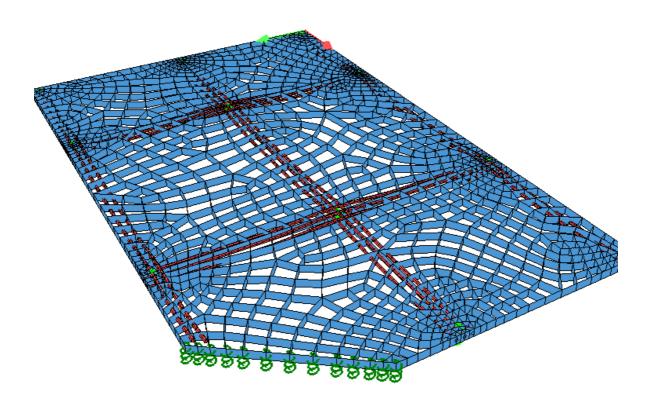


# Quick Start Guide Prestressd Slabs





## 1 Scope

Slab prestressing provides an economical way to decrease the amount of required reinforcement (ULS) while allowing for larger spans with slender slabs and better structural performance regarding crack and deflection control. For similar economical graphical input and FEA analysis, SOFiSTiK software offers special features within the Structural Desktop SSD and SOFiPLUS. In the following quick start guide the different tasks and features will be explained briefly.



**Required versions:** SSD 10.64-23 or higher for analysis / SOFiPLUS(-X) 16.4/17.1-16 or higher for the graphical input.

6

system type



## 2 System 2D Prestressed Slab and SSD Tasks for Slab Prestress

When starting a new project, the System Information dialogue offers a new system type: 2D Prestressed Slab. This system type allows for plane slab systems including membrane effects and varying slab thicknesses with eccentric elements.

For 3D structures and inplane restraints use the 2D Prestressd Slab

SOFiSTiK: System Information		8	
Project			
Title: SOFiSTiK AG 2006 - Slab Prestressing			
Database: pt_slab_quickstart			<b>2</b>
Directory: D:\sm_work\tendon\tnd\quickstart\system\			<b></b>
Design Code Class(Tab.7.1N) N V EU V Altitud Zones: Wind: V Snow. V Earthquake:	e (m) 0.0		
System	Calculation		
O 3D Frame O 3D FEA	Orientation of Deadload:	Positive Z-Axis	~
O 2D Frame O 2D Wall	Type of Calculation:	Plane Stress System	×
○ 2D Grillage ○ 2D Slab ○ 2D Prestressed Slab	Module:	SEPP	~
Groups	System preview		
Fixed Group Divisor: 10000     Free Distribution			
Standard model (SI) Language			
Graphical Preprocessing	Coordinate System	Drawing Units	
Graphical Preprocessing Groups on Separate Layers			
Standard model (SI) Language Graphical Preprocessing Groups on Separate Layers tial Workspace [m]: 20 Databases (CDB)	Coordinate System	Drawing Units	

Figure 1: System Information dialogue for example project

After confirming the project setting, the SSD Task tree offers two special tasks.



Project	~ 🖗 🖬 🖪	
System System Information Materials 1 C 30/37 (EN 1992) 2 S 500 (EN 1992) 3 Y 1770 C (EN 1992) Cross Sections Prestressing systems I SUSPA 6-4 Y1770S7 15,7 GUI for Model Creation (SOFiPLUS Clinear Analysis Linear Analysis	Animation Settings Amplitude [-] Amplitude Speed [%] Rotation Speed [%] O Coadcase Loop O Off Automatic	
Analysis of Slab Prestress Define Superpositioning Analysis Superpositioning Design Area Elements Design Parameters of area element Design ULS - area elements	C From 1 To 1 List of Loadcases System LC 1 total dead load LC 2 variable load LC 3 variable load LC 4 variable load LC 5 variable load	-

Figure 2: Task Tree for 2D Prestressed Slab System

#### Task Prestressing System

The Task Prestressing System provides the possibility to select various predefined prestressing systems which are provided by the software. A preselection is performed according to the defined design code of the project.



The textfile **tendon.tab** in the sofistik.23 folder contains the PT systems library



Individual prestressing systems can be defined by the user generating the file tendon\_usr.tab

lumber	Company			System		Tendan	Ductio
1	SUSPA				fshren ohne Verbund 150mn#, \1770\$7 C35/40 * 💌	SUSPA 6-4 1/17706 7 15,7 💌	20
Analysis	Construction	Protocol	-			R	
Steel	3 Y 1770 C (EN 199	21 - 12		Prestressing force P0,max	820.0		kN
				Young's modulus	199000		N/mm
				Vield strength	1520		N/mm
				Tensile strength	1770		N/mm*
				Анеа	600.0		mm <sup>2</sup>
				Number of strands	4		

Figure 3: Task Prestressing System with example system selected



Example System: SUSPA/DSI® Monostrands 150 mm<sup>2</sup> acc. ETA-03/0036: **Company:** SUSPA **System:** ETA Monolitzenspannverfahren ohne Verbund 150mm<sup>2</sup> **Tendon:** SUSPA 6-4 Y 1770 (Pack of 4 Monostrands) Check of the prestressing force: **P0, max:** with **ft0.1k = 1520 N/mm<sup>2</sup> =** 0.9\*1520 N/mm<sup>2</sup> \* 600 mm<sup>2</sup>= <u>820 kN</u>

The corresponding prestressing steel Y1770 (EN1992) can be generated in advance using the Task: Materials or directly in the Prestressing System Task:

Material safety factor [-]	1.15		
Yield stress [MPa]	1520		
Tensile strength [MPa]	1770		
Compressive strength [MPa]	1770		
FliessSpannung Druck	1520	Ratio of bond properties [-]	0.75
Limit of proportionality [o/oo]	60	EC2 bond coefficient (K1) [-]	2
Permanent strain of yield stres	s [MPa] 1520	Relaxation (0.70 ft) [-]	8
Limit strain (o/oo)	0	Relaxation (0.55 ft) [-]	ECL1 💌
Hardenig module (MPa)	0	Max. thickness [mm]	18000
Dynamic strength [MPa]	0		

Figure 4: Material Strength Properties

#### Task: Analysis of Slab Prestress

The Task Analysis of Slab Prestress computes the resulting forces for existing slab tendons, per default the loadcase number 700 and the action P is assigned to the results.



Example

oadcases	Groups	Control Parameters	Text Output	Graphical Output	
Prestre	ss CS 🕴 In	fo Tendons	Loadcase	group CS	
1	1.	,2,3,4,5,6,7,8,9,10,11,12,	13 700	0	

Figure 5: Task Analysis of Slab Prestress

## **3** Graphical Input of Tendons with SOFiPLUS(-X)

The tendons layout can be defined easily within the graphical pre-processor SOFiPLUS(-X), the tendons are generated in ground view, computation of the complete tendon layout including friction loss calculation is performed during the 'Export' (Meshing) of the system.

Only important boundary conditions, as support lines, stop lines, distance of tendons to the concrete faces and e.g. the transition lengths of the free tendon layout (Freie Spanngliedlage <sup>1</sup>) have to be specified by the user.

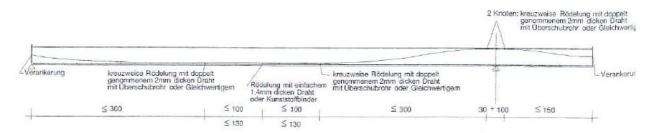


Figure 6: Free Tendon Layout (Freie Spanngliedlage) [1]

#### SOFiPLUS Toolbox: Prestressing



<sup>&</sup>lt;sup>1</sup> Maier, K.; Wicke, M.; Die freie Spanngliedlage. Beton- und Stahlbetonbau 95, 2000, Heft 2 Pp.: 62



The input of tendons and their layout is done in SOFiPLUS using the Toolbox Prestressing. Three icons for the input of three elements: Input of Tendons, Input of Support Lines and Input of so called Stop Lines are available, their input options and the modification of existing elements is explained below.

-	Task: Generates new Tendons in ground view
	Options:
Input of Tendon	<ul> <li>AutoCAD lines and polylines without kinks can be directly transferred into tendons</li> <li>Points picked generate straight tendons parallel to the global x- or y-Axis</li> <li>Tendons along a side of the structure are best generated using the 'distribute along line' option</li> <li>Skew layouts are possible using user coordinate systems (UCS)</li> <li>Modification of tendons: The tendon dialogue opens with a double-click on one or more selected tendon elements</li> </ul>
	<b>Task:</b> Generates support lines which define the height of tendon
<b>A</b>	elements crossing the line
Innut of	Options:
Input of	
Support Line	<ul> <li>Direct input of support lines</li> <li>Curved object can be transferred into support lines</li> </ul>
	Modification of support lines: The properties (i.e. distance of
	tendon from concrete face along line) of a support line are edited
	using the AutoCAD properties dialogue
+	Task: Generates stop lines out of AutoCAD objects which cause
	the intersecting tendons to end
Input of Stop	Options:
Line	Selection of Lines etc. to become a stop line
	Modification of stop lines: The stop line objects are copied in a
	separate layer, modification is possible in the same way as for all
	AutoCAD objects



#### SOFiPLUS Tendon Dialogue

Double clicking on one or more selected tendon elements opens the SOFiPLUS Dialog Tendon, here the necessary input for tendon parameters is possible.

h.
1

The arrow on one end of the tendon indicates the 'left' end

	🚽 SOFiSTiK: Tendon		
	General Points		
	Number of tendon	9	
	Name of tendon		
	Construction stage build in	1	
	Construction stage grouting	1	
	Construction stage removal	0	
	Prestressing system	1 SUSPA 6-4 Y1770S7 15,7	
-	Prestress direction	from right	
	Kind of prestressing	Stressing and slip	
	Tendon geometry	Free tendon geometry	
	straight part in top position	0.300	
	Transition	3.000	
	Distance of axis to upper concrete ec	ge 0.100	
	Distance of axis to lower concrete ed	ne 0.100	

Figure 7: Tendon dialogue

- **§ Prestress direction:** Definition of active and passive anchor side
- § Kind of prestressing
- **§ Tendon geometry:** Free tendon geometry or cubic spline geometry can be selected
- **Straight part in top position:** Length of the straight part over highpoints (colums etc.), *only for free tendon layout*
- § Transition: Transition length of the free tendon layout, only for free tendon layout
- **§** Distances of axis to upper and lower concrete edge



Der sich unter der Annahme der Biegalinie nach der linearen Stabtheorie ergebende Zusammenhang zwischen der Anhebung e und der Freien Durchhangslänge / von

$$l = 4 \sqrt{\frac{72 \cdot E \cdot I \cdot (e_1 + e_2)}{g}}$$

ergibt für die Monolitze F150 mit I = 269,2 mm<sup>4</sup>, E = 195000 N/mm<sup>2</sup>, g = 13,03 N/m

 $l = 130,504 \cdot \sqrt[4]{e_1 + e_2}$   $e_1, e_2, l[cm]$ .

#### Figure 8: Formula for transition lenght [1]

	Auto	Position	Tura	Relative	Distance	Comment	
1	Auto	0.000 m	Type	centred	Distance	Comment	
2	I have a		high point	0.0111.0.0	0.000	and the superations	
		5.000 m	high point	from top	0.060 m	created by support line	
3		13.000 m	high point	homitop	0.000 m	created by support line	
4		16.070174 m	high point	from top	0.060 m	2	

Figure 9: The Points tab allows for geometry modification of single tendons

(***	) )		
s	panngliedunterstü	tzun 🖌 🏦 🎝	74
(C	)ata		\$
	Spanngliedun	High point	
	Länge	*VARIES*	
	Ausrichtung	from top	
	Verteilung 🍡	Constant	
	Anfangswert	0.1	
	This drigs for the		

Figure 10: Input of tendon distance for a support line



**(†)** 

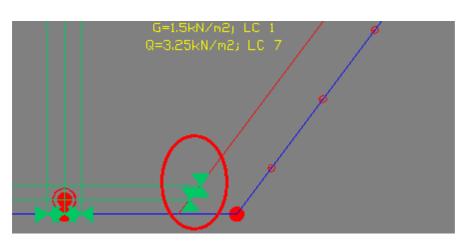
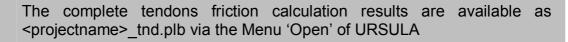


Figure 11: Stop Line (red line)

### 4 Analysis and Post Processing

After the definition of the tendons with SOFiPLUS, the SSD is used to control the further analysis and the post processing, the Task Linear Analysis is used to calculate all loadcases except prestress, here the aforementioned Task Analysis of Slab Prestress is employed. The reports of all calculation steps are managed using the URSULA button of the SSD, further reference on the SSD can be found via Menu 'Help' Quick Reference.



Suchen in	: 🗀 system			-	* 🗈 💣	<b>.</b>	🔲 Vorschau	i.
	Sept_slab_r	juickstart_003.p	olb				 Öffnen	1
	_ 🙀 pt_slab_	quickstart_004.p	ыр				Abbrechen	
Zuletzt erwendete D		quickstart_005.p					Abbiechen	
		quickstart_008.p						
	1 T T T	uickstart_009.p						
Desktop		uickstart_010.p						
DUSKOP		uickstart_012.p						
100	- Sat slab 🖉	uickstart_013.p	D					
		NE 200 - 2000-200 - 200						
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<b>S1</b>	pt_slab	wickstart_lfd.plt wickstart_msh.p	DID				Hinzufügen	
Arbeitsplatz	pt_slab	wickstart_lfd.plt wickstart_msh.p			Favoriten:	<b>_</b>	 Hinzufügen	
<b>S1</b>	pt_slab_	wickstart_lfd.pli quickstart_msh.p quickstart_tnd.p	tart_tnd.plb	<u> </u>		   D:\am	Hinzufügen	

Figure 12: Report of tendon calculation



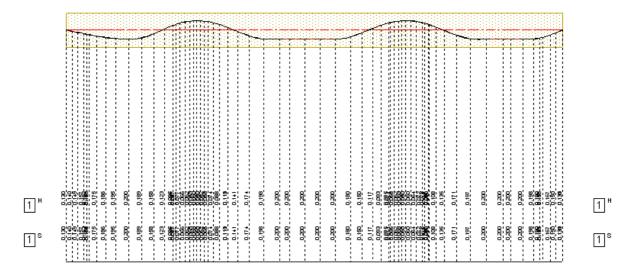


Figure 13: Tendon axis of free tendon layout

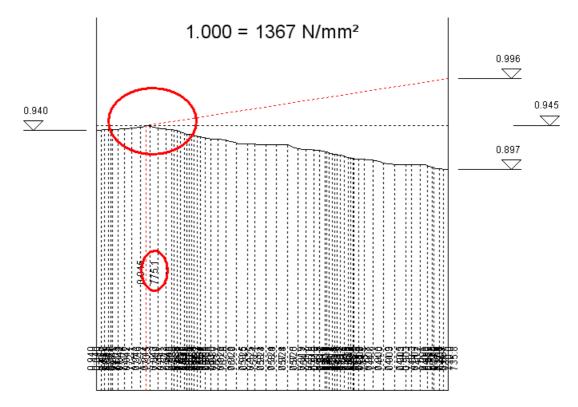


Figure 14: Tendon stresses (dashed line: Pm0,max=0.945\*P0,max=0.85\*1520 N/mm<sup>2</sup>); Maximum tendon force indicated red.

For simplified consideration of creep, shrinkage and relaxation losses, the Task Define Superpositioning is used to assign a factor (e.g. 0.88 for 12% CSR losses) to

the prestressing loadcase in the automatically generated loadcase combinations (e.g. EC2-2004, ULS and SLS combination).

E 2": Deflections	Loadcare	
G total dead load     Al loadcases with same time as the action     Plefilessing     Loadcase 200. Type FERM, Factor 0.98: aum_PV= 0.00     O vancer tose     Al loadcases with same type as the action     C - Al loadcases with same type as the action     Plefilessing     Loadcase 200. Type FERM, Factor 0.98: sum_PV= 0.0     O vancer tood     Al loadcases with same type as the action     Plefilessing     Loadcase 200. Type FERM, Factor 0.98: sum_PV= 0.0     O vancer tood     Al loadcases with same type as the action	700 Tille [nam_Pic= 0.00334	All loadcases with same type as the action     Source PRI= 0.00 KN
	Factor	0.88
4 // 3	<u>N</u>	
": manually created or modified	Combination Rule	Action Loadcase

Figure 15: Factor for simple CSR consideration

The design in ULS and SLS of the prestressed slab is carried our using the standard design Tasks: Design ULS/SLS – area elements.

Remark on punching design for prestressed slabs:

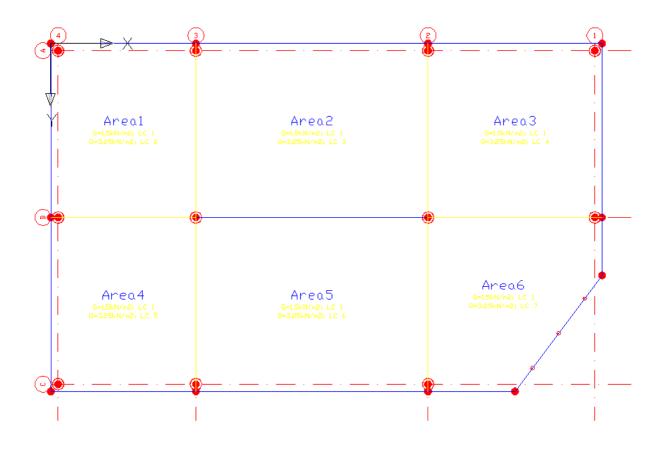
Using BEMESS 11.90-23 the inclination and force of tendons crossing the punching area is automatically detected and considered in the punching design and checks, the mean compressive stress sigma-cd is considered for EC2-2004 and DIN 1045-1, selecting extensive text output for punching the prestress reduction force Vpd and the individual contributions can be checked.

Punching Design (EC				
Node number	= 1 X= 5.000 [m] Y= 6.	000 [m]		
	= 705.9 [KN] LC= 2102 via QUAD conne			
	⊨ 188.0 [kN]) V-ED= 517.9 [kN] — in peri			
	prestress due to creep and shrinkage are			
dz/ds=inclination,	ha=horizontal deviation, dVPD=shear force	positive=relieve		
perimeter 1:				
tendon no.	ZV= 675.0 [kN] dz/ds=0.020 alpha= 0.000 [°	] dVPD= 13.2 [kN]		
2. cut	ZV= 673.0 [kN] dz/ds=0.022 alpha= 0.000 [°	] dVPD= 14.7 [kN]		
tendon no.	ZV= 658.5 [kN] dz/ds=0.023 alpha= 0.000 [°	] dVPD= 15.4 [kN]		
2. cut	ZV= 656.5 [kN] dz/ds=0.023 alpha= 0.000 [°			
tendon no.	ZV= 676.4 [kN] dz/ds=0.027 alpha= 9.010 [°			
2. cut	ZV= 674.0 [kN] dz/ds=0.025 alpha= 8.569 [°			
tendon no.	ZV= 676.4 [kN] dz/ds=0.027 alpha= 9.010 [°	] dVPD= 18.2 [kN]		
2. cut	ZV= 674.0 [kN] dz/ds=0.025 alpha= 8.569 [°			
tendon no.	ZV= 658.5 [kN] dz/ds=0.023 alpha= 15.91 [°	] dVPD= 14.8 [kN]		
2. cut	ZV= 656.5 [kN] dz/ds=0.023 alpha= 15.91 [°	] dVPD= 14.8 [kN]		
tendon no.	ZV= 658.5 [kN] dz/ds=0.023 alpha= 15.91 [°	] dVPD= 14.8 [kN]		
2. cut	ZV= 656.5 [kN] dz/ds=0.023 alpha= 15.91 [°	] dVPD= 14.8 [kN]		
		=========		
		188.0 [kN]		
perimeter 2 :				
tendon no.	ZV= 675.7 [kN] dz/ds=0.035 alpha= 0.000 [°			
tendon no.	ZV= 659.4 [kN] dz/ds=0.043 alpha= 0.000 [°			
2. cut	ZV= 655.6 [kN] dz/ds=0.043 alpha= 0.000 [°			
tendon no.	ZV= 677.3 [kN] dz/ds=0.050 alpha= 5.567 [°			
2. cut	ZV= 673.1 [kN] dz/ds=0.046 alpha= 5.222 [°			
tendon no.	ZV= 677.3 [kN] dz/ds=0.050 alpha= 5.567 [°			
2. cut	ZV= 673.1 [kN] dz/ds=0.046 alpha= 5.222 [°			
tendon no.	ZV= 659.4 [kN] dz/ds=0.043 alpha= 10.47 [°			
2. cut	ZV= 655.6 [kN] dz/ds=0.043 alpha= 10.47 [°			
	ZV= 659.4 [kN] dz/ds=0.043 alpha= 10.47 [°			
2. cut	ZV= 655.6 [kN] dz/ds=0.043 alpha= 10.47 [°	] dVPD= 27.4 [kN]		
		318.4 [kN]		
Circular column	= 0.400 [m]	010.4 [KN]		
Plate thickness h-s				
1. perimeter at 2.		021 [m]		
Min.reinforc. ac apper= 7.09 [cm2/m] (Min.design-moment-> inner column)				
Normal stress sigma-cd= -1.19 [MPa]				
Tension reinforas ≥= 9.68 [cm2/m] mue= 0.44 [c/c] Vrd1= 148.1 [kN/m]				
v-Sd = <u>1.15*V/u</u> = <u>148_1_[kN/m]</u> <= 148.1 [kN/m]				
NO punching shear reinforcement necessary.				
In the critical punching zone at least 9.68 [cm2/m]				
tension reinforcement is required				
•				

#### Figure 16: Extensive BEMESS output for punching design with tendons



## 5 Example System



Example Slab System according EC2-2004				
Lx = 5/8/6 m	and I	_y = 6/6m		
Columns:	diameter	40 cm/ heigth 3.00 m/ C 30/37		
Slab thickness:	t = 26 cm			
Concrete:	C 30/37			
Rsteel:	S 500			
Prestressing steel:	S Y1770			
Concrete cover:	3 cm			
Permanent loads:	automatic	selfweight + 1.50 kN/m²		
Live loading:	3.25 kN/m	2		