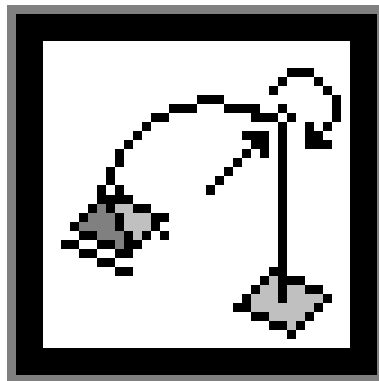


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Smart-Bars V1.00

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

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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

- beam and truss elements
- global moment and shear hinges
- all kind of supports (fixed, hinged and moveable in various directions)
- additional springs for hinges and supports
- global node loads
- local and global trapezoidal element loads
- temperature load case (increase/decrease and gradient)
- forced displacement load case
- dead load
- fast calculation routine
- input via dialog boxes
- 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
- scroll and zoomable drawing area
- scroll and zoomable tables
- calculated values:
 - deformations of each element and node
 - internal forces for each element (axial- and lateral forces, moments)
 - minimum and maximum deformation and moment for each element
 - support reactions of each support

3 Requirements

- TI89, TI89-Titanium, TI92+, V200 with OS-Version 2.05 or higher
- Minimum 120kB free RAM
- Minimum 140kB free Flash-ROM

4 Recommendations

- Program “Auto Alpha-Lock Off“ from Kevin Kofler (<http://kevinkofler.cjb.net>) only for TI89
- Program “HW3Patch“ from Kevin Kofler (<http://kevinkofler.cjb.net>) for OS-Version 3.00 or higher

5 Files

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

1. launcher:
 - smartbar.(89z, 9xz, v2z)
2. dlls:
 - sbmain.(89y, 9xy, v2y)
 - sbcalc1.(89y, 9xy, v2y)
3. text file:
 - sbarhelp.(89t, 9xt, v2t)
4. pictures:
 - sbarp01 - sbarp15.(89i, 9xi, v2i)

6 Installation

Transfer all files of you calculator type via link cable to your calculator and archive following files:

1. sbmain.dll
2. sbcalc1.dll
3. sbarhelp.text

4. sbarp01.pic - sbarp15.pic

- that's all. All files must be in one folder.

When you have a TI89/TI89-Titanium you can install the program "Auto Alpha-Lock Off" from Kevin Kofler (<http://kevinkofler.cjb.net>) to avoid pressing the alpha button every time you make an input.

7 Starting the program

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

8 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".

9 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 Christian Urich (csac7688@uibk.ac.at) or Valentini Bernhard (csac7912@uibk.ac.at) or visit our forum (the link is on our web site: <http://homepage.uibk.ac.at/~csac7688/> or <http://homepage.uibk.ac.at/~csac7912/>).

10 Menu structure

File	Create	Load	View	Results	Edit	Info
New Save Open Options Exit	Node Material Section Spring Hinge Element Support	Node load Element load Temperature Displacement Dead load		Calculate Graphic structure - Axial forces - Lateral forces - Moments - Deformations Graphic elements Tabular elements - Internal forces - Deformations Tabular nodes Support reactions	List Edit Delete	Help System status About

Table 1: Menu structure

11 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!

12 File

12.1 New

Deletes the actual structure.

12.2 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".

12.3 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.

12.4 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.sbp" and reloaded each time you enter the program.

12.5 Exit

Exits the program.

13 Create

13.1 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:

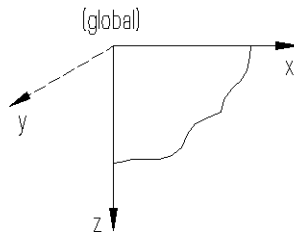


Figure 1: *Coordinate system downward*

Coordinate system upward:

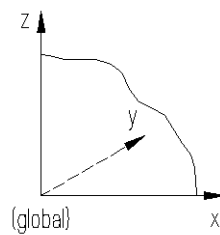


Figure 2: *Coordinate system upward*

13.2 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.

13.3 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).

13.4 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]

13.5 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

13.6 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:

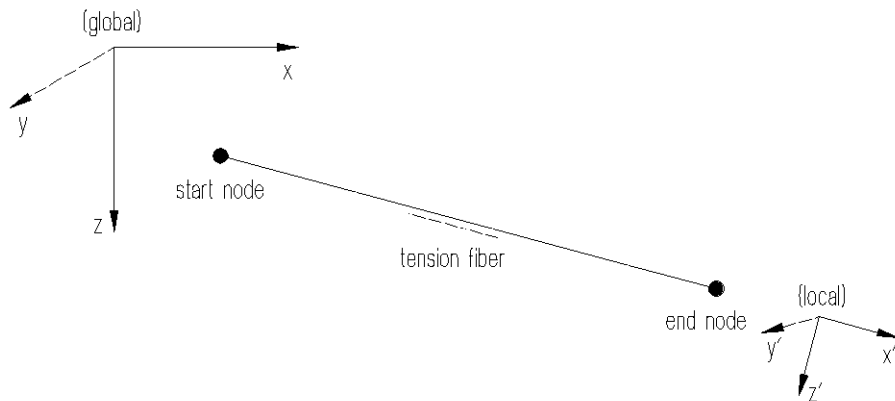


Figure 3: *Element definition (coordinate system downward)*

Element definition for coordinate system upward:

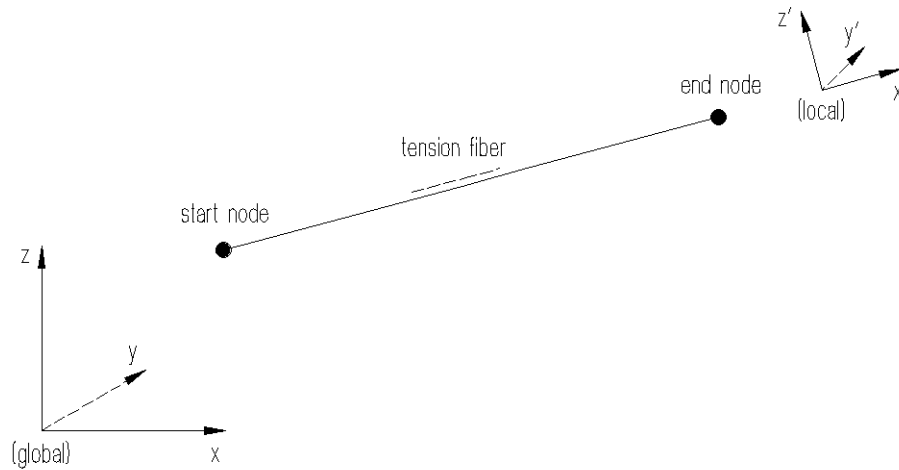


Figure 4: *Element definition (coordinate system upward)*

13.7 Support

Only supports with global grade of liberties can be entered.

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

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

14 Load

14.1 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:

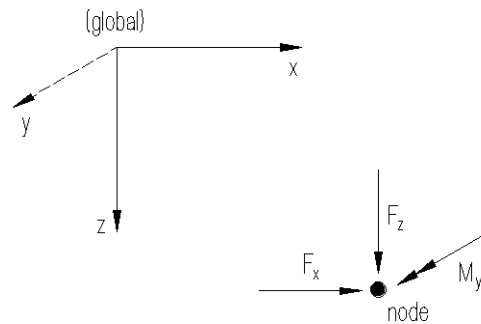


Figure 5: Node load definition (coordinate system downward)

Node load definition for coordinate system upward:

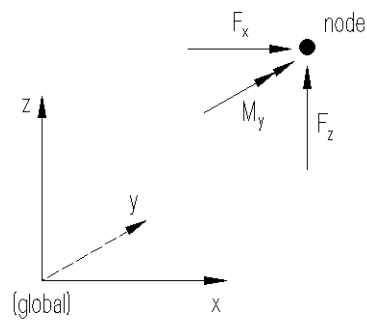


Figure 6: Node load definition (coordinate system upward)

14.2 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:

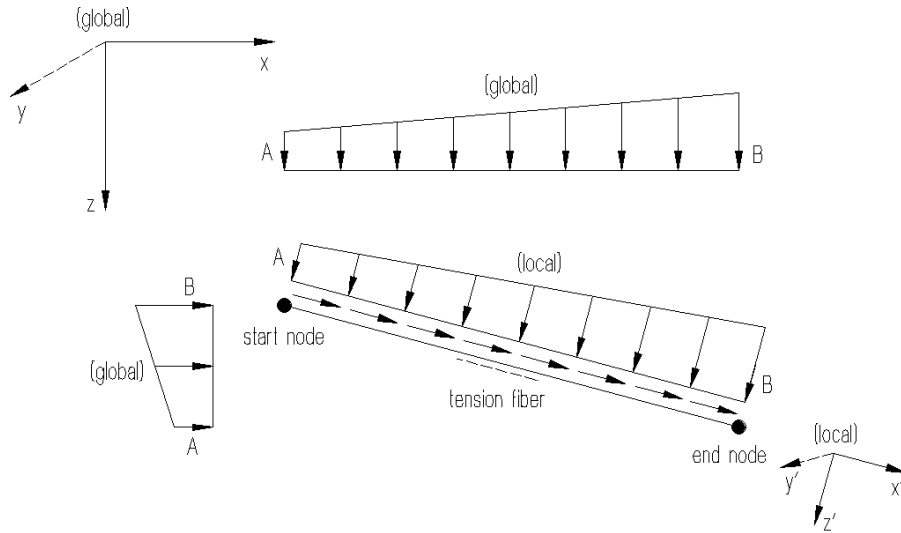


Figure 7: *Element load definition (coordinate system downward)*

Element load definition for coordinate system upward:

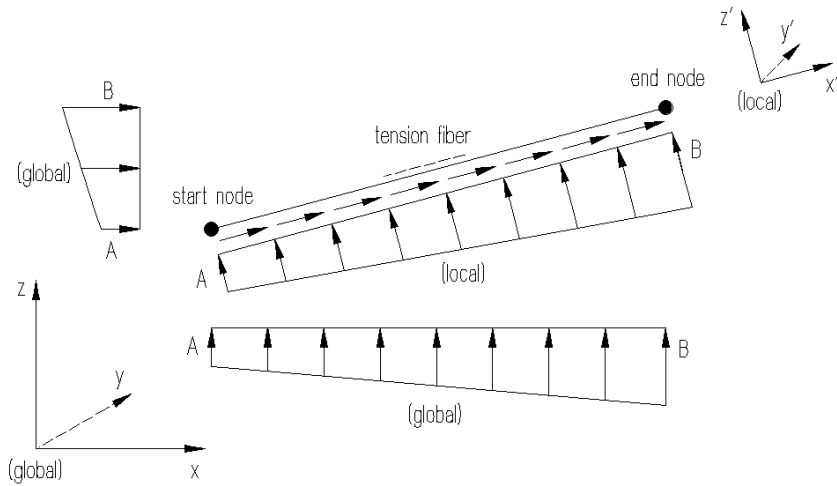


Figure 8: *Element load definition (coordinate system upward)*

14.3 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 $[K]$

$$\Delta T = T_o - T_u \quad (1)$$

14.4 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 $[rad]$

14.5 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.

15 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
- Esc ... cancel the view-mode

16 Results

16.1 Calculation

Very short introduction:

The calculation of the structure follows the stiffness matrix method. The program builds up the global stiffness matrix \mathbf{K} and the global load vector \mathbf{P} of the whole structure. Then the program solves the equation

$$\mathbf{v} = \mathbf{K}^{-1}\mathbf{P} \quad (2)$$

for the global displacement vector \mathbf{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.

16.2 Graphic structure

16.2.1 Axial forces, lateral forces, moments and deformations

Prints the internal forces or deformation of the whole structure.

16.3 Graphic elements

Prints the internal forces or deformation of each element.

Controls:

- \updownarrow ... switch between axial force, lateral force, moment around y-axis and deformation
- \longleftrightarrow ... switch between elements
- Esc ... cancel the graphic routine

16.4 Tabular elements 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]
- Phi_y ... rotation around local y-axis [rad]

The minimum and maximum deformation ($maxw, minw$) and moment ($maxM_y, minM_y$) is shown for each element.

The tabular output are scroll and zoomable.

Controls:

- $\updownarrow\leftarrow\rightarrow$... scroll the table in one of these directions
- $+/-$... zoom the table (and font)
- 2nd ... move to row number one
- Esc ... cancel the table

16.5 Support reactions

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 16.4.

17 Edit

17.1 List

All input elements are listed there.

The controls are described in section 16.4.

17.2 Edit

You can edit all input elements with this routine.

17.3 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.

18 Info

18.1 Help

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

18.2 About

Prints some information about the program.

18.3 System Status

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

19 Developer

- Ulrich Christian (csac7688@uibk.ac.at)
- Valentini Bernhard (csac7912@uibk.ac.at)
 - menus, graphic, data handling and calculation

Web site: <http://homepage.uibk.ac.at/~csac7688/> or <http://homepage.uibk.ac.at/~csac7912/>

20 Thanks

- the TIGCC Team for making it possible to program in C (<http://tigcc.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
- Elisabeth Nägele for the proof-reading (of Smart-Bars 2D V0.03)
- all beta testers and bug reports writers

21 History

- Smart-Bars V 1.00:
 - 13.03.2005 - final release
- Smart-Bars V 1.00 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 V 1.00 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 V 0.50:
 - 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 V 0.50 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 V 0.10:
 - 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 V 0.03a:
 - 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 V 0.03:
 - 11.12.2003 - first release
- Smart-Bars 2D V 0.02:
 - 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.
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