MÜPRO

European Technical Assessment
ETA

valable pour

Rail d'installation MPR

CSTB
le futur en construction

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Evaluation Technique Européenne

ETE-25/0296 du 28/04/2025

(Version originale en langue française)

Partie Générale

Organisme d'Evaluation Technique (TAB) délivrant l'Evaluation Technique Européenne :	
Centre Scientifique et Technique du Bâtiment (CSTB)	
Nom commercial du produit de construction :	Rails MÜPRO
Famille de produit à laquelle le produit de construction appartient :	Produits pour les systèmes d'installation pour le support des équipements techniques du bâtiment
Fabricant :	MÜPRO Services GmbH Borsigstrasse 14 65205 Wiesbaden Germany
Usine(s) de fabrication :	UBB Umformtechnik GmbH Im Grund 1 91593 Burgbernheim Germany
Cette Evaluation Technique Européenne contient :	45 pages incluant 44 pages d'annexes qui font partie intégrante de cette évaluation
Cette Evaluation Technique Européenne est délivrée en accord avec la réglementation (EU) No 305/2011, sur la base de :	European Assessment Document (EAD) 280016-00-0602 version Juin 2020
Cette Evaluation remplace :	-

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Partie Spécifique

1   Description Technique du Produit

Cette Evaluation Technique Européenne couvre les rails MÜPRO décrits dans les Tableaux A1 à A5.

Les rails MÜPRO MPR 41/21/1.5, MPR 41/21/2.0, MPR 41/41/2.0, MPR 41/41/2.5 et MPR 41/62/2.5 sont fabriqués en acier de faible épaisseur, en forme de C. Des trous de formes circulaire ou oblongue permettent l'utilisation de fixation ou de pièces à fixer.

Les rails MÜPRO MPR 41/42/2.0 H, MPR 41/82/2.0 H, MPR 41/82/2.5 H et MPR 41/124/2.5 H se composent de deux profils de même type, reliés au niveau de l'arrière des rails de manière à assurer un ajustement de forme et une liaison résistante. Des évidements sous forme de trous oblongs et ronds permettent l'utilisation de fixations et d'attaches.

Les rails MÜPRO peuvent être coupés sur leur longueur selon les instructions du fabricant sans compromettre les performances déclarées.

Les dessins, dimensions et matériaux des rails MÜPRO sont donnés en Annexe A.

2   Définition de l'usage prévu

Les performances données dans la section 3 sont seulement valides si les rails MÜPRO répondent aux exigences des spécifications et conditions données en Annexe B.

Les essais et la méthode d'évaluation sur laquelle cette Evaluation Technique Européenne est basée mènent à supposer une durée de vie des rails MÜPRO d'au moins 50 ans à température ambiante et en atmosphère intérieure. Les indications relatives à la durée de vie ne peuvent pas être interprétées comme une garantie donnée par le fabricant, mais ne doivent être considérées que comme un moyen pour choisir le produit qui convient à la durée de vie économiquement raisonnable attendue des ouvrages.

En accord avec le Document d'Evaluation Européen EAD 280016-00-0602, le produit peut être utilisé pour :

a) Installations pour le support des kits de sprinklers,

b) Installations pour le support des équipements techniques du bâtiment en général,

c) Installations pour le support des tuyaux pour le transport de gaz/carburant destinés à l'alimentation des systèmes de chauffage/refroidissement des bâtiments.

d) Installations pour les supports visant à soutenir des tuyaux pour le transport de l'eau non destinée à la consommation humaine

3   Performances du produit et références aux méthodes utilisées pour leur évaluation

3.1   Sécurité en cas d'incendie (BWR 2)

No.	Caractéristique essentielle	Performance
1	Réaction au feu	Classe A1
2	Résistance au poinçonnement des trous au dos des rails sous exposition au feu	Performance non évaluée
3	Caractéristiques à la flexion sous exposition au feu	Performance non évaluée

3.2   Sécurité et accessibilité en cours d'utilisation (BWR 4)

No.	Caractéristique essentielle	Performance
4	Forme	Voir Annexe A
5	Dimensions	Voir Annexe A
6	Matériaux et caractéristiques de la section	Voir Annexe A et B
7	Résistance caractéristiques des trous au dos des rails à température ambiante	Performance non évaluée

4   Système d'Evaluation et de Vérification de la Constance des Performances (AVCP) appliqué, avec référence à sa base juridique

Conformément au Document d'Evaluation Européen EAD 280016-00-0602, les bases juridiques suivantes s'appliquent :

-    En cas de domaine d'emploi a) prévu en Section 2 :

Décision de la commission N° 96/577/EC telle que modifiée par la Décision 2002/592/EC de la Commission :

Le système 1 s'applique pour l'évaluation et la vérification de la constance des performances (AVCP).

-    En cas de domaine d'emploi b) prévu en Section 2 :

Décision de la commission N° 97/161/EC de la Commission :

Le système 2+ s'applique pour l'évaluation et la vérification de la constance des performances (AVCP).

-    En cas de domaine d'emploi d) prévu en Section 2 :

Décision de la commission N° 1999/472/EC telle que modifiée par la Décision 2001/596/EC de la Commission :

Le système 3 s'applique pour l'évaluation et la vérification de la constance des performances (AVCP).

-    En cas de domaine d'emploi c) prévu en Section 2 :

Décision de la commission N° 1999/472/EC telle que modifiée par la Décision 2001/596/EC de la Commission :

Le système 4 s'applique pour l'évaluation et la vérification de la constance des performances (AVCP).

5   Détails techniques nécessaires à l'implémentation du système AVCP, tel que proposé dans l'EAD concerné

Les données techniques nécessaires à la mise en œuvre du système d'Evaluation et de Vérification de la Constance des Performances (AVCP) sont définies dans le plan de contrôle (partie confidentielle de l'Evaluation Technique Européenne) déposé au Centre Scientifique et Technique du Bâtiment.

Le fabricant doit, sous la forme d'un contrat, impliquer un organisme notifié approuvé dans le domaine des systèmes de supportage pour la délivrance d'un certificat de conformité CE basé sur le plan de contrôle.

Délivrée à Marne La Vallée le 28/04/2025 par :

Loïc PAYET

Responsable de la division Structure, Maçonnerie et Partition

Tableau A1 : Dimensions et matériaux des rails MÜPRO MPR 41/21/1.5 et MPR 41/21/2.0
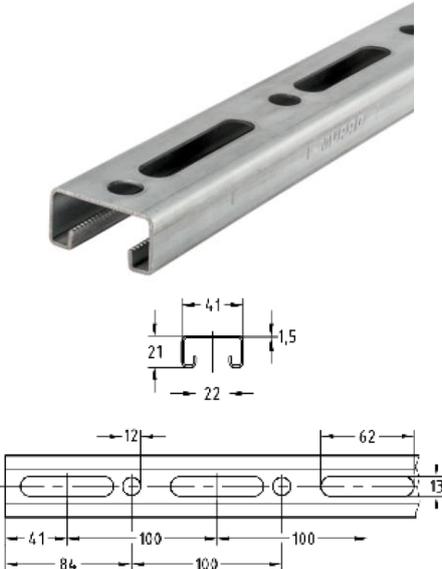
Illustration (Dimensions en mm et pouces)	Référence	N° de l'élément	Longueur [mm]	Matériaux et revêtements
	Rail MÜPRO MPR 41/21/1.5	175787	3 000	S250GD + Z275NA Selon la EN 10346
		175788	6 000	
	Rail MÜPRO MPR 41/21/2.0	150930 150931 150932	2 000 3 040 6 000	S250GD + Z275NA Selon la EN 10346
		154173 154174 154175	2 000 3 040 6 000	S235JR, galvanisé à chaud Selon la EN 10025-2
		154393 154394 154395	2 000 3 040 6 000	V4A (1.4404) Selon la EN 10088-2
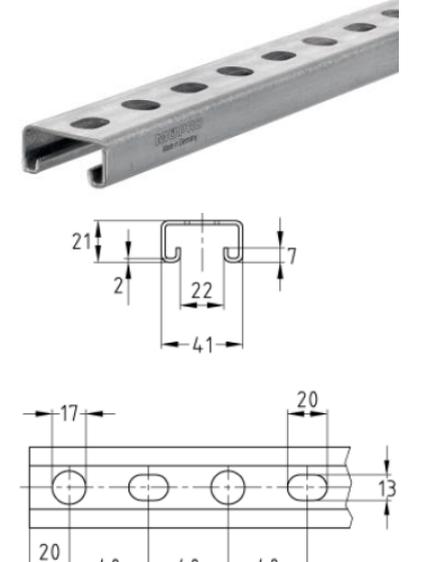
Rails MÜPRO	
Description du produit Forme, dimensions, matériaux et revêtement	**Annexe A1**

Tableau A2 : Dimensions et matériaux des rails MÜPRO MPR 41/41/2.0 et MPR 41/41/2.5

Illustration (Dimensions en mm et pouces)	Référence	N° de l'élément	Longueur [mm]	Matériaux et revêtements
	Rail MÜPRO MPR 41/41/2.0	150933 150934 150935	2 000 3 040 6 000	S250GD + Z275NA Selon la EN 10346
		154176 154177 154178	2 000 3 040 6 000	S235JR, galvanisé à chaud Selon la EN 10025-2
		154396 154397	2 000 6 000	V4A (1.4404) Selon la EN 10088-2
	Rail MÜPRO MPR 41/41/2.5	150864 150937 150938	2 000 3 040 6 000	S250GD + Z275NA Selon la EN 10346
		154179 154180 154181	2 000 3 040 6 000	S235JR, galvanisé à chaud Selon la EN 10025-2

Rails MÜPRO

Description du produit
Forme, dimensions, matériaux et revêtement

Annexe A2

Tableau A3 : Dimensions et matériaux des rails MÜPRO MPR 41/62/2.5 et MPR 41/42/2.0 H

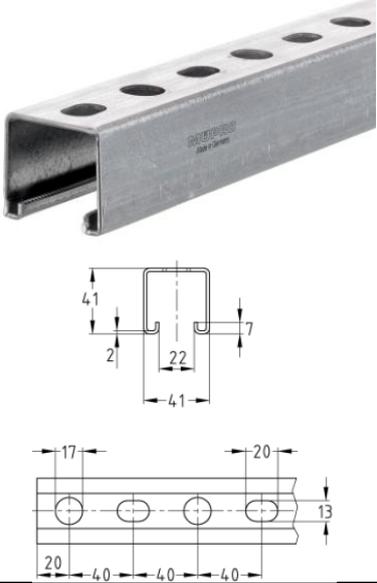| Illustration (Dimensions en mm et pouces)	Référence	N° de l'élément	Longueur [mm]	Matériaux et revêtements
	Rail MÜPRO MPR 41/62/2.5	150936 150978 150979	2 000 3 040 6 000	S250GD + Z275NA Selon la EN 10346
		154182 154183 154184	2 000 3 040 6 000	S235JR, galvanisé à chaud Selon la EN 10025-2
		154404	6 000	V4A (1.4404) Selon la EN 10088-2
	Rail MÜPRO MPR 41/42/2.0 H	150968	6 640	S250GD + Z275NA Selon la EN 10346
		154185	6 640	S235JR, galvanisé à chaud Selon la EN 10025-2
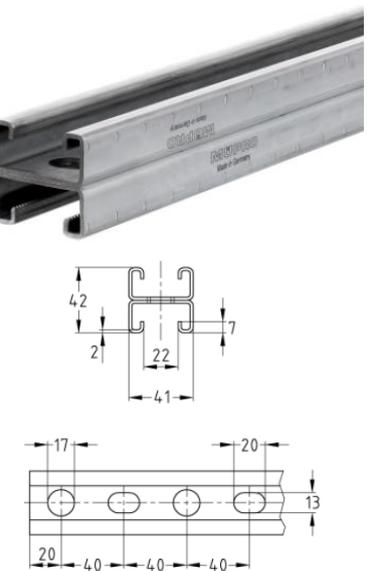
Rails MÜPRO

Description du produit
Forme, dimensions, matériaux et revêtement

Annexe A3

Tableau A4 : Dimensions et matériaux des rails MÜPRO MPR 41/82/2.0 H et MPR 41/82/2.5 H

Illustration (Dimensions en mm et pouces)	Référence	N° de l'élément	Longueur [mm]	Matériaux et revêtements
	Rail MÜPRO MPR 41/82/2.0 H	150969	6 640	S250GD + Z275NA Selon la EN 10346
		154186	6 640	S235JR, galvanisé à chaud Selon la EN 10025-2
		154406	6 000	V4A (1.4404) Selon la EN 10088-2
	Rail MÜPRO MPR 41/82/2.5 H	177352	6 000	S250GD + Z275NA Selon la EN 10346

Les doubles canaux sont constitués de deux profils simples MPR 41/41/2.5, reliés à l'arrière des rails par un assemblage par emboîtement et par liaison mécanique, de type sertissage ou soudage.
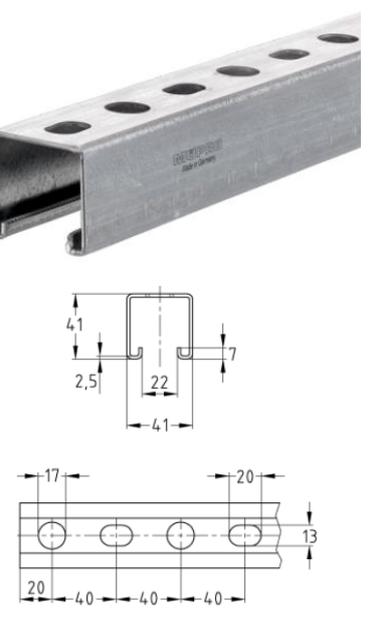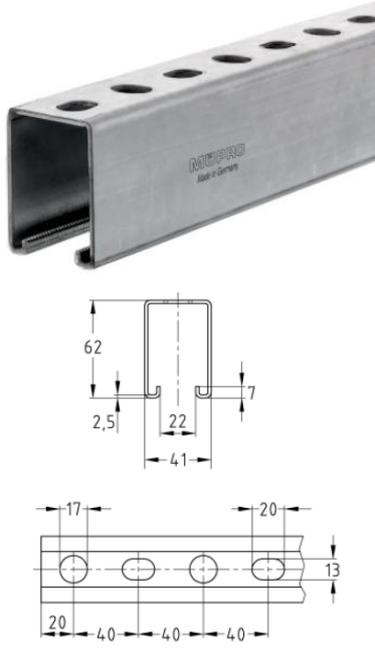
Rails MÜPRO

Description du produit
Forme, dimensions, matériaux et revêtement

Annexe A4

Tableau A5 : Dimensions et matériaux des rails MÜPRO MPR 41/124/2.5 H
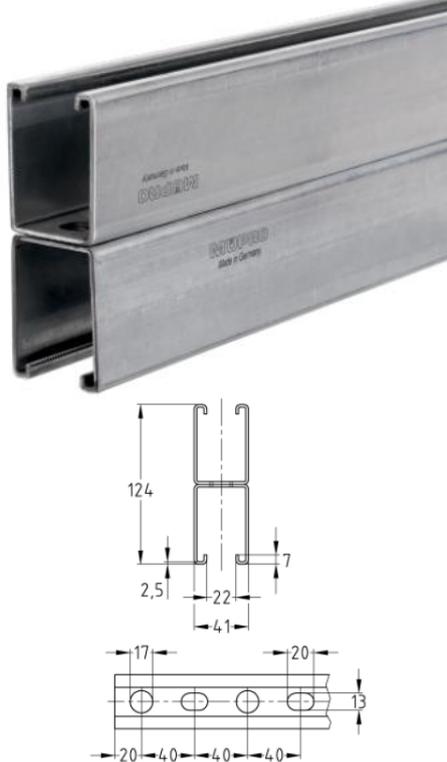
Illustration (Dimensions en mm et pouces)	Référence	N° de l'élément	Longueur [mm]	Matériaux et revêtements
	Rail MÜPRO MPR 41/124/2.5 H	151050	6 640	S250GD + Z275NA Selon la EN 10346
		154187	6 640	S235JR, galvanisé à chaud Selon la EN 10025-2
		154407	6 000	V4A (1.4404) Selon la EN 10088-2

Les doubles canaux sont constitués de deux profils simples MPR 41/41/2.5, reliés à l'arrière des rails par un assemblage par emboîtement et par liaison mécanique, de type sertissage ou soudage.

Rails MÜPRO	
Description du produit Forme, dimensions, matériaux et revêtement	**Annexe A5**

Précisions sur le domaine d'emploi

- Les rails MÜPRO sont utilisés pour reprendre les charges des composants de service du bâtiment tel que les conduits et équipement pour les sprinklers, l'eau, le chauffage, le refroidissement, la ventilation, les systèmes électriques et autres à température ambiante et en cas d'incendie. Les rails du Système MT de Hilti remplissent cette fonction de reprise de charges dans les conditions décrites dans la section 2 de la présente Evaluation Technique Européenne.

- Les rails MÜPRO MPR (sans considération de longueur ou de revêtement) faisant partie de cette Evaluation Technique Européenne sont utilisés pour des applications à température ambiante.

Rails MÜPRO

Cross-section characteristics

Annexe B1

Tableau B1 : Propriétés de la section des rails Müpro MPR 41/21/1.5, zone perforée, trou circulaire

Description	Symbol	Value	Unit	Comment
Cross-sectional area	A	131,28	mm²	
	A_{geom}	131,28	mm²	geometric cross-sectional area (not ideal)
Shear areas	A_y	39,22	mm²	
	A_z	42,59	mm²	
Centroid position	$y_{S,0}$	20,50	mm	relative to zero point
	$z_{S,0}$	11,13	mm	
Moments of inertia	I_y	7776,64	mm⁴	about centroidal axes y
	I_z	35532,19	mm⁴	
Inclination of principal axes	α	0,00	°	clockwise
Polar moments of inertia	I_p	43308,83	mm⁴	
	$I_{p,M}$	104828,94	mm⁴	about shear center M
Radii of gyration	i_y	7,70	mm	relative to centroid C
	i_z	16,45	mm	
Polar radii of gyration	i_p	18,16	mm	
	$i_{p,M}$	28,26	mm	about shear center M
Warping radius of gyration	$i_{\omega,M}$	7,01	mm	
Cross-section weight	G	1,03	kg/m	
Cross-section perimeter	U	181,02	mm	incl. inner side of cells
Torsional constant	I_t	87,34	mm⁴	calculated analytically
Secondary torsional constant	$I_{t,s}$	26165,15	mm⁴	
Location of the shear center	$y_{M,0}$	20,50	mm	relative to zero point
	$z_{M,0}$	32,78	mm	
	y_M	0,00	mm	relative to centroid C
	z_M	21,65	mm	
Warping constants	$I_{\omega,S}$	2,181E+07	mm⁶	relative to centroid C
	$I_{\omega,M}$	5,157E+06	mm⁶	about shear center M
Auxiliary value for warp rotation	$r_{\omega,M}$	0,000		
Section moduli	$W_{y,max}$	787,95	mm³	in distance 9.87 mm
	$W_{y,min}$	-698,67	mm³	in distance -11.13 mm
	$W_{z,max}$	1733,28	mm³	in distance 20.50 mm
	$W_{z,min}$	-1733,28	mm³	in distance -20.50 mm
Warping section moduli	$W_{\omega,M,max}$	14435,36	mm⁴	in node 40
	$W_{\omega,M,min}$	-14449,92	mm⁴	in node 28
Torsional section modulus	W_t	58,22	mm³	
Stability parameters	r_u	-2,88	mm	
	$r_{M,v}$	-46,17	mm	
Reduction factor	λ_M	0,00	1/mm	

Rails MÜPRO

Cross-section characteristics   **Annexe B2**

Tableau B2 : Propriétés de la section des rails Müpro MPR 41/21/1.5, zone perforée, trou oblong

Description	Symbol	Value	Unit	Comment
Cross-sectional area	A	129,78	mm²	
	A_{geom}	129,78	mm²	geometric cross-sectional area (not ideal)
Shear areas	A_y	39,19	mm²	
	A_z	42,88	mm²	
Centroid position	$y_{S,0}$	20,50	mm	relative to zero point
	$z_{S,0}$	11,03	mm	
Moments of inertia	I_y	7650,17	mm⁴	about centroidal axes y
	I_z	35473,56	mm⁴	
Inclination of principal axes	α	0,00	°	clockwise
Polar moments of inertia	I_p	43123,73	mm⁴	
	$I_{p,M}$	104651,83	mm⁴	about shear center M
Radii of gyration	i_y	7,68	mm	relative to centroid C
	i_z	16,53	mm	
Polar radii of gyration	i_p	18,23	mm	
	$i_{p,M}$	28,40	mm	about shear center M
Warping radius of gyration	$i_{\omega,M}$	7,01	mm	
Cross-section weight	G	1,02	kg/m	
Cross-section perimeter	U	179,02	mm	incl. inner side of cells
Torsional constant	I_t	87,34	mm⁴	calculated analytically
Secondary torsional constant	$I_{t,s}$	26174,55	mm⁴	
Location of the shear center	$y_{M,0}$	20,50	mm	relative to zero point
	$z_{M,0}$	32,80	mm	
	y_M	0,00	mm	relative to centroid C
	z_M	21,77	mm	
Warping constants	$I_{\omega,S}$	2,197E+07	mm⁶	relative to centroid C
	$I_{\omega,M}$	5,148E+06	mm⁶	about shear center M
Auxiliary value for warp rotation	$r_{\omega,M}$	0,000		
Section moduli	$W_{y,max}$	766,94	mm³	in distance 9.97 mm
	$W_{y,min}$	-693,89	mm³	in distance -11.03 mm
	$W_{z,max}$	1730,42	mm³	in distance 20.50 mm
	$W_{z,min}$	-1730,42	mm³	in distance -20.50 mm
Warping section moduli	$W_{\omega,M,max}$	14419,31	mm⁴	in node 40
	$W_{\omega,M,min}$	-14434,05	mm⁴	in node 28
Torsional section modulus	W_t	58,22	mm³	
Stability parameters	r_u	-2,34	mm	
	$r_{M,v}$	-45,89	mm	
Reduction factor	λ_M	0,00	1/mm	

Rails MÜPRO

Cross-section characteristics   **Annexe B3**

Tableau B3 : Propriétés de la section des rails Müpro MPR 41/21/1.5, zone non perforée

Description	Symbol	Value	Unit	Comment
Cross-sectional area	A	149,28	mm²	
	A_{geom}	149,28	mm²	geometric cross-sectional area (not ideal)
Shear areas	A_y	39,33	mm²	
	A_z	39,06	mm²	
Centroid position	$y_{s,0}$	20,50	mm	relative to zero point
	$z_{s,0}$	12,23	mm	
Moments of inertia	I_y	9096,32	mm⁴	about centroidal axes y
	I_z	35748,19	mm⁴	
Inclination of principal axes	α	0,00	°	clockwise
Polar moments of inertia	I_p	44844,51	mm⁴	
	$I_{p,M}$	107407,44	mm⁴	about shear center M
Radii of gyration	i_y	7,81	mm	relative to centroid C
	i_z	15,47	mm	
Polar radii of gyration	i_p	17,33	mm	
	$i_{p,M}$	26,82	mm	about shear center M
Warping radius of gyration	$i_{\omega,M}$	6,95	mm	
Cross-section weight	G	1,17	kg/m	
Cross-section perimeter	U	202,02	mm	incl. inner side of cells
Torsional constant	I_t	88,40	mm⁴	calculated analytically
Secondary torsional constant	$I_{t,s}$	26122,70	mm⁴	
Location of the shear center	$y_{M,0}$	20,50	mm	relative to zero point
	$z_{M,0}$	32,70	mm	
	y_M	0,00	mm	relative to centroid C
	z_M	20,47	mm	
Warping constants	$I_{\omega,S}$	2,018E+07	mm⁶	relative to centroid C
	$I_{\omega,M}$	5,191E+06	mm⁶	about shear center M
Auxiliary value for warp rotation	$r_{\omega,M}$	0,000		
Section moduli	$W_{y,max}$	1037,33	mm³	in distance 8.77 mm
	$W_{y,min}$	-743,71	mm³	in distance -12.23 mm
	$W_{z,max}$	1743,81	mm³	in distance 20.50 mm
	$W_{z,min}$	-1743,81	mm³	in distance -20.50 mm
Warping section moduli	$W_{\omega,M,max}$	14494,55	mm⁴	in node 37
	$W_{\omega,M,min}$	-14507,29	mm⁴	in node 25
Torsional section modulus	W_t	58,93	mm³	
Stability parameters	r_u	-8,39	mm	
	$r_{M,v}$	-49,33	mm	
Reduction factor	λ_M	0,00	1/mm	

Rails MÜPRO

Cross-section characteristics

Annexe B4

Tableau B4 : Propriétés de la section des rails Müpro MPR 41/21/1.5, section moyennée

Description	Symbol	Value	Unit	Comment
Cross-sectional area	A	136,02	mm²	
	A_{geom}	136,02	mm²	geometric cross-sectional area (not ideal)
Shear areas	A_y	24,10	mm²	
	A_z	41,50	mm²	
Centroid position	$y_{S,0}$	20,50	mm	relative to zero point
	$z_{S,0}$	11,45	mm	
Moments of inertia	I_y	8156,93	mm⁴	about centroidal axes y
	I_z	35561,44	mm⁴	
Inclination of principal axes	α	0,00	°	clockwise
Polar moments of inertia	I_p	43718,37	mm⁴	
	$I_{p,M}$	105541,42	mm⁴	about shear center M
Radii of gyration	i_y	7,74	mm	relative to centroid C
	i_z	16,17	mm	
Polar radii of gyration	i_p	17,93	mm	
	$i_{p,M}$	27,86	mm	about shear center M
Warping radius of gyration	$i_{\omega,M}$	6,99	mm	
Cross-section weight	G	1,07	kg/m	
Cross-section perimeter	U	204,06	mm	incl. inner side of cells
Torsional constant	I_t	74,25	mm⁴	calculated analytically
Secondary torsional constant	$I_{t,s}$	25909,94	mm⁴	
Location of the shear center	$y_{M,0}$	20,50	mm	relative to zero point
	$z_{M,0}$	32,77	mm	
	y_M	0,00	mm	relative to centroid C
	z_M	21,32	mm	
Warping constants	$I_{\omega,S}$	2,133E+07	mm⁶	relative to centroid C
	$I_{\omega,M}$	5,162E+06	mm⁶	about shear center M
Auxiliary value for warp rotation	$r_{\omega,M}$	0,000		
Section moduli	$W_{y,max}$	854,01	mm³	in distance 9.55 mm
	$W_{y,min}$	-712,48	mm³	in distance -11.45 mm
	$W_{z,max}$	1734,70	mm³	in distance 20.50 mm
	$W_{z,min}$	-1734,70	mm³	in distance -20.50 mm
Warping section moduli	$W_{\omega,M,max}$	14443,60	mm⁴	in node 39
	$W_{\omega,M,min}$	-14457,64	mm⁴	in node 27
Torsional section modulus	W_t	49,50	mm³	
Stability parameters	r_u	-4,61	mm	
	$r_{M,v}$	-47,25	mm	
Reduction factor	λ_M	0,00	1/mm	

Rails MÜPRO

Caractéristiques de la section

Annexe B5

Tableau B5 : Propriétés de la section des rails Müpro MPR 41/21/2.0, zone perforée, trou circulaire

Description	Symbol	Value	Unit	Comment
Cross-sectional area	A	160,32	mm²	
	A_{geom}	160,32	mm²	geometric cross-sectional area (not ideal)
Shear areas	A_y	51,97	mm²	
	A_z	57,42	mm²	
Centroid position	$y_{S,0}$	20,50	mm	relative to zero point
	$z_{S,0}$	10,64	mm	
Moments of inertia	I_y	8783,35	mm⁴	about centroidal axes y
	I_z	44901,68	mm⁴	
Inclination of principal axes	α	0,00	°	clockwise
Polar moments of inertia	I_p	53685,03	mm⁴	
	$I_{p,M}$	128104,27	mm⁴	about shear center M
Radii of gyration	i_y	7,40	mm	relative to centroid C
	i_z	16,74	mm	
Polar radii of gyration	i_p	18,30	mm	
	$i_{p,M}$	28,27	mm	about shear center M
Warping radius of gyration	$i_{\omega,M}$	6,76	mm	
Cross-section weight	G	1,26	kg/m	
Cross-section perimeter	U	168,31	mm	incl. inner side of cells
Torsional constant	I_t	196,26	mm⁴	calculated analytically
Secondary torsional constant	$I_{t,s}$	32712,83	mm⁴	
Location of the shear center	$y_{M,0}$	20,50	mm	relative to zero point
	$z_{M,0}$	32,19	mm	
	y_M	0,00	mm	relative to centroid C
	z_M	21,54	mm	
Warping constants	$I_{\omega,S}$	2,671E+07	mm⁶	relative to centroid C
	$I_{\omega,M}$	5,856E+06	mm⁶	about shear center M
Auxiliary value for warp rotation	$r_{\omega,M}$	0,000		
Section moduli	$W_{y,max}$	848,08	mm³	in distance 10.36 mm
	$W_{y,min}$	-825,25	mm³	in distance -10.64 mm
	$W_{z,max}$	2190,33	mm³	in distance 20.50 mm
	$W_{z,min}$	-2190,33	mm³	in distance -20.50 mm
Warping section moduli	$W_{\omega,M,max}$	17539,77	mm⁴	in node 41
	$W_{\omega,M,min}$	-17558,05	mm⁴	in node 29
Torsional section modulus	W_t	98,13	mm³	
Stability parameters	r_u	-0,46	mm	
	$r_{M,v}$	-43,55	mm	
Reduction factor	λ_M	0,00	1/mm	

Rails MÜPRO	
Caractéristiques de la section	**Annexe B6**

Tableau B6: Propriétés de la section des rails Müpro MPR 41/21/2.0, zone perforée, trou oblong

Description	Symbol	Value	Unit	Comment
Cross-sectional area	A	168,32	mm²	
	A_{geom}	168,32	mm²	geometric cross-sectional area (not ideal)
Shear areas	A_y	52,22	mm²	
	A_z	55,94	mm²	
Centroid position	$y_{S,0}$	20,50	mm	relative to zero point
	$z_{S,0}$	11,09	mm	
Moments of inertia	I_y	9453,09	mm⁴	about centroidal axes y
	I_z	45354,35	mm⁴	
Inclination of principal axes	α	0,00	°	clockwise
Polar moments of inertia	I_p	54807,43	mm⁴	
	$I_{p,M}$	128886,01	mm⁴	about shear center M
Radii of gyration	i_y	7,49	mm	relative to centroid C
	i_z	16,41	mm	
Polar radii of gyration	i_p	18,04	mm	
	$i_{p,M}$	27,67	mm	about shear center M
Warping radius of gyration	$i_{\omega,M}$	6,78	mm	
Cross-section weight	G	1,32	kg/m	
Cross-section perimeter	U	176,31	mm	incl. inner side of cells
Torsional constant	I_t	196,26	mm⁴	calculated analytically
Secondary torsional constant	$I_{t,s}$	32651,89	mm⁴	
Location of the shear center	$y_{M,0}$	20,50	mm	relative to zero point
	$z_{M,0}$	32,07	mm	
	y_M	0,00	mm	relative to centroid C
	z_M	20,98	mm	
Warping constants	$I_{\omega,S}$	2,590E+07	mm⁶	relative to centroid C
	$I_{\omega,M}$	5,922E+06	mm⁶	about shear center M
Auxiliary value for warp rotation	$r_{\omega,M}$	0,000		
Section moduli	$W_{y,max}$	953,73	mm³	in distance 9.91 mm
	$W_{y,min}$	-852,53	mm³	in distance -11.09 mm
	$W_{z,max}$	2212,41	mm³	in distance 20.50 mm
	$W_{z,min}$	-2212,41	mm³	in distance -20.50 mm
Warping section moduli	$W_{\omega,M,max}$	17662,60	mm⁴	in node 39
	$W_{\omega,M,min}$	-17679,88	mm⁴	in node 27
Torsional section modulus	W_t	98,13	mm³	
Stability parameters	r_u	-2,75	mm	
	$r_{M,v}$	-44,71	mm	
Reduction factor	λ_M	0,00	1/mm	

Rails MÜPRO

Caractéristiques de la section

Annexe B7

Tableau B7: Propriétés de la section des rails Müpro MPR 41/21/2.0, zone non perforée

Description	Symbol	Value	Unit	Comment
Cross-sectional area	A	194,32	mm²	
	A_{geom}	194,32	mm²	geometric cross-sectional area (not ideal)
Shear areas	A_y	52,40	mm²	
	A_z	50,80	mm²	
Centroid position	$y_{S,0}$	20,50	mm	relative to zero point
	$z_{S,0}$	12,28	mm	
Moments of inertia	I_y	11250,15	mm⁴	about centroidal axes y
	I_z	45720,51	mm⁴	
Inclination of principal axes	α	0,00	°	clockwise
Polar moments of inertia	I_p	56970,66	mm⁴	
	$I_{p,M}$	132304,96	mm⁴	about shear center M
Radii of gyration	i_y	7,61	mm	relative to centroid C
	i_z	15,34	mm	
Polar radii of gyration	i_p	17,12	mm	
	$i_{p,M}$	26,09	mm	about shear center M
Warping radius of gyration	$i_{\omega,M}$	6,72	mm	
Cross-section weight	G	1,53	kg/m	
Cross-section perimeter	U	198,31	mm	incl. inner side of cells
Torsional constant	I_t	199,62	mm⁴	calculated analytically
Secondary torsional constant	$I_{t,s}$	32577,93	mm⁴	
Location of the shear center	$y_{M,0}$	20,50	mm	relative to zero point
	$z_{M,0}$	31,97	mm	
	y_M	0,00	mm	relative to centroid C
	z_M	19,69	mm	
Warping constants	$I_{\omega,S}$	2,371E+07	mm⁶	relative to centroid C
	$I_{\omega,M}$	5,975E+06	mm⁶	about shear center M
Auxiliary value for warp rotation	$r_{\omega,M}$	0,000		
Section moduli	$W_{y,max}$	1290,38	mm³	in distance 8.70 mm
	$W_{y,min}$	-916,02	mm³	in distance -12.30 mm
	$W_{z,max}$	2230,27	mm³	in distance 20.50 mm
	$W_{z,min}$	-2230,27	mm³	in distance -20.50 mm
Warping section moduli	$W_{\omega,M,max}$	17759,81	mm⁴	in node 36
	$W_{\omega,M,min}$	-17774,69	mm⁴	in node 24
Torsional section modulus	W_t	99,81	mm³	
Stability parameters	r_u	-8,83	mm	
	$r_{M,v}$	-48,21	mm	
Reduction factor	λ_M	0,00	1/mm	

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Caractéristiques de la section

Annexe B8

Tableau B8: Propriétés de la section des rails Müpro MPR 41/21/2.0, section moyennée

Description	Symbol	Value	Unit	Comment
Cross-sectional area	A	183,10	mm²	
	A_{geom}	183,10	mm²	geometric cross-sectional area (not ideal)
Shear areas	A_y	43,86	mm²	
	A_z	52,46	mm²	
Centroid position	$y_{S,0}$	20,50	mm	relative to zero point
	$z_{S,0}$	11,81	mm	
Moments of inertia	I_y	10532,80	mm⁴	about centroidal axes y
	I_z	45450,30	mm⁴	
Inclination of principal axes	α	0,00	°	clockwise
Polar moments of inertia	I_p	55983,10	mm⁴	
	$I_{p,M}$	130945,54	mm⁴	about shear center M
Radii of gyration	i_y	7,58	mm	relative to centroid C
	i_z	15,76	mm	
Polar radii of gyration	i_p	17,49	mm	
	$i_{p,M}$	26,74	mm	about shear center M
Warping radius of gyration	$i_{\omega,M}$	6,73	mm	
Cross-section weight	G	1,44	kg/m	
Cross-section perimeter	U	199,63	mm	incl. inner side of cells
Torsional constant	I_t	167,92	mm⁴	calculated analytically
Secondary torsional constant	$I_{t,s}$	32546,82	mm⁴	
Location of the shear center	$y_{M,0}$	20,50	mm	relative to zero point
	$z_{M,0}$	32,04	mm	
	y_M	0,00	mm	relative to centroid C
	z_M	20,23	mm	
Warping constants	$I_{\omega,S}$	2,456E+07	mm⁶	relative to centroid C
	$I_{\omega,M}$	5,936E+06	mm⁶	about shear center M
Auxiliary value for warp rotation	$r_{\omega,M}$	0,000		
Section moduli	$W_{y,max}$	1145,89	mm³	in distance 9.19 mm
	$W_{y,min}$	-891,99	mm³	in distance -11.81 mm
	$W_{z,max}$	2217,09	mm³	in distance 20.50 mm
	$W_{z,min}$	-2217,09	mm³	in distance -20.50 mm
Warping section moduli	$W_{\omega,M,max}$	17689,06	mm⁴	in node 37
	$W_{\omega,M,min}$	-17704,92	mm⁴	in node 25
Torsional section modulus	W_t	83,96	mm³	
Stability parameters	r_u	-6,66	mm	
	$r_{M,v}$	-47,13	mm	
Reduction factor	λ_M	0,00	1/mm	

Rails MÜPRO

Caractéristiques de la section   **Annexe B9**

Tableau B9: Propriétés de la section des rails Müpro MPR 41/41/2.0, zone perforée, trou circulaire

Description	Symbol	Value	Unit	Comment
Cross-sectional area	A	240,32	mm²	
	A_{geom}	240,32	mm²	geometric cross-sectional area (not ideal)
Shear areas	A_y	44,26	mm²	
	A_z	136,15	mm²	
Centroid position	$y_{S,0}$	20,50	mm	relative to zero point
	$z_{S,0}$	20,39	mm	
Moments of inertia	I_y	49227,59	mm⁴	about centroidal axes y
	I_z	75348,35	mm⁴	
Inclination of principal axes	α	0,00	°	clockwise
Polar moments of inertia	I_p	124575,94	mm⁴	
	$I_{p,M}$	560274,16	mm⁴	about shear center M
Radii of gyration	i_y	14,31	mm	relative to centroid C
	i_z	17,71	mm	
Polar radii of gyration	i_p	22,77	mm	
	$i_{p,M}$	48,28	mm	about shear center M
Warping radius of gyration	$i_{\omega,M}$	7,41	mm	
Cross-section weight	G	1,89	kg/m	
Cross-section perimeter	U	248,31	mm	incl. inner side of cells
Torsional constant	I_t	302,92	mm⁴	calculated analytically
Secondary torsional constant	$I_{t,s}$	78591,10	mm⁴	
Location of the shear center	$y_{M,0}$	20,50	mm	relative to zero point
	$z_{M,0}$	62,97	mm	
	y_M	0,00	mm	relative to centroid C
	z_M	42,58	mm	
Warping constants	$I_{\omega,S}$	1,675E+08	mm⁶	relative to centroid C
	$I_{\omega,M}$	3,078E+07	mm⁶	about shear center M
Auxiliary value for warp rotation	$r_{\omega,M}$	0,000		
Section moduli	$W_{y,max}$	2388,89	mm³	in distance 20.61 mm
	$W_{y,min}$	-2413,94	mm³	in distance -20.39 mm
	$W_{z,max}$	3675,53	mm³	in distance 20.50 mm
	$W_{z,min}$	-3675,53	mm³	in distance -20.50 mm
Warping section moduli	$W_{\omega,M,max}$	41486,76	mm⁴	in node 43
	$W_{\omega,M,min}$	-41511,21	mm⁴	in node 31
Torsional section modulus	W_t	151,46	mm³	
Stability parameters	r_u	0,76	mm	
	$r_{M,v}$	-84,39	mm	
Reduction factor	λ_M	0,00	1/mm	

Rails MÜPRO

Caractéristiques de la section

Annexe B10

Tableau B10 : Propriétés de la section des rails Müpro MPR 41/41/2.0, zone perforée, trou oblong

Description	Symbol	Value	Unit	Comment
Cross-sectional area	A	248,32	mm²	
	A_{geom}	248,32	mm²	geometric cross-sectional area (not ideal)
Shear areas	A_y	44,46	mm²	
	A_z	135,16	mm²	
Centroid position	$y_{S,0}$	20,50	mm	relative to zero point
	$z_{S,0}$	21,03	mm	
Moments of inertia	I_y	52206,58	mm⁴	about centroidal axes y
	I_z	75801,01	mm⁴	
Inclination of principal axes	α	0,00	°	clockwise
Polar moments of inertia	I_p	128007,59	mm⁴	
	$I_{p,M}$	562100,73	mm⁴	about shear center M
Radii of gyration	i_y	14,50	mm	relative to centroid C
	i_z	17,47	mm	
Polar radii of gyration	i_p	22,70	mm	
	$i_{p,M}$	47,58	mm	about shear center M
Warping radius of gyration	$i_{\omega,M}$	7,43	mm	
Cross-section weight	G	1,95	kg/m	
Cross-section perimeter	U	256,31	mm	incl. inner side of cells
Torsional constant	I_t	302,92	mm⁴	calculated analytically
Secondary torsional constant	$I_{t,s}$	78504,84	mm⁴	
Location of the shear center	$y_{M,0}$	20,50	mm	relative to zero point
	$z_{M,0}$	62,84	mm	
	y_M	0,00	mm	relative to centroid C
	z_M	41,81	mm	
Warping constants	$I_{\omega,S}$	1,636E+08	mm⁶	relative to centroid C
	$I_{\omega,M}$	3,102E+07	mm⁶	about shear center M
Auxiliary value for warp rotation	$r_{\omega,M}$	0,000		
Section moduli	$W_{y,max}$	2613,61	mm³	in distance 19.97 mm
	$W_{y,min}$	-2483,06	mm³	in distance -21.03 mm
	$W_{z,max}$	3697,61	mm³	in distance 20.50 mm
	$W_{z,min}$	-3697,61	mm³	in distance -20.50 mm
Warping section moduli	$W_{\omega,M,max}$	41715,30	mm⁴	in node 38
	$W_{\omega,M,min}$	-41738,90	mm⁴	in node 26
Torsional section modulus	W_t	151,46	mm³	
Stability parameters	r_u	-0,77	mm	
	$r_{M,v}$	-84,39	mm	
Reduction factor	λ_M	0,00	1/mm	

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Caractéristiques de la section	**Annexe B11**

Tableau B11 : Propriétés de la section des rails Müpro MPR 41/41/2.0, zone perforée, zone non perforée

Description	Symbol	Value	Unit	Comment
Cross-sectional area	A	274,32	mm²	
	A_{geom}	274,32	mm²	geometric cross-sectional area (not ideal)
Shear areas	A_y	44,62	mm²	
	A_z	129,72	mm²	
Centroid position	$y_{s,0}$	20,50	mm	relative to zero point
	$z_{s,0}$	22,82	mm	
Moments of inertia	I_y	60688,80	mm⁴	about centroidal axes y
	I_z	76167,18	mm⁴	
Inclination of principal axes	α	0,00	°	clockwise
Polar moments of inertia	I_p	136855,98	mm⁴	
	$I_{p,M}$	573636,69	mm⁴	about shear center M
Radii of gyration	i_y	14,87	mm	relative to centroid C
	i_z	16,66	mm	
Polar radii of gyration	i_p	22,34	mm	
	$i_{p,M}$	45,73	mm	about shear center M
Warping radius of gyration	$i_{\omega,M}$	7,38	mm	
Cross-section weight	G	2,15	kg/m	
Cross-section perimeter	U	278,31	mm	incl. inner side of cells
Torsional constant	I_t	306,28	mm⁴	calculated analytically
Secondary torsional constant	$I_{t,s}$	78421,05	mm⁴	
Location of the shear center	$y_{M,0}$	20,50	mm	relative to zero point
	$z_{M,0}$	62,73	mm	
	y_M	0,00	mm	relative to centroid C
	z_M	39,90	mm	
Warping constants	$I_{\omega,S}$	1,526E+08	mm⁶	relative to centroid C
	$I_{\omega,M}$	3,121E+07	mm⁶	about shear center M
Auxiliary value for warp rotation	$r_{\omega,M}$	0,000		
Section moduli	$W_{y,max}$	3339,02	mm³	in distance 18.18 mm
	$W_{y,min}$	-2658,95	mm³	in distance -22.82 mm
	$W_{z,max}$	3715,47	mm³	in distance 20.50 mm
	$W_{z,min}$	-3715,47	mm³	in distance -20.50 mm
Warping section moduli	$W_{\omega,M,max}$	41898,91	mm⁴	in node 36
	$W_{\omega,M,min}$	-41920,23	mm⁴	in node 24
Torsional section modulus	W_t	153,14	mm³	
Stability parameters	r_u	-5,30	mm	
	$r_{M,v}$	-85,10	mm	
Reduction factor	λ_M	0,00	1/mm	

Rails MÜPRO

Caractéristiques de la section

Annexe B12

Tableau B12 : Propriétés de la section des rails Müpro MPR 41/41/2.0, zone perforée, section moyennée

Description	Symbol	Value	Unit	Comment
Cross-sectional area	A	263,10	mm²	
	A_{geom}	263,10	mm²	geometric cross-sectional area (not ideal)
Shear areas	A_y	38,83	mm²	
	A_z	131,81	mm²	
Centroid position	$y_{s,0}$	20,50	mm	relative to zero point
	$z_{s,0}$	22,09	mm	
Moments of inertia	I_y	57229,73	mm⁴	about centroidal axes y
	I_z	75896,96	mm⁴	
Inclination of principal axes	α	0,00	°	clockwise
Polar moments of inertia	I_p	133126,69	mm⁴	
	$I_{p,M}$	569291,22	mm⁴	about shear center M
Radii of gyration	i_y	14,75	mm	relative to centroid C
	i_z	16,98	mm	
Polar radii of gyration	i_p	22,49	mm	
	$i_{p,M}$	46,52	mm	about shear center M
Warping radius of gyration	$i_{\omega,M}$	7,39	mm	
Cross-section weight	G	2,07	kg/m	
Cross-section perimeter	U	279,63	mm	incl. inner side of cells
Torsional constant	I_t	274,58	mm⁴	calculated analytically
Secondary torsional constant	$I_{t,s}$	78348,31	mm⁴	
Location of the shear center	$y_{M,0}$	20,50	mm	relative to zero point
	$z_{M,0}$	62,81	mm	
	y_M	0,00	mm	relative to centroid C
	z_M	40,72	mm	
Warping constants	$I_{\omega,S}$	1,570E+08	mm⁶	relative to centroid C
	$I_{\omega,M}$	3,107E+07	mm⁶	about shear center M
Auxiliary value for warp rotation	$r_{\omega,M}$	0,000		
Section moduli	$W_{y,max}$	3026,68	mm³	in distance 18.91 mm
	$W_{y,min}$	-2590,57	mm³	in distance -22.09 mm
	$W_{z,max}$	3702,29	mm³	in distance 20.50 mm
	$W_{z,min}$	-3702,29	mm³	in distance -20.50 mm
Warping section moduli	$W_{\omega,M,max}$	41764,32	mm⁴	in node 39
	$W_{\omega,M,min}$	-41786,58	mm⁴	in node 27
Torsional section modulus	W_t	137,29	mm³	
Stability parameters	r_u	-3,52	mm	
	$r_{M,v}$	-84,95	mm	
Reduction factor	λ_M	0,00	1/mm	

Rails MÜPRO

Caractéristiques de la section

Annexe B13

Tableau B13 : Propriétés de la section des rails Müpro MPR 41/41/2.5, zone perforée, trou circulaire

Description	Symbol	Value	Unit	Comment
Cross-sectional area	A	294,51	mm²	
	A_{geom}	294,51	mm²	geometric cross-sectional area (not ideal)
Shear areas	A_y	54,98	mm²	
	A_z	168,69	mm²	
Centroid position	$y_{S,0}$	20,50	mm	relative to zero point
	$z_{S,0}$	20,50	mm	
Moments of inertia	I_y	58672,28	mm⁴	about centroidal axes y
	I_z	90855,46	mm⁴	
Inclination of principal axes	α	0,00	°	clockwise
Polar moments of inertia	I_p	149527,74	mm⁴	
	$I_{p,M}$	661360,94	mm⁴	about shear center M
Radii of gyration	i_y	14,11	mm	relative to centroid C
	i_z	17,56	mm	
Polar radii of gyration	i_p	22,53	mm	
	$i_{p,M}$	47,39	mm	about shear center M
Warping radius of gyration	$i_{\omega,M}$	7,19	mm	
Cross-section weight	G	2,31	kg/m	
Cross-section perimeter	U	245,49	mm	incl. inner side of cells
Torsional constant	I_t	581,57	mm⁴	calculated analytically
Secondary torsional constant	$I_{t,s}$	92350,95	mm⁴	
Location of the shear center	$y_{M,0}$	20,50	mm	relative to zero point
	$z_{M,0}$	62,19	mm	
	y_M	0,00	mm	relative to centroid C
	z_M	41,69	mm	
Warping constants	$I_{\omega,S}$	1,923E+08	mm⁶	relative to centroid C
	$I_{\omega,M}$	3,421E+07	mm⁶	about shear center M
Auxiliary value for warp rotation	$r_{\omega,M}$	0,000		
Section moduli	$W_{y,max}$	2861,86	mm³	in distance 20.50 mm
	$W_{y,min}$	-2862,27	mm³	in distance -20.50 mm
	$W_{z,max}$	4431,97	mm³	in distance 20.50 mm
	$W_{z,min}$	-4431,97	mm³	in distance -20.50 mm
Warping section moduli	$W_{\omega,M,max}$	48581,49	mm⁴	in node 42
	$W_{\omega,M,min}$	-48608,53	mm⁴	in node 30
Torsional section modulus	W_t	232,63	mm³	
Stability parameters	r_u	0,47	mm	
	$r_{M,v}$	-82,91	mm	
Reduction factor	λ_M	0,00	1/mm	

Rails MÜPRO

Caractéristiques de la section

Annexe B14

Tableau B14 : Propriétés de la section des rails Müpro MPR 41/41/2.5, zone perforée, trou oblong

Description	Symbol	Value	Unit	Comment
Cross-sectional area	A	304,51	mm²	
	A_{geom}	304,51	mm²	geometric cross-sectional area (not ideal)
Shear areas	A_y	55,24	mm²	
	A_z	167,40	mm²	
Centroid position	$y_{S,0}$	20,50	mm	relative to zero point
	$z_{S,0}$	21,13	mm	
Moments of inertia	I_y	62261,90	mm⁴	about centroidal axes y
	I_z	91421,29	mm⁴	
Inclination of principal axes	α	0,00	°	clockwise
Polar moments of inertia	I_p	153683,20	mm⁴	
	$I_{p,M}$	663510,83	mm⁴	about shear center M
Radii of gyration	i_y	14,30	mm	relative to centroid C
	i_z	17,33	mm	
Polar radii of gyration	i_p	22,47	mm	
	$i_{p,M}$	46,68	mm	about shear center M
Warping radius of gyration	$i_{\omega,M}$	7,21	mm	
Cross-section weight	G	2,39	kg/m	
Cross-section perimeter	U	253,49	mm	incl. inner side of cells
Torsional constant	I_t	581,57	mm⁴	calculated analytically
Secondary torsional constant	$I_{t,s}$	92249,79	mm⁴	
Location of the shear center	$y_{M,0}$	20,50	mm	relative to zero point
	$z_{M,0}$	62,05	mm	
	y_M	0,00	mm	relative to centroid C
	z_M	40,92	mm	
Warping constants	$I_{\omega,S}$	1,877E+08	mm⁶	relative to centroid C
	$I_{\omega,M}$	3,450E+07	mm⁶	about shear center M
Auxiliary value for warp rotation	$r_{\omega,M}$	0,000		
Section moduli	$W_{y,max}$	3133,63	mm³	in distance 19.87 mm
	$W_{y,min}$	-2946,46	mm³	in distance -21.13 mm
	$W_{z,max}$	4459,58	mm³	in distance 20.50 mm
	$W_{z,min}$	-4459,58	mm³	in distance -20.50 mm
Warping section moduli	$W_{\omega,M,max}$	48867,65	mm⁴	in node 40
	$W_{\omega,M,min}$	-48893,74	mm⁴	in node 28
Torsional section modulus	W_t	232,63	mm³	
Stability parameters	r_u	-1,06	mm	
	$r_{M,v}$	-82,90	mm	
Reduction factor	λ_M	0,00	1/mm	

Rails MÜPRO

Caractéristiques de la section

Annexe B15

Tableau B15 : Propriétés de la section des rails Müpro MPR 41/41/2.5, zone non perforée

Description	Symbol	Value	Unit	Comment
Cross-sectional area	A	337,01	mm²	
	A_{geom}	337,01	mm²	geometric cross-sectional area (not ideal)
Shear areas	A_y	55,45	mm²	
	A_z	160,43	mm²	
Centroid position	$y_{s,0}$	20,50	mm	relative to zero point
	$z_{s,0}$	22,93	mm	
Moments of inertia	I_y	72458,46	mm⁴	about centroidal axes y
	I_z	91879,00	mm⁴	
Inclination of principal axes	α	0,00	°	clockwise
Polar moments of inertia	I_p	164337,46	mm⁴	
	$I_{p,M}$	677255,43	mm⁴	about shear center M
Radii of gyration	i_y	14,66	mm	relative to centroid C
	i_z	16,51	mm	
Polar radii of gyration	i_p	22,08	mm	
	$i_{p,M}$	44,83	mm	about shear center M
Warping radius of gyration	$i_{\omega,M}$	7,16	mm	
Cross-section weight	G	2,65	kg/m	
Cross-section perimeter	U	274,49	mm	incl. inner side of cells
Torsional constant	I_t	589,77	mm⁴	calculated analytically
Secondary torsional constant	$I_{t,s}$	92155,83	mm⁴	
Location of the shear center	$y_{M,0}$	20,50	mm	relative to zero point
	$z_{M,0}$	61,94	mm	
	y_M	0,00	mm	relative to centroid C
	z_M	39,01	mm	
Warping constants	$I_{\omega,S}$	1,747E+08	mm⁶	relative to centroid C
	$I_{\omega,M}$	3,473E+07	mm⁶	about shear center M
Auxiliary value for warp rotation	$r_{\omega,M}$	0,000		
Section moduli	$W_{y,max}$	4009,30	mm³	in distance 18.07 mm
	$W_{y,min}$	-3160,35	mm³	in distance -22.93 mm
	$W_{z,max}$	4481,90	mm³	in distance 20.50 mm
	$W_{z,min}$	-4481,90	mm³	in distance -20.50 mm
Warping section moduli	$W_{\omega,M,max}$	49097,77	mm⁴	in node 38
	$W_{\omega,M,min}$	-49121,29	mm⁴	in node 26
Torsional section modulus	W_t	235,91	mm³	
Stability parameters	r_u	-5,59	mm	
	$r_{M,v}$	-83,61	mm	
Reduction factor	λ_M	0,00	1/mm	

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Caractéristiques de la section   **Annexe B16**

Tableau B16 : Propriétés de la section des rails Müpro MPR 41/41/2.5, section moyennée

Description	Symbol	Value	Unit	Comment
Cross-sectional area	A	322,90	mm²	
	A_{geom}	322,90	mm²	geometric cross-sectional area (not ideal)
Shear areas	A_y	48,12	mm²	
	A_z	163,09	mm²	
Centroid position	$y_{s,0}$	20,50	mm	relative to zero point
	$z_{s,0}$	22,19	mm	
Moments of inertia	I_y	68275,21	mm⁴	about centroidal axes y
	I_z	91539,19	mm⁴	
Inclination of principal axes	α	0,00	°	clockwise
Polar moments of inertia	I_p	159814,40	mm⁴	
	$I_{p,M}$	672055,17	mm⁴	about shear center M
Radii of gyration	i_y	14,54	mm	relative to centroid C
	i_z	16,84	mm	
Polar radii of gyration	i_p	22,25	mm	
	$i_{p,M}$	45,62	mm	about shear center M
Warping radius of gyration	$i_{\omega,M}$	7,17	mm	
Cross-section weight	G	2,53	kg/m	
Cross-section perimeter	U	276,15	mm	incl. inner side of cells
Torsional constant	I_t	527,62	mm⁴	calculated analytically
Secondary torsional constant	$I_{t,s}$	92108,61	mm⁴	
Location of the shear center	$y_{M,0}$	20,50	mm	relative to zero point
	$z_{M,0}$	62,02	mm	
	y_M	0,00	mm	relative to centroid C
	z_M	39,83	mm	
Warping constants	$I_{\omega,S}$	1,799E+08	mm⁶	relative to centroid C
	$I_{\omega,M}$	3,456E+07	mm⁶	about shear center M
Auxiliary value for warp rotation	$r_{\omega,M}$	0,000		
Section moduli	$W_{y,max}$	3630,10	mm³	in distance 18.81 mm
	$W_{y,min}$	-3076,58	mm³	in distance -22.19 mm
	$W_{z,max}$	4465,33	mm³	in distance 20.50 mm
	$W_{z,min}$	-4465,33	mm³	in distance -20.50 mm
Warping section moduli	$W_{\omega,M,max}$	48928,27	mm⁴	in node 42
	$W_{\omega,M,min}$	-48952,85	mm⁴	in node 30
Torsional section modulus	W_t	211,05	mm³	
Stability parameters	r_u	-3,80	mm	
	$r_{M,v}$	-83,46	mm	
Reduction factor	λ_M	0,00	1/mm	

Rails MÜPRO

Caractéristiques de la section

Annexe B17

Tableau B17 : **Propriétés de la section des rails Müpro MPR 41/62/2.5, Zone perforée, trou circulaire**

Description	Symbol	Value	Unit	Comment
Cross-sectional area	A	399,51	mm²	
	A_{geom}	399,51	mm²	geometric cross-sectional area (not ideal)
Shear areas	A_y	46,25	mm²	
	A_z	269,34	mm²	
Centroid position	$y_{s,0}$	20,50	mm	relative to zero point
	$z_{s,0}$	30,89	mm	
Moments of inertia	I_y	173330,48	mm⁴	about centroidal axes y
	I_z	129819,21	mm⁴	
Inclination of principal axes	α	0,00	°	clockwise
Polar moments of inertia	I_p	303149,70	mm⁴	
	$I_{p,M}$	1,894E+06	mm⁴	about shear center M
Radii of gyration	i_y	20,83	mm	relative to centroid C
	i_z	18,03	mm	
Polar radii of gyration	i_p	27,55	mm	
	$i_{p,M}$	68,85	mm	about shear center M
Warping radius of gyration	$i_{\omega,M}$	7,10	mm	
Cross-section weight	G	3,14	kg/m	
Cross-section perimeter	U	329,49	mm	incl. inner side of cells
Torsional constant	I_t	800,32	mm⁴	calculated analytically
Secondary torsional constant	$I_{t,s}$	143682,79	mm⁴	
Location of the shear center	$y_{M,0}$	20,50	mm	relative to zero point
	$z_{M,0}$	93,99	mm	
	y_M	0,00	mm	relative to centroid C
	z_M	63,10	mm	
Warping constants	$I_{\omega,S}$	6,129E+08	mm⁶	relative to centroid C
	$I_{\omega,M}$	9,540E+07	mm⁶	about shear center M
Auxiliary value for warp rotation	$r_{\omega,M}$	0,000		
Section moduli	$W_{y,max}$	5571,64	mm³	in distance 31.11 mm
	$W_{y,min}$	-5611,11	mm³	in distance -30.89 mm
	$W_{z,max}$	6332,64	mm³	in distance 20.50 mm
	$W_{z,min}$	-6332,64	mm³	in distance -20.50 mm
Warping section moduli	$W_{\omega,M,max}$	85117,90	mm⁴	in node 40
	$W_{\omega,M,min}$	-85150,41	mm⁴	in node 28
Torsional section modulus	W_t	320,13	mm³	
Stability parameters	r_u	0,67	mm	
	$r_{M,v}$	-125,52	mm	
Reduction factor	λ_M	0,00	1/mm	

Rails MÜPRO

Caractéristiques de la section

Annexe B18

Tableau B18 : Propriétés de la section des rails Müpro MPR 41/62/2.5, Zone perforée, trou oblong

Description	Symbol	Value	Unit	Comment
Cross-sectional area	A	409,51	mm²	
	A_{geom}	409,51	mm²	geometric cross-sectional area (not ideal)
Shear areas	A_y	46,45	mm²	
	A_z	269,05	mm²	
Centroid position	$y_{S,0}$	20,50	mm	relative to zero point
	$z_{S,0}$	31,62	mm	
Moments of inertia	I_y	182033,75	mm⁴	about centroidal axes y
	I_z	130385,05	mm⁴	
Inclination of principal axes	α	0,00	°	clockwise
Polar moments of inertia	I_p	312418,79	mm⁴	
	$I_{p,M}$	1,898E+06	mm⁴	about shear center M
Radii of gyration	i_y	21,08	mm	relative to centroid C
	i_z	17,84	mm	
Polar radii of gyration	i_p	27,62	mm	
	$i_{p,M}$	68,08	mm	about shear center M
Warping radius of gyration	$i_{\omega,M}$	7,11	mm	
Cross-section weight	G	3,21	kg/m	
Cross-section perimeter	U	337,49	mm	incl. inner side of cells
Torsional constant	I_t	800,32	mm⁴	calculated analytically
Secondary torsional constant	$I_{t,s}$	143591,82	mm⁴	
Location of the shear center	$y_{M,0}$	20,50	mm	relative to zero point
	$z_{M,0}$	93,85	mm	
	y_M	0,00	mm	relative to centroid C
	z_M	62,23	mm	
Warping constants	$I_{\omega,S}$	6,015E+08	mm⁶	relative to centroid C
	$I_{\omega,M}$	9,602E+07	mm⁶	about shear center M
Auxiliary value for warp rotation	$r_{\omega,M}$	0,000		
Section moduli	$W_{y,max}$	5991,89	mm³	in distance 30.38 mm
	$W_{y,min}$	-5756,92	mm³	in distance -31.62 mm
	$W_{z,max}$	6360,25	mm³	in distance 20.50 mm
	$W_{z,min}$	-6360,25	mm³	in distance -20.50 mm
Warping section moduli	$W_{\omega,M,max}$	85541,55	mm⁴	in node 40
	$W_{\omega,M,min}$	-85573,24	mm⁴	in node 28
Torsional section modulus	W_t	320,13	mm³	
Stability parameters	r_u	-0,51	mm	
	$r_{M,v}$	-124,96	mm	
Reduction factor	λ_M	0,00	1/mm	

Rails MÜPRO

Caractéristiques de la section

Annexe B19

Tableau B19 : Propriétés de la section des rails Müpro MPR 41/62/2.5, zone non perforée

Description	Symbol	Value	Unit	Comment
Cross-sectional area	A	442,01	mm²	
	A_{geom}	442,01	mm²	geometric cross-sectional area (not ideal)
Shear areas	A_y	46,61	mm²	
	A_z	264,05	mm²	
Centroid position	$y_{S,0}$	20,50	mm	relative to zero point
	$z_{S,0}$	33,76	mm	
Moments of inertia	I_y	207600,37	mm⁴	about centroidal axes y
	I_z	130842,75	mm⁴	
Inclination of principal axes	α	0,00	°	clockwise
Polar moments of inertia	I_p	338443,12	mm⁴	
	$I_{p,M}$	1,928E+06	mm⁴	about shear center M
Radii of gyration	i_y	21,67	mm	relative to centroid C
	i_z	17,21	mm	
Polar radii of gyration	i_p	27,67	mm	
	$i_{p,M}$	66,05	mm	about shear center M
Warping radius of gyration	$i_{\omega,M}$	7,08	mm	
Cross-section weight	G	3,47	kg/m	
Cross-section perimeter	U	358,49	mm	incl. inner side of cells
Torsional constant	I_t	808,52	mm⁴	calculated analytically
Secondary torsional constant	$I_{t,s}$	143522,71	mm⁴	
Location of the shear center	$y_{M,0}$	20,50	mm	relative to zero point
	$z_{M,0}$	93,73	mm	
	y_M	0,00	mm	relative to centroid C
	z_M	59,97	mm	
Warping constants	$I_{\omega,S}$	5,677E+08	mm⁶	relative to centroid C
	$I_{\omega,M}$	9,652E+07	mm⁶	about shear center M
Auxiliary value for warp rotation	$r_{\omega,M}$	0,000		
Section moduli	$W_{y,max}$	7351,96	mm³	in distance 28.24 mm
	$W_{y,min}$	-6148,83	mm³	in distance -33.76 mm
	$W_{z,max}$	6382,57	mm³	in distance 20.50 mm
	$W_{z,min}$	-6382,57	mm³	in distance -20.50 mm
Warping section moduli	$W_{\omega,M,max}$	85883,25	mm⁴	in node 38
	$W_{\omega,M,min}$	-85912,59	mm⁴	in node 26
Torsional section modulus	W_t	323,41	mm³	
Stability parameters	r_u	-4,31	mm	
	$r_{M,v}$	-124,25	mm	
Reduction factor	λ_M	0,00	1/mm	

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Caractéristiques de la section	**Annexe B20**

Tableau B20 : Propriétés de la section des rails Müpro MPR 41/62/2.5, section moyennée

Description	Symbol	Value	Unit	Comment
Cross-sectional area	A	427,90	mm²	
	A_{geom}	427,90	mm²	geometric cross-sectional area (not ideal)
Shear areas	A_y	41,53	mm²	
	A_z	266,24	mm²	
Centroid position	$y_{S,0}$	20,50	mm	relative to zero point
	$z_{S,0}$	32,87	mm	
Moments of inertia	I_y	196969,22	mm⁴	about centroidal axes y
	I_z	130502,94	mm⁴	
Inclination of principal axes	α	0,00	°	clockwise
Polar moments of inertia	I_p	327472,16	mm⁴	
	$I_{p,M}$	1,917E+06	mm⁴	about shear center M
Radii of gyration	i_y	21,45	mm	relative to centroid C
	i_z	17,46	mm	
Polar radii of gyration	i_p	27,66	mm	
	$i_{p,M}$	66,93	mm	about shear center M
Warping radius of gyration	$i_{\omega,M}$	7,08	mm	
Cross-section weight	G	3,36	kg/m	
Cross-section perimeter	U	360,15	mm	incl. inner side of cells
Torsional constant	I_t	746,37	mm⁴	calculated analytically
Secondary torsional constant	$I_{t,s}$	143465,26	mm⁴	
Location of the shear center	$y_{M,0}$	20,50	mm	relative to zero point
	$z_{M,0}$	93,82	mm	
	y_M	0,00	mm	relative to centroid C
	z_M	60,94	mm	
Warping constants	$I_{\omega,S}$	5,815E+08	mm⁶	relative to centroid C
	$I_{\omega,M}$	9,615E+07	mm⁶	about shear center M
Auxiliary value for warp rotation	$r_{\omega,M}$	0,000		
Section moduli	$W_{y,max}$	6762,28	mm³	in distance 29.13 mm
	$W_{y,min}$	-5991,94	mm³	in distance -32.87 mm
	$W_{z,max}$	6366,00	mm³	in distance 20.50 mm
	$W_{z,min}$	-6366,00	mm³	in distance -20.50 mm
Warping section moduli	$W_{\omega,M,max}$	85631,07	mm⁴	in node 40
	$W_{\omega,M,min}$	-85661,39	mm⁴	in node 28
Torsional section modulus	W_t	298,55	mm³	
Stability parameters	r_u	-2,74	mm	
	$r_{M,v}$	-124,63	mm	
Reduction factor	λ_M	0,00	1/mm	

Rails MÜPRO

Caractéristiques de la section

Annexe B21

Tableau B21 : Propriétés de la section des rails Müpro MPR 41/42/2.0 H, Zone perforée, trou circulaire

Description	Symbol	Value	Unit	Comment
Cross-sectional area	A	320,65	mm²	
	A_{geom}	320,65	mm²	geometric cross-sectional area (not ideal)
Shear areas	A_y	103,94	mm²	
	A_z	122,77	mm²	
Centroid position	$y_{S,0}$	20,50	mm	relative to zero point
	$z_{S,0}$	21,00	mm	
Moments of inertia	I_y	51931,06	mm⁴	about centroidal axes y
	I_z	89803,35	mm⁴	
Inclination of principal axes	α	0,00	°	clockwise
Polar moments of inertia	I_p	141734,42	mm⁴	
	$I_{p,M}$	141734,42	mm⁴	about shear center M
Radii of gyration	i_y	12,73	mm	relative to centroid C
	i_z	16,74	mm	
Polar radii of gyration	i_p	21,02	mm	
	$i_{p,M}$	21,02	mm	about shear center M
Warping radius of gyration	$i_{\omega,M}$	13,88	mm	
Cross-section weight	G	2,52	kg/m	
Cross-section perimeter	U	302,62	mm	incl. inner side of cells
Torsional constant	I_t	916,96	mm⁴	calculated analytically
Secondary torsional constant	$I_{t,s}$	64783,04	mm⁴	
Location of the shear center	$y_{M,0}$	20,50	mm	relative to zero point
	$z_{M,0}$	21,00	mm	
	y_M	0,00	mm	relative to centroid C
	z_M	0,00	mm	
Warping constants	$I_{\omega,S}$	2,732E+07	mm⁶	relative to centroid C
	$I_{\omega,M}$	2,732E+07	mm⁶	about shear center M
Auxiliary value for warp rotation	$r_{\omega,M}$	0,000		
Section moduli	$W_{y,max}$	2472,91	mm³	in distance 21.00 mm
	$W_{y,min}$	-2472,91	mm³	in distance -21.00 mm
	$W_{z,max}$	4380,65	mm³	in distance 20.50 mm
	$W_{z,min}$	-4380,65	mm³	in distance -20.50 mm
Warping section moduli	$W_{\omega,M,max}$	54240,20	mm⁴	in node 63
	$W_{\omega,M,min}$	-54242,93	mm⁴	in node 51
Torsional section modulus	W_t	272,00	mm³	
Reduction factor	λ_M	0,00	1/mm	

Rails MÜPRO

Caractéristiques de la section

Annexe B22

Tableau B22 : Propriétés de la section des rails Müpro MPR 41/42/2.0 H, Zone perforée, trou circulaire

Description	Symbol	Value	Unit	Comment
Cross-sectional area	A	336,65	mm²	
	A_{geom}	336,65	mm²	geometric cross-sectional area (not ideal)
Shear areas	A_y	104,43	mm²	
	A_z	122,78	mm²	
Centroid position	$y_{S,0}$	20,50	mm	relative to zero point
	$z_{S,0}$	21,00	mm	
Moments of inertia	I_y	51952,39	mm⁴	about centroidal axes y
	I_z	90708,69	mm⁴	
Inclination of principal axes	α	0,00	°	clockwise
Polar moments of inertia	I_p	142661,08	mm⁴	
	$I_{p,M}$	142661,08	mm⁴	about shear center M
Radii of gyration	i_y	12,42	mm	relative to centroid C
	i_z	16,41	mm	
Polar radii of gyration	i_p	20,59	mm	
	$i_{p,M}$	20,59	mm	about shear center M
Warping radius of gyration	$i_{\omega,M}$	13,84	mm	
Cross-section weight	G	2,64	kg/m	
Cross-section perimeter	U	310,62	mm	incl. inner side of cells
Torsional constant	I_t	916,96	mm⁴	calculated analytically
Secondary torsional constant	$I_{t,s}$	64781,66	mm⁴	
Location of the shear center	$y_{M,0}$	20,50	mm	relative to zero point
	$z_{M,0}$	21,00	mm	
	y_M	0,00	mm	relative to centroid C
	z_M	0,00	mm	
Warping constants	$I_{\omega,S}$	2,733E+07	mm⁶	relative to centroid C
	$I_{\omega,M}$	2,733E+07	mm⁶	about shear center M
Auxiliary value for warp rotation	$r_{\omega,M}$	0,000		
Section moduli	$W_{y,max}$	2473,92	mm³	in distance 21.00 mm
	$W_{y,min}$	-2473,92	mm³	in distance -21.00 mm
	$W_{z,max}$	4424,81	mm³	in distance 20.50 mm
	$W_{z,min}$	-4424,81	mm³	in distance -20.50 mm
Warping section moduli	$W_{\omega,M,max}$	54241,68	mm⁴	in node 61
	$W_{\omega,M,min}$	-54244,28	mm⁴	in node 85
Torsional section modulus	W_t	272,00	mm³	
Stability parameters	r_u	-2,75	mm	
	$r_{M,v}$	-44,71	mm	
Reduction factor	λ_M	0,00	1/mm	

Rails MÜPRO

Caractéristiques de la section

Annexe B23

Tableau B23 : Propriétés de la section des rails Müpro MPR 41/42/2.0 H, zone non perforée

Description	Symbol	Value	Unit	Comment
Cross-sectional area	A	388,65	mm²	
	A_{geom}	388,65	mm²	geometric cross-sectional area (not ideal)
Shear areas	A_y	104,80	mm²	
	A_z	122,81	mm²	
Centroid position	$y_{S,0}$	20,50	mm	relative to zero point
	$z_{S,0}$	21,00	mm	
Moments of inertia	I_y	52021,72	mm⁴	about centroidal axes y
	I_z	91441,02	mm⁴	
Inclination of principal axes	α	0,00	°	clockwise
Polar moments of inertia	I_p	143462,74	mm⁴	
	$I_{p,M}$	143462,74	mm⁴	about shear center M
Radii of gyration	i_y	11,57	mm	relative to centroid C
	i_z	15,34	mm	
Polar radii of gyration	i_p	19,21	mm	
	$i_{p,M}$	19,21	mm	about shear center M
Warping radius of gyration	$i_{\omega,M}$	13,80	mm	
Cross-section weight	G	3,05	kg/m	
Cross-section perimeter	U	328,62	mm	incl. inner side of cells
Torsional constant	I_t	923,68	mm⁴	calculated analytically
Secondary torsional constant	$I_{t,s}$	64780,47	mm⁴	
Location of the shear center	$y_{M,0}$	20,50	mm	relative to zero point
	$z_{M,0}$	21,00	mm	
	y_M	0,00	mm	relative to centroid C
	z_M	0,00	mm	
Warping constants	$I_{\omega,S}$	2,733E+07	mm⁶	relative to centroid C
	$I_{\omega,M}$	2,733E+07	mm⁶	about shear center M
Auxiliary value for warp rotation	$r_{\omega,M}$	0,000		
Section moduli	$W_{y,max}$	2477,23	mm³	in distance 21.00 mm
	$W_{y,min}$	-2477,23	mm³	in distance -21.00 mm
	$W_{z,max}$	4460,54	mm³	in distance 20.50 mm
	$W_{z,min}$	-4460,54	mm³	in distance -20.50 mm
Warping section moduli	$W_{\omega,M,max}$	54243,00	mm⁴	in node 57
	$W_{\omega,M,min}$	-54245,25	mm⁴	in node 81
Torsional section modulus	W_t	272,00	mm³	
Reduction factor	λ_M	0,00	1/mm	

Rails MÜPRO

Caractéristiques de la section

Annexe B24

Tableau B24 : Propriétés de la section des rails Müpro MPR 41/42/2.0 H, section moyennée

Description	Symbol	Value	Unit	Comment
Cross-sectional area	A	366,21	mm²	
	A_{geom}	366,21	mm²	geometric cross-sectional area (not ideal)
Shear areas	A_y	87,71	mm²	
	A_z	122,76	mm²	
Centroid position	$y_{S,0}$	20,50	mm	relative to zero point
	$z_{S,0}$	21,00	mm	
Moments of inertia	I_y	51983,44	mm⁴	about centroidal axes y
	I_z	90900,59	mm⁴	
Inclination of principal axes	α	0,00	°	clockwise
Polar moments of inertia	I_p	142884,03	mm⁴	
	$I_{p,M}$	142884,03	mm⁴	about shear center M
Radii of gyration	i_y	11,91	mm	relative to centroid C
	i_z	15,76	mm	
Polar radii of gyration	i_p	19,75	mm	
	$i_{p,M}$	19,75	mm	about shear center M
Warping radius of gyration	$i_{\omega,M}$	13,84	mm	
Cross-section weight	G	2,87	kg/m	
Cross-section perimeter	U	365,26	mm	incl. inner side of cells
Torsional constant	I_t	763,33	mm⁴	calculated analytically
Secondary torsional constant	$I_{t,s}$	64858,03	mm⁴	
Location of the shear center	$y_{M,0}$	20,50	mm	relative to zero point
	$z_{M,0}$	21,00	mm	
	y_M	0,00	mm	relative to centroid C
	z_M	0,00	mm	
Warping constants	$I_{\omega,S}$	2,738E+07	mm⁶	relative to centroid C
	$I_{\omega,M}$	2,738E+07	mm⁶	about shear center M
Auxiliary value for warp rotation	$r_{\omega,M}$	0,000		
Section moduli	$W_{y,max}$	2475,40	mm³	in distance 21.00 mm
	$W_{y,min}$	-2475,40	mm³	in distance -21.00 mm
	$W_{z,max}$	4434,18	mm³	in distance 20.50 mm
	$W_{z,min}$	-4434,18	mm³	in distance -20.50 mm
Warping section moduli	$W_{\omega,M,max}$	54313,00	mm⁴	in node 63
	$W_{\omega,M,min}$	-54315,45	mm⁴	in node 87
Torsional section modulus	W_t	182,24	mm³	
Stability parameters	r_u	-6,66	mm	
	$r_{M,v}$	-47,13	mm	
Reduction factor	λ_M	0,00	1/mm	

Rails MÜPRO	
Caractéristiques de la section	**Annexe B25**

Tableau B25 : Propriétés de la section des rails Müpro MPR 41/82/2.0 H, Zone perforée, trou circulaire

Description	Symbol	Value	Unit	Comment
Cross-sectional area	A	480,65	mm²	
	A_{geom}	480,65	mm²	geometric cross-sectional area (not ideal)
Shear areas	A_y	88,51	mm²	
	A_z	272,10	mm²	
Centroid position	$y_{S,0}$	20,50	mm	relative to zero point
	$z_{S,0}$	41,00	mm	
Moments of inertia	I_y	302445,57	mm⁴	about centroidal axes y
	I_z	150696,69	mm⁴	
Inclination of principal axes	α	0,00	°	clockwise
Polar moments of inertia	I_p	453142,26	mm⁴	
	$I_{p,M}$	453142,26	mm⁴	about shear center M
Radii of gyration	i_y	25,08	mm	relative to centroid C
	i_z	17,71	mm	
Polar radii of gyration	i_p	30,70	mm	
	$i_{p,M}$	30,70	mm	about shear center M
Warping radius of gyration	$i_{\omega,M}$	18,04	mm	
Cross-section weight	G	3,77	kg/m	
Cross-section perimeter	U	462,62	mm	incl. inner side of cells
Cross-section outer perimeter	U_o	462,62		
Cross-section inner perimeter	U_i	0,00		
Torsional constant	J	1130,29	mm⁴	calculated analytically
Torsional constant St. Ven.	$J_{St.Ven.}$	616,51		
Torsional constant, Bredt portion.	J_{Bredt}	513,78		
Secondary torsional constant	$I_{t,s}$	136202,24	mm⁴	
Location of the shear center	$y_{M,0}$	20,50	mm	relative to zero point
	$z_{M,0}$	41,00	mm	
	y_M	0,00	mm	relative to centroid C
	z_M	0,00	mm	
Warping constants	$I_{\omega,S}$	1,474E+08	mm⁶	relative to centroid C
	$I_{\omega,M}$	1,474E+08	mm⁶	about shear center M
Auxiliary value for warp rotation	$r_{\omega,M}$	0,000		
Section moduli	$W_{y,max}$	7376,72	mm³	in distance 41.00 mm
	$W_{y,min}$	-7376,72	mm³	in distance -41.00 mm
	$W_{z,max}$	7351,06	mm³	in distance 20.50 mm
	$W_{z,min}$	-7351,06	mm³	in distance -20.50 mm
Warping section moduli	$W_{\omega,M,max}$	141870,08	mm⁴	in node 70
	$W_{\omega,M,min}$	-1,419E+05	mm⁴	in node 58
Torsional section modulus	W_t	272,00	mm³	
Reduction factor	λ_M	0,00	1/mm	

Rails MÜPRO

Caractéristiques de la section

Annexe B26

Tableau B26 : Propriétés de la section des rails Müpro MPR 41/82/2.0 H, Zone perforée, trou oblong

Description	Symbol	Value	Unit	Comment
Cross-sectional area	A	496,65	mm²	
	A_{geom}	496,65	mm²	geometric cross-sectional area (not ideal)
Shear areas	A_y	88,92	mm²	
	A_z	272,11	mm²	
Centroid position	$y_{s,0}$	20,50	mm	relative to zero point
	$z_{s,0}$	41,00	mm	
Moments of inertia	I_y	302466,90	mm⁴	about centroidal axes y
	I_z	151602,03	mm⁴	
Inclination of principal axes	α	0,00	°	clockwise
Polar moments of inertia	I_p	454068,93	mm⁴	
	$I_{p,M}$	454068,93	mm⁴	about shear center M
Radii of gyration	i_y	24,68	mm	relative to centroid C
	i_z	17,47	mm	
Polar radii of gyration	i_p	30,24	mm	
	$i_{p,M}$	30,24	mm	about shear center M
Warping radius of gyration	$i_{\omega,M}$	18,02	mm	
Cross-section weight	G	3,90	kg/m	
Cross-section perimeter	U	470,62	mm	incl. inner side of cells
Cross-section outer perimeter	U_o	470,62		
Cross-section inner perimeter	U_i	0,00		
Torsional constant	J	1130,29	mm⁴	calculated analytically
Torsional constant St. Ven.	$J_{St.Ven.}$	616,51		
Torsional constant, Bredt portion.	J_{Bredt}	513,78		
Secondary torsional constant	$I_{t,s}$	136201,54	mm⁴	
Location of the shear center	$y_{M,0}$	20,50	mm	relative to zero point
	$z_{M,0}$	41,00	mm	
	y_M	0,00	mm	relative to centroid C
	z_M	0,00	mm	
Warping constants	$I_{\omega,S}$	1,474E+08	mm⁶	relative to centroid C
	$I_{\omega,M}$	1,474E+08	mm⁶	about shear center M
Auxiliary value for warp rotation	$r_{\omega,M}$	0,000		
Section moduli	$W_{y,max}$	7377,24	mm³	in distance 41.00 mm
	$W_{y,min}$	-7377,24	mm³	in distance -41.00 mm
	$W_{z,max}$	7395,22	mm³	in distance 20.50 mm
	$W_{z,min}$	-7395,22	mm³	in distance -20.50 mm
Warping section moduli	$W_{\omega,M,max}$	141870,81	mm⁴	in node 60
	$W_{\omega,M,min}$	-1,419E+05	mm⁴	in node 48
Torsional section modulus	W_t	272,00	mm³	
Reduction factor	λ_M	0,00	1/mm	

Rails MÜPRO

Caractéristiques de la section

Annexe B27

Tableau B27 : Propriétés de la section des rails Müpro MPR 41/82/2.0 H, zone non perforée

Description	Symbol	Value	Unit	Comment
Cross-sectional area	A	548,65	mm²	
	A_{geom}	548,65	mm²	geometric cross-sectional area (not ideal)
Shear areas	A_y	89,24	mm²	
	A_z	272,12	mm²	
Centroid position	$y_{S,0}$	20,50	mm	relative to zero point
	$z_{S,0}$	41,00	mm	
Moments of inertia	I_y	302536,24	mm⁴	about centroidal axes y
	I_z	152334,36	mm⁴	
Inclination of principal axes	α	0,00	°	clockwise
Polar moments of inertia	I_p	454870,59	mm⁴	
	$I_{p,M}$	454870,59	mm⁴	about shear center M
Radii of gyration	i_y	23,48	mm	relative to centroid C
	i_z	16,66	mm	
Polar radii of gyration	i_p	28,79	mm	
	$i_{p,M}$	28,79	mm	about shear center M
Warping radius of gyration	$i_{\omega,M}$	18,00	mm	
Cross-section weight	G	4,31	kg/m	
Cross-section perimeter	U	488,62	mm	incl. inner side of cells
Cross-section outer perimeter	U_o	488,62		
Cross-section inner perimeter	U_i	0,00		
Torsional constant	J	1137,01	mm⁴	calculated analytically
Torsional constant St. Ven.	$J_{St.Ven.}$	623,23		
Torsional constant, Bredt portion.	J_{Bredt}	513,78		
Secondary torsional constant	$I_{t,s}$	136200,95	mm⁴	
Location of the shear center	$y_{M,0}$	20,50	mm	relative to zero point
	$z_{M,0}$	41,00	mm	
	y_M	0,00	mm	relative to centroid C
	z_M	0,00	mm	
Warping constants	$I_{\omega,S}$	1,474E+08	mm⁶	relative to centroid C
	$I_{\omega,M}$	1,474E+08	mm⁶	about shear center M
Auxiliary value for warp rotation	$r_{\omega,M}$	0,000		
Section moduli	$W_{y,max}$	7378,93	mm³	in distance 41.00 mm
	$W_{y,min}$	-7378,93	mm³	in distance -41.00 mm
	$W_{z,max}$	7430,94	mm³	in distance 20.50 mm
	$W_{z,min}$	-7430,94	mm³	in distance -20.50 mm
Warping section moduli	$W_{\omega,M,max}$	141871,47	mm⁴	in node 56
	$W_{\omega,M,min}$	-1,419E+05	mm⁴	in node 44
Torsional section modulus	W_t	272,00	mm³	
Reduction factor	λ_M	0,00	1/mm	

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Caractéristiques de la section   **Annexe B28**

Tableau B28 : Propriétés de la section des rails Müpro MPR 41/82/2.0 H, section moyennée

Description	Symbol	Value	Unit	Comment
Cross-sectional area	A	526,21	mm²	
	A_{geom}	526,21	mm²	geometric cross-sectional area (not ideal)
Shear areas	A_y	77,66	mm²	
	A_z	272,10	mm²	
Centroid position	$y_{s,0}$	20,50	mm	relative to zero point
	$z_{s,0}$	41,00	mm	
Moments of inertia	I_y	302498,02	mm⁴	about centroidal axes y
	I_z	151793,93	mm⁴	
Inclination of principal axes	α	0,00	°	clockwise
Polar moments of inertia	I_p	454291,95	mm⁴	
	$I_{p,M}$	454291,95	mm⁴	about shear center M
Radii of gyration	i_y	23,98	mm	relative to centroid C
	i_z	16,98	mm	
Polar radii of gyration	i_p	29,38	mm	
	$i_{p,M}$	29,38	mm	about shear center M
Warping radius of gyration	$i_{\omega,M}$	18,03	mm	
Cross-section weight	G	4,13	kg/m	
Cross-section perimeter	U	525,26	mm	incl. inner side of cells
Cross-section outer perimeter	U_o	489,94		
Cross-section inner perimeter	U_i	35,32		
Torsional constant	J	976,66	mm⁴	calculated analytically
Torsional constant St. Ven.	$J_{St.Ven.}$	559,83		
Torsional constant, Bredt portion.	J_{Bredt}	416,83		
Secondary torsional constant	$I_{t,s}$	136278,41	mm⁴	
Location of the shear center	$y_{M,0}$	20,50	mm	relative to zero point
	$z_{M,0}$	41,00	mm	
	y_M	0,00	mm	relative to centroid C
	z_M	0,00	mm	
Warping constants	$I_{\omega,S}$	1,476E+08	mm⁶	relative to centroid C
	$I_{\omega,M}$	1,476E+08	mm⁶	about shear center M
Auxiliary value for warp rotation	$r_{\omega,M}$	0,000		
Section moduli	$W_{y,max}$	7378,00	mm³	in distance 41.00 mm
	$W_{y,min}$	-7378,00	mm³	in distance -41.00 mm
	$W_{z,max}$	7404,58	mm³	in distance 20.50 mm
	$W_{z,min}$	-7404,58	mm³	in distance -20.50 mm
Warping section moduli	$W_{\omega,M,max}$	141969,27	mm⁴	in node 62
	$W_{\omega,M,min}$	-1,420E+05	mm⁴	in node 50
Torsional section modulus	W_t	182,24	mm³	
Reduction factor	λ_M	0,00	1/mm	

Rails MÜPRO

Caractéristiques de la section

Annexe B29

Tableau B29 : Propriétés de la section des rails Müpro MPR 41/82/2.5 H, Zone perforée, trou circulaire

Description	Symbol	Value	Unit	Comment
Cross-sectional area	A	589,03	mm²	
	A_{geom}	589,03	mm²	geometric cross-sectional area (not ideal)
Shear areas	A_y	109,97	mm²	
	A_z	340,00	mm²	
Centroid position	$y_{s,0}$	20,50	mm	relative to zero point
	$z_{s,0}$	41,00	mm	
Moments of inertia	I_y	364791,97	mm⁴	about centroidal axes y
	I_z	181710,92	mm⁴	
Inclination of principal axes	α	0,00	°	clockwise
Polar moments of inertia	I_p	546502,89	mm⁴	
	$I_{p,M}$	546502,89	mm⁴	about shear center M
Radii of gyration	i_y	24,89	mm	relative to centroid C
	i_z	17,56	mm	
Polar radii of gyration	i_p	30,46	mm	
	$i_{p,M}$	30,46	mm	about shear center M
Warping radius of gyration	$i_{\omega,M}$	17,59	mm	
Cross-section weight	G	4,62	kg/m	
Cross-section perimeter	U	456,99	mm	incl. inner side of cells
Cross-section outer perimeter	U_o	456,99		
Cross-section inner perimeter	U_i	0,00		
Torsional constant	J	2178,91	mm⁴	calculated analytically
Torsional constant St. Ven.	$J_{St.Ven.}$	1189,18		
Torsional constant, Bredt portion.	J_{Bredt}	989,73		
Secondary torsional constant	$I_{t,s}$	161880,90	mm⁴	
Location of the shear center	$y_{M,0}$	20,50	mm	relative to zero point
	$z_{M,0}$	41,00	mm	
	y_M	0,00	mm	relative to centroid C
	z_M	0,00	mm	
Warping constants	$I_{\omega,s}$	1,691E+08	mm⁶	relative to centroid C
	$I_{\omega,M}$	1,691E+08	mm⁶	about shear center M
Auxiliary value for warp rotation	$r_{\omega,M}$	0,000		
Section moduli	$W_{y,max}$	8897,36	mm³	in distance 41.00 mm
	$W_{y,min}$	-8897,36	mm³	in distance -41.00 mm
	$W_{z,max}$	8863,95	mm³	in distance 20.50 mm
	$W_{z,min}$	-8863,95	mm³	in distance -20.50 mm
Warping section moduli	$W_{\omega,M,max}$	168325,35	mm⁴	in node 78
	$W_{\omega,M,min}$	-1,683E+05	mm⁴	in node 90
Torsional section modulus	W_t	425,00	mm³	
Reduction factor	λ_M	0,00	1/mm	

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Caractéristiques de la section

Annexe B30

Tableau B30 : Propriétés de la section des rails Müpro MPR 41/82/2.5 H, Zone perforée, trou oblong

Description	Symbol	Value	Unit	Comment
Cross-sectional area	A	609,03	mm²	
	A_{geom}	609,03	mm²	geometric cross-sectional area (not ideal)
Shear areas	A_y	110,49	mm²	
	A_z	340,01	mm²	
Centroid position	$y_{s,0}$	20,50	mm	relative to zero point
	$z_{s,0}$	41,00	mm	
Moments of inertia	I_y	364833,54	mm⁴	about centroidal axes y
	I_z	182842,59	mm⁴	
Inclination of principal axes	α	0,00	°	clockwise
Polar moments of inertia	I_p	547676,13	mm⁴	
	$I_{p,M}$	547676,13	mm⁴	about shear center M
Radii of gyration	i_y	24,48	mm	relative to centroid C
	i_z	17,33	mm	
Polar radii of gyration	i_p	29,99	mm	
	$i_{p,M}$	29,99	mm	about shear center M
Warping radius of gyration	$i_{\omega,M}$	17,57	mm	
Cross-section weight	G	4,78	kg/m	
Cross-section perimeter	U	464,99	mm	incl. inner side of cells
Cross-section outer perimeter	U_o	464,99		
Cross-section inner perimeter	U_i	0,00		
Torsional constant	J	2178,90	mm⁴	calculated analytically
Torsional constant St. Ven.	$J_{St.Ven.}$	1189,17		
Torsional constant, Bredt portion.	J_{Bredt}	989,72		
Secondary torsional constant	$I_{t,s}$	161879,53	mm⁴	
Location of the shear center	$y_{M,0}$	20,50	mm	relative to zero point
	$z_{M,0}$	41,00	mm	
	y_M	0,00	mm	relative to centroid C
	z_M	0,00	mm	
Warping constants	$I_{\omega,S}$	1,691E+08	mm⁶	relative to centroid C
	$I_{\omega,M}$	1,691E+08	mm⁶	about shear center M
Auxiliary value for warp rotation	$r_{\omega,M}$	0,000		
Section moduli	$W_{y,max}$	8898,38	mm³	in distance 41.00 mm
	$W_{y,min}$	-8898,38	mm³	in distance -41.00 mm
	$W_{z,max}$	8919,15	mm³	in distance 20.50 mm
	$W_{z,min}$	-8919,15	mm³	in distance -20.50 mm
Warping section moduli	$W_{\omega,M,max}$	168326,70	mm⁴	in node 76
	$W_{\omega,M,min}$	-1,683E+05	mm⁴	in node 88
Torsional section modulus	W_t	425,00	mm³	
Reduction factor	λ_M	0,00	1/mm	

Rails MÜPRO

Caractéristiques de la section

Annexe B31

Tableau B31 : Propriétés de la section des rails Müpro MPR 41/82/2.5 H, zone non perforée

Description	Symbol	Value	Unit	Comment
Cross-sectional area	A	674,03	mm²	
	A_{geom}	674,03	mm²	geometric cross-sectional area (not ideal)
Shear areas	A_y	110,90	mm²	
	A_z	340,03	mm²	
Centroid position	$y_{s,0}$	20,50	mm	relative to zero point
	$z_{s,0}$	41,00	mm	
Moments of inertia	I_y	364968,96	mm⁴	about centroidal axes y
	I_z	183758,00	mm⁴	
Inclination of principal axes	α	0,00	°	clockwise
Polar moments of inertia	I_p	548726,97	mm⁴	
	$I_{p,M}$	548726,97	mm⁴	about shear center M
Radii of gyration	i_y	23,27	mm	relative to centroid C
	i_z	16,51	mm	
Polar radii of gyration	i_p	28,53	mm	
	$i_{p,M}$	28,53	mm	about shear center M
Warping radius of gyration	$i_{\omega,M}$	17,56	mm	
Cross-section weight	G	5,29	kg/m	
Cross-section perimeter	U	480,99	mm	incl. inner side of cells
Cross-section outer perimeter	U_o	480,99		
Cross-section inner perimeter	U_i	0,00		
Torsional constant	J	2195,30	mm⁴	calculated analytically
Torsional constant St. Ven.	$J_{St.Ven.}$	1205,58		
Torsional constant, Bredt portion.	J_{Bredt}	989,72		
Secondary torsional constant	$I_{t,s}$	161878,41	mm⁴	
Location of the shear center	$y_{M,0}$	20,50	mm	relative to zero point
	$z_{M,0}$	41,00	mm	
	y_M	0,00	mm	relative to centroid C
	z_M	0,00	mm	
Warping constants	$I_{\omega,S}$	1,691E+08	mm⁶	relative to centroid C
	$I_{\omega,M}$	1,691E+08	mm⁶	about shear center M
Auxiliary value for warp rotation	$r_{\omega,M}$	0,000		
Section moduli	$W_{y,max}$	8901,68	mm³	in distance 41.00 mm
	$W_{y,min}$	-8901,68	mm³	in distance -41.00 mm
	$W_{z,max}$	8963,81	mm³	in distance 20.50 mm
	$W_{z,min}$	-8963,80	mm³	in distance -20.50 mm
Warping section moduli	$W_{\omega,M,max}$	168327,91	mm⁴	in node 68
	$W_{\omega,M,min}$	-1,683E+05	mm⁴	in node 84
Torsional section modulus	W_t	425,00	mm³	
Reduction factor	λ_M	0,00	1/mm	

Rails MÜPRO

Caractéristiques de la section

Annexe B32

Tableau B32 : Propriétés de la section des rails Müpro MPR 41/82/2.5 H, section moyennée

Description	Symbol	Value	Unit	Comment
Cross-sectional area	A	645,81	mm²	
	A_{geom}	645,81	mm²	geometric cross-sectional area (not ideal)
Shear areas	A_y	96,23	mm²	
	A_z	339,99	mm²	
Centroid position	$y_{S,0}$	20,50	mm	relative to zero point
	$z_{S,0}$	41,00	mm	
Moments of inertia	I_y	364893,88	mm⁴	about centroidal axes y
	I_z	183078,37	mm⁴	
Inclination of principal axes	α	0,00	°	clockwise
Polar moments of inertia	I_p	547972,26	mm⁴	
	$I_{p,M}$	547972,26	mm⁴	about shear center M
Radii of gyration	i_y	23,77	mm	relative to centroid C
	i_z	16,84	mm	
Polar radii of gyration	i_p	29,13	mm	
	$i_{p,M}$	29,13	mm	about shear center M
Warping radius of gyration	$i_{\omega,M}$	17,58	mm	
Cross-section weight	G	5,07	kg/m	
Cross-section perimeter	U	518,31	mm	incl. inner side of cells
Cross-section outer perimeter	U_o	482,65		
Cross-section inner perimeter	U_i	35,66		
Torsional constant	J	1884,96	mm⁴	calculated analytically
Torsional constant St. Ven.	$J_{St.Ven.}$	1081,28		
Torsional constant, Bredt portion.	J_{Bredt}	803,69		
Secondary torsional constant	$I_{t,s}$	162026,91	mm⁴	
Location of the shear center	$y_{M,0}$	20,50	mm	relative to zero point
	$z_{M,0}$	41,00	mm	
	y_M	0,00	mm	relative to centroid C
	z_M	0,00	mm	
Warping constants	$I_{\omega,S}$	1,694E+08	mm⁶	relative to centroid C
	$I_{\omega,M}$	1,694E+08	mm⁶	about shear center M
Auxiliary value for warp rotation	$r_{\omega,M}$	0,000		
Section moduli	$W_{y,max}$	8899,85	mm³	in distance 41.00 mm
	$W_{y,min}$	-8899,85	mm³	in distance -41.00 mm
	$W_{z,max}$	8930,65	mm³	in distance 20.50 mm
	$W_{z,min}$	-8930,65	mm³	in distance -20.50 mm
Warping section moduli	$W_{\omega,M,max}$	168513,19	mm⁴	in node 79
	$W_{\omega,M,min}$	-1,685E+05	mm⁴	in node 90
Torsional section modulus	W_t	283,90	mm³	
Reduction factor	λ_M	0,00	1/mm	

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Caractéristiques de la section

Annexe B33

Tableau B33 : Propriétés de la section des rails Müpro MPR 41/124/2.5 H, zone perforée, trou circulaire

Description	Symbol	Value	Unit	Comment
Cross-sectional area	A	799,03	mm²	
	A_{geom}	799,03	mm²	geometric cross-sectional area (not ideal)
Shear areas	A_y	92,50	mm²	
	A_z	528,27	mm²	
Centroid position	$y_{s,0}$	20,50	mm	relative to zero point
	$z_{s,0}$	62,00	mm	
Moments of inertia	I_y	1,120E+06	mm⁴	about centroidal axes y
	I_z	259638,43	mm⁴	
Inclination of principal axes	α	0,00	°	clockwise
Polar moments of inertia	I_p	1,379E+06	mm⁴	
	$I_{p,M}$	1,379E+06	mm⁴	about shear center M
Radii of gyration	i_y	37,43	mm	relative to centroid C
	i_z	18,03	mm	
Polar radii of gyration	i_p	41,55	mm	
	$i_{p,M}$	41,55	mm	about shear center M
Warping radius of gyration	$i_{\omega,M}$	18,97	mm	
Cross-section weight	G	6,27	kg/m	
Cross-section perimeter	U	624,99	mm	incl. inner side of cells
Cross-section outer perimeter	U_o	624,99		
Cross-section inner perimeter	U_i	0,00		
Torsional constant	J	2616,40	mm⁴	calculated analytically
Torsional constant St. Ven.	$J_{St.Ven.}$	1626,68		
Torsional constant, Bredt portion.	J_{Bredt}	989,72		
Secondary torsional constant	$I_{t,s}$	241187,79	mm⁴	
Location of the shear center	$y_{M,0}$	20,50	mm	relative to zero point
	$z_{M,0}$	62,00	mm	
	y_M	0,00	mm	relative to centroid C
	z_M	0,00	mm	
Warping constants	$I_{\omega,S}$	4,962E+08	mm⁶	relative to centroid C
	$I_{\omega,M}$	4,962E+08	mm⁶	about shear center M
Auxiliary value for warp rotation	$r_{\omega,M}$	0,000		
Section moduli	$W_{y,max}$	18059,12	mm³	in distance 62.00 mm
	$W_{y,min}$	-18059,12	mm³	in distance -62.00 mm
	$W_{z,max}$	12665,29	mm³	in distance 20.50 mm
	$W_{z,min}$	-12665,29	mm³	in distance -20.50 mm
Warping section moduli	$W_{\omega,M,max}$	319229,22	mm⁴	in node 76
	$W_{\omega,M,min}$	-3,192E+05	mm⁴	in node 88
Torsional section modulus	W_t	425,00	mm³	
Reduction factor	λ_M	0,00	1/mm	

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Caractéristiques de la section

Annexe B34

Tableau B34 : Propriétés de la section des rails Müpro MPR 41/124/2.5 H, Zone perforée, trou oblong

Description	Symbol	Value	Unit	Comment
Cross-sectional area	A	819,03	mm²	
	A_{geom}	819,03	mm²	geometric cross-sectional area (not ideal)
Shear areas	A_y	92,90	mm²	
	A_z	528,27	mm²	
Centroid position	$y_{s,0}$	20,50	mm	relative to zero point
	$z_{s,0}$	62,00	mm	
Moments of inertia	I_y	1,120E+06	mm⁴	about centroidal axes y
	I_z	260770,10	mm⁴	
Inclination of principal axes	α	0,00	°	clockwise
Polar moments of inertia	I_p	1,380E+06	mm⁴	
	$I_{p,M}$	1,380E+06	mm⁴	about shear center M
Radii of gyration	i_y	36,97	mm	relative to centroid C
	i_z	17,84	mm	
Polar radii of gyration	i_p	41,05	mm	
	$i_{p,M}$	41,05	mm	about shear center M
Warping radius of gyration	$i_{\omega,M}$	18,96	mm	
Cross-section weight	G	6,43	kg/m	
Cross-section perimeter	U	632,99	mm	incl. inner side of cells
Cross-section outer perimeter	U_o	632,99		
Cross-section inner perimeter	U_i	0,00		
Torsional constant	J	2616,40	mm⁴	calculated analytically
Torsional constant St. Ven.	$J_{St.Ven.}$	1626,67		
Torsional constant, Bredt portion.	J_{Bredt}	989,72		
Secondary torsional constant	$I_{t,s}$	241187,06	mm⁴	
Location of the shear center	$y_{M,0}$	20,50	mm	relative to zero point
	$z_{M,0}$	62,00	mm	
	y_M	0,00	mm	relative to centroid C
	z_M	0,00	mm	
Warping constants	$I_{\omega,S}$	4,962E+08	mm⁶	relative to centroid C
	$I_{\omega,M}$	4,962E+08	mm⁶	about shear center M
Auxiliary value for warp rotation	$r_{\omega,M}$	0,000		
Section moduli	$W_{y,max}$	18059,79	mm³	in distance 62.00 mm
	$W_{y,min}$	-18059,79	mm³	in distance -62.00 mm
	$W_{z,max}$	12720,49	mm³	in distance 20.50 mm
	$W_{z,min}$	-12720,49	mm³	in distance -20.50 mm
Warping section moduli	$W_{\omega,M,max}$	319230,10	mm⁴	in node 76
	$W_{\omega,M,min}$	-3,192E+05	mm⁴	in node 88
Torsional section modulus	W_t	425,00	mm³	
Reduction factor	λ_M	0,00	1/mm	

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Caractéristiques de la section	**Annexe B35**

Tableau B35 : Propriétés de la section des rails Müpro MPR 41/124/2.5 H, zone non perforée

Description	Symbol	Value	Unit	Comment
Cross-sectional area	A	884,03	mm²	
	A_{geom}	884,03	mm²	geometric cross-sectional area (not ideal)
Shear areas	A_y	93,21	mm²	
	A_z	528,28	mm²	
Centroid position	$y_{S,0}$	20,50	mm	relative to zero point
	$z_{S,0}$	62,00	mm	
Moments of inertia	I_y	1,120E+06	mm⁴	about centroidal axes y
	I_z	261685,51	mm⁴	
Inclination of principal axes	α	0,00	°	clockwise
Polar moments of inertia	I_p	1,382E+06	mm⁴	
	$I_{p,M}$	1,382E+06	mm⁴	about shear center M
Radii of gyration	i_y	35,59	mm	relative to centroid C
	i_z	17,21	mm	
Polar radii of gyration	i_p	39,53	mm	
	$i_{p,M}$	39,53	mm	about shear center M
Warping radius of gyration	$i_{\omega,M}$	18,95	mm	
Cross-section weight	G	6,94	kg/m	
Cross-section perimeter	U	648,99	mm	incl. inner side of cells
Cross-section outer perimeter	U_o	648,99		
Cross-section inner perimeter	U_i	0,00		
Torsional constant	J	2632,80	mm⁴	calculated analytically
Torsional constant St. Ven.	$J_{St.Ven.}$	1643,08		
Torsional constant, Bredt portion.	J_{Bredt}	989,72		
Secondary torsional constant	$I_{t,s}$	241186,46	mm⁴	
Location of the shear center	$y_{M,0}$	20,50	mm	relative to zero point
	$z_{M,0}$	62,00	mm	
	y_M	0,00	mm	relative to centroid C
	z_M	0,00	mm	
Warping constants	$I_{\omega,S}$	4,962E+08	mm⁶	relative to centroid C
	$I_{\omega,M}$	4,962E+08	mm⁶	about shear center M
Auxiliary value for warp rotation	$r_{\omega,M}$	0,000		
Section moduli	$W_{y,max}$	18061,97	mm³	in distance 62.00 mm
	$W_{y,min}$	-18061,97	mm³	in distance -62.00 mm
	$W_{z,max}$	12765,15	mm³	in distance 20.50 mm
	$W_{z,min}$	-12765,15	mm³	in distance -20.50 mm
Warping section moduli	$W_{\omega,M,max}$	319230,89	mm⁴	in node 69
	$W_{\omega,M,min}$	-3,192E+05	mm⁴	in node 85
Torsional section modulus	W_t	425,00	mm³	
Reduction factor	λ_M	0,00	1/mm	

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Caractéristiques de la section   **Annexe B36**

Tableau B36 : Propriétés de la section des rails Müpro MPR 41/124/2.5 H, section moyennée

Description	Symbol	Value	Unit	Comment
Cross-sectional area	A	855,81	mm²	
	A_{geom}	855,81	mm²	geometric cross-sectional area (not ideal)
Shear areas	A_y	83,06	mm²	
	A_z	528,26	mm²	
Centroid position	$y_{S,0}$	20,50	mm	relative to zero point
	$z_{S,0}$	62,00	mm	
Moments of inertia	I_y	1,120E+06	mm⁴	about centroidal axes y
	I_z	261005,88	mm⁴	
Inclination of principal axes	α	0,00	°	clockwise
Polar moments of inertia	I_p	1,381E+06	mm⁴	
	$I_{p,M}$	1,381E+06	mm⁴	about shear center M
Radii of gyration	i_y	36,17	mm	relative to centroid C
	i_z	17,46	mm	
Polar radii of gyration	i_p	40,17	mm	
	$i_{p,M}$	40,17	mm	about shear center M
Warping radius of gyration	$i_{\omega,M}$	18,97	mm	
Cross-section weight	G	6,72	kg/m	
Cross-section perimeter	U	686,31	mm	incl. inner side of cells
Cross-section outer perimeter	U_o	650,65		
Cross-section inner perimeter	U_i	35,66		
Torsional constant	J	2322,46	mm⁴	calculated analytically
Torsional constant St. Ven.	$J_{St.Ven.}$	1518,78		
Torsional constant, Bredt portion.	J_{Bredt}	803,69		
Secondary torsional constant	$I_{t,s}$	241335,40	mm⁴	
Location of the shear center	$y_{M,0}$	20,50	mm	relative to zero point
	$z_{M,0}$	62,00	mm	
	y_M	0,00	mm	relative to centroid C
	z_M	0,00	mm	
Warping constants	$I_{\omega,S}$	4,968E+08	mm⁶	relative to centroid C
	$I_{\omega,M}$	4,968E+08	mm⁶	about shear center M
Auxiliary value for warp rotation	$r_{\omega,M}$	0,000		
Section moduli	$W_{y,max}$	18060,76	mm³	in distance 62.00 mm
	$W_{y,min}$	-18060,76	mm³	in distance -62.00 mm
	$W_{z,max}$	12731,99	mm³	in distance 20.50 mm
	$W_{z,min}$	-12731,99	mm³	in distance -20.50 mm
Warping section moduli	$W_{\omega,M,max}$	319477,47	mm⁴	in node 76
	$W_{\omega,M,min}$	-3,195E+05	mm⁴	in node 88
Torsional section modulus	W_t	283,90	mm³	
Reduction factor	λ_M	0,00	1/mm	

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Caractéristiques de la section   **Annexe B37**