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EN Engineering Department

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ANNEX 1

REQUIREMENTS FOR OVERHEAD CRANES RAILS

Installation in new buildings

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HISTORY OF CHANGES

REV. NO.	DATE	PAGES	DESCRIPTIONS OF THE CHANGES

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INTRODUCTION

This document contains design, manufacturing and installation requirements that crane rails installed in new building at CERN shall fulfil.

More technical solutions are presented in order to match any specific case; based on the following information the EN-HE group will be able to give advice on the most suitable solution and the proper rail size:

- Crane capacity;
- Crane span (i.e. distance between rails);
- Lifting height;
- Travelling speed;
- Intended use;
- Supporting material (steel or concrete).

Loads transmitted by the crane wheels, needed for the design of the supporting beam, will be provided too.

1. STEEL SUPPORTED RAIL

1.1 WELDED FLAT BAR

Welded flat bars shall be used as rails for light-duty cranes with a small capacity (i.e. up to 15 ton).

1.1.1 STEEL BAR

Flat bar shall be made out of non-alloy structural steel according to EN 10025-2; minimum yield stress shall be 250 N/mm^2.

Length of each portion shall be chosen in order to minimize the number of junctions.

1.1.2 WELDING

Whenever possible, welding of the bar to the supporting beam shall be executed in the workshop in order to obtain better results in terms of alignment and welding quality.

Prior to welding, any trace of rust or grease shall be removed from the surfaces in proximity of the junction.

The flat bar shall be fixed with an intermittent fillet weld as shown in the picture below:

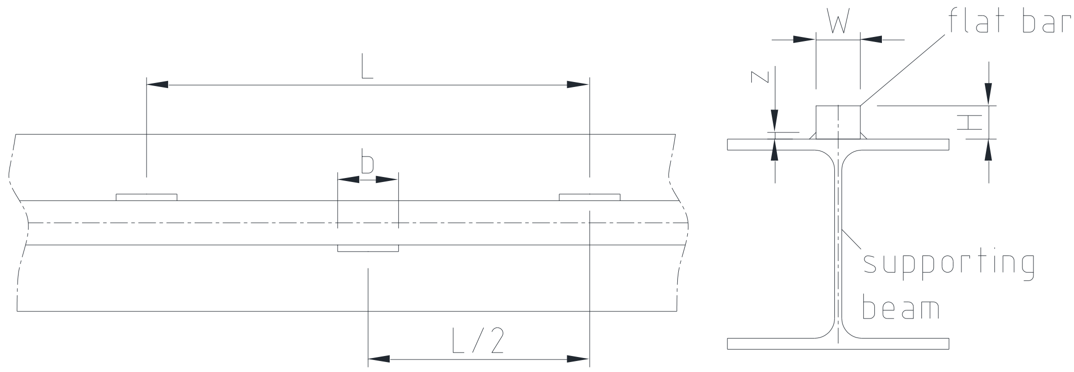


Figure 1 – Flat bar welding

Table 1 provides the parameters values:

Flat bar (W x H)	L [mm]	b [mm]	z [mm]
40 x 30	450	40	6
50 x30	400	55	8

Table 1 – Intermittent weld parameters

Design of junctions between adjacent parts of flat bar and supporting beam shall respect the constraints shown below:

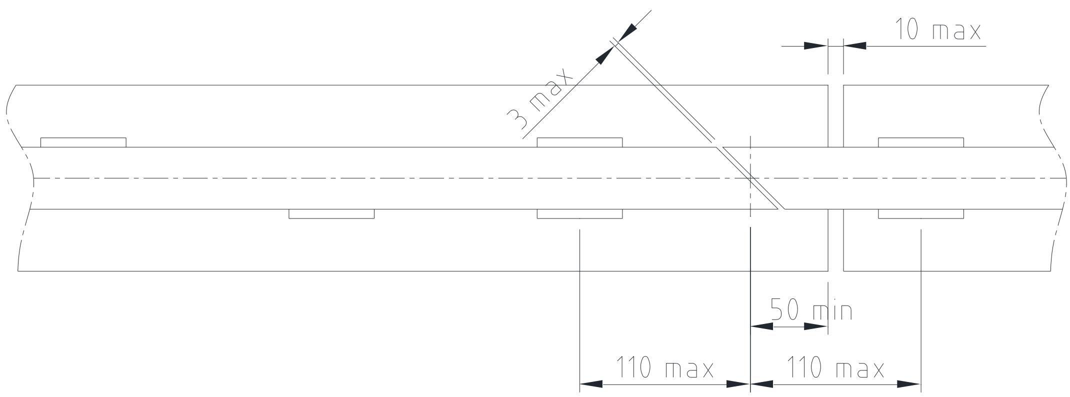


Figure 2 – Junction details

Welds shall be at least of quality level C according to EN ISO 5817.

Magnetic particle inspection shall be carried out, by an operator qualified according to EN ISO 9712, on 20% of welds.

1.1.3 SUPPORTING BEAM

Design of supporting beam shall include the possibility to precisely align the rails and to recover possible structure deformations that might occur during the building's life; to this end, supporting beam shall be bolted to the corbels and slotted holes foreseen. Shims shall be used to recover difference in height between corbels.

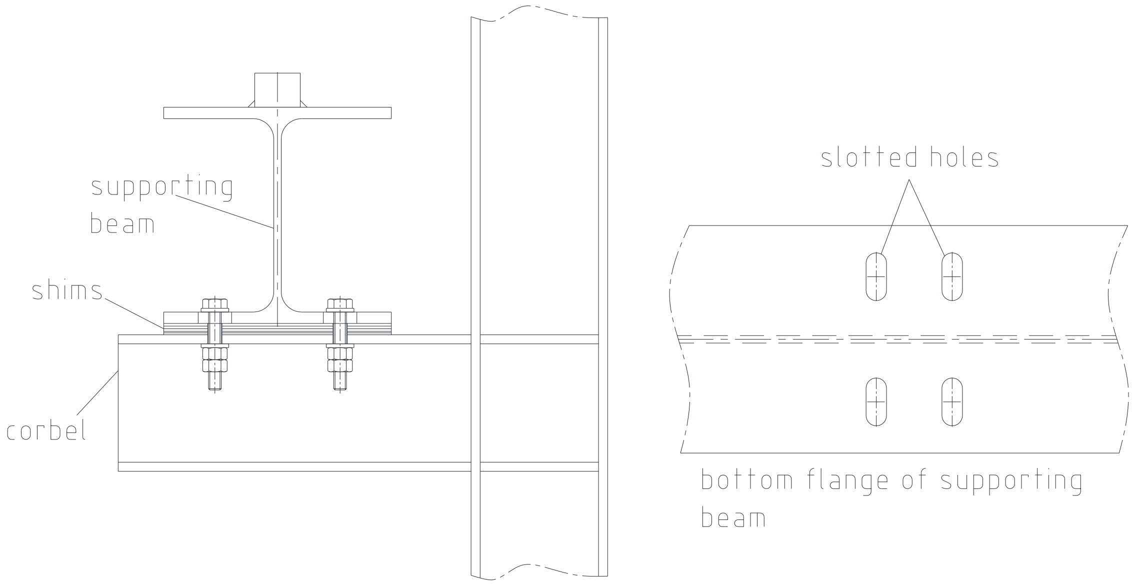


Figure 3 – Example of beam-corbel connection

1.1.4 CORROSION PROTECTION

Top surface of the bar, which will come in contact with the crane wheels, shall be covered during the whole painting process to ensure that it remains unpainted.

In case the flat bar is welded in the workshop, the same painting cycle shall be used for the supporting beam and flat bar sides.

In case the flat bar is welded on site, the sides of the bar shall be protected at least by a 50 micron primer coat.

1.1.5 INSTALLATION TOLERANCES

Tolerances shall not exceed the values shown in D.2.19 and D.2.21 of EN 1090-2; the structure shall be classified as class 2.

1.2 DIN "A" (BURBACK) RAIL

Burback rails shall be used as rails for medium and heavy duty cranes having a capacity equal or bigger than 15 ton.

In order to reduce the vibration transmitted to the structure and distribute the load transmitted by the wheel, the rail shall be soft-mounted to the supporting beam: to this purpose, an elastomer pad shall be installed below the rails and clips with rubber nose shall be used:

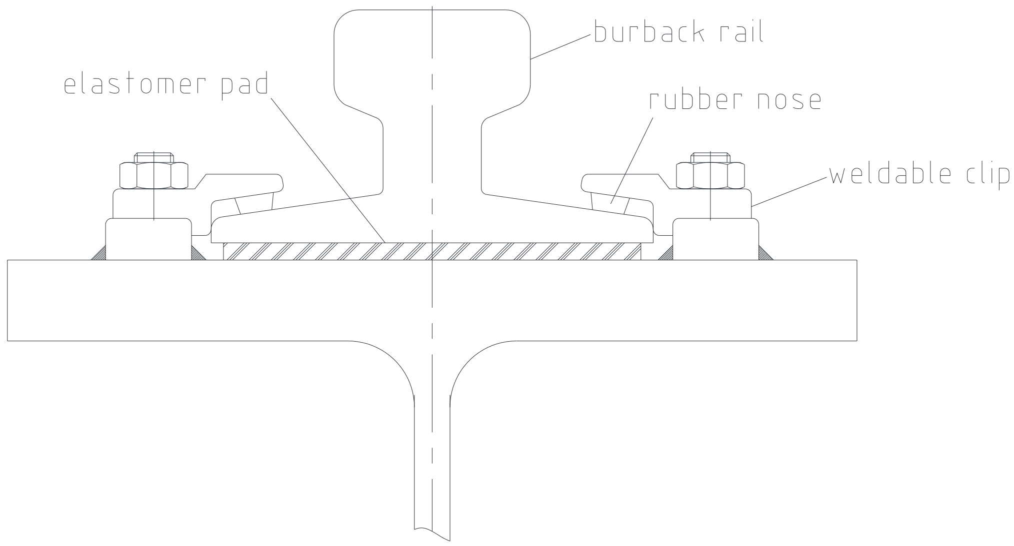


Figure 4 – Example of soft-mounted rail

1.2.1 RAIL

Rail profile shall fulfil requirements of DIN 536 and have a minimum tensile strength of 650 N/mm².

Length of each portion shall not be less than 12 m in order to reduce the number of junctions.

1.2.2 CLIPS

Clips shall be composed of two parts: a lower part to be welded on the supporting beam and an upper one bolted on it which will push downward the rail.

The upper part shall be endowed with a rubber nose to limit the stress transmitted to the bolts.

Clips shall be chosen in order to support the minimum side load shown in Table 2 below; design shall guarantee horizontal adjustability to allow rails alignment (see dimension "R" in Table 2).

Spacing between clips shall be 700 mm maximum.

Clips positioning and welding shall follow strictly manufacturer's recommendations; welds shall be at least of quality level C according to EN ISO 5817.

Magnetic particle inspection shall be carried out, by an operator qualified according to EN ISO 9712, on 20% of welds.

1.2.3 ELASTOMER PAD

An elastomer pad shall be installed between the rail and the supporting beam to reduce noise and vibrations transmitted to the structure; it shall be reinforced with an internal steel plate.

If the 45° cut solution is chosen instead of the welded rails (see § 1.2.6), pad junctions and rail junctions shall be at least 500 mm offset.

1.2.4 SUPPORTING BEAM

Upper flange of supporting beam shall be wide enough to accommodate the rail and the clips; 40 mm clearance shall be left between the clips and the flange edges (see 1.2.5).

Stiffening plates shall be foreseen to limit the deflection of the beam flange under the loads transmitted by the clips.

Shims between the beam and the corbel shall be used to recover difference in height between corbels.

1.2.5 INSTALLATION

The following picture shows a typical installation drawing with requirements to be taken into account during the design:

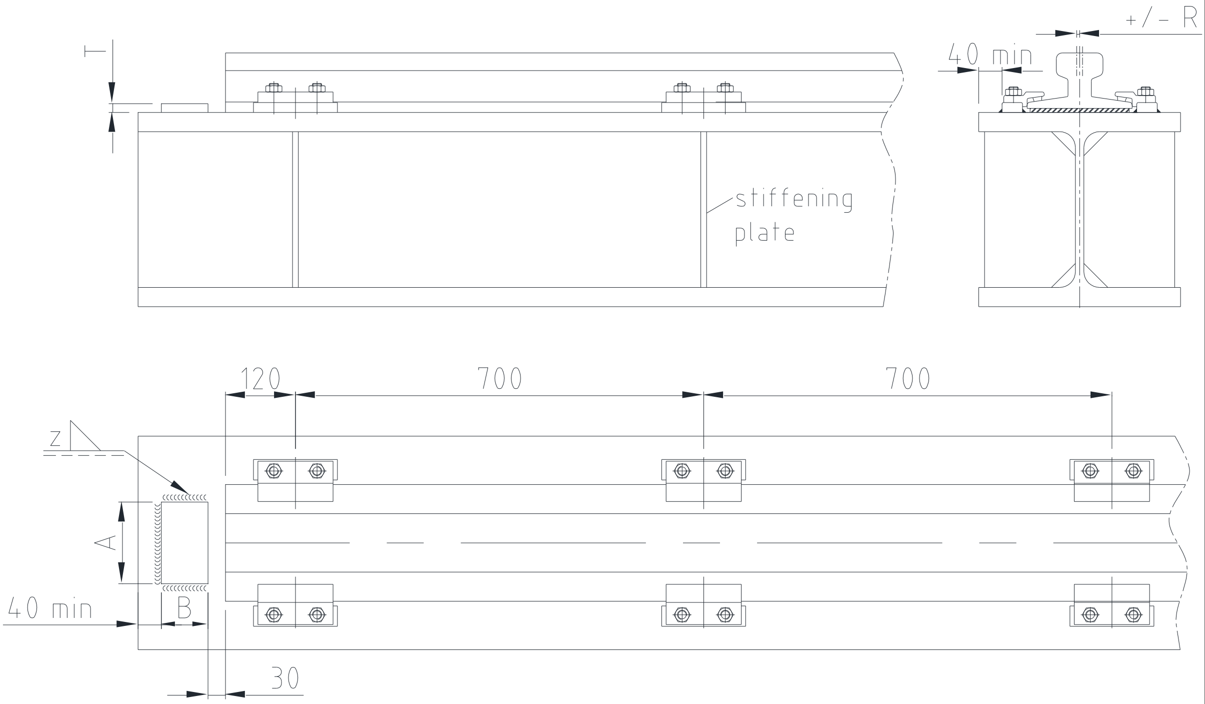


Figure 5 – Burback over steel support installation

A plate shall be welded at the two extremities of the supporting beam to limit the rail displacement due to crane longitudinal actions. A 30 mm gap between the rail and the end plate shall be left to allow rail thermal deformation; this value shall be increased when the total runway length exceeds 100 metres.

Welding of the clips lower part shall be preferably executed in the workshop; rail and pad installation shall be instead done on site.

Table 2 provides the parameters values:

Rail profile	Clips minimum side load [kN]	A [mm]	B [mm]	T [mm]	z [mm]	R [mm]
A45	28	70	40	10	6	5
A55	40	90	40	10	8	5
A65	50	110	50	10	8	5
A75	85	140	50	15	10	8
A100	120	140	80	15	10	8
A120	160	150	80	15	12	10

Table 2 – Burback over steel support parameters

1.2.6 JUNCTIONS

Adjacent portions of rails shall be welded on site whenever possible; in case the rails will be used by a light-duty crane, welding can be discarded and the effects of the discontinuity mitigated by a 45° cut on the two extremities of the portions. This solution shall be nevertheless agreed with the EN-HE group.

1.2.6.1 Welded junction

The requirements shown below shall be taken into account:

- Portion of rails shall be welded through aluminothermic welding; arc welding is not allowed;
- Welding shall be executed by an experienced team and the process approved according to EN 14730-1 or, alternatively, supported by a dossier showing proof of a good quality weld executed on a similar joint.

  Dossier shall describe at least the following aspects:

  - Equipment and consumables used;
  - Welding specification (i.e. rail end preparation, gap, preheating, weld protection, grinding);
  - Testing procedure (which shall include internal examination) and results.
- A minimum distance between rail junctions and supporting beam junctions shall be respected as shown below:

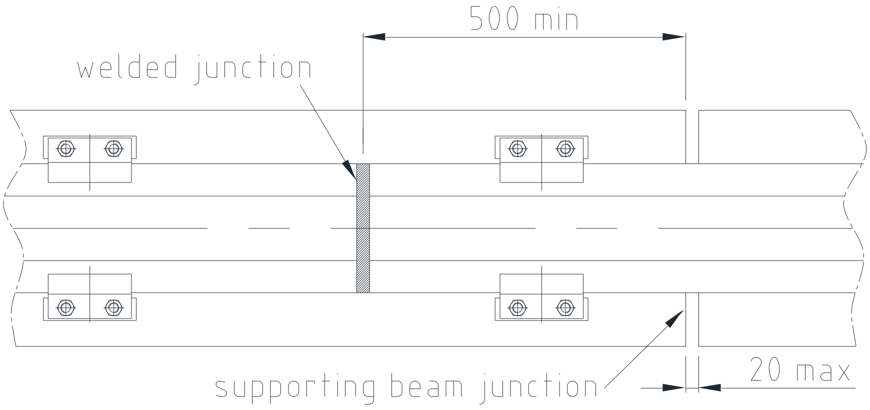


Figure 6 – Welded junction location

- Rails extremities shall be cut square in both the vertical and transverse plane; faces shall be visually inspected and any defect removed;
- Any trace of oil and dust shall be removed before welding;
- After weld execution and cooling down of the surface, the weld shall be ground to the rail head profile;
- Each weld shall be examined through magnetic particles and ultrasonic inspection by an operator qualified according to EN ISO 9712; examination shall be extended to top surface and sides of the rails.

1.2.6.2 Cut junction

In order to partially recover the rail discontinuity, additional clips and side plates shall be foreseen across the junction as shown below:

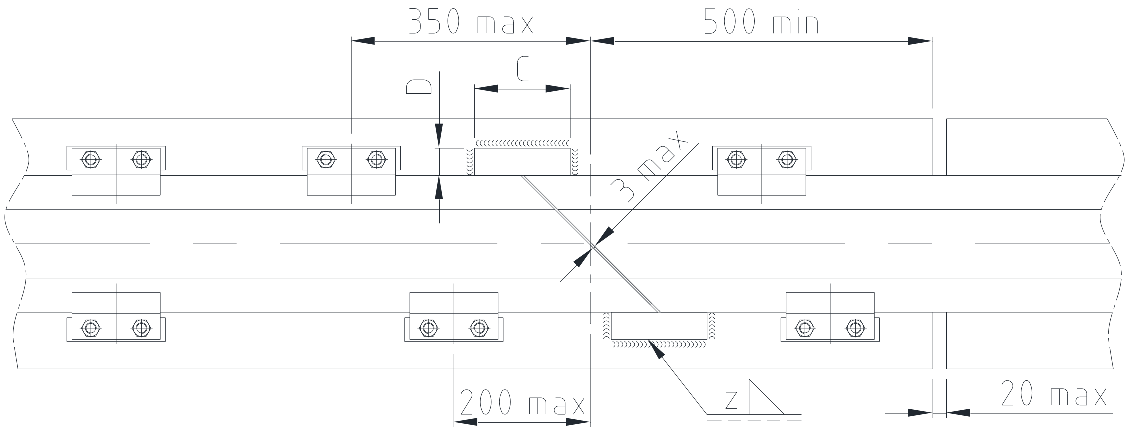


Figure 7 – Cut junction detail

Side plates design parameters are given below:

Rail	C [mm]	D [mm]	T [mm]	z [mm]

profile				
A45	80	45	10	6
A55	90	45	10	8
A65	110	50	10	8
A75	150	60	15	10
A100	180	90	15	10
A120	220	100	15	12

Table 3 – Side plates parameters

1.2.7 CORROSION PROTECTION

Rail sides shall be protected at least by a 50 micron primer coat.

Rail top surface and its extremities (in case of welded junction) shall be covered during the whole painting process to ensure that it remains unpainted.

Clips shall remain unpainted.

1.2.8 INSTALLATION TOLERANCES

Tolerances shall not exceed the values shown in D.2.19 and D.2.21 of EN 1090-2; the structure shall be classified as class 2.

2. CONCRETE SUPPORTED RAIL

Two solutions are described below for the design of a rail system on a concrete support: continuous and intermittent soleplate system.

When a heavy-duty or fast (i.e. travelling speed bigger than 20 m/min) crane will use the rails the continuous soleplate system is strictly recommended; in the other cases the intermittent soleplates system can be adopted.

2.1 CONTINUOUS SOLEPLATE

Several soleplates shall be installed sequentially to create a continuous steel support fixed to the concrete and to allow a soft-mounting (as in § 1.2). Picture below shows a typical layout:

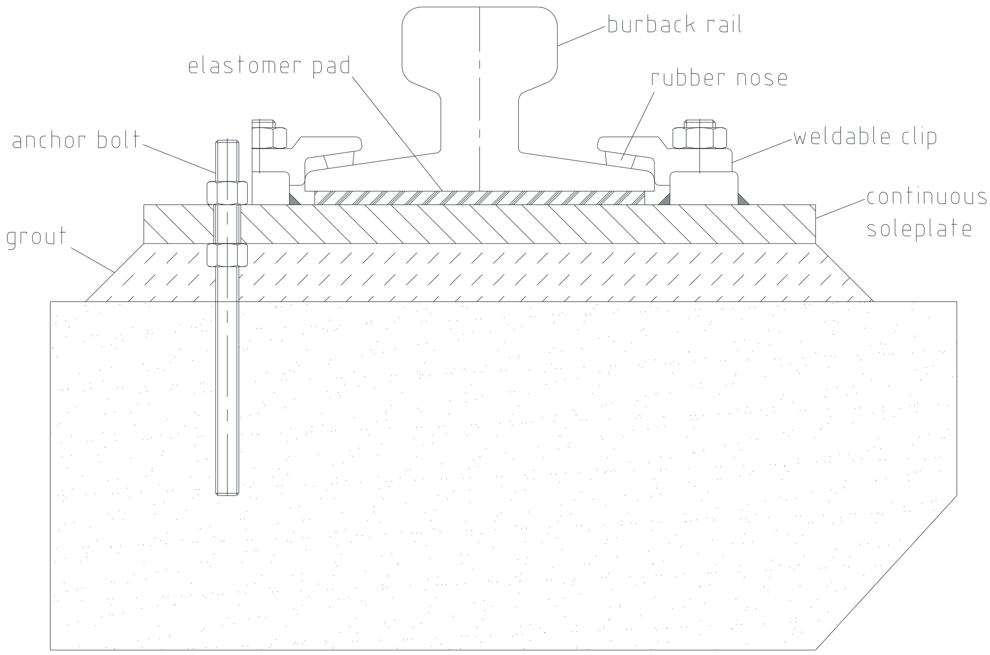


Figure 8 – Soft-mounted rail over concrete support

Anchor bolts fixed onto the concrete allow a fine soleplate levelling.

The elastomer pad and the soleplate help spreading the load over a wider surface.

Grout shall be poured after the rail installation to fill all the gaps and guarantee proper load distribution between the soleplate and the concrete support.

2.1.1 RAIL

Rail profile shall fulfil requirements of DIN 536 and have a minimum tensile strength of 650 N/mm^2.

Length of each portion shall not be less than 12 m in order to reduce the number of junctions.

2.1.2 CLIPS

Clips shall be composed of two parts: a lower part to be welded on the soleplate and an upper one bolted on it which will push downward the rail.

The upper part shall be endowed with a rubber nose to limit the stress transmitted to the bolts.

Allowable side load and minimum horizontal adjustability (dimension “R”) shall be as specified in Table 4.

Spacing between clips shall be 700 mm maximum.

Clips positioning and welding shall follow strictly manufacturer’s recommendations; welds shall be at least of quality level C according to EN ISO 5817.

Magnetic particle inspection shall be carried out, by an operator qualified according to EN ISO 9712, on 20% of welds.

2.1.3 ELASTOMER PAD

An elastomer pad shall be installed between the rail and the supporting beam to reduce noise and vibrations transmitted to the structure; it shall be reinforced with an internal steel plate.

If the 45° cut solution is chosen instead of the welded rails (see § 2.1.8), pad junctions and rail junctions shall be at least 500 mm offset.

2.1.4 SOLEPLATES

Soleplates shall be made out of non-alloy structural steel according to EN 10025-2.

Length of each soleplate shall be chosen in order to minimize the total number of plates without making handling operations of each soleplate too difficult; regular clips spacing shall also be taken into account. A reference length of 2500-3000 mm shall be considered.

Plates shall be 20 mm thick.

Width shall be enough to accommodate the rail and the clips, including 40 mm clearance between the clips and the flange edges.

If anchor bolts will be installed after concrete castings (drilled anchors), additional holes shall be foreseen in order to overcome the problem of encountering reinforcing steel bars during drilling.

Holes for anchor bolts and welding of clips lower parts shall be preferably executed in the workshop.

A gap of 20 mm maximum (control joint) shall be foreseen between two following soleplates.

Design details are shown in § 2.1.7.

2.1.5 ANCHOR BOLTS

A couple of anchor bolts shall be installed between each couple of clips (see Figure 10 below).

Anchor bolts can be fixed to the supporting concrete beam before (cast-in-place anchors) or after (drilled anchors) the concrete castings: the solution that guarantees the best positioning tolerances shall be chosen.

Size, length and material shall guarantee enough shear resistance to sustain the side load transmitted by the clips to the soleplate and listed in Table 4.

2.1.6 GROUT

A layer of non-shrink grout shall be poured between the soleplate and the supporting concrete after rail installation; recommended layer thickness is 50 mm but it may vary according to the grout flowability and the concrete casting tolerances.

Compressive strength after curing shall sustain the vertical load transmitted by the crane wheel (provided by EN-HE group for any specific case).

Grout pouring shall follow strictly manufacturer’s procedure.

2.1.7 INSTALLATION

Rails shall be fixed to the supporting beam according to the following drawings:

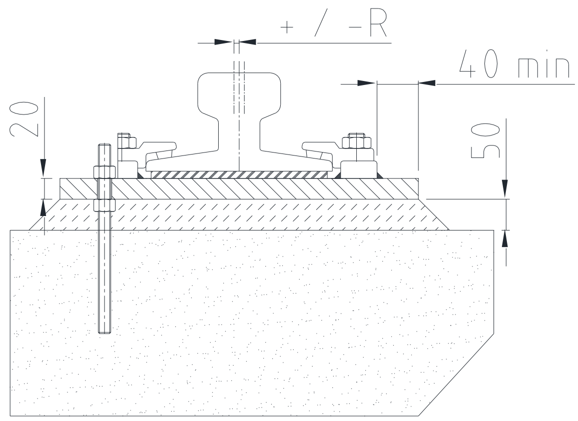


Figure 9 – Continuous soleplate transversal section

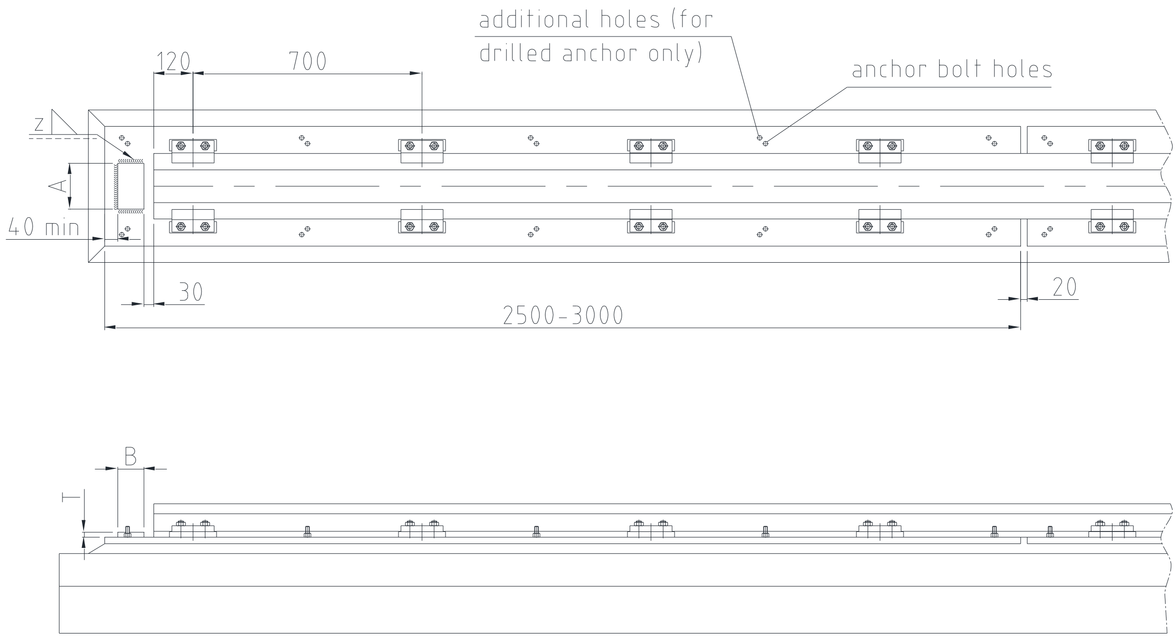


Figure 10 - Continuous soleplate plan and longitudinal view

A plate shall be welded at the two extremities of the soleplate to limit the rail displacement due to crane longitudinal actions. A 30 mm gap between the rail and the end plate shall be left to allow rail thermal deformation; this value shall be increased when the total runway length exceeds 100 metres.

Table 4 provides the parameters values:

Rail profile	Clips minimum side load [kN]	A [mm]	B [mm]	T [mm]	z [mm]	R [mm]
A45	28	70	40	10	6	5
A55	40	90	40	10	8	5
A65	50	110	50	10	8	5
A75	85	140	50	15	10	8
A100	120	140	80	15	10	8
A120	160	150	80	15	12	10

Table 4 – Continuous soleplate installation parameters

2.1.8 JUNCTIONS

The same requirements described in § 1.2.6 shall be applied.

2.1.9 CORROSION PROTECTION

Rail sides and soleplates shall be protected at least by a 50 micron primer coat.

Rail top surface and its extremities (in case of welded junction) shall be covered during the whole painting process to ensure that it remains unpainted.

Clips shall remain unpainted.

2.1.10 INSTALLATION TOLERANCES

Tolerances shall not exceed the values shown in D.2.19 and D.2.21 of EN 1090-2; the structure shall be classified as class 2.

2.2 INTERMITTENT SOLEPLATES

A discrete number of soleplates, spaced one from the other, shall be fixed to the concrete; for each soleplate a pair of clips to fix the rails and four anchor bolts for fine levelling shall be foreseen.

No elastomer pad shall be installed between the rails and the soleplate.

Due to its low bending stiffness, the rail shall be nevertheless continuously supported by a grout layer poured afterwards.

Picture below shows a typical layout:

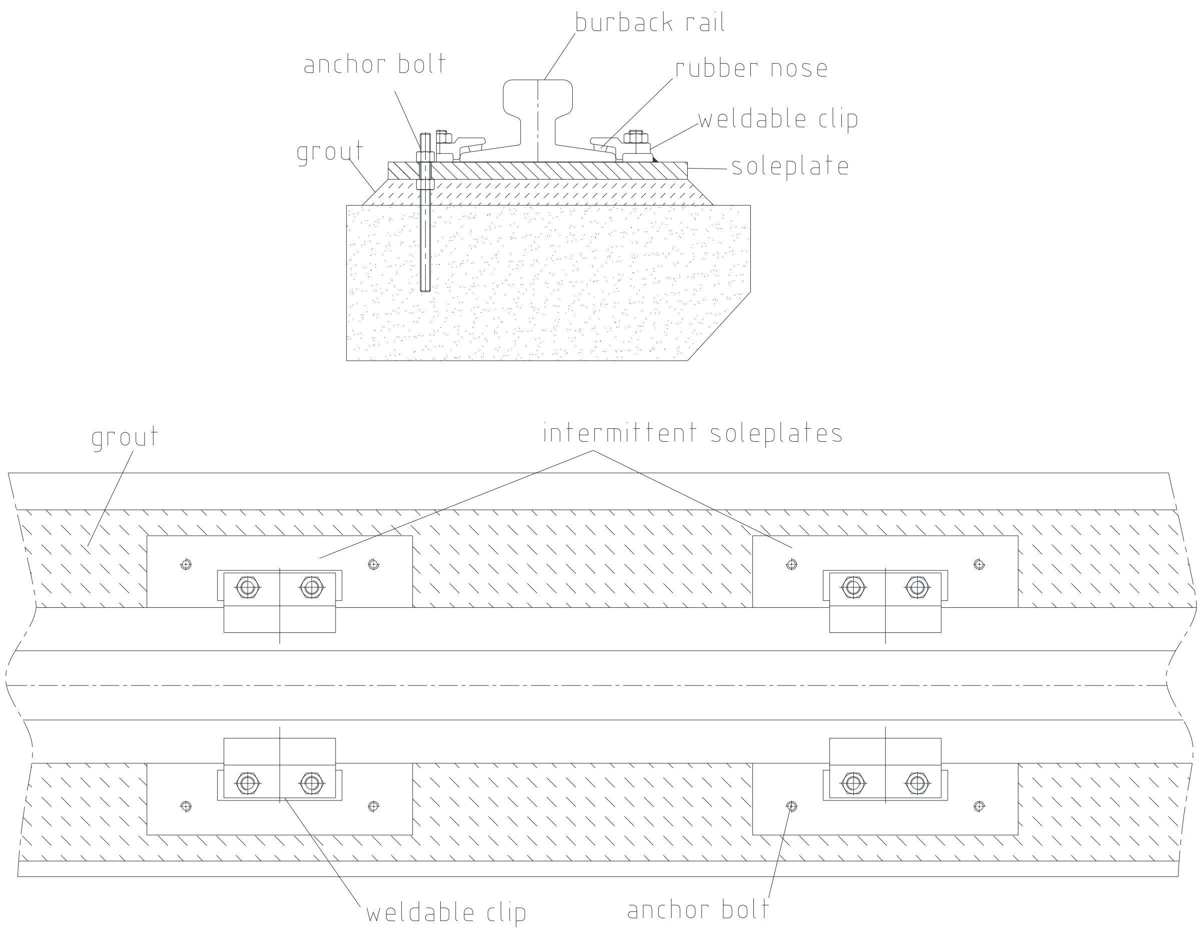


Figure 11 – Intermittent soleplates system

2.2.1 RAIL

Same requirements of § 2.1.1 are applicable.

2.2.2 CLIPS

Same requirements of § 2.1.2 are applicable.

2.2.3 SOLEPLATES

Soleplates shall be made out of non-alloy structural steel according to EN 10025-2.

Length and width of each soleplate shall be enough to accommodate the rail and the clips, including a correct margin, depending on the hole dimension, between the anchor holes and the plate edges; plates shall be 20 mm thick.

If anchor bolts will be installed after concrete castings (drilled anchors), additional holes shall be foreseen in order to overcome the problem of encountering reinforcing steel bars during drilling.

Holes for anchor bolts and welding of clips lower parts shall be preferably executed in the workshop.

Spacing between soleplates shall be 700 maximum.

Design details are shown in § 2.2.6.

2.2.4 ANCHOR BOLTS

Four anchor bolts shall be installed for each soleplate.

Anchor bolts can be fixed to the supporting concrete beam before (cast-in-place anchors) or after (drilled anchors) the concrete castings: type shall be chosen considering the positioning tolerance that can be reached with each type.

Size, length and material shall guarantee enough shear resistance to sustain the side load transmitted by the clips to the soleplate and listed in Table 5.

2.2.5 GROUT

A layer of non-shrink grout shall be poured between the soleplates and the supporting concrete and between the rail and the concrete after rail installation; recommended layer thickness (below the soleplate) is 50 mm but it may vary according to the grout flowability and the concrete casting tolerances.

Compressive strength after curing shall sustain the vertical load transmitted by the crane wheel (provided by EN-HE group for any specific case).

Grout pouring shall follow strictly manufacturer’s procedure.

2.2.6 INSTALLATION

Rails shall be fixed to the supporting beam according to the following drawings:

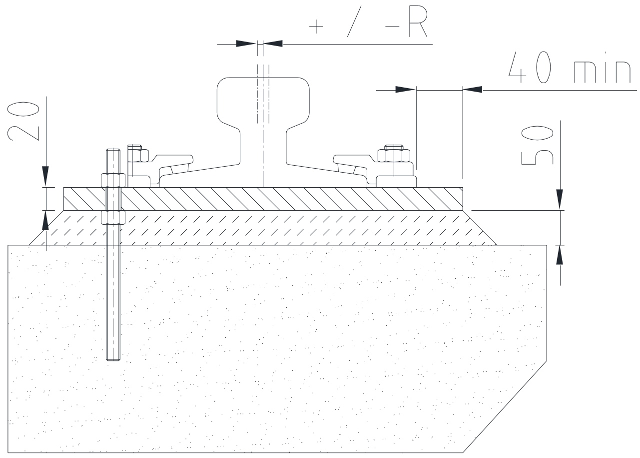


Figure 12 – Intermittent soleplate transversal section

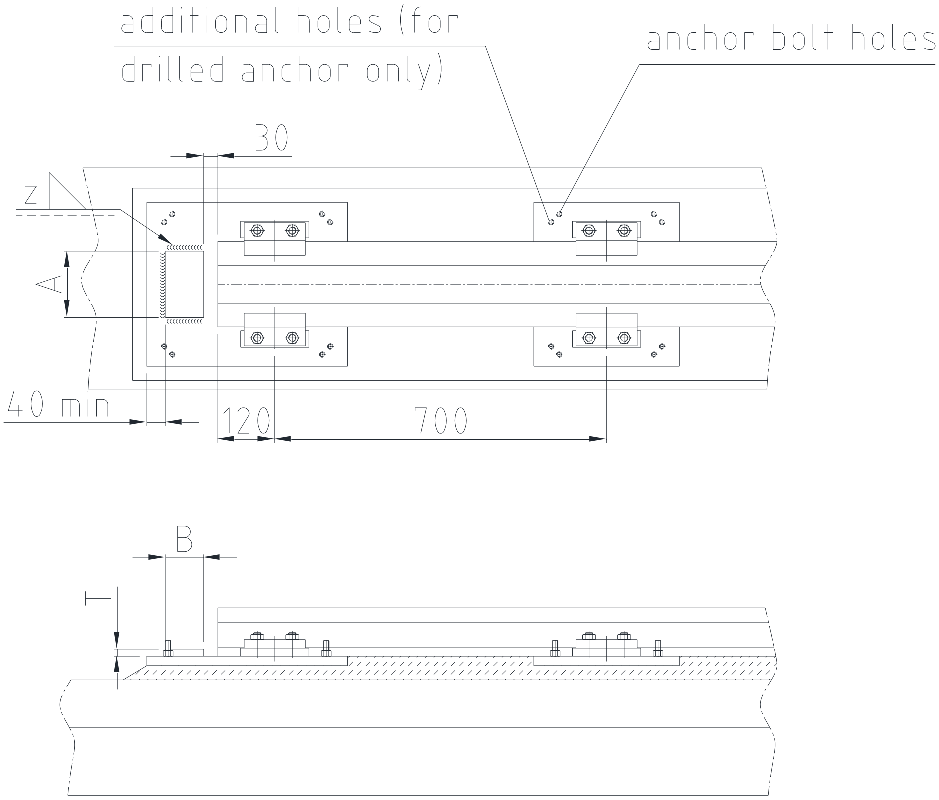


Figure 13 – Intermittent soleplate plan and longitudinal view

A plate shall be welded on the two extremity soleplates to limit the rail displacement due to crane longitudinal actions; length of the soleplates shall be increased accordingly. A 30 mm gap between the rail and the end plate shall be left to allow rail thermal deformation; this value shall be increased when the total runway length exceeds 100 metres.

Table 5 provides the parameters values:

Rail profile	Clips minimum side load [kN]	A [mm]	B [mm]	T [mm]	z [mm]	R [mm]
A45	28	70	40	10	6	5
A55	40	90	40	10	8	5
A65	50	110	50	10	8	5
A75	85	140	50	15	10	8
A100	120	140	80	15	10	8
A120	160	150	80	15	12	10

Table 5 – Intermittent soleplate installation parameters

2.2.7 JUNCTIONS

The same requirements described in § 1.2.6 shall be applied; the following remarks shall be noted:

- Welded junction: rail welding doesn't necessarily have to occur in correspondence of a soleplate.
- Cut junction:
  - The rail junction shall occur over a soleplate having a proper length to allow installation of the side plates and the additional clips.
  - Six anchor bolts shall be foreseen.

2.2.8 CORROSION PROTECTION

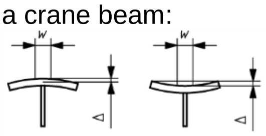
Rail sides and soleplates shall be protected at least by a 50 micron primer coat.

Rail top surface and its extremities (in case of welded junction) shall be covered during the whole painting process to ensure that it remains unpainted.

Clips shall remain unpainted.

2.2.9 INSTALLATION TOLERANCES

Tolerances shall not exceed the values mentioned in D.2.19 and D.2.21 of EN 1090-2 that are resumed in Table 6 and Table 7; the structure shall be classified as class 2.

Criterion	**Parameter**	**Permitted deviation Δ**	
		Class 1	**Class 2**
Flatness of top flange of a crane beam: 	Out of flatness over a central width *w* equal to the rail width plus 10 mm either side of rail in nominal position:	Δ= ± 1 mm	Δ= ± 1 mm

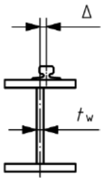
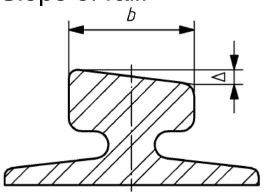
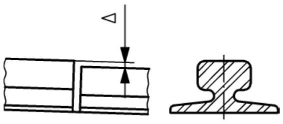
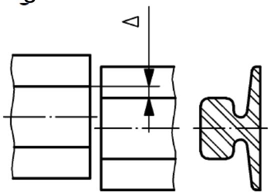
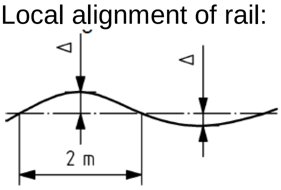
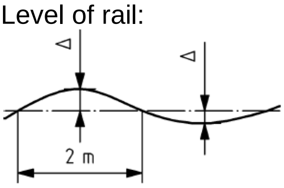
Eccentricity of rail relative to web:: 	For $t_w \leq 10$ mm For $t_w > 10$ mm	± 5 mm ± 0,5 t_w	± 5 mm ± 0,5 t_w
Slope of rail: 	Slope of top surface of cross-section:	Δ = ± *b*/100	Δ = ± *b* / 100
Level of rail: 	Step in top of rail at joint:	Δ = ± 1 mm	Δ = ± 0,5 mm
Edge of rail: 	Step in edge of rail at joint:	Δ = ± 1 mm	Δ = ± 0,5 mm

Table 6 – Functional manufacturing and erection tolerances - Crane beams and rails

Criterion	**Parameter**	**Permitted deviation Δ**	
		Class 1	**Class 2**
Location of rail in plan:	Relative to the intended location:	Δ = ± 10 mm	Δ = ± 5 mm
Local alignment of rail: 	Alignment over 2 m gauge length:	Δ = ± 1,5 mm	Δ = ± 1 mm
Level of rail	Relative to the intended level:	Δ = ± 15 mm	Δ = ± 10 mm
Level of rail	Level over span *L* of crane beam:	Δ = ± *L* / 500 but |Δ| ≥ 10 mm	Δ = ± *L* / 1 000 but |Δ| ≥ 10 mm
Level of rail: 	Variation over 2 m gauge length:	Δ = ± 3 mm	Δ = ± 2 mm

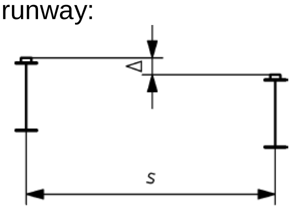
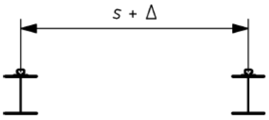
Relative levels of rails on the two sides of a runway: 	Deviation of level: for *s* ≤ 10 m for *s* > 10 m	Δ = ± 20 mm Δ = ± *s* / 500	Δ = ± 10 mm Δ = ± *s* / 1 000
Spacing *s* between centres of crane rails: 	Deviation of spacing: for *s* ≤ 16 m for *s* > 16 m	Δ = ± 10 mm Δ = ± (10 + [*s* - 16]/3) mm, with *s* in m and result in mm	Δ = ± 5 mm Δ = ± (5 + [*s* - 16]/4) mm, with *s* in m and result in mm
Structural end stops:	Relative location of the stops at the same end, measured in the direction of travel on the runway:	Δ = ± *s* / 1 000 but |Δ| ≤ 10 mm	= ± *s* / 1 000 but |Δ| ≤ 10 mm

Table 7 – Functional erection tolerances – Crane runways