RIB RTcDesign DIN 1045-1:2008 © 2018 RIB Software SE

Project: Introductory Example
Structural member: Beam

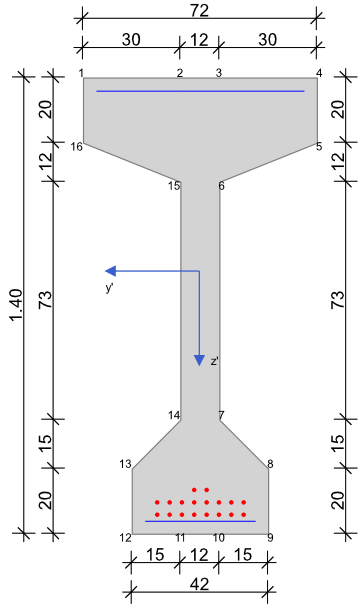
Beam - Pos101

Structure class: Building construction
Type of action: Beam cross-section uniaxia
Requirement class: D
Design standard: DIN 1045-1:2008
Design situation: permanent/transient
Type of action: Load action

Material data: [N/mm2]
C55/67 fcd 30.9 fctm 4.2 Ecm 35700 Cem 32,5 R
B500S fyd 434.8 Es 200000 highly ductile
ST1660/1860 fp01k 1600.0 fpk 1860.0 Ep 195000

Default reinforc. [cm,cm2]	d1-t	d1-l	d1-b	minAst	minAsl	minAsb	Minimum reinforcement
	4.0	4.0	4.0	0.00	0.00	0.00	compute

Prestressing [cm,N/mm2,kN,cm2]	z	tg	r.sup	r.inf	sig.rsk	V	Ap	Prest. steel
Pre-tensioned bond	134.0	0.000	1.05	0.95	100.0	672.0	7.44	ST1660/1860
Pre-tensioned bond	130.2	0.000	1.05	0.95	100.0	672.0	7.44	ST1660/1860
Pre-tensioned bond	126.4	0.000	1.05	0.95	100.0	168.0	1.86	ST1660/1860



Section properties	A	Iy	Iz	zs	Woy	Wuy
[m2,m4,cm,m3]	0.4065	0.100641	0.009002	59.56	0.16897	0.12511

Combination [kN,kNm]		NEd	MEd,y	VEd,z	MEd,z	VEd,y	MEd,x	Lc
Basic combination	minMy	-1512.0	562.8	0.0	0.0	0.0	0.0	1 2 4
Basic combination	maxMy	-1512.0	1612.8	0.0	0.0	0.0	0.0	1 2 3 4
Rare	minMy	-1512.0	562.8	0.0	0.0	0.0	0.0	1 2 4
Rare	maxMy	-1512.0	877.8	0.0	0.0	0.0	0.0	1 2 3 4
Frequent	minMy	-1512.0	562.8	0.0	0.0	0.0	0.0	1 2 4
Frequent	maxMy	-1512.0	625.8	0.0	0.0	0.0	0.0	1 2 3 4
Quasi-permanent	maxMy	-1512.0	562.8	0.0	0.0	0.0	0.0	1 2 4

selected analysis: Bending(M+N) Shear Crack width Stresses Fire protection

Bending design [o/oo,cm,cm2] - Time of initial loading: 28 d

Basic combination:	eps.c	eps.s	zi	x/d	**req Ast**	**req Ass**	**req Asb**

	-3.0	25.0	126.1	0.11	**2.18**	**0.00** **2.19**

Shear design [kN,%,cm2/m] - Time of initial loading: 28 d - alfa: 90 degrees

Basic combination:	VEd	VRdmin	VRdct	VRdmax	rho.l	theta	as.min	**req asw**
	0.0	122.1	122.1	1768.6	0.10	45.0	2.58	**2.58**M

Crack width analysis [mm,cm,cm2] - Time of crack formation: 28 d - ds(top/bottom): 8/10 mm

Frequent combination:	Sigc/fctm	w.prov	w.all	xII	Asr.t	Asr.s	Asr.b
	0.47	0.00	0.20	140.0	2.18	0.00	2.19

Limitation of stresses [N/mm2] - Time of initial loading: 28 d

Rare combination:	Sigs/adm	Sigp/adm	Sigc/adm	Sigs.s	Sigp.q	Sigc.q	Sigc.s
	0.30	0.75	0.35	120.0	907.0	-7.08	-11.57
allowable:	1.00	1.00	1.00	400.0	1209.0	-24.75	-33.00

Fire protection: Analysis of R60 established

Project: Introductory Example
Structural member: Beam

RIB RTcDesign 18.0

Design parameters

Structure class	:Building construction
Using as	:Building construction
Design standard	:DIN 1045-1:2008
Design situation	:permanent
Superstructure type	:Beam elements
Cross-section type	:T-beam
Action type	:Predominantly bending
Action	:uniaxial
Requirement class	:D
Building element	:prestressed with bond
System	:statically determinate
Surface reinforcement detailing/prestressed	:yes/yes
Ductility reinforcement	:yes
Structural fire protection	:R 60

Conc. C 55/ 67

fck	:	55.0	N/mm2
Ecm(28)	:	35700	N/mm2
gamc	:	1.50	
alfa.cc(28)	:	0.85	
fcd(28), n=1.75 (S-D Line)	:	31.2	N/mm2
fctd(28)	:	1.67	N/mm2
fcd,fat(N*=10^6)	:	27.1	N/mm2
fctm(28)	:	4.21	N/mm2
fctk,0.05(28)	:	2.95	N/mm2
fcto	:	3.00	N/mm2
w,cal	:	0.20	mm
fbd	:	4.43	N/mm2
CEM RS	:	0.20	

ReinfSteel B500(B)

fyk	:	500	N/mm2
Es	:	200000	N/mm2
gams	:	1.15	
fyd	:	434.8	N/mm2
kmin = ftk / fyk (Ductility class B)	:	1.08	

Prestressing steel St 1660/1860 (within bond)

fp0.1,k	:	1600	N/mm2
Ep	:	195000	N/mm2
gamp	:	1.15	
kmin = fpk / fp0.1,k (S-D Line)	:	1.01	
fbpd	:	2.34	N/mm2
r.inf / r.sup	:	0.95/1.05	

Reinforcement

max ds / web top	:	8.0	mm
max ds / web bottom	:	10.0	mm
max ds / top flange	:	12.0	mm
max ds / bottom flange	:	10.0	mm
d1x,t	:	4.00	cm
d1x,l	:	4.00	cm
cvL	:	2.50	cm
lb,rqd / Web,top (Basic value, anchorage length)	:	19.7	cm
lb,rqd / Web, bottom	:	24.6	cm
lb,rqd / Top chord	:	29.5	cm
lb,rqd / Bottom chord	:	24.6	cm

Concrete age

Time of individual crack formation / Min. reinforcement	:	28 d
Time of stabilised cracking / Crack width limitation	:	28 d
Time of 1st loading / Conrete compressive strength	:	28 d
Time of 1st fatigue loading / Fatigue strength	:	100 d

Action type
Action by loading

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RIB RTcDesign 18.0 Design concr struct t = 28 d

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Pos101 - My

Ultimate limit states for bending with longitudinal force

Conc.: C 55/ 67 gamma.c= 1.50 alfa.cc= 0.85 **Cross-sect.: Pos101 -**
ReinfSteel: B500(B) gamma.s= 1.15 uniaxial Bending
Pres.Steel fp0.1,d: 1391 gamma.s= 1.15 **permanent situation**

Design values of actions without P.dir within bond (Basic combination STR/GEO)

Decisive lc-combinations	Lc	MEdy(kNm)	MEdz(kNm)	NEdx(kN)	P.k
max MEdy;accord.MEdz, NEdx	1	2700.0	0.0	0.0	1.0*Pm
min MEdy;accord.MEdz, NEdx	2	1650.0	0.0	0.0	1.0*Pm

Req. longitudinal reinforcement:

Edge	min.As (cm2)	max.As (cm2)	required As (cm2)	cm2/m	Coordinates (m) y1	z1	y2	z2	Eps.pmo o/oo	Mat -
1- 2	0.5	299.7	0.5	1.75	-0.360	0.040	-0.060	0.040		
2- 3	1.1	119.9	1.1	9.44	-0.060	0.040	0.060	0.040		
3- 4	0.5	299.7	0.5	1.75	0.060	0.040	0.360	0.040		
9-10	0.3	149.8	0.3	1.99	0.060	1.360	0.210	1.360		
10-11	1.6	119.9	1.6	13.28	-0.060	1.360	0.060	1.360		
11-12	0.3	149.8	0.3	1.99	-0.210	1.360	-0.060	1.360		
Spg 1	7.4	7.4	7.4		0.000	1.340			4.632	3
Spg 2	7.4	7.4	7.4		0.000	1.302			4.632	3
Spg 3	1.9	1.9	1.9		0.000	1.264			4.632	3
Total	21.1	1155.6	21.1		required.As/A.gross =				0.519	%

Design values of resistance:

Lc	Resistance Rd NRdx(kN)	MRdy(kNm)	MRdz(kNm)	Strain (o/oo) Eps.1	Eps.2	Eps.s	Beta Degr	Gamma	Utilization
1	-0.	3094.	0.	-2.969	25.823	25.00	0.0	1.000	0.873
2	-0.	3094.	0.	-2.969	25.823	25.00	0.0	1.000	0.533

Lc	Compressive resultant (kN)	y(m)	z(m)	Acp(m2)	Tensile resultant (kN)	y(m)	z(m)	Act(m2)	Lever arm(m)
1	-2453.	-0.000	0.056	0.1039	2453.	-0.000	1.317	0.00189	1.2609
2	-2453.	-0.000	0.056	0.1039	2453.	-0.000	1.317	0.00189	1.2609

Project: Introductory Example
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RIB RTcDesign 18.0 Design concr struct t = 28 d

Pos101 - My

Limitation of concrete compressive stresses and reinforcing steel stresses:

Conc.: C 55/ 67 Ecm = 35700.0 N/mm2 Cross-sect.: Pos101 -
ReinfSteel: B500(B) 0.80*fyk= 400.0 N/mm2 uniaxial Bending
Compressive strength: fck(28)= 55.0 ßcc=1.000 **Requirement class:D**

Concrete stresses in uncracked cross-section (rare combination)

Area	Point	Sig.c ---(N/mm2)---	fctm	adm. compr. stresses (N/mm2)
top	4	-6.84		0.60*fck(t) -33.0
Botto	9	3.98		0.60*fck(t) -33.0

Design values of actions without P.dir within bond (rare combi.):

Decisive lc-combinations	Lc	MEdy(kNm)	MEdz(kNm)	NEdx(kN)	P.k
max MEdy;accord.MEdz, NEdx	15	1965.0	0.0	0.0	0.95*Pm
min MEdy;accord.MEdz, NEdx	16	1650.0	0.0	0.0	1.05*Pm

Stress strain plane in cracked cross-section (without tensile strength):

Lc	Resistance Rd			Strain (o/oo)			Beta	H.ten
	MRdy(kNm)	MRdz(kNm)	NRdx(kN)	Eps.1	Eps.2	Eps.s	Degr	(m)
15	1965.0	0.0	0.0	-0.324	0.625	0.60	0.0	0.92
16	1650.0	0.0	0.0	-0.193	0.005	-0.00	0.0	0.03

Design Values --- Reinforcement stresses--- Concrete compression

Locat	As	Lc	Eps.s	Sig.s	Lc	Eps.s	Sig.s	Utili	Lc	min Sig.c	Utili
	(cm2)		(o/oo)	N/mm2		(o/oo)	N/mm2	tion		N/mm2	tion
1- 2	0.5	15	-0.297	-59	16	-0.187	-37	0.000	15	-11.57	0.351
2- 3	1.1	15	-0.297	-59	16	-0.187	-37	0.000	15	-11.57	0.351
3- 4	0.5	15	-0.297	-59	16	-0.187	-37	0.000	15	-11.57	0.351
10- 9	0.3	16	-0.001	0	15	0.598	120	0.300	16	0.00	0.000
11-10	1.6	16	-0.001	0	15	0.598	120	0.300	16	0.00	0.000
12-11	0.3	16	-0.001	0	15	0.598	120	0.300	16	0.00	0.000

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RIB RTcDesign 18.0 Design concr struct t = 28 d

Pos101 - My

Limitation of stresses wihin cracking cross-section

Conc.: C 55/ 67 Ecm = 35700.0 N/mm2 Cross-sect.: Pos101 -
Pres.Steel fpk: 1860 0.65*fpk= 1209.0 N/mm2 uniaxial Bending
Compressive strength: fck(28)= 55.0 ßcc=1.000 **Requirement class:D**

Concrete stresses in uncracked cross-section (rare combination)

Area	Point	Sig.c ---(N/mm2)---	fctm	adm. compr. stresses (N/mm2)
top	4	-6.84		0.45*fck(t) -24.8
Botto	9	3.98		0.45*fck(t) -24.8

Design values of actions without P.dir within bond (quasi-permanent combi.):

Decisive lc-combinations	Lc	MEdy(kNm)	MEdz(kNm)	NEdx(kN)	P.k
min MEdy;accord.MEdz, NEdx	11	1650.0	0.0	0.0	1.00*pm
min MEdy;accord.MEdz, NEdx	12	1650.0	0.0	0.0	1.00*pm

Stress strain plane in cracked cross-section (without tensile strength):

Lc	Resistance Rd			Strain (o/oo)			Beta	H.ten
	MRdy(kNm)	MRdz(kNm)	NRdx(kN)	Eps.1	Eps.2	Eps.s	Degr	(m)
11	1650.0	0.0	-0.0	-0.198	0.029	0.02	0.0	0.18
12	1650.0	0.0	-0.0	-0.198	0.029	0.02	0.0	0.18

Design Values --- Prestress steel stresses--- Concrete compr. stress

Locat.	Ap (cm2)	Eps.pmo (o/oo)	Lc	Eps.p (o/oo)	Sig.p N/mm2	Lc	Eps.p (o/oo)	Sig.p N/mm2	Utili zation	Lc	minSig.c N/mm2	Uti- liza.
1- 2										11	-7.08	
2- 3										11	-7.08	
3- 4										11	-7.08	
Spg 1	7.4	4.632	11	4.652	907	11	4.652	907	0.750			
Spg 2	7.4	4.632	11	4.645	906	11	4.645	906	0.749			
Spg 3	1.9	4.632	11	4.639	905	11	4.639	905	0.749			

Project: Introductory Example
Structural member: Beam

RIB RTcDesign 18.0 Design concr struct t = 28 d

Pos101 - My

Tabular fire resistance analysis

Analysis of the constructive resistance of fire according to DIN 4102-4
- mainly bending stressed beams according to table 3 + 6
- statically determinate or statically indeterminate with moment redistribution > 15 %
- trilateral fire load with ETK DIN 4102-4
- Further fire resistance design features must be complied with

Conc.: C 55/ 67 gamma.c= 1.50 alfa.cc= 0.85 **Cross-sect.: Pos101 - flexion mem**
ReinfSteel: B500(B) gamma.s= 1.15
Pres.Steel fp0.1,d: 1391 gamma.s= 1.15 **accidental situation**

Fire resistance class R 60

existing reinforcement	As.tot(cm2) =	4.37		rho =	0.11%
Accidental combination (kNm)				MEd,fi =	1650.0
Basic combination (kNm)				MEd =	2700.0
As.prov/As.req				=	1.1
crit. temperature reinf. steel	crit.Ts =	526.7 °C		del.as =	-0.3
crit. temperature prestr. steel	crit.Tp =	403.4 °C		del.ap =	1.0

Web table 5.5 modified due to *crit T:*

web thickness - class:	exis.bw (cm) =	12.0	>=	req.bw =	9.2
Beam width S-S reinforcement	ex.bmin(cm) =	42.0	>=	req.bmin=	16.0
Center dist. tens. reinf.	exis.am (cm) =	9.8	>=	req.am =	2.2
Center distance of multilayer reinforcement				req.am/2=	4.9
Center distance single-ply reinforcement web sideward				req.asd =	2.2

=> Design conditions fulfilled

Project: Introductory Example
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RIB RTcDesign 18.0 Design concr struct t = 28 d

Longitudinal reinforcement

Conc.: C 55/67 - ReinfSteel: B500(B) Requirement class D

(M) Robustness and surface reinforcement
(B) Bending strength with longitudinal force
(R) Individual and final crack formation
(E) Analysis against fatigue - bending with longitudinal force
(P) internal prestressing bonded tendons

			--- Total reinforcement cm2 -----				cm2/mPE
Memb	Locat	Ap(P)	As(M)	As(B)	As(R)	As(E)	As(Q)	As(TL)
1	0.0	16.7	4.4	4.4				

Project: Introductory Example
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RIB RTcDesign 18.0 Design concr struct t = 28 d

Utilization ratio

Conc.: C 55/67 - ReinfSteel: B500(B) Requirement class D

(B) Bending strength with longitudinal force
(R) w.cal terminated cracking
(E) dSig.equ Analysis against fatigue - reinforcing steel
(Ep) dSig.equ Analysis against fatigue - prestressing steel
(Q) Earthquake bearing capacity
(D) Shear bearing capacity of the strut
(F) dSig.sw Analysis against fatigue - shear force
(C) Sig.c in the cracked cross-section
(S) Sig.s within cracked cross-section
(P) Sig.p within cracked cross-section
(H) Sig.I Principal tensile stresses in the uncracked cross-section

Memb	Sect	A(B)	A(R)	A(E)	(Ep)	A(Q)	A(D)	A(F)	A(C)	A(S)	A(P)	A(H)	A(Z)	ULS	FLS	SLS
1	0.00	0.87							0.35	0.30	0.75			0.87		0.75
maxUtilization														**0.87**	**0.00**	**0.75**