast concrete safety barrier of 82 cm height is shown. Barrier prefabricated elements are laid down onto a 3 cm thick levelling layer of cement mortar applied to the waterproofing. To enable flowing of eventual water from the inclined cantilever towards the seepage water pipe located on the edge, 10 cm wide openings shall be left at spacing of 1.0 m. Each barrier element of 6 m length has an opening of 40/8 cm serving for the walkway dewatering. Anchoring is achieved by linking into a longitudinal chain in accordance with the detail shown in the figure 7.8.
- 7.1.23** In the figure 7.5 a detail of a steel railing placed onto the outer concrete safety barrier is presented.

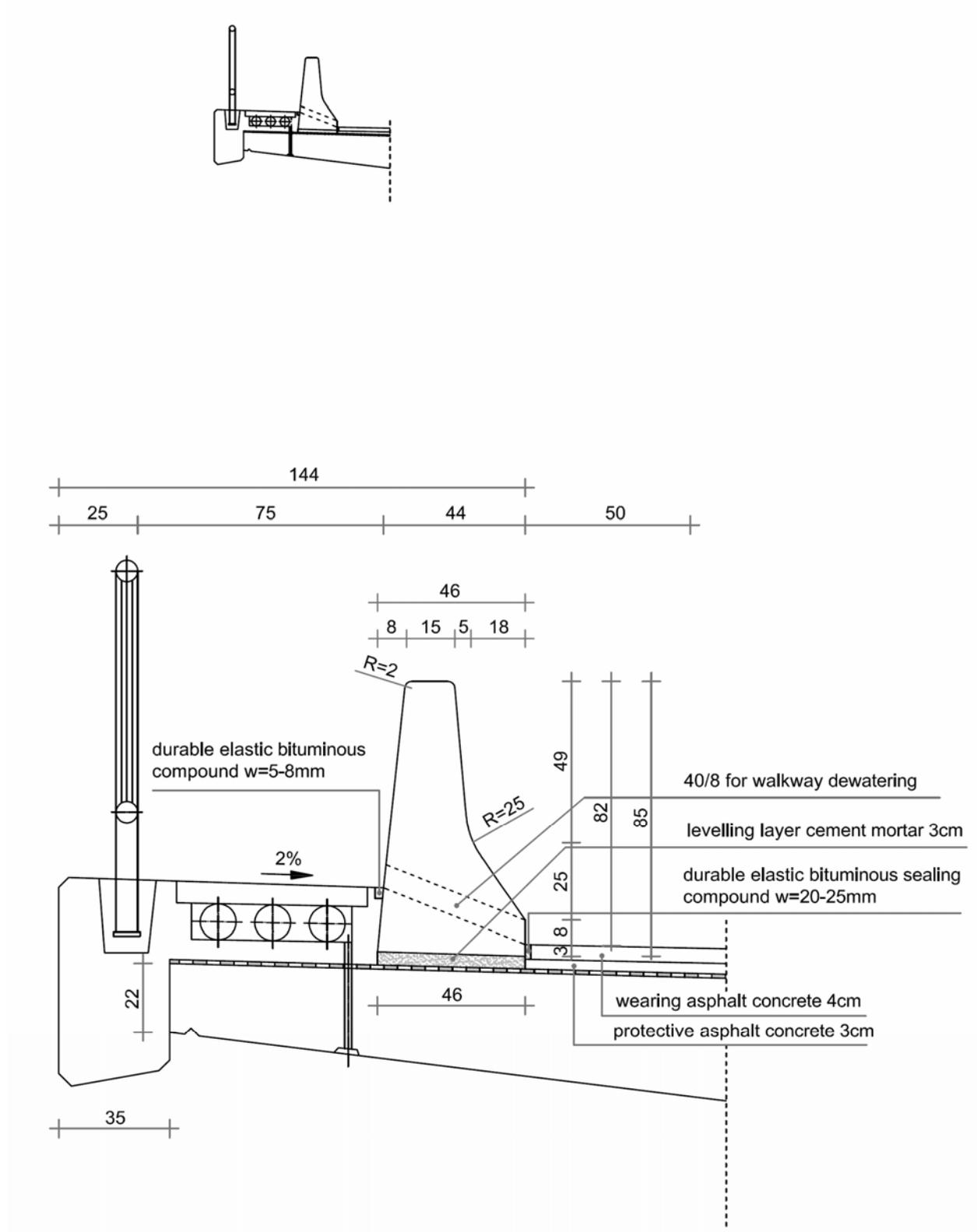
7.2 Outer semi-prefabricated concrete safety barrier



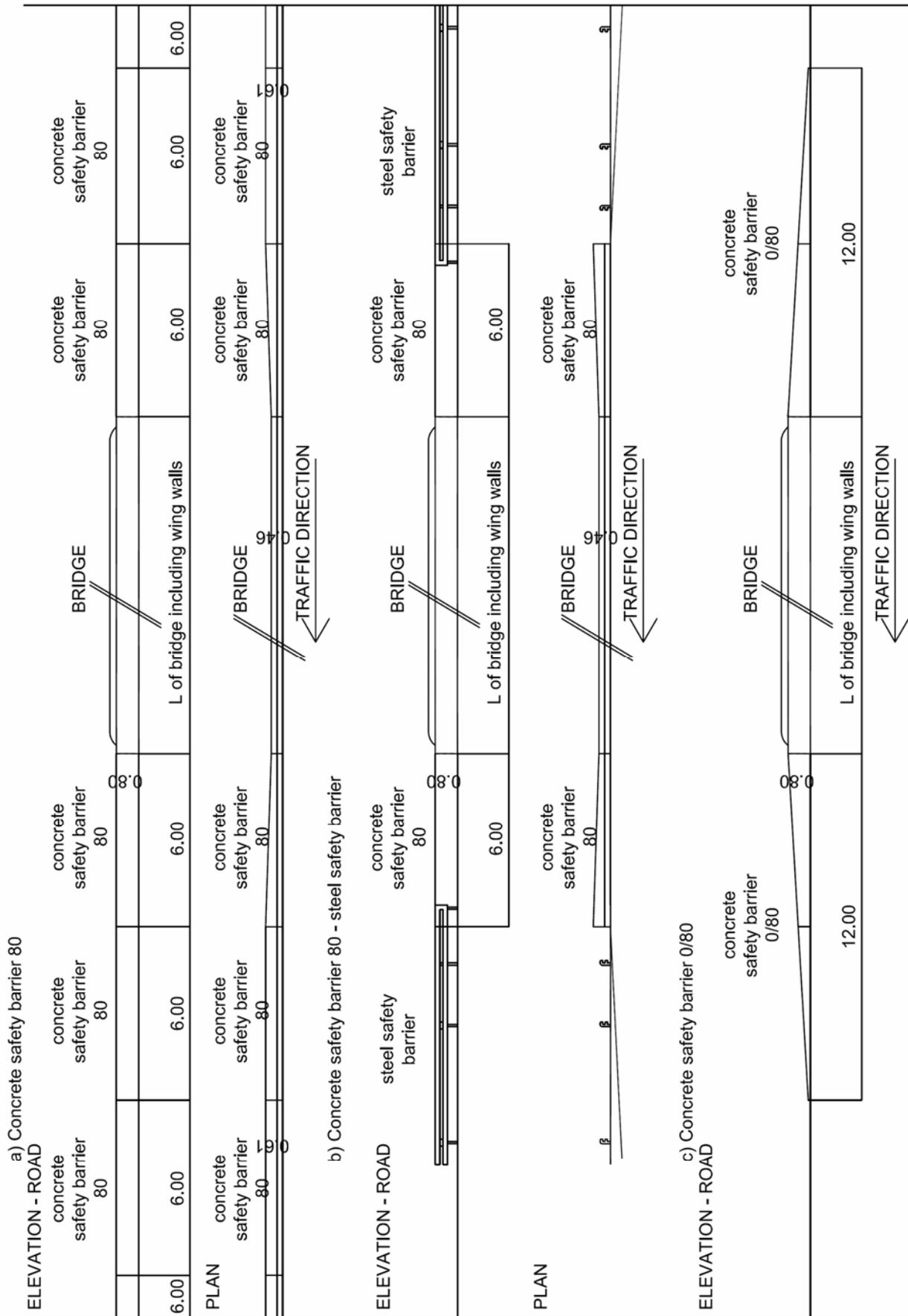
7.3 Outer monolithic concrete safety barrier



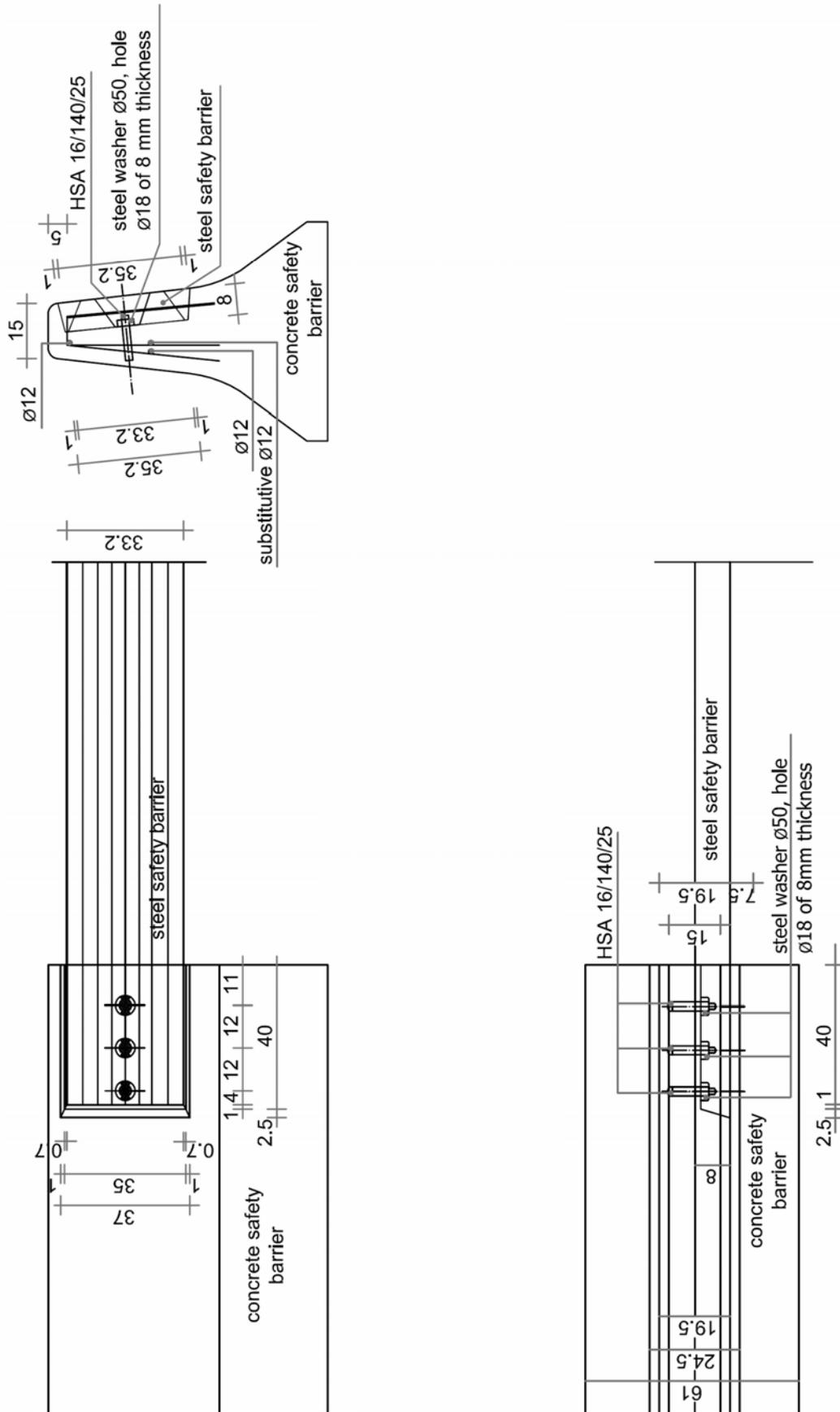
7.4 Inner prefabricated concrete safety barrier



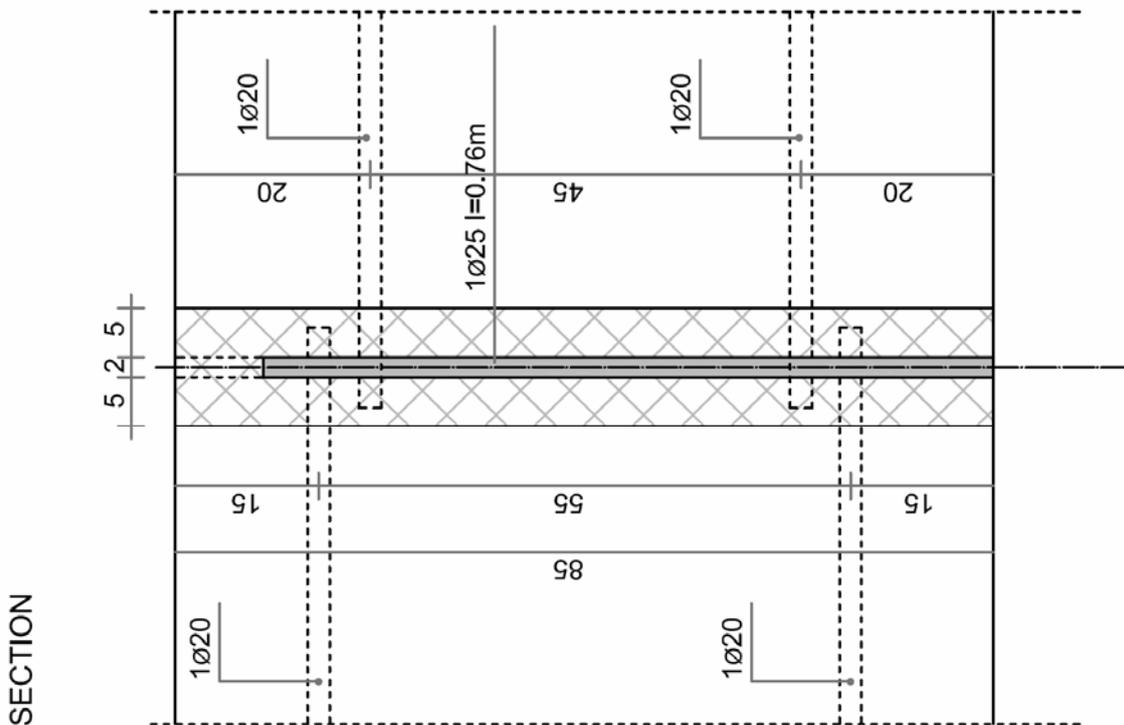
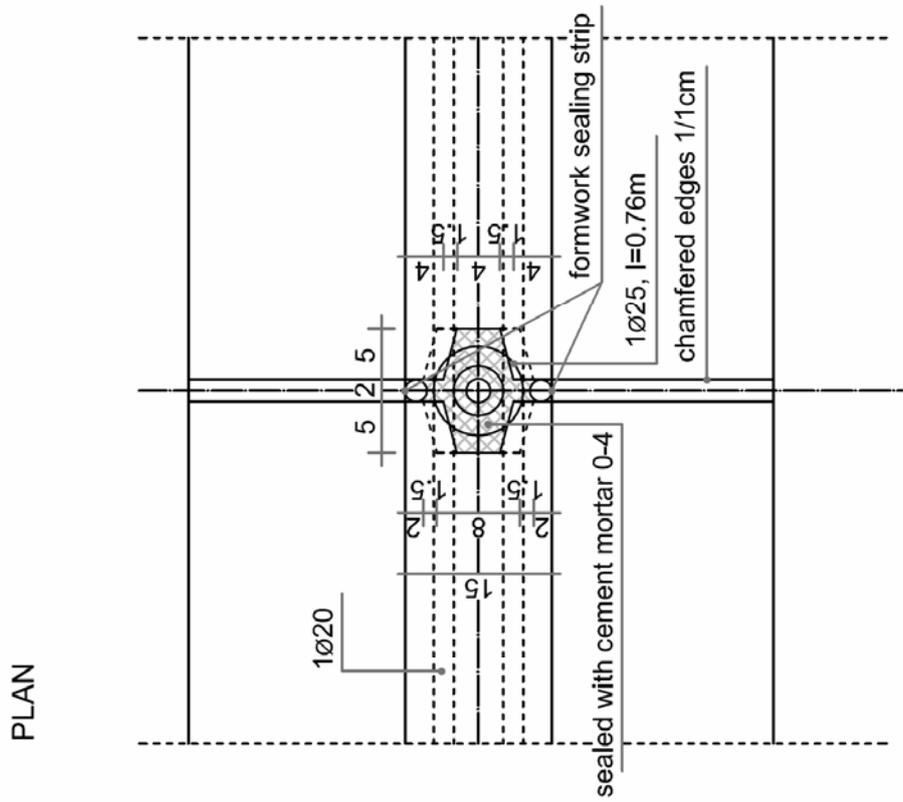
7.6 Arrangement of concrete safety barrier elements on bridges



7.7 Detail of connection concrete safety barrier – steel safety barrier



7.8 Detail of fixed connection of two concrete safety barriers



8. PROTECTIVE BARRIERS

8.1 Introduction

8.1.1 Protective barriers are designed to protect humans and traffic out of bridges as well as the traffic on bridges.

8.1.2 With regard to their purpose the following protective barriers are distinguished:

- Noise barriers;
- Wind barriers;
- Protective barriers on overpasses (above railway tracks or motorways) and underpasses.

8.1.3 Noise barriers are placed on bridge edges to protect settlements and inhabitants at motorways from noise. The necessity, position and height of noise barriers on bridges are specified in the motorway design.

8.1.4 Wind barriers are installed on bridge edges to protect the traffic and pedestrians from harmful wind impacts. The necessity, position and height of wind barriers on bridges are specified in the motorway design.

8.1.5 Protective barriers on overpasses above motorways are foreseen with the intention of protecting the motorway traffic from falling of snow due to ploughing and from accidental or intentional falling of objects from the overpass onto the motorway.

8.1.6 Protective barriers on bridges above railway tracks are designed to prevent any contact with high-tension overhead wires. Any approach to those installations is deadly dangerous.

8.1.7 Protective barriers on underpasses protect the road traffic at the underpass entrance or exit.

8.1.8 In the figure 8.2, a portion of the protective barrier of 2.0 m height on a bridge above railway tracks is shown. Fixing of protective barrier to steel safety barrier pillars is shown as well.

8.1.9 In the figure 8.3, a detail of anchoring of noise barrier pillars into bridge

edge beams is presented. The number and diameter of anchors depends on the noise barrier height. Wind barriers are anchored in the similar way as well.

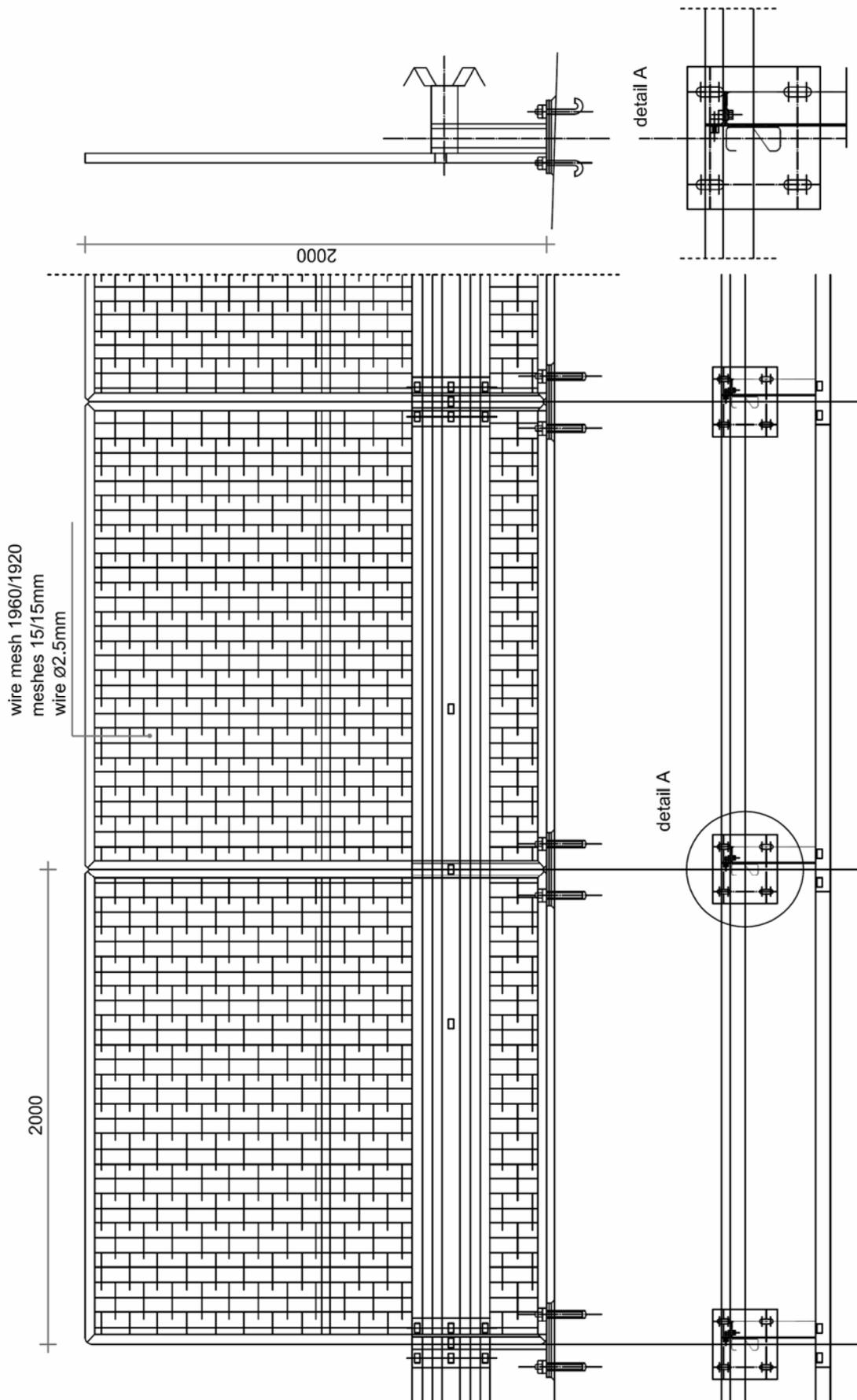
8.1.10 Noise barrier and wind barrier pillars and anchoring shall be statically verified. In case that the barrier height exceeds 2.0 m, the wind action on the load bearing structure is changed as well.

8.1.11 For protective barriers on overpasses different materials and solutions can be introduced on condition that the basic principles indicated in the present design guideline DG 1.2.3 are taken into consideration.

8.1.12 The minimum length of protective barriers on overpasses is equal to the motorway width below the overpass increased by at least 1.0 m on either side. The minimum length of protective barriers above railway tracks equals to the width of the clear profile below the bridge increased by 1.0 m on either side.

8.1.13 Steel protective barriers are protected from corrosion by hot dip galvanizing. The zinc coating shall not be damaged during transportation and installation of the barrier.

8.2 Protective mesh 2.0 x 2.0 m fixed to steel safety barrier



8.3 Noise barrier – anchoring on bridges

