**BUCKLING LENGTH of a CONCRETE COLUMN**

Name: **BUCKLING v1.1**

**Description:**

The program determines for a concrete column fixed to a system of beams and columns the effective (buckling) length on the basis of EUROCODE 2, section 5.8.3.2 in combination with the National Annex for Germany **[1]**. In contrast to the “approximate” functions (Eq. 5.15 and 5.16) given there this program applies the “exact” transcendental buckling equations given in **[2].**

Figure 1) describes the shape of the total system with column “**i**” to be checked.

The program requires the inputs of:

**a)** - the moments of inertia of beam I1–I4 and columns It/Ib by entering “b,eff” “hf” “b0” “h0”

for T-shaped beams or “b0” , “h0” for rectangular beams/columns ( fig. 3) or (**new in rel. 1.1** ) only “h0” for circular sections. If already known, “I” may be entered directly (positive value)

**b)** - the lengths of beams and columns

**c)** - the coefficients of support for each beam (see fig. 3) : **** = 3 (Default) for beam 1 and 4 , **** = 4 for beam 3. In the example beam 2 is omitted (cantilever beam without support !)

For horizontally not fixed ( free ) systems **** = 6.

**d)** – reduction factor for I of horizontal beams (**50%**, as recommended in **[1]** )

The system may be horizontally fixed or free ! It Lt

L1 , I1 L2, I2

(top left) **Ii** (top right) **Li**

L3, I3 L4, I4

base left) (base right) Lb

Ib

Figure 1

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

L1 – L4: length of beam 1 – 4 ; I1 – I4: moment of inertia of beam 1 – 4

It, Ib: moment of inertia of columns t, b(top / bottom column )

**Ii: moment of inertia of column i that is to be checked.**

(The terms in brackets identify the beams’ input boxes in the program )

There are different kinds available for the input of the moments of inertia I:

***1***) Enter a value > 0 for I **[cm4]** in the corresponding request box, then key in the length

L **[cm],** the support index **** and the reduction value for I (default : 50%, as recommended in **[1]**) and do so for the next beams, **t**op column, **b**ase column and the column i to be checked.

***2***) Key in ***0*** . That will set the stiffness of that beam/column to zero.

***3***) Key in a ***positive*** value for **I** (for instance **1**) and a ***negative*** value (**-1**) for **L** (**Be sure to use the (-) – key !** ). If you do so in the request boxes for beam 1 or 3, the neighbouring beams ( 2 or 4, respectively) may be set to **0** as explained in step 2). That will set this node being fixed rigidly for bending moments.

***4***) Key in ***-1*** for I, then enter the values for L, ****, and reduction factor. After that four new boxes will open to enter beff, hf, b0 ,and h0. For the different contours you have to enter now:

For: b,eff : hf :b0: h0:

T-shaped beam : >0 >0 >0 >0

Rectangular Beam: **0 0** >0 >0

Circular section: **0** **0 0** >0

In the last case h0 is assumed to be the diameter of the section !

If you have entered the length L of the checked column, the program computes the degrees of restraint k1 on top and k2 at the base of the column, where ki = 0 stands for rigid restraint and

ki oo ( depicted as **ki = 100000** ) for a hinged connection. According to EUROCODE 2 the minimum value of ki is restricted to **ki = 0.1**, as there is no totally fixed connection in practice !

From both values the factor ****and the effective length **\* Li** on the basis **[1]** and **[2]** are calculated. These results are depicted in a plot on page 1.3 of the document.

1

2

3

4

Figure 2

i

System horizontally fixed !

simply cantilever beam

supported **A**

= 3

Li = L,**A-B** = 400

**B**

clamped simply supported

4 3

Lb = 400

L1 = L3 = 2.0

600 L4 = 500

**How to run:**

Store the file “**Buckling.tns**” in the MyLib-folder and start “**buckl()**” on page 1.2 of the document.

**EXAMPLE**

All beams (T-shaped): columns: hf

= 18

h0 =60 h0 = 50

b0 = 40

b0 = 40

Figure 3

b,eff = 150

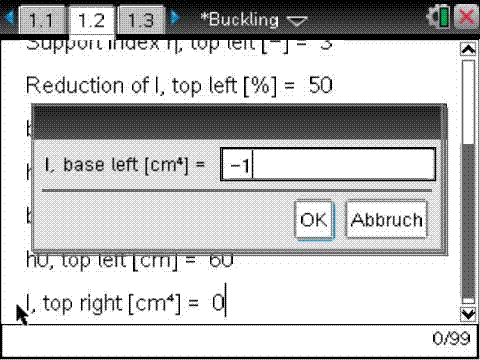
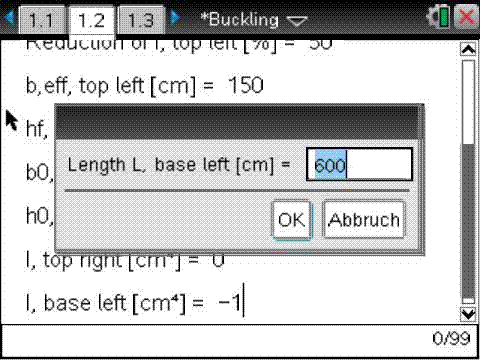
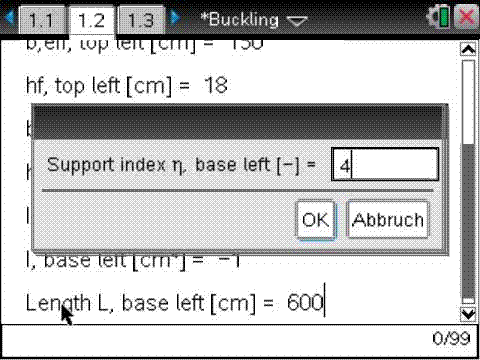
The program is demonstrated by an example using the values of figures 2) and 3).

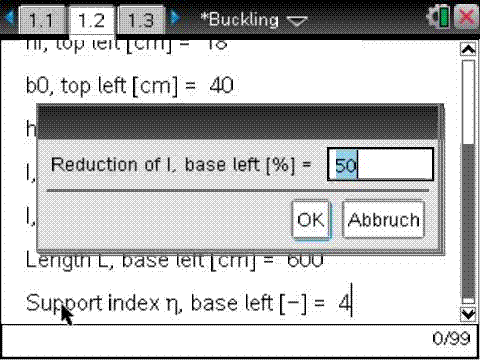
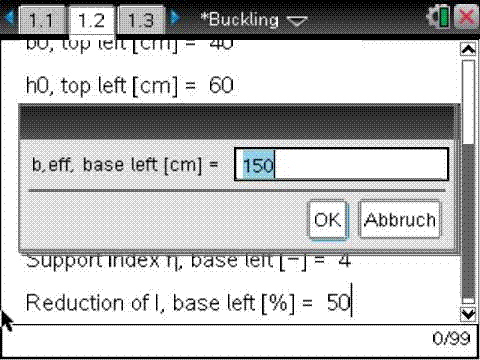
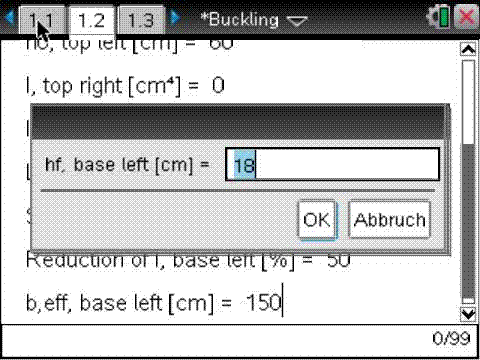
Start **“buckl()”** on page 1.2 and enter or leave **1** (given as default value) in the first request box for the condition of the system (being horizontally fixed or moveable).

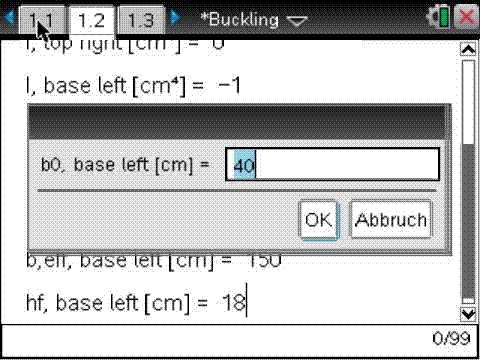
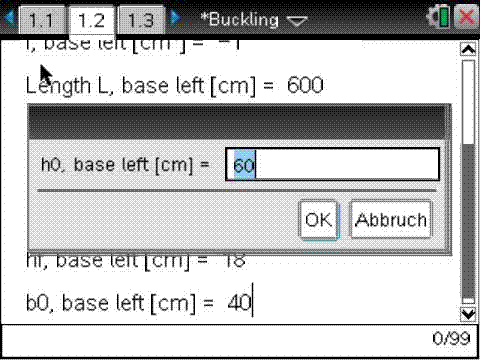
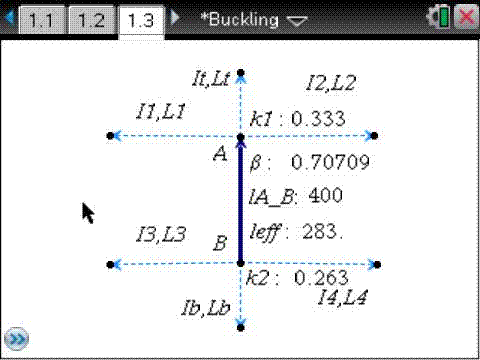
Now the program prompts to enter the values for beam 1 (top left). Key in **-1** for I, **600** for L and leave **3** and **50** as default values for ****and the reduction factor in the input line. In the following input lines enter **150 18 40** and **60** for the beam’s dimensions, see fig. 3).

As beam 2 is a cantilever, enter **0** for I,**top right** and continue with beam 3.

figs. 4) – 11) demonstrate the input for this section ( base left ).

4)  5)  6)

 7)  8)  9)

10)  11)  12)

To make the input easier for repeating values the recent calculation/input for “I” is in the display.

So leave “**1251914.79**” for I4 in the line and continue with **500 3 50**.

As in this example there is no top column, enter **0** for I,**top column.** Then key in **-1 400** for the bottom column and **0 0 40 50** for the size. Take over “**416666.67**” for I of the checked col.

and **400** for L,checked col. . After the calculation is finished, you may switch to page 1.3 and see the results (fig. 12) :

k1 : 0.333 coefficient k1 of top

k2 : 0.263 coefficient k2 of base

Coeff. **** :0.70709 buckling factor depending on k1 and k2

System length L,**A-B** : 400 cm

Effective length : 283 cm **** \* L,**A-B**

**Special cases**:

Rigid restraint (I1 = I2 = infinite )

Ii Enter  **1** for **I**,**top left** , **-1** for L,**top left** and **0** for

I,**top right**

I3 I4

Iu

I1 = It = I2 = **0** (hinged)

Ii Enter **0** for **I1, I2** and **I4,** but **1** forI,**base left**

and **-1** for L,**base left**

Rigid restraint (I3 = I4 = infinite )

hinged

I Enter **0** into the I-line for all beams, top and base columns, a positive value for I,**checked col.** and the height (400) and get the result : k1 = k2 = 100000 , ß = 1.0, Leff = L,A-B = 400

hinged

**LIMITATIONS** :

All measures and moments of inertia should be in [cm, cm4], but the program will also be correct for **ALL** lengths entered in [m] !

The calculation of the stiffness assumes that Young’s modulus E = constant for the complete system.

The program is provided as a free release for non-commercial purpose without any warranty or responsibility of any kind.

Though several tests compared to examples in the technical literature have been made, mistakes

can not ruled out !

So check each result, in no event will the author be liable for damages arising out of the use or inability to use this program!

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**LITERATURE:**

**[1]** EUROCODE 2, section 5.8.3.2 and the additional National Annex for Germany

**[2]** O. Ehrigsen, U. Quast: „Knicklaengen, Ersatzlaengen und Modellstuetzen

( Beton- und Stahlbetonbau, Heft ( Issue ) 5 – 2003 )

**[3]** Deutscher Ausschuss fuer Stahlbeton , Heft (Manual) 525: „Erlaeuterungen zu DIN 1045-1“

2**nd** edition 2010 ( Beuth Publisher’s, September 2003 )