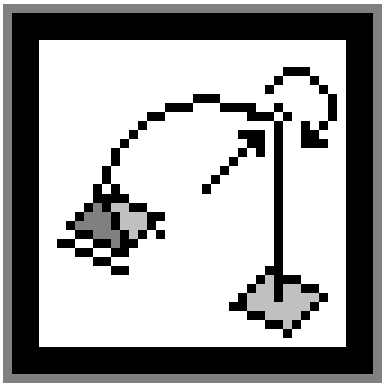
Valentini Bernhard
Urich Christian

Smart-Bars V2.50



Structural analysis program on TI89, TI89-Titanium,
TI92+, V200

Contents

1 Introduction

Smart-Bars is a structural analysis program for 2D structures on TI89, TI89-Titanium, TI92+, V200. It provides graphic input/output and a tabular view of the results. It is distributed to help students of civil engineering and other technical fields.

2 Features

- material and section database
- moment and shear hinges (global)
- supports (fixed, hinged and moveable in various directions)(rotatable)
- springs for hinges and supports
- element types:
  - beam
  - truss
- load types:
  - node loads (global)
  - trapezoidal element loads (local and global)
  - temperature load case (increase/decrease and gradient)
  - forced displacements at supports
  - dead load for the whole structure
- calculated values:
  - deformations of each element and node
  - internal forces of each element (axial- and lateral forces, moments)
  - minimum and maximum deformation and moment of each element
  - support reactions of each support
- input:
  - via dialog boxes
- output
  - graphic and tabular output of the results for the whole structure

  - graphic and tabular output of the results for each element and node
  - tabular output of the results for each node
  - tabular output of the support reactions
  - graphic routines:
    * scroll and zoomable drawing area
    * scroll and zoomable tables

- available languages:
  - English
  - French
  - German
  - Polish
  - Portuguese
  - Spanish

3 Requirements

- TI89, TI89-Titanium, TI92+ or V200 with AMS-Version 2.05 or higher
- Minimum 120kB free RAM
- Minimum 160kB free Flash-ROM
- Program "HW3Patch" to run the program on TI89-Titanium (You can download it from Kevin Koflers' homepage http://kevinkofler.cjb.net.)

4 Files

Smart-Bars contains following files (for TI89/TI89-Titanium, TI92+, V200):

1. launcher:
   - smartbar.(89z, 9xz, v2z)
2. dlls:
   - sbinput.(89y, 9xy, v2y)
   - sboutput.(89y, 9xy, v2y)
   - sbcalc1.(89y, 9xy, v2y)

3. text files:
    - sbarhelp.(89t, 9xt, v2t)
    - sbmatdb.(89t, 9xt, v2t)
    - sbsecdb.(89t, 9xt, v2t)
4. pictures:
    - sbpic01.(89i, 9xi, v2i)
    - sbpic02.(89i, 9xi, v2i)
    - sbpic03.(89i, 9xi, v2i)

5 Installation

Check if you have minimum 120kB free RAM and minimum 160kB Flash-ROM available.

Transfer all files of you calculator type

- TI89/TI89-Titanium (*.89*)
- TI92+ (*.9x*)
- V200 (*.v2*)

via link cable to ONE FOLDER on your calculator and ARCHIEVE (not only lock) all files - that's all.

If you have transfered them to the main folder, you have to do nothing more. Elsewhere if you have moved them to another folder you have to set this folder active, before you start Smart-Bars. For example, if you have transfered all files to the folder "sbar". Before you start the program you should write on the homescreen "setfold(sbar)" and press the enter-key afterwards. So your active folder should now be "sbar". You can see the active folder in the left lower corner on the display. If you miss this, you won't be able to load the databases and help file.

When you have a TI89-Titanium you have to install the program "HW3Patch" on your calculator.

When you have a TI89 or TI89-Titanium you can install the program "Auto Alpha-Lock Off" to avoid pressing the alpha button every time you make an input.

Check once again if you have minimum 120kB free RAM available. If not, you have forgotten to archieve some (all) files.

6 Starting the program

Write in the command line of the TI-application “Home“ the expression “smartbar()“.

7 General Notes

The handling of the program is made as easy as possible, so the input of a structure can be done very quickly.

Negative numbers you have to input with the “(-)“ sign next to the “.“ at the bottom of the numeric block. You should never make an input with the sign minus “-“.

The numbering of the nodes is pretexted by the program and should NEVER be changed.

NO INPUT IS AUTOMATICALLY SET “0“.

8 Notes and warnings

This program is distributed to help students of civil engineering and other technical fields, but WITHOUT ANY WARRANTY. (The authors make no representations or warranties about the suitability of the software, either express or implied. The authors are not liable for any damages suffered as a result of using or distributing this software.) Every kind of commercial use is forbidden without the permission of the authors.

Certainly there are several bugs within the program. For this reason it’s useful to make a backup of your calculator before using it.

Wrong operation can lead to a complete crash of the calculator’s system which can only be repaired with a reset (on+2nd+hand). The consequence is that all data on your calculator which is not archived could be deleted.

Therefore you should be careful, especially at the start of using this program.

If you have comments, bug reports or anything else, email Valentini Bernhard (bernhard.valentini@smart-programs.org) or visit the forum on our web site http://www.smart-programs.org/.

9 Menu structure

All structure and load inputs can be done in the input routine.

File	Create	Load	View	Results	Edit	Info
New	Node	Node load		Calculate	List	Help
Save	Material	Element load			Edit	System status
Open	Section	Temperature			Delete	About
Options	Spring	Displacement				
Exit	Hinge	Dead load				
	Element					
	Support					

Table 1: *Menu structure input*

After the calculation the program automatically opens the output routine. So the results should be more structured now than in Smart-Bars V1.00.

File	Graphic	Tabular	View	Info
Input	Axial forces	Internal forces		Help
Options	Lateral forces	Deformations		System status
Exit	Moments	Nodes		About
	Deformations	Supports		
	Elements			

Table 2: *Menu structure output*

You can change back to the input routine with the menu point “Input“ (section 12.1.1).

10 Unit system

Following units are used:

- m ... meters
- kN ... kilo Newton (=1000[N])
- rad ... radian
- K ... Kelvin

You can also use other units instead of, but you should use them consequently during the WHOLE in- and output!

11 Input

11.1 File

11.2 New

Deletes the actual structure.

11.2.1 Save

The name of the save file can't have more signs than eight. The files are saved to the actual folder. From Smart-Bars V0.50 on save files have the ending ".sbar".

11.2.2 Open

The program now searches for all files with the ending ".sbar".
So save files from Smart-Bars V0.50 downward can't be loaded anymore.

11.2.3 Options

Here you can change the visibility of the numbering of all elements (nodes, materials, sections, elements, supports, node loads, element loads, temperatures, displacements (not implemented yet)), the visibility of the coordinate cross and the numerical output of the results. The direction of the coordinate system can also be changed (z-axis upward or downward).

The options are saved to "sboption.sbop" and reloaded each time you enter the program.

11.2.4 Exit

Exits the program.

11.3 Create

11.3.1 Node

Following petition you have to enter:

- X-coordinate $[m]$
- Z-coordinate $[m]$

The global system of coordinates is a right hand system.

Coordinate system downward:

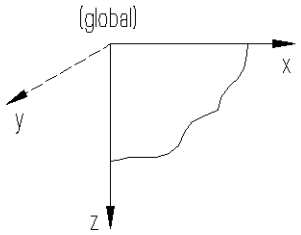


Figure 1: *Coordinate system downward*

Coordinate system upward:

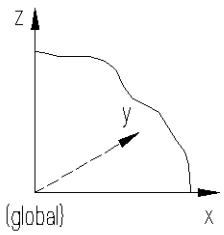


Figure 2: *Coordinate system upward*

11.3.2 Material

Following petition you have to enter:

- Elastic modulus $[kN/m^2]$
- Specific weight (only for dead load case) $[kN/m^3]$
- Coefficient thermal (only for temperature load case) $[m/K]$

If you input an isostatic structure take realistic values like the pretexted values for steel.

Section 13 shows how to edit or write your own material database.

11.3.3 Section

Following petition you have to enter:

- Material number of this section
- Area $[m^2]$
- I_y ... moment of inertia around y-axis $[m^4]$
- Height of section (in local z-direction) (only for temperature load case) $[m]$

Elements without deformations in axial direction can be simulated by choosing a relatively big cross sectional area toward to the other properties of the section.

If you input an isostatic structure take realistic values like the pretexted values for a steelwork-profile (HEB 300).

Section 13 shows how to edit or write your own section database.

11.3.4 Spring

Following petition you have to enter:

- X ... value of spring in global x-direction $[kN/m]$
- Z ... value of spring in global z-direction $[kN/m]$
- Φ_y ... value of spring around global y-axis $[kNm/rad]$

11.3.5 Hinge

Only hinges with global grade of liberties can be entered.

Following petition you have to enter:

- Spring number (none, if there is no spring)
- Displacement in global x-direction fixed or free
- Displacement in global z-direction fixed or free
- Rotation around global y-axis fixed or free

11.3.6 Element

Elements always have to be defined from one existing node to an other.

Following petition you have to enter:

- Start and end node
- Type (beam or truss)
- Section number of this element
- Hinge at start and end of this element (none, if there is no hinge)

Element definition for coordinate system downward:

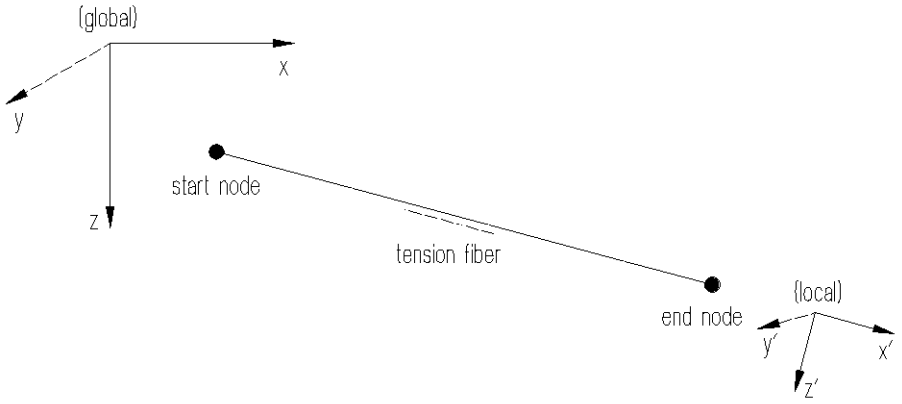


Figure 3: *Element definition (coordinate system downward)*

Element definition for coordinate system upward:

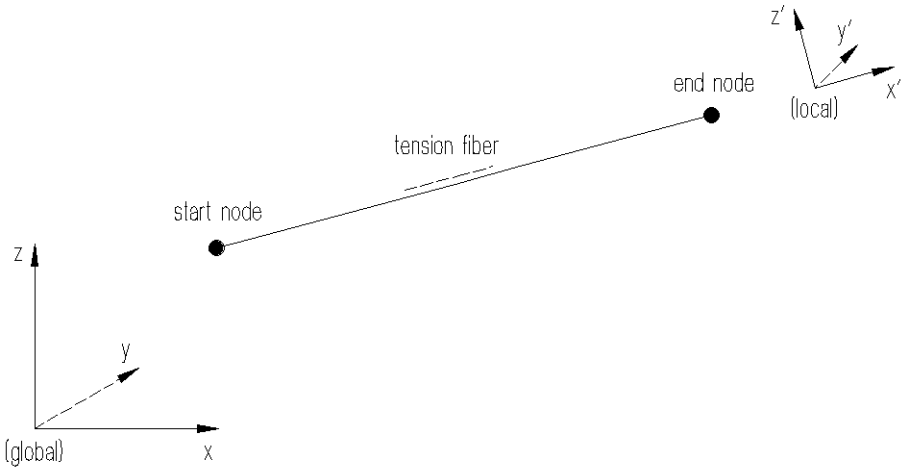


Figure 4: *Element definition (coordinate system upward)*

11.3.7 Support

Following petition you have to enter (like those of hinges):

- Node number
- Displacement in local x-direction fixed or free
- Displacement in local z-direction fixed or free
- Rotation around local y-axis fixed or free
- Spring number (none, if there is no spring)

In a second dialog box you have to enter:

- Rotation of the support around global y-axis [rad]

11.4 Load

11.4.1 Node load

The positive node load directions are like those of the global coordinate system (see figure 1 and figure 2).

You can only enter node loads in global direction. So if you have a local force (with a specific angle to the global coordinate system) you should

split it up into the global directions first.

Following petition you have to enter:

- Node number of this node load
- F_x ... force in global x-direction [kN]
- F_z ... force in global z-direction [kN]
- M_y ... moment around global y-axis [kNm]

Node load definition for coordinate system downward:

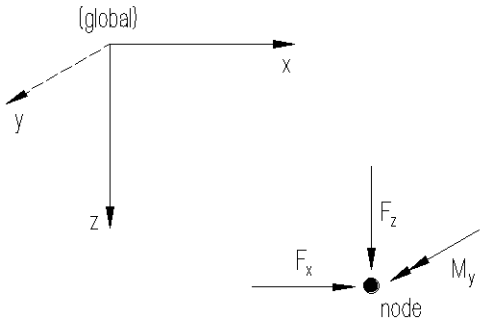


Figure 5: *Node load definition (coordinate system downward)*

Node load definition for coordinate system upward:

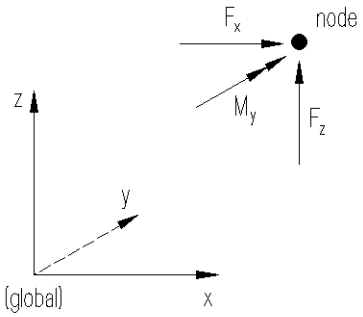


Figure 6: *Node load definition (coordinate system upward)*

11.4.2 Element load

The positive node load directions are like those of the global coordinate system (see figure 1 and figure 2).

You have to input the element loads' amplitude and its direction. The start and end value of the element loads' size can differ as far as the value and the signs are concerned.

Following petition you have to enter:

- Element number of this element load
- A ... start value of the element load $[kN/m]$
- B ... end value of the element load $[kN/m]$
- Direction (global x, global z, local x, local z)

The inscription is like this: $\boxed{DA/B}$

- A ... start value of the element load
- B ... end value of the element load
- D ... direction
  - Gx ... global x-direction (Global x)
  - Gz ... global z-direction (Global z)
  - Lx ... local x-direction (Local x)
  - Lz ... local z-direction (Local z)

Example:
Global z-direction element load with start value $10[kN/m]$ and end value $15[kN/m]$

$\rightarrow \boxed{Gz10/15}$

Element load definition for coordinate system downward:

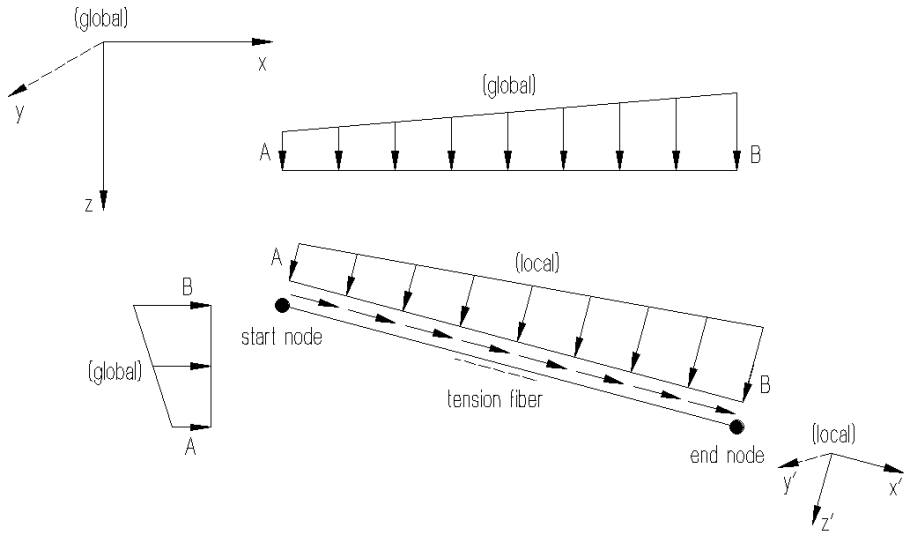


Figure 7: *Element load definition (coordinate system downward)*

Element load definition for coordinate system upward:

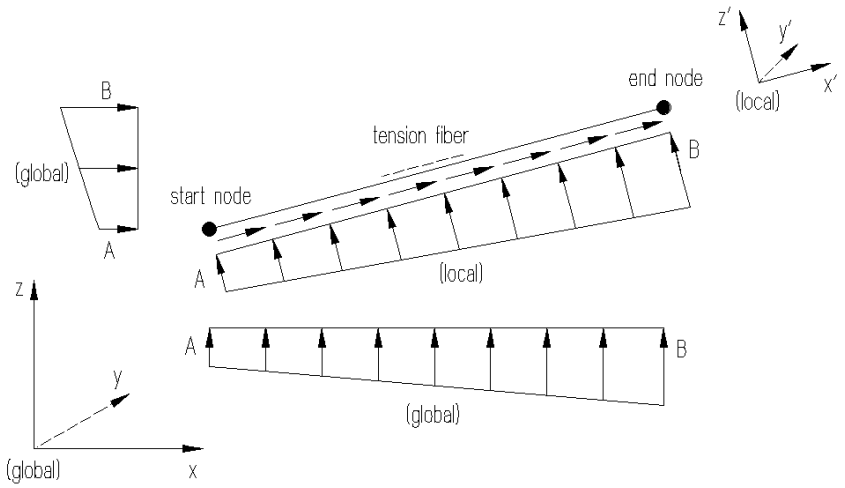


Figure 8: *Element load definition (coordinate system upward)*

11.4.3 Temperature

Following petition you have to enter:

- Element number of this temperature load case
- Temp. increase ... temperature increase (positive) or decrease (negative) of the element's axis $[K]$
- Temp. gradient ... temperature gradient ΔT between temperature at top T_o and bottom T_u of the element $[K]$

$$\Delta T = T_o - T_u \tag{1}$$

11.4.4 Displacement

The forced displacements must be added to a fixed degree of freedom of a support.

Following petition you have to enter:

- X ... value of forced displacement in global x-direction $[m]$
- Z ... value of forced displacement in global z-direction $[m]$
- Φ_y ... value of forced rotation around global y-axis $[rad]$

11.4.5 Dead load

The dead load is valid for the whole structure without exceptions. It is automatically calculated by the program.

For coordinate system downward gravitation is in positive z-direction, for coordinate system upward in negative z-direction.

11.5 View

When you enter the view-mode you can scroll and zoom the drawing area. Only in the view-routine and in the tabular output four color grayscale is turned on.

Controls:

- $\uparrow\downarrow\leftarrow\rightarrow$ ... scroll in one of these directions
- $+/-$ ... zoom in and out
- 2nd ... center the section to the area

- APPS ... move labels of elements and values of results (for better visibility)
- Esc ... cancel the view-mode

11.6 Results

11.6.1 Calculation

Very short introduction:
The calculation of the structure follows the stiffness matrix method. The program builds up the global stiffness matrix **K** and the global load vector **P** of the whole structure. Then the program solves the equation

$$\mathbf{v} = \mathbf{K}^{-1}\mathbf{P} \tag{2}$$

for the global displacement vector **v**. Finally the program calculates the local displacements of each element and then the internal forces by using the local stiffness and transformation matrices.

If the calculation returns “Cholesky failed“, the structure isn’t stable.

The minimum and maximum moment around y-axis and deformation in z-direction for each element are found with a Newton-Iteration.

11.7 Edit

11.7.1 List

All input elements are listed there.

Controls:

- ↑↓←→ ... scroll the table in one of these directions
- +/− ... zoom the table (and font)
- 2nd ... move to row number one
- Esc ... cancel the table

11.7.2 Edit

You can edit all input elements with this routine.

11.7.3 Delete

You can delete all input elements with this routine.

Elements which aren't independent from others are automatically locked by the program to avoid not existing connections.
When you have deleted an element and you save the structure or press calculation, the structure will automatically be renumbered.

11.8 Info

11.8.1 Help

Shows a list of short cuts used in the program and the control-keys for the view-mode and tables.

11.8.2 About

Prints some information about the program.

11.8.3 System Status

Shows how many nodes, materials, springs, hinges, elements, supports, node and element loads the structure has at the moment.

12 Output

12.1 File

12.1.1 Input

Change back to the input surface.
The structure will be automatically reloaded.

12.1.2 Options

The same as in section 11.2.3.

12.1.3 Exit

Exits the program.

12.2 Graphic

12.2.1 Axial forces, lateral forces, moments and deformations

Prints the internal forces or deformation of the whole structure.

The controls are the described in section 11.5.

12.2.2 Elements

Prints the internal forces or deformation of each element separate.

Controls:

- ↑↓ ... switch between axial force, lateral force, moment around y-axis and deformation
- ←→ ... switch between elements
- Esc ... cancel the graphic routine

12.3 Tabular

12.3.1 Internal forces, deformations and nodes

Prints the internal forces and local deformation of each element and the global deformation of each node.

- x ... point of internal force or deformation in local x-direction from the start of the element $[m]$
- N ... axial force in local x-direction $[kN]$

- V_z ... lateral force in local z-direction $[kN]$
- M_y ... moment around local y-axis $[kNm]$
- u ... deformation in local x-direction $[m]$
- w ... deformation in local z-direction $[m]$
- Φ_y ... rotation around local y-axis $[rad]$

The minimum and maximum deformation (max w, min w) and moment (max M_y, min M_y) is shown for each element.

The tabular output are scroll and zoomable.

The controls are described in section 11.7.1.

12.3.2 Supports

Prints the global support reactions of all supports.

Positive support reactions point to positive global coordinate system directions, negative support reactions point to negative global coordinate system directions.

- F_x ... support reaction in global x-direction $[kN]$
- F_z ... support reaction in global z-direction $[kN]$
- M_y ... support reaction around global y-axis $[kNm]$

The controls are described in section 11.7.1.

12.4 View

The same as in section 11.5.

12.5 Info

The same as in section 11.8.

13 Editing the material or section database

First of all, if you write a new database or extend one, please share it to other users of this program.
To do this, just send it to (bernhard.valentini@smart-programs.org) and it will be added to the Smart-Bars databases our site http://www.smart-programs.org/.

The name of the material database is sbmatdb.(89t, 9xt, v2t) and of the section database sbsecdb.(89t, 9xt, v2t).

Syntax:

- A comment line starts with "//".
- In front of the material/section name there must be the "*" character.
- Values need no special character in front.

Construction of the material database:

//Material database	//comment
*Steel	*material name
210000000	elastic modulus $[kN/m^2]$
78.5	specific weight $[kN/m^3]$
0.000012	coefficient thermal $[m/K]$
*Cast iron	*material name
100000000	elastic modulus $[kN/m^2]$
...	...

Construction of the section database:

//Section database	//comment
*HEB 300	*section name
0.0149	area $[m^2]$
0.0002517	moment of inertia $[m^4]$
0.3	height [m]
*HEB 400	*section name
0.0198	area $[m^2]$
...	...

Important instructions:

- All rows, except comment rows, may be maximum 15 characters long (without the "*" character in front of the material/section name)!!!

- No empty rows or rows with comments within one material/section definition. If possible use them only at the top of the file.
- The floating point character is ".".
- If you are not sure if you've made it correctly, mail the file to bernhard.valentini@smart-programs.org.

Example of the default section database:

```
//Smart-Bars V2.50 section database
//(star)Section name (≤15char)
//Area [m^2] (≤15char)
//Moment of inertia [m^4] (≤15char)
//Height [m] (≤15char)
*HEB 300
0.0149
0.0002517
0.3
*HEB 400
0.0198
0.0005768
0.4
*HEB 500
0.0239
0.001072
0.5
*HEB 600
0.027
0.00171
0.6
*Rect. 100/200
0.02
0.00006667
0.2
*Rect. 200/400
0.08
0.00106667
0.4
*RD 20
0.000314
0.0000000079
0.02
```

14 Developer

- Valentini Bernhard (bernhard.valentini@smart-programs.org)
- Urich Christian (until Smart-Bars V0.10) (christian.urich@smart-programs.org)

Web site: http://www.smart-programs.org/

15 Thanks

- the TIGCC Team for making it possible to program in C (http://ticalc.ticalc.org)
- the TICT (TI-Chess Team) for their ExtGraph library (http://tict.ticalc.org)
- Pablo Lasheras for the Spanish translation
- Miguel Coelho for the Portuguese translation
- Raoul Aguirre for the French translation
- Szymon Luczak for the Polish translation
- Elisabeth Nägele for the proof-reading (of Smart-Bars 2D V0.03)
- all beta testers

16 History

- Smart-Bars V2.50:
  - 08.12.2005 - update
    - detailed installation guide in the manual
    - Polish version available (translated by: Szymon Luczak)
- Smart-Bars V2.50 Beta 1:
  - 09.11.2005 - update
    - material and section database implemented
    - support rotations implemented
    - bug in delete routine fixed
    - transfer problem with help files solved
- Smart-Bars V2.00:
  - 20.09.2005 - update
    - start screen changed
    - manual actualized
- Smart-Bars V2.00 Beta 2:
  - 19.09.2005 - update
    - sbmain.dll split up into sbinput.dll and sboutput.dll
      (So there should be more space available for features of the in- and output-routines in the future.)
    - picture files merged to three files
    - new menu structure
    - new control element for view-routine added
    - graphic routines improved
    - graphic element loads implemented
    - Greece characters implemented
    - French version available (translated by: Raoul Aguirre)
    - manual actualized
- Smart-Bars V1.00:
  - 13.03.2005 - final release
- Smart-Bars V1.00 Beta 4:
  - 27.02.2005 - update
    - forced displacement load case added

    * dead load added
    * support reactions added
    * minimum and maximum routine improved
    * help actualized
    * manual actualized

- Smart-Bars V1.00 Beta 3:
  - 14.02.2005 - update
    * temperature load case added
    * sbcalc2.dll implemented in sbcalc1.dll
    * minimum and maximum moment around y-axis and deformation in z-direction are now calculated for each kind of load
    * menus new arranged
    * error handling improved
    * graphic routines improved
    * graphic routine for results of each element added
    * bug in delete function fixed (found by: Marco Grollmus)
    * Portuguese version available (translated by: Miguel Coelho)
- Smart-Bars V0.50:
  - 16.01.2005 - update
    * bug with truss elements and fixed supports fixed
    * bug in save and load routine fixed
    * save file for options added
    * sprites for hinges added
    * German version available (translated by: Bernhard Valentini)
    * Spanish version available (translated by: Pablo Lasheras)
- Smart-Bars V0.50 Beta 6:
  - 01.01.2005 - update
    * sbmain.dll completely new rewritten
    * new save and load routine
    * options added
    * materials and springs added
    * input lists, edit and delete function added
    * tabular output of deformations of each node added

    * minimum and maximum deformation and moment for each element added
    * help added
    * pictures for better understanding added
    * scroll and zoomable drawing area in four color grayscale
    * scroll and zoomable table in four color grayscale
    * calculation routine improved

- Smart-Bars V0.10:
  - 29.09.2004 - update
    * bugs in calculation routine fixed
    * bugs in graphic output fixed
    * calculation routine split up into two dlls
    * input of dialog boxes changed
    * “clear input“ added

- Smart-Bars 2D V0.03a:
  - 22.01.2004 - update
    * calculation error with elements in the 2nd and 3rd sector fixed (element with start node in the center and end node in the sector x)
      (found by: Bernhard Valentini)

- Smart-Bars 2D V0.03:
  - 11.12.2003 - first release

- Smart-Bars 2D V0.02:
  - 21.11.2003 - beta test release

References

[Mang/Hofstetter (2000)] H. Mang and G. Hofstetter, *Festigkeitslehre*, Springer Verlag, Wien, 2000.

[Falter (1992)] B. Falter, *Statikprogramme für Personalcomputer*, 4.Auflage, Werner Ingenieur Texte, Düsseldorf, 1992.

[Hofstetter (2002)] G. Hofstetter, *Grundlagen der Baustatik*, 3.Auflage, 2002.

List of Figures

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