

New version for Designing members of Reinforced Concrete, Steel or Timber according to Eurocode 2, Eurocode 3 and Eurocode 5

# **New-Updated version of Frame2Dexpress:**

- Design for reinforced concrete, steel and timber according to Eurocodes.
- Frame prototypes for easy generation of structural models.
- Steel profiles. All the standard steel profiles for the design of steel frame structures.

# 1. Designing elements from reinforced concrete according to Eurocode 2

NA - National Annex

Partial safety factors for actions

After you select material *Concrete* an additional page Concrete shows in the material session. In this page you input all necessary data for the reinforced concrete design of the frame elements.

eler	nents	closs se	ctions e	lement loa	ds elem.	masses, self we	ight R.Concret	$\supset$
stru	cture r	material	Elastici	ty modulus	s cro	oss section units		
R.0	Concre	ete 🔽	E (GPa	i)= 26.00	) <b>0</b> ci	m 🗸		
N	Cr. se	b [cm]	h [cm]	b1 [cm]	h1 [cm]	A [cm²]	l [cm4]	^
1	T	25.0	70.0	120.0	15.0	31.750E002	13.353E005	
2		30.0	60.0	0.0	0.0	18.000E002	54.000E004	
								~

## 1.1 Design parameters for reinforced concrete

In page Concrete you define parameters for the reinforced design.

1. To select concrete and reinforcing steel class, click

The concrete and reinforcing steel classes are adjusted according to the selected National Annex. You can change strength properties for the concrete and reinforcing steel from Design/Materials/Concrete or Design/Materials/Reinforcing steel.

2. Partial factors for materials. This is defined according to National annex, usual values:  $\gamma c = 1.50$ ,  $\gamma s = 1.15$ .

3. Concrete Cnom, cover in mm.

4. Preferable rebar diameter. If you check *fixed* the selected diameter will be used. If not, some

5. For every element you can defile:

Lcy: Buckling length for in-plane flexural buckling (meters), usually the length of the member. Lcz: Buckling length for out-of-plane buckling (meters), usually the length of the member.

6. Design: = 1 The reinforced concrete design of this element is performed.
 = 0 This element is skipped in the design.

## **1.2** Reinforced concrete design according to Eurocode 2

Click Reinforced Concrete Design. All the marked with Design = 1 elements will be verified according to Eurocode 2, §6, for axial force, shear and bending moment in ultimate limit state. The design for reinforcement is performed for mid span, left end and right end of each element. The vertical elements in compression (columns) are verified for second order effects according to Eurocode 2, §5.8.3.

optimum diameter will be used, around the preferable.

Euro code	•
	Reinforced concrete design,EN1992-1-1,
1	Timber design, EN1995-1-1,
	Steel design, EN1993-1-1,

elements cross sections element loads elem. masses, self weight R.Concrete

Eurocode EN

vG=1.35 vQ=1.50 w2=0.30

Concrete-Stee	l class	C25/30 -	B500C	影				
Partial factors	for materials	ye= 1.50 ,	ye= 1.50 , ys= 1.15 🛛 👻					
Concrete cove	er (mm)	Cnom= 30	) 🔁					
Rebar diamete	er (mm)	Ø 2	0 🔽 fixed	diameter Ø 🛛	•			
Reset elem	ent design dat	а						
Elm.	L[m]	Phi[mm]	Lcy[m]	Lcz[m]	Design			
1	4.600	20	6.200	6.200	1			
2	8.400	20	12.400	12.400	1			
3	4.600	20	6.200	6.200	1			

for the steel design of the frame elements.	1	I
	2	I
If you click on a line of the table on cross sect	tion	Standard s

or click III the table with cross sections shows up and you select a standard profile for this element.

In order to proceed with the steel design you have to select standard profiles for all the elements.

#### 2.1 **Design parameters for steel**

In page Steel you define parameters for the steel design.

1. Select Steel grade.

The steel grades are adjusted according

to the selected National Annex.

2. Partial factors for materials. This is defined according to National annex, usual values: γM0=1.00, γM1=1.00, γM2=1.25

3. For every element you can defile: Lcy: Buckling length for in-plane flexural buckling (meters), usually the length of the member. Lcz: Buckling length for out-of-plane flexural buckling (meters), usually the distance of lateral supports as purlins for rafters. Lt: Buckling length for lateral

torsional buckling (meters), usually distance of lateral supports as purlins.

4. Design: = 1 The steel design of this element is performed.

= 0 This element is skipped in the design.

#### 2.2 Steel design according to Eurocode 3

Click Steel design. All the marked with Design = 1 elements will be verified according to Eurocode 3, §6.2, for axial force, shear and bending moment in ultimate limit state, according to §6.3 for flexural and lateral torsional buckling.

The buckling critical lengths are the ones defined in the steel design page. The strength checks are performed for mid span, left end and right end of each element.

Timber design, EN1995-1-1	,
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Steel design, EN1993-1-1,

Reinforced concrete design, EN1992-1-1,

After you select material Steel an additional page Steel shows in the

In this page you input all necessary data

material session.

elements cross sections element loads elem. masses, self weight (Steel)	}
structure material Elasticity modulus cross section units Steel V E (GPa)= 210.000 mm V III	
N         cr. sect.         A [mm²]         I [mm4]	^
1 王 IPE 500 11.550E003 48.200E00	7
2 I IPE 600 15.600E003 92.080E00	7
	~



Eurocode EN

Lt[m]

4.600

2.100

4.600

fy=355N/mm² fu=510N 🔽

γ<sub>M2</sub>= 1.25 🚔

Design

1

1

0



www.runet-software.com

Euro code

γG=1.35 γQ=1.50 ψ2=0.30 Partial safety factors for actions You can change properties for structural steel from Design/Materials/Structural steel.

γ<sub>м1</sub>= 1.00 😭

Lcz[m]

4.600

2.100

4.600

elements cross sections element loads elem. masses, self weight Steel

γ<sub>M0</sub>= 1.00 😭

Lcy[m]

8.600

8.400

8.600

S 355

NA - National Annex

Reset element design data

L[m]

4.600

8.400

4.600

Structural steel

Partial factors

Elm.

1

2

3

# 3. Designing timber members according to Eurocode 5

After you select material *Timber* an additional page Timber shows in the material session where you define the additional parameters for timber design.

### 3.1 Design parameters for timber

In page Timber you define parameters for the timber design.

1. Select Timber class. The material properties are according to the selected EN in *Design/Materials/Timber.* 

The EN standards are EN338:1997, EN338:2003, or EN 338:2009 or one user defined. Last EN standard is EN 338:2009. You must notice that using an older EN338:1997, EN338:2003 standard with lower defined shear strength the shear strength checks are performed with kcr = 1. Selecting EN 338:2009 (which has increased shear strengths) the shear strength checks are performed with kcr 0.67 as is defined in addition A1:2008 of Eurocode 5 (Eq. 6.13a).

2. Select service class.

Select load duration class. Usually self weight is permanent, snow load and live load is long term, wind load is short term.

3. Partial factors for materials. This is defined according to National annex, usual values:  $\gamma$ M=1.30, for timber and  $\gamma$ M=1.10 for steel connectors.

- 4. For every element you can defile:
- Lcy: Buckling length for in-plane flexural buckling (meters), usually the length of the member.
- Lcz: Buckling length for out-of-plane flexural buckling (meters), usually the distance of lateral supports as purlins for rafters.
- 5. Design: = 1 The timber design of this element is performed. = 0 This element is skipped in the design.

### 3.2 Timber design according to Eurocode 5

Click Timber Design. All the marked width Design = 1 elements will be verified according to Eurocode 5, §6, for axial force, shear and bending moment in ultimate limit state and according to §6.3 for stability. The buckling critical lengths are defined in the timber design page.

The checks are performed for mid span, left end and right end of each element.



elements	cross section	s element loa	ds 🛛 elem. masses, s	self weight Timber	>
structure Timber	material El	asticity modulus (GPa)= 10.00	cross section	1 units	
N	b [cm]	h [cm]	A [cm²]	l [cm4]	^
1	12.0	12.0	14.400E001	17.280E002	
2	12.0	15.0	18.000E001	33.750E002	
3	6.0	10.0	60.000E000	50.000E001	
					~

Standard of strength class		×
	_	
O EN 338:1997 Solid wood, EN 1194 Glulam	<u>a</u>	
O EN 338:2003 Solid wood, EN 1194:2000 Glulam		
EN 338:2009 Solid wood, EN 1194:2000 Glulam	A	
🔿 South African pine		
🔿 User-1		
O User-2		

elements cros	ss sections 🛛 eleme	ent loads elem.	masses, self weig	ght Timber
Timber class		C16, fm	<=16.0N/mm², ftc	ik=10.0N/mm² 💌
Service class		Class 2,	moisture content	(=20%
Load duration c	lasses		Long-te	rm 🔽
Material factors		Timber 1	.30	Steel 1.10
Reset eleme	nt design data			
Elm.	L[m]	Lcy[m]	Lcz[m]	Design 🔼
1	1.900	1.900	1.900	1
2	1.900	1.900	1.900	0
3	1.200	1.200	1.200	1
4	1.200	1.200	1.200	0
5	1.000	1.000	1.000	1 🗸
<				>

### 3.3 Design notes

The connections in frame are fixed connections. In case you have to define some timber elements which they are pinconnected to other elements then for these elements define a separate material-section group and after you define the b and

h of the cross section, change the moment of inertia to a small number. Example in the structure showing at the right, the

horizontal member carries only axial force. The moment of inertia of this member has been changed by dividing the original by  $10^4$ .



elements cross sections element loads elem. masses, self weight Timber

structure material			asticity r	nodulus		cross	section	n units
Timber	*	Е	(GPa)=	10.00	10	cm	$\sim$	
N	b [cm]		h [cm]		A	cm²]		l [cm4]
1		6.0		22.0		13.20	0E001	53.240E002
2		6.0		22.0		13.20	0E001	53.240E-002

# 4. Materials for Reinforcing Concrete, Structural Steel and Timber

The materials for concrete, reinforcing steel, structural steel and timber are adjusted according to the selected National Annex.

You can change material properties from Design/Materials.

In order to change values for materials first you have to unlock the tables with properties. Click Closed.

For timber you can select one of the EN prototypes. EN338:1997, EN338:2003 or EN 338:2009 or one defined by the user. The user defined prototype allows you do change the material properties.

Reinforcing Steel (EC2 EN1992-1-1:2004, §3.2)



Reinforcing steel Class	fyk [MPa]	ftk,c [MPa]	Es [GPa]	euk [%]	L [m]
\$220	220.00	220.00	200.00	2.50	14.00
S400	400.00	400.00	200.00	2.50	14.00
S400s	400.00	400.00	200.00	7.50	14.00
\$500	500.00	500.00	200.00	2.50	14.00
S500s	500.00	500.00	200.00	7.50	14.00
B500A	500.00	500.00	200.00	2.50	14.00
B500B	500.00	500.00	200.00	5.00	14.00
B500C	500.00	500.00	200.00	7.50	14.00
B450C	450.00	450.00	200.00	7.50	14.00
S670/800	670.00	800.00	200.00	7.50	14.00
yk: characteristic yield strengt	n, ftk.,c: tensile strengtl	n, Es: modulus of elast	icity, euk: maximum str	ain, L: steel bar length	
击 🖃 Reset 🛛 Anch	orages		🖌 ок	🔒 Locked 🚽	Print 💡 Help

				fung. al	funsal.	[MPa]	[GPa]	[GPa]	[klim?]
12.00	15.00	1.60	1.10	2.00	3.20	0.27	26	11	25
16.00	20.00	1.90	1.30	2.50	5.00	0.33	28	12	25
20.00	25.00	2.20	1.50	2.90	5.80	0.39	29	13	25
25.00	30.00	2.60	1.80	3.30	6.60	0.45	31	13	25
30.00	37.00	2.90	2.00	3.80	7.80	0.45	32	14	25
35.00	45.00	3.20	2.20	4.20	8.40	0.45	34	15	25
40.00	50.00	3.50	2.50	4.60	9.20	0.45	35	15	25
45.00	55.00	3.80	2.70	4.90	9.60	0.45	36	16	25
50.00	60.00	4.10	2.90	5.30	10.40	0.45	37	16	25
55.00	67.00	4.20	3.00	5.50	10.40	0.45	38	16	25
60.00	75.00	4.40	3.10	5.70	10.40	0.45	37	16	25
70.00	85.00	4.60	3.20	6.00	10.40	0.45	37	16	25
80.00	95.00	4.80	3.40	6.30	10.40	0.45	37	16	25
90.00	105.00	5.00	3.50	6.60	10.40	0.45	37	16	25
	12.00 16.00 20.00 25.00 30.00 35.00 40.00 45.00 55.00 55.00 60.00 70.00 80.00 90.00	12.00         15.00           16.00         20.00           25.00         25.00           25.00         30.00           30.00         37.00           35.00         45.00           46.00         55.00           55.00         67.00           55.00         67.00           60.00         75.60           70.00         65.00           80.00         55.00           90.00         105.00	12.00         15.00         15.00           15.00         2.00         1.30           20.00         2.500         2.260           25.00         3.000         2.60           35.00         4.500         3.20           40.00         55.00         3.50           55.00         4.500         3.50           55.00         4.500         4.50           55.00         4.500         4.50           55.00         4.500         4.40           70.00         45.00         4.60           90.00         45.00         4.60           90.00         45.00         4.60	1200         1300         130         130         130           1200         2500         2500         150         130           2000         2500         2200         150         130           2000         2500         2200         150         130           2000         2500         260         260         130           3500         4500         320         220         1400           4000         500         320         250         200           5000         6700         410         230         550           5000         7500         440         210           7000         650         460         323         300           9000         1550         550         450         323	1.00         1.00         1.00         1.00         2.00         2.50         2.00         1.50         1.00         2.00         2.50         2.00         1.50         2.00         2.50         2.00         1.50         2.00         2.50         2.00         1.50         2.00         2.50         2.00         2.50         2.00         3.00         2.00         3.00         2.00         3.00         3.00         2.00         3.00 <th< th=""><th>1000         1000         1000         1000         1000         1000         2000         <th< th=""><th>12.00         13.00         13.00         13.00         13.00         23.00         <th< th=""><th>1200         1300         1400         110         200&lt;</th><th>12.00         13.00         13.00         13.00         13.00         23.00         <th< th=""></th<></th></th<></th></th<></th></th<>	1000         1000         1000         1000         1000         1000         2000 <th< th=""><th>12.00         13.00         13.00         13.00         13.00         23.00         <th< th=""><th>1200         1300         1400         110         200&lt;</th><th>12.00         13.00         13.00         13.00         13.00         23.00         <th< th=""></th<></th></th<></th></th<>	12.00         13.00         13.00         13.00         13.00         23.00 <th< th=""><th>1200         1300         1400         110         200&lt;</th><th>12.00         13.00         13.00         13.00         13.00         23.00         <th< th=""></th<></th></th<>	1200         1300         1400         110         200<	12.00         13.00         13.00         13.00         13.00         23.00 <th< th=""></th<>

Structural t	tructural timber Strength classes EN 338:2009, EN 1194:2000											×	
Class	ID	fmk [MPa]	ftOk [MPa]	ft90k [MPa]	fcOk [MPa]	fc90k [MPa]	fvk [MPa]	EOm [MPa]	E05 [MPa]	E90m [MPa]	Gm [MPa]	pk [Kg/m²]	
C14	0	14.00	8.00	0.40	16.00	2.00	3.00	7000	4700	230	440	290	
C16	0	16.00	10.00	0.40	17.00	2.20	3.20	8000	5400	270	500	310	
C18	0	18.00	11.00	0.40	18.00	2.20	3.40	9000	6000	300	560	320	
C20	0	20.00	12.00	0.40	19.00	2.30	3.60	9500	6400	320	590	330	
C22	0	22.00	13.00	0.40	20.00	2.40	3.90	10000	6700	330	630	340	
C24	0	24.00	14.00	0.40	21.00	2.50	4.00	11000	7400	370	690	350	
C27	0	27.00	16.00	0.40	22.00	2.60	4.00	11500	7700	380	720	370	
C30	0	30.00	18.00	0.40	23.00	2.70	4.00	12000	8000	400	750	390	
C35	0	35.00	21.00	0.40	25.00	2.90	4.00	13000	8700	430	810	400	
C40	0	40.00	24.00	0.40	26.00	2.90	4.00	14000	9400	470	880	420	
C45	0	45.00	27.00	0.40	27.00	3.10	4.00	15000	10000	500	940	440	
C50	0	50.00	30.00	0.40	29.00	3.20	4.00	16000	10700	530	1000	460	
D18	1	18.00	11.00	0.60	18.00	7.50	3.40	9500	8000	630	590	475	
D24	1	24.00	14.00	0.60	21.00	7.80	4.00	10000	8500	670	620	485	
D 30	1	30.00	18.00	0.60	23.00	8.00	4.00	11000	9200	730	690	530	
D35	1	35.00	21.00	0.60	25.00	8.10	4.00	12000	10100	800	750	540	
D40	1	40.00	24.00	0.60	26.00	8.30	4.00	13000	10900	960	810	550	
D50	1	50.00	30.00	0.60	29.00	9.30	4.00	14000	11800	930	880	620	
D60	1	60.00	36.00	0.60	32.00	10.50	4.50	17000	14300	1130	1060	700	
D70	1	70.00	42.00	0.60	34.00	13.50	5.00	20000	16800	1330	1250	900	
GL24h	2	24.00	16.50	0.40	24.00	2.70	2.70	11600	9400	390	720	390	
GL28h	2	28.00	19.50	0.45	26.50	3.00	3.20	12600	10200	420	780	410	
GL32h	2	32.00	22.50	0.50	29.00	3.30	3.80	13700	11100	460	850	430	
GL36h	2	36.00	26.00	0.60	31.00	3.60	4.30	14700	11900	490	910	450	
GL24c	2	24.00	14.00	0.35	21.00	2.40	2.20	11600	9400	320	590	350	
GL28c	2	28.00	16.50	0.40	24.00	2.70	2.70	12600	10200	390	720	380	
GL32c	2	32.00	19.50	0.45	26.50	3.00	3.20	13700	11100	420	785	410	
GL36c	2	36.00	22.50	0.50	29.00	3.30	3.90	14700	11900	460	850	430	
									<ul> <li>Image: A start of the start of</li></ul>	ок	Print	? Help	

Steel	Grade	fy (MPa) t<=40mm	fu (MPa) t<=40mm	fy (MPa) 40 <t<=100mm< th=""><th>fu (MPa) 40<t<=100mm< th=""></t<=100mm<></th></t<=100mm<>	fu (MPa) 40 <t<=100mm< th=""></t<=100mm<>
\$ 235	EN 10025-2	235	360	215	360
\$ 275	EN 10025-2	275	430	255	410
\$ 355	EN 10025-2	355	510	335	470
S 450	EN 10025-2	440	550	410	550
S 275 N/NL	EN 10025-3	275	390	255	370
S 355 N/NL	EN 10025-3	355	490	335	470
S 420 N/NL	EN 10025-3	420	520	390	520
S 460 N/NL	EN 10025-3	460	540	430	540
S 275 M/ML	EN 10025-4	275	370	255	360
S 355 M/ML	EN 10025-4	355	470	335	450
\$ 420 M/ML	EN 10025-4	420	520	390	500
S 460 M/ML	EN 10025-4	460	540	430	530
S 235 W	EN 10025-5	235	360	215	340
S 355 W	EN 10025-5	355	510	335	490
S 460 Q/QL	EN 10025-6	460	570	440	550
S 235 H	EN 10210-1	235	360	215	340
S 275 H	EN 10210-1	275	430	255	410
S 355 H	EN 10210-1	355	510	335	490
S 275 NH/N	EN 10210-1	275	390	255	370
S 355 NH/N	EN 10210-1	355	490	335	470
S 420 NH/N	EN 10210-1	420	540	390	520
S 460 NH/N	EN 10210-1	460	560	430	550

# 5. Frame prototypes

Selecting a Frame prototypes the program defines the nodal coordinates, support conditions and element properties and connectivity.

FH ·							
Frame prototypes	A1	⊣ в1	<b>—</b> C1	D1	Ê∏ E1	— F1	<sub>G1</sub>
Γ	T A2	<b>FH</b> B2	<b>FF</b> C2		FT E2	F2	<sub>G2</sub>
П	П АЗ	<b>П П В</b> З	ा वि	<b>∩</b> ₀	E3	∕_ F3	<sub>63</sub>

## 6. Effective lengths for columns

A difficult problem for frames is to define the buckling length for the columns. To help for this special tools have been included in the program (Design/Effective length for columns) for braced and unbraced frames. The curves and tools are based on Eurocode 2 §5.8.3.2 for concrete and Eurocode 3 for steel.

In the appearing windows for computing the effective lengths of columns in braced or



unbraced frames, you input the basic frame dimensions and section properties. For steel frames you input the ratio of flexural stiffness's, column stiffness/beam stiffness. The critical buckling lengths of the columns are displayed as ratios of the column lengths eg.  $Lcr = 0.62 \times L$ , 0.59  $\times L$ 



# 7. Examples

# 7.1 Example 1

# Frame of reinforced concrete 8.40 m x 4.60 m C25/30 B500C



Select a frame from File/Frame prototypes:

FTI ·							
Frame prototypes	• 🗌 A1	<b>Н</b> в1	<b>—</b> C1	D1	ĤΕΊ	—— F1	<sub>G1</sub>
	A2	н В2	<b>E</b> C2		FT ₽2	F2	<sub>G2</sub>
	∏∏ A3	Н ВЗ	<b>₩</b> 3	<b>D</b> 3	ĒΒ	∕ <sub>F3</sub>	<sub>G3</sub>

Select material R. Concrete and give the basic dimensions, sections and loads. You can always change and adjust these values afterwards.

Frame prototypes		×
	Material R.Concrete	
	Lengths L = 6.000 m	
L	Heights H = 3.000 m	
	Cross section of horizontal members B= 200 mm	H= 500 mm
	Cross section of vertical members B= 300 mm	H= 300 mm
	Permanent load g= 8.50 kN/m	Variable load q= 6.50 kN/m
	σκ	X Cancel ? Help

Click Yes and give the file name.

Inform	ation 🔀
(į)	Click YES to open a new file with data as the prototype Frame NO to reset the existing file to the prototype Frame CANCEL to exit
	Yes No Cancel

Then check and adjust the rest of the values for the structural model.

Select National Annex of your region and partial safety factors. Usual values for partial safety factors ULS (ultimate limit state)  $\gamma$ G=1.35,  $\gamma$ Q=1.50 and SLS (serviceability limit state)  $\gamma$ G=1.00,  $\gamma$ Q=1.00.

NA - National Annex	Eurocode EN	¥
Partial safety factors for actions	γG=1.35 γQ=1.50 ψ2=0.30	¥

Check the drawing of the structure.

Nodes. Coordinate system at lower left point.
 Axis x from left to right, axis y from down up.
 The numbering of the nodal points is displayed on the drawing of the structure.

nodes supports nodal loads nodal masses

node	x [m]	y [m]
1	0.000	0.000
2	0.000	4.600
3	8.400	4.600
4	8.400	0.000

....

• Supports. Nodes 1 and 4 fixed.

.....

nodes supports nodal loads nodal masses										
node	support	ux[mm]	uy[mm]	ur[rad]						
1	TITT	0.00000	0.00000	0.00000						
4	ππ	0.00000	0.00000	0.00000						

• Nodal loads are zero, (in this example there are no loads on the nodal points).

nodes su	nodes supports nodal loads nodal masses									
	load com	bination 1.3	35 <b>xFg+</b>	1.50 <b>xFq</b>						
node Fgx[kN] Fqx[kN] Fgy[kN] Fqy[kN] Mg[kNm] Mq[kNm]										

• Nodal masses are necessary only in dynamic analysis.

• Elements. The element numbering is displayed on the drawing of the structure. Nodes A and B are the left and right nodes of each element. Cross section is the number in parenthesis next to each element and represents the number of the section group which properties defined in the page *cross sections*.

elements	cross sections	eleme	ent loads		
element	node A		node B		cr. sect.
1		1		2	2
2		2		3	1
3		3		4	2

Cross sections. The material is R. Concrete. The modulus of elasticity is automatically adjusted (26 GPa R. concrete, 210 GPa Structural steel and 10 GPa timber). Select units for cross section dimensions (eg. cm). For every cross-section group, (1 for horizontal beams, 2 columns) select cross section, T or rectangular cross section. The cross section sizes are: b (width), h (height), b1 (effective flange for T section) and h1 (slab thickness for T section). The values for A and I (area and moment of inertia of the cross section) are automatically set from b, h and b1, h1 values.

	elements cross sections element loads elem. masses, self weight R.Concrete									
structure material Elasticity modulus cross section units										
R.Concrete 🛛 🖌 E (GPa)= 26.00					26.00	cm	*			
	N	cr. se	b [cm]	h [cm]	b1 [cm]	h1 [cm]	A [cm²]	l [cm4]		
	1	Ъ	25.0	70.0	120.0	15.0	31.750E002	13.353E005		
	2		30.0	60.0	0.0	0.0	18.000E002	54.000E004		

• Element loads. For every element loaded with distributed load supply one or more loads. Number of loaded element (eg. 2), kind (uniform triangular etc.), load value (dead load g kN/m or live load q kN/m). Careful with dead load, give the additional to the element self weight. The program computes the self weight of the elements if it is checked in the next page (mass self weight) of data. The load direction is (2) downwards for gravity loads and snow load, (1) for wind and pressure and (3) for horizontal loads as seismic load.

elements cross sections element loads elem. masses, self weight R.Concrete

load combination 1.35 $\mathbf{xG}$ + 1.50 $\mathbf{xQ}$							
element	kind	dead g [kN/m]	live q [kN/m]	direction			
2		22.500	12.400	ł			

• Element masses, self weight. The weight density of the material. If you check to include the self weight in the load and masses, the program adds in dead loads the self weight of each element (unit weight) x (cross section area). The weight density is set automatically by the program (R. concrete 25 KN/m<sup>3</sup>, steel 78.50 kN/m<sup>3</sup>, timber 9kN/m<sup>3</sup>).

elements cros	s sections element load	ls elem. masses, self weigh	t R.Concrete				
Weight density kN/m3 25.00 include self weight in loads and masses							
Mass combination 1.00 xMg + 0.30 xMq							
element	Gg (kN/m)	Gq [kN/m]					

• Concrete. You specify the basic data for the design of reinforced concrete according to Eurocode 2. Select Concrete and Steel class. Partial factors for materials, according to the

National Annex, for ULS (ultimate limit state)  $\gamma c=1.50$ ,  $\gamma s=1.15$  and SLS (serviceability limit state)  $\gamma c=1.00$ ,  $\gamma s=1.00$ . Cnom is the concrete cover according to Eurocode 2 §3.4.1. The rebar diameter is used as the optimum desired by the program. If you check next to the rebar diameter then is only this diameter selected by the program. For every element you may specify in the column Phi [mm] the desired rebar diameter eg. 20 mm for columns and 16 mm for beams.

The buckling lengths Lcy and Lcz for in and out of plane buckling are used for stability checks using second order effects for the columns, according to Eurocode 2 §5.8.3. In the column Design, mark with 1 the elements which you want to be included in the design of reinforced concrete. In this example the elements 1 and 2 are marked with (1) and element 3 with (0), as there is no need because of symmetry to include element 3 (right column) in the reinforced concrete design.

elements cross sections element l	oads elem. masses, self weight R.Concrete
Concrete-Steel class	C25/30 - B500C
Partial factors for materials	yc= 1.50, ys= 1.15 🛛 🗸
Concrete cover [mm]	Cnom= 30 😭
Rebar diameter [mm]	Ø 20 💌 fixed diameter Ø 🔽

Reset element design data

Elm.	L[m]	Phi[mm]	Lcy[m]	Lcz[m]	Design
1	4.600	20	8.650	8.650	1
2	8.400	16	8.400	8.400	1
3	4.600	20	8.650	8.650	0

In order to define the buckling lengths of the columns for unbraced frame according to Eurocode 2 5.8.3.2, use the extra tools of the program Design/Effective length-Unraced members.

For this example we obtain  $Lcr = 1.88 \times L = 1.88 \times 4.60 = 8.65 \text{ m}$ 

Euro code				
	Reinforced concrete design,EN1992-1-1,			
	Timber design, EN1995-1-1,			
	Steel design, EN1993-1-1,			
Ι	Steel profiles,EN1993-1-1,§ 5.5			
H	Effective length of columns (R.Concrete)	۲	2	Effective length (R.Concrete), EN1992-1-1, § 5.8.3.2
Ħ	Effective length of columns (Steel)	• ]	Ð	Effective length-Braced members
r-	Materials	۰	ŦŦ	Effective length-Unbraced members



After you give all the data the reinforced concrete design is performed according to Eurocode 2.



Check if every element is verified in the design.

<u>1-Fi</u>	nite element model (FEM)		
	element:1, Reinforced con element:2, Reinforced con element:3, Reinforced con	ncrete design is OK ncrete design is OK ncrete design not performed	
Nodal	points		
Node	x [m] y[m]		
2	0.000 4.600		
3	8,400 4,600		
4	8.400 0.000		
Suppo	ts		
Node	kind ux[mm	m] uy[mm] ur[rad]	
Node 1	fixed ux=uy=ur=0	m] uy[mm] ur[rad]	
Node 1 4	kind ux[mm fixed ux=uy=ur=0 fixed ux=uy=ur=0	m] uy[mm] ur[rad]	
Node 1 4 Nater	kind ux mm fixed ux=uy=ur=0 fixed ux=uy=ur=0 als	m] uy[mm] ur[rad]	
Node 1 4 Mater Hater	kind ux[am fixed ux=uy=ur=0 fixed ux=uy=ur=0 .als .al : R.Concrete, E= 26.000	<u>u) uy[ma] uz[zad]</u> 0 [GPa]	
Node 1 4 Mater Nater Veigh	kind         ux[mm           fixed ux=uy=ur=0	uy[ma] ur[rad] 0 [GPa] m <sup>2</sup> ]	
Node 1 4 Mater Mater Veigh The e	kind uxuy=ur=0 fixed ux=uy=ur=0 als al: R.Concrete, E= 26.000 c density : p= 25.000 [kN/m ement self weight is included	uy[mm] ux[xed] 0 [GPa] a*] d in loads and masses	
Node 1 4 Mater Mater Weigh The e	kind ux=uy=ur=0 fixed ux=uy=ur=0 als al: R.Concrete, E= 26.000 c density : p= 25.000 [kN/m ement self wight is included	uy[man] uz[zad] 0 [GPa] m <sup>*</sup> ] d in loads and masses	
Node 1 4 Mater Hater Veigh The e	kind ux(mm fixed ux=uy=ur=0 al: R.Concrete, E= 26.000 density : p= 25.000 [kN/m ement self wight is included t cross sections	uy[man] ux[rad] 0 [GPa] a <sup>2</sup> ] d in loads and masses b(rad)	
Node 1 4 Mater Mater Veigh The e <u>Eleme</u> <u>Cr.se</u>	kind ux(mm fixed ux-uy=ur=0 als al: R.Concrete, E= 26.000 density : p= 25.000 [kN/m ement self weight is included th cross sections b[cm] h[cm] h[cm] h1[cm] h1	uy[mm] uz[zed] 0 [GPa] *] d in loads and masses 1(cm] Ac[cm*] Ic[cm4]	
Node 1 4 Mater Mater Veigh The e Eleme Cr.se	kind ux(am fixed ux=uy=ur=0 als als: R.Concrete, E= 26.000 cdensity: p= 25.000 [kH/m casent self weight is included at cross sections c. b[cm] h[cm] h[cm] h1 m) u	uy[mn] ux[rad] 0 [6Pa] m <sup>3</sup> ] d in loads and masses 1(cm] Ac[cm <sup>4</sup> ] Ic[cm4]	

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🐴 Print preview exBETON01 Pg. 1 1-Finite element model (FEM) 6 Nodal points y[m] 0.000 4.600 4.600 0.000 x [m] 0.000 Node 1 0.000 8.400 8.400 2 Supports kind fixed ux=uy=ur=0 fixed ux=uy=ur=0 ux[mm] uy[mm] ur[rad] Node 1 <u>Materials</u> Material : R.Concrete, B= 26.000 [GPa] Weight density : p= 25.000 [kW/m<sup>3</sup>] The element self weight is included in loads and masses > 0% Page

## 7.2 Example 2

## Steel frame 8.40 x 4.60 S355



Select a frame from File/Frame prototypes:

FF							
Frame prototypes	• A1	<b>Н</b> в1	<b>—</b> C1	D1	ĤΕΊ	F1	<sub>G1</sub>
	A2	н В2	<b>E</b> C2		FT E2	F2	<sub>G2</sub>
	ПП А3	₩Н ВЗ	🖽 сз	<b>□</b> D3	Ē	∕_ F3	<sub>G3</sub>

Select material Steel and give the basic dimensions, cross sections and loads. You can always change and adjust these values afterwards.

For element cross sections click

Frame prototypes			X
	Material	Steel 💌	
	Lengths L = 8.400 m		
L	Heights H = 4.600 m		
	Cross section of horizontal members		IPE 500
	A= 11550 Cross section of vertical members	mm² I=	482000000 mm4
	A= 15600	mm² l=	920800000 mm4
	Permanent load g= 8.60 kN/m	Va q=	ariable load = 12.40 kN/m
11			
		🗸 ок	X Cancel ? Help

Click Yes and give the file name.

Informa	ation 🔀
(į)	Click YES to open a new file with data as the prototype Frame NO to reset the existing file to the prototype Frame CANCEL to exit
	Yes <u>N</u> o Cancel

Then check and adjust the rest of the values for the structural model.

Select National Annex of your region and partial safety factors. Usual values for partial safety factors ULS (ultimate limit state)  $\gamma$ G=1.35,  $\gamma$ Q=1.50 and SLS (serviceability limit state)  $\gamma$ G=1.00,  $\gamma$ Q=1.00.

NA - National Annex	Eurocode EN	~
Partial safety factors for actions	γG=1.35 γQ=1.50 ψ2=0.30	¥

Check the drawing of the structure.

Nodes. Coordinate system at lower left point.
 Axis x from left to right, axis y from down up.
 The numbering of the nodal points is displayed on the drawing of the structure.

nodes	supports	nodal loads	nodal m	nasses	
node		x [m]		y (m	]
	1	0	.000		0.000
	2	0	.000		4.600
	3	8	.400		4.600
	4	8	.400		0.000

• Supports. Nodes 1 and 4 fixed.

nodes	supports	nodal loads	nodal masses	
-------	----------	-------------	--------------	--

node	support	ux[mm]	uy[mm]	ur[rad]
1	TTTT	0.00000	0.00000	0.00000
4	77777	0.00000	0.00000	0.00000

• Nodal loads. Vertical loads on nodal points 2 and 3, permanent 95 kN and variable 125 kN. Sign of loads (-) negative, loads downwards.

nodes supports nodal loads nodal masses

load combination 1.35 <b>xFg+</b> 1.50 <b>xFq</b>							
node	Fgx[kN]	Fqx[kN]	Fgy[kN]	Fay[kN]	Mg[kNm]	Mq[kNm]	
2	0.000	0.000	-95.000	-125.000	0.000	0.000	
3	0.000	0.000	-95.000	-125.000	0.000	0.000	

• Nodal masses are necessary only in dynamic analysis.

• Elements. The element numbering is displayed on the drawing of the structure. Nodes A and B are the left and right nodes of each element. Cross section is the number in parenthesis next to each element and represents the number of the section group which properties defined in the page cross sections.

elements cross sections element loads						
element	node A	node B	cr. sect.			
1	1	2	2			
2	2	3	1			
3	3	4	2			

• Cross sections. Material Steel. The modulus of elasticity is automatically adjusted (210 GPa for steel). Select units for cross section dimensions eg. mm). For every cross section group (1 for horizontal beams, 2 columns) select cross section. In the column with the name of the cross section click is and the library with all the steel cross sections is display to select cross section type and size.

elements	cross sections	element loads	elem, masses, self w	eight Steel
structure r	material Ela	sticity modulus	cross section unit:	3
Steel 🔽 E (GPa)= 210.00 mm 🔽 🎞				
N cr. sect. A [mm²] I [mm4]				
1	I	IPE 500	11.550E003	48.200E007
2	I	IPE 600	15.600E003	92.080E007

• Element loads. For every element loaded with distributed load supply one or more loads. Number of loaded element (eg. 2), kind (uniform triangular etc.) load value (dead load g kN/m or live load q kN/m). Careful with dead load, give the additional to the element self weight. The program computes the self weight of the elements if it is checked in the next page (mass self weight) of data. The load direction is (2) downwards for gravity loads and snow load, (1) for wind and pressure and (3) for horizontal loads as seismic load.

elements cross sections element loads elem. masses, self weight Steel						
load combination 1.35 $\mathbf{xG}$ + 1.50 $\mathbf{xQ}$						
element kind dead g [kN/m] live q [kN/m] direction						
2			8.600	12.400	Y	

• Element masses, self weight. The weight density of the material. If you check to include the self weight in the load and masses, the program adds in dead loads the self weight of each element (unit weight) x (cross-section area). The weight density is set automatically by the program (steel 78.50 kN/m<sup>3</sup>).

elements cro	oss sections	element lo	ads elem. ma	asses, self	weight	Steel
Weight densit	y kN/m3	78.50 in Io	clude self weig ads and masse	µhtin es	~	
Mass combination 1.00 xMg + 0.30 xMq						
element	Gg [kN/m]	]	Gq[kN/m]			

• Steel. You specify the basic data for the design of steel according to Eurocode 3. Select Steel grade. Partial factors for materials, according to National annex, for ULS (ultimate limit state)  $\gamma$ M0 = 1.00,  $\gamma$ M1 = 1.00,  $\gamma$ M2 = 1.25. You have to define the buckling lengths. Lcy buckling length for in plane buckling. For braced frames this is less or equal to the member length, for unbraced members is grater. Lcz buckling length for out of plane buckling and it is defined from the lateral supports. For horizontal beams it is usually the distance of the lateral beams or the purlins. In the column Design mark with 1 the elements which you want to be included in the design of steel according to Eurocode 3. In this example the elements 1 and 2 are marked with (1) and element 3 with (0), as there is no need because of symmetry to include element 3 (right column) in the steel design,

elements cross sections element loads elem. masses, self weight Steel					Steel	
Structural steel     S 355     fy=355N/mm² fu=510N       Partial factors     γ <sub>M0</sub> =     1.00     γ <sub>M1</sub> =     1.00       Reset element design data						
Elm.	L[m]	Lcy[m]	Lcz[m]	Lt[m]	Design	
1	4.600	6.67	4.600	4.600	1	
2	8.400	8.400	2.100	2.100	1	
3	4.600	6.67	4.600	4.600	0	

In order to define the buckling lengths of the columns for unbraced and braced frame according to Eurocode 3, use the extra tools of the program Design/Effective length of columns/Unraced members.

For this example we obtain  $Lcr = 1.45 \times L = 1.45 \times 4.60 = 6.67 \text{ m}$ 





After you give all the data the steel design is performed according to Eurocode 3.

Euro code	•
	Reinforced concrete design, EN1992-1-1,
	Timber design,EN1995-1-1,
V.	Steel design,EN1993-1-1,
Ι	Steel profiles, EN1993-1-1, § 5.5
I Fl	Steel profiles, EN1993-1-1,§5.5 Effective length of columns (R.Concrete)
L L I	Steel profiles, EN1993-1-1, § 5.5 Effective length of columns (R.Concrete)

Check if every element is verified in the design,

		element:1, Steel design is OK element:2, Steel design is OK element:3, Steel design not performed	
			]
Nodal	points		
Node	x [m]	γ[m]	
1	0.000	0.000	
2	0.000	4.600	
3	8.400	4.600	
4	8.400	0.000	
Suppor	ts		
Node	kind	ux[mm] uy[mm] ur[rad]	
1	fixed ux=	iy=ur=0	
4	fixed ux=	iy=ur=0	
Natori	ale		
Materi	ial : Steel.	E= 210.000 [GPa]	
Weight	density :	= 78.500 [kN/m <sup>3</sup> ]	
The el	lement self	eight is included in loads and masses	
Elemen	t cross sec	ions	
1	։ ոլտայ	1 AC[IIII-] IC[IIII4]	
2		1.56000E+004 9.20800E+008	
	3) w		🕀 Close 💡 He
26			

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## 7.3 Example 3

# Timber structure 6.40 x 4.60 C24



Structural model



Create a new file:

File
New
Frame prototypes
Open
Save
Save
Save As
Delete
Delete all data

Supply all the data of the Timber structure.

Select National Annex of your region and partial safety factors. Usual values for partial safety factors ULS (ultimate limit state) yG=1.35, yQ=1.50 and SLS (serviceability limit state)  $\gamma$ G=1.00,  $\gamma$ Q=1.00.

NA - National Annex	Eurocode EN	~
Partial safety factors for actions	γG=1.35 γQ=1.50 ψ2=0.30	¥

Nodes. Coordinate system at lower left point.

Axis x from left to right, axis y from down up. The numbering of the nodal points is displayed on the drawing of the structure. Use **Improvement** for adding or altering lines in the table.

nodes supports nodal loads nodal masses							
node		x [m]	y [m]				
	1	0.000	0.000				
	2	0.000	3.100				
	3	4.400	3.100				
	4	4.400	0.000				
	5	0.000	1.900				
	6	4.400	1.900				
	7	1.000	3.100				
	8	3.400	3.100				

Supports. Nodes 1 and 4 are pin supports. Click support to select support kind.

nodes supports nodal loads nodal masses

node	support	ux[mm]	uy[mm]	ur[rad]
1		0.00000	0.00000	0.00000
4	$\bigtriangleup$	0.00000	0.00000	0.00000

Nodal loads are zero (in this example there are no loads on the nodal points). •

nodes	upports nod	al loads 🛛	nodal masses			
	load con	nbination [	1.35 <b>xFg+</b>	1.50 <b>xF</b> c	1	
node	Fgx[kN]	Fqx[kN]	Fgy[kN]	Fqy[kN]	Mg[kNm]	Mq[kNm]

- Nodal masses are necessary only in dynamic analysis. •
- Elements. For every element according to the numbering of the line drawing of the model • supply the element number, the number of the left and right. Number of cross section 1 for vertical elements, 2 for horizontal and 3 for diagonal elements.

element	node A	node B	cr. sect.
1	1	5	1
2	6	4	1
3	5	2	1
4	3	6	1
5	2	7	2
6	8	3	2
7	7	8	2
8	5	7	3
9	8	6	3

#### elements cross sections element loads

Cross sections. Select material timber. The modulus of elasticity is automatically adjusted (10 Gpa timber). Select units for cross section dimensions (eg cm). For every cross section group (1 vertical elements 12x12, 2 horizontal 12x15, 3 diagonal 8x8) supply the cross section sizes b width, h height. The values for A and I (area and moment of inertia of the cross-section) are automatically set from b h. The diagonal elements usually are pin connected with the vertical and horizontal elements. In order to approximate such a model with the program (pin connections for nodes 5 and 7 for element 8), after you give the cross section dimensions b = 8 and h = 8 for group section 3, change the moment of inertia value I to a much smaller value. In the example instead of 341.33 has been changed to 34.13 (10 times smaller). With this change the diagonal elements become flexible and do not take bending moments (see bending moment diagram).

elements	cross sections	element loads	elem, masses, self v	veight Timber
structure material Elasticity modulus cross section units Timber   E (GPa)= 10.000  Cm				
N	b [cm]	h [cm]	A [cm²]	l [cm4]
1	12.0	12.0	14.400E001	17.280E002
2	12.0	15.0	18.000E001	33.750E002
2		0.0	C4 000E 000	24 1225 001

• Element loads. For every element loaded with distributed load supply one or more loads. Number of loaded element (eg. 2), kind (uniform triangular etc.), load value (dead load g kN/m or live load q kN/m. Careful with dead load, give the additional to the element self weight. The program computes the self weight of the elements if it is checked in the next page (mass self weight) of data. The load direction is (2) downwards for gravity loads and snow load, (1) for wind and pressure and (3) for horizontal loads as seismic load.

elements	cross sections ele	ement loads elem, m	asses, self weight 🛛 T	imber		
load combination 1.35 <b>xG +</b> 1.50 <b>xQ</b>						
element	kind	dead g [kN/m]	live q [kN/m]	direction		
5		0.800	1.600	<u> </u>		
6		0.800	1.600	_ <del>ا</del>		
7		0.800	1.600	+		

. . . .

 Element masses self weight. The weight density of the material. If you check to include the self weight in the load and masses, the program adds in dead loads the self weight of each element (unit weight) x (cross section area). The weight density is set automatically by the material (timber 9 kN/m<sup>3</sup>).  Timber. You specify the basic data for the design of the timber members according to Eurocode 5. Select timber class (C24), service class and load duration class. Material factors according to national Annex. For ULS (ultimate limit state) γM=1.30 and for SLS (serviceability limit state) γM=1.00. You have to specify the buckling lengths Lcy and Lcz for in plane and out of plane buckling. For the horizontal elements Lcz is the distance between transverse beams or purlins (1.20 m).

elements cross sections element loads elem. masses, self weight Timber							
Timber class		C24, fmk=24.0N/mm², ftok=14.0N/mm² 💟					
Service class			Class 2, moisture content<=20%			~	
Load duration classes Long-term			erm	~			
Material factors			Timber	1.30		Steel 1.1	0
Reset element o	design data						
Elm.	L[m]	Lcy[m]		Lcz[m]	1	Design	T
1	1.900	1.900		1.900		1	
2	1.900	1.900		1.900		0	
3	1.200	1.200		1.200		1	
4	1.200	1.200		1.200		0	
5	1.000	1.000		1.000		1	
6	1.000	1.000		1.000		0	
7	2.400	2.400		1.200		1	
8	1.562	1.562		1.562		1	
9	1.562	1.562		1.562		0	

After you give all the data the timber design is performed according to Eurocode 5.

Euro code	•
	Reinforced concrete design,EN1992-1-1,
*	Timber design, EN1995-1-1,
	Steel design,EN1993-1-1,
Ι	Steel profiles, EN1993-1-1, § 5.5
T	Steel profiles, EN1993-1-1, § 5.5 Effective length of columns (R.Concrete)
H H I	Steel profiles, EN1993-1-1, § 5.5 Effective length of columns (R.Concrete)

Check if every element is verified in the design.

ń		
		<u> </u>
<u>l-Finite elem</u>	ent model (FEM)	
Г		
	element:1. Timber design is OK	
	element:2, Timber design not performed	
	element:3, Timber design is OK	
	element:4, Timber design not performed	
	element:5, Timber design is OK	
	element:6, Timber design not performed	
	element:7, Timber design is OK	
	element:8, Timber design is OK	
	element:9, Timber design not performed	
Nodal points		
Node x [m]	<u> </u>	
1 0.000	0.000	
2 0.000	3.100	
3 4.400	3.100	
4 4.400	0.000	
5 0.000	1.900	
6 4.400	1.900	
7 1.000	3.100	
0 3.400	3.100	
Summorts		
Node kind	່ ງາງໄພຍາການເປັນທີ່ມາເມັນເປັນເປັນເປັນເປັນເປັນເປັນເປັນເປັນເປັນເປ	
1 pin	$\frac{1}{1} ux = uy = 0$	
4 pin	n ux=uy=0	
Materials		~
8 🗗 🖤		🎘 Close 📔 💡 Help 📔
- 201		

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