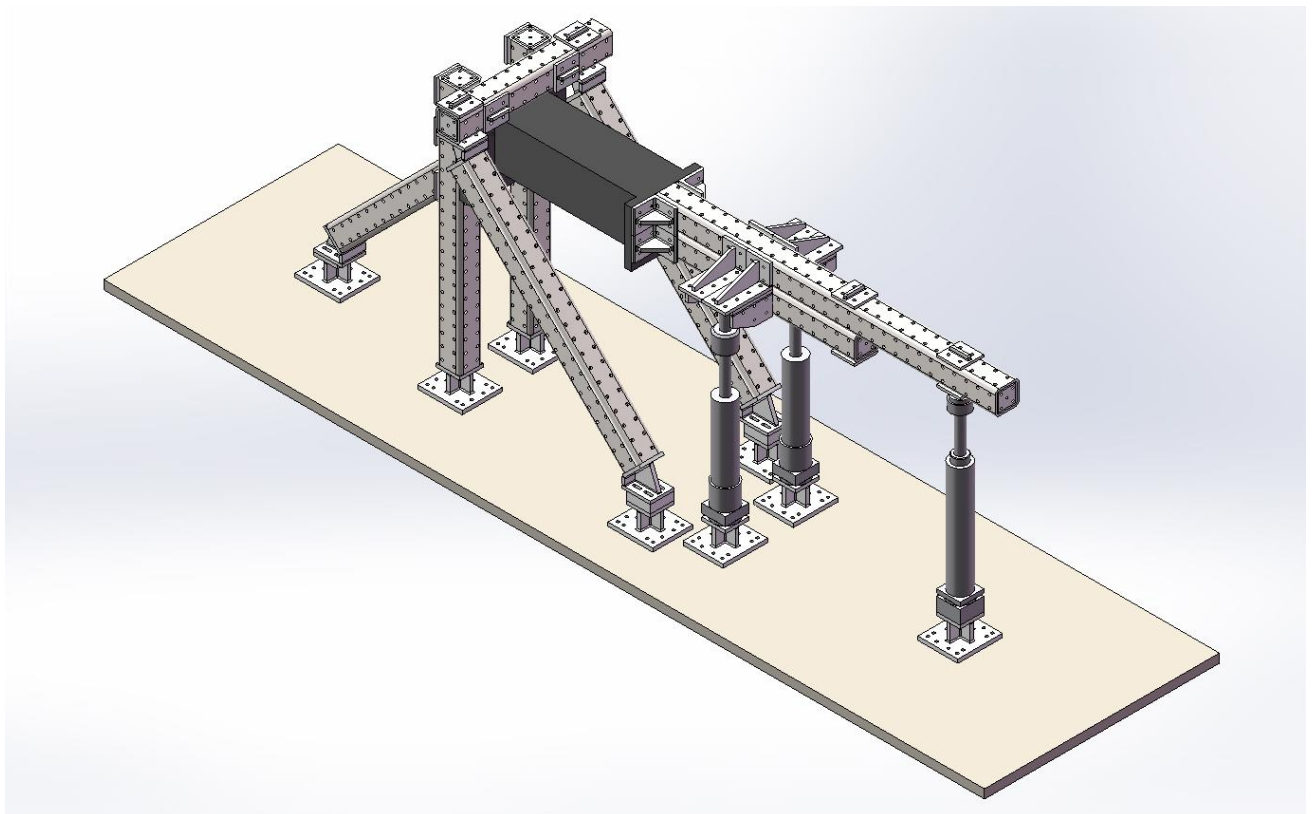




# USER CATALOG

## MODULAR CONSTRUCTION KIT



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## LOAD-BEARING FUNCTION AND SUPPORTING STRUCTURE

Every product of the machine and vehicle construction has to fulfil one or several functions. When describing a function it is often overlooked, that all products have one function in common: the supporting structure.

To satisfy the load-bearing function the product needs a supporting structure. This supporting structure can be formed out of assemblies, which also take over other functions. An example is self-supporting containers. However, a supporting structure can also consist of assemblies, which do not take over any other functions.

As supporting structures are generally more unlikely to wear out quickly in physical and moral way than other modules, we decided to produce reusable structures. The result of our work is the construction kit system, described in the following.

This construction kit system has features of a modern product.

Simplicity	The construction kits get along with extremely few elements and with standardized screw connections.
Modular construction	The few elements allow to fabricate many different frames.
Construction series	The construction kits are dimensioned for different stresses.
Stability	The change of an element in the modular system has no influence on other elements. Therefore, changes do not cause any limitation in the practical value.

The construction kit system is of high benefit for many cases of application. We tried to simplify the product in the interest of the user.

***It seems that perfection is attained not when there is nothing more to add, but when there is nothing more to remove.***

Antoine de Saint-Exupéry

## CONSTRUCTION KIT SYSTEM

The construction kit system allows assembling different supporting structures in a short time.

These supporting structures are usable as:

- Devices for all production areas
- Devices for strength testing machines
- Measuring devices

In the beginning, this system was only intended to be used for strength tests. Therefore, the following features are advantageous:

- High stiffness and therefore low testing costs
- Free play of the connections, also with changing loads
- Easy applications due to the limited number of different elements

The construction kit system consists of seven individual construction sets which cap a wide field of application.

All construction kits are compatible with each other.

The construction kits were developed taking into account their operational environment. For example, there are elements which can connect to every size of foundation raster.

The construction kits are distinguished according to their adjustability. There are three construction kits SPR, which have an adjustable raster, and there are four construction kits SPS, which are gradually adjustable. The basic element of the construction kits is a beam.

These beams are square box girders with construction kits with adjustable raster. The construction kits are marked by the side length of the beam cross-section. The basic element of the construction kit SPR400, a box girder, has cross-section measures of 400 mm x 400 mm. The same applies for construction kits SPR200 and SPR100.

All construction kits with infinite variability have tubular beams as basic elements. The outside diameter of the pipe is used to mark the construction kits.

In the construction kit SPS80 pipes with 80 mm are used, the same applies for the construction kits SPS63, SPS40 and SPS20.

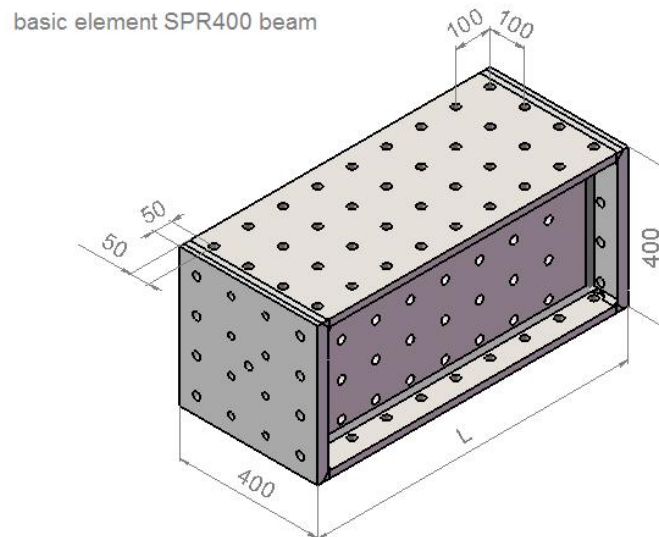
The connection elements, which are used in all construction kits, are commercial standard parts. The bolts and tie rods are in the sizes of M6, M12 and M20.

In the following explanation, the construction kits of the system are dealt with individually.

## CONSTRUCTION KIT SPR400

For years the construction kit SPR400 has proved its worth in operational stability laboratories. Different supporting structures were produced out of the kit for many different supporting structures for strength tests. This construction kit is highly loadable in static and dynamic way.

Basic elements of this construction kit are beams with dimensions 400 mm x 400 mm in cross-section.



**Picture 1: Basic element of the construction kit SPR400 beam**

The cross-section form of the beams assures a high stiffness during bending and torsion.

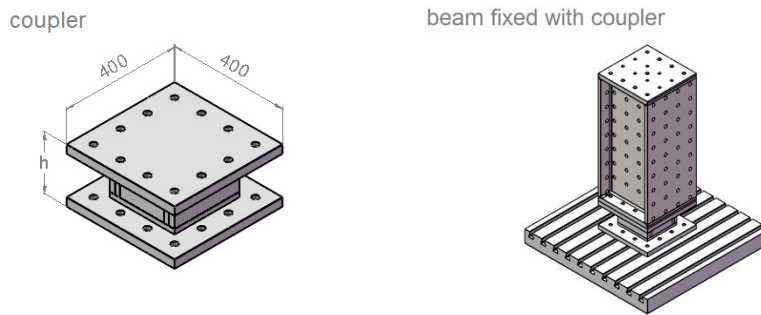
The beams are completely mechanically processed.

The beam as well as all the other elements of the kit are provided with a hole pattern 100 mm x 100 mm for screws M20 (through holes  $\varnothing$  22 mm) on all sides if necessary.

This allows producing many different supporting structures out of the construction kit. The outer holes are each 50 mm from the edge, so the above-mentioned hole pattern is continued without any gaps with beams next to each other.

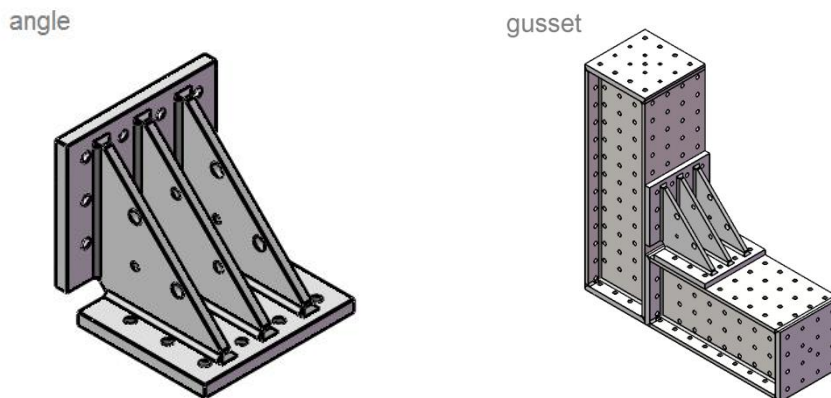
The beams are especially offered in lengths  $l = 500, 900, 1300, 1700, 2100, 2900$  and 3700.

To attach the beams on the foundation, couplers are offered, which have a height of  $h = 100, 200$  or 300 mm. The couplers have a hole pattern of 100 mm x 100 mm on the side facing the beams. In addition, a hole pattern according to the fixing grid of the foundation can be attached on the side facing the foundation. Picture 2 shows a coupler and a beam, which was attached on the foundation by means of a coupler.



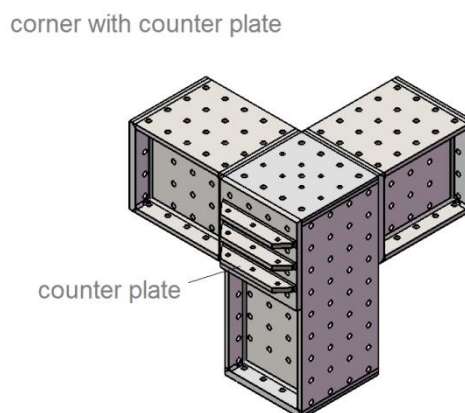
**Picture 2: Coupler (left) and beam fixed with a coupler (right)**

With the help of the offered angles in the construction kit, stiff frame corners can be produced. This is very important at particularly high stresses. These angles have the standard hole pattern, too. Picture 3 shows the strengthened corner of a plane frame.



**Picture 3: Angle and gusset**

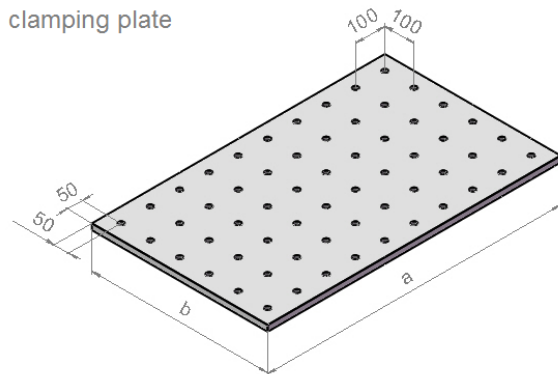
The corner of a spatial frame can be constructed according to picture 4. So-called counter plates are included in the construction kit. These counter plates can also be attached where high local stresses are introduced into the frame.



**Picture 4: Corner of a spatial frame with counter plate**

Furthermore, clamping plates are included in the construction kit (picture 5). They have a hole pattern of 100 mm x 100 mm, too. The fixing plate can be produced out of steel or high strength aluminum alloys, as desired.

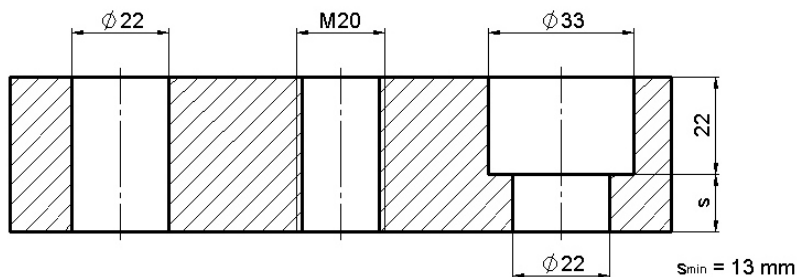
The measures a and b are freely selectable in a 100 mm raster. The thickness of the plate is freely selectable as well.



**Picture 5: Clamping plate**

Picture 6 shows the design options of the fixing plate holes.

clamping plate holes

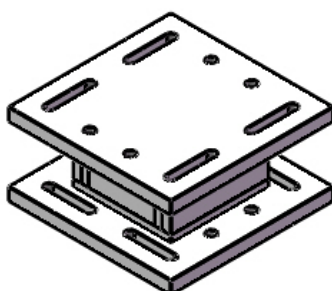


**Picture 6: Design options of the clamping plate holes**

Through holes or threaded holes can be produced for a screw thread M20. If the connecting elements should not compromise the smooth plate surface, recessed cylindrical screws are put in, according to DIN 912. This requires a minimum thickness of the plate of 35 mm.

In order to implement measures that do not arise from the hole pattern, adjusting elements are offered. By means of a sliding element, intermediate sizes can be adjusted. A shift in two coordinate directions at the same time can be achieved by slots on both sides of the element (picture 7).

sliding element

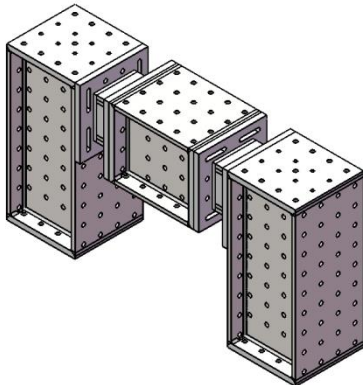


**Picture 7: Sliding element**



Picture 8 shows a portal with the height  $h_1$  of the cross beam adjusted with the help of a sliding element.

portal with sliding elements



**Picture 8: Portal with sliding elements**

To adjust an angle different from  $90^\circ$  as well, a rotary element was developed (picture 9).

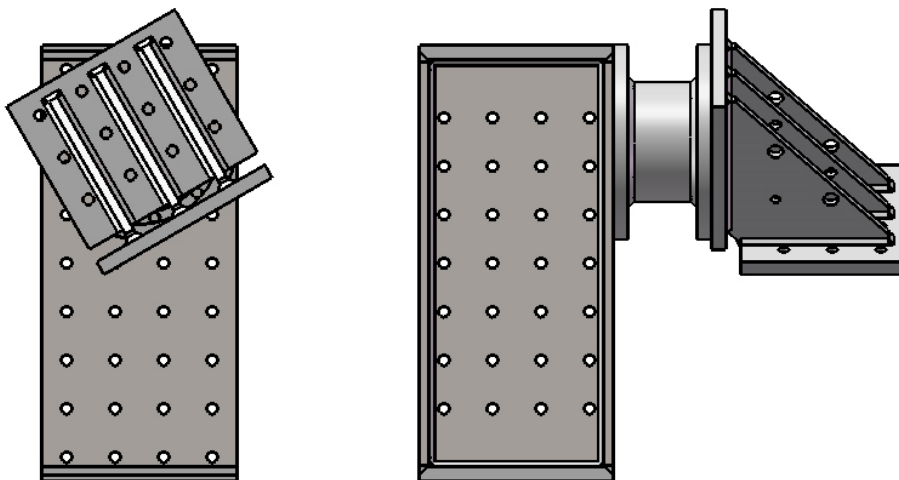
rotary element



**Picture 9: Rotary element**

Picture 10 shows a possible use of the rotary element.

rotary element between column and angle



**Picture 10: Rotary element between column and angle, to realize the angle of attack**

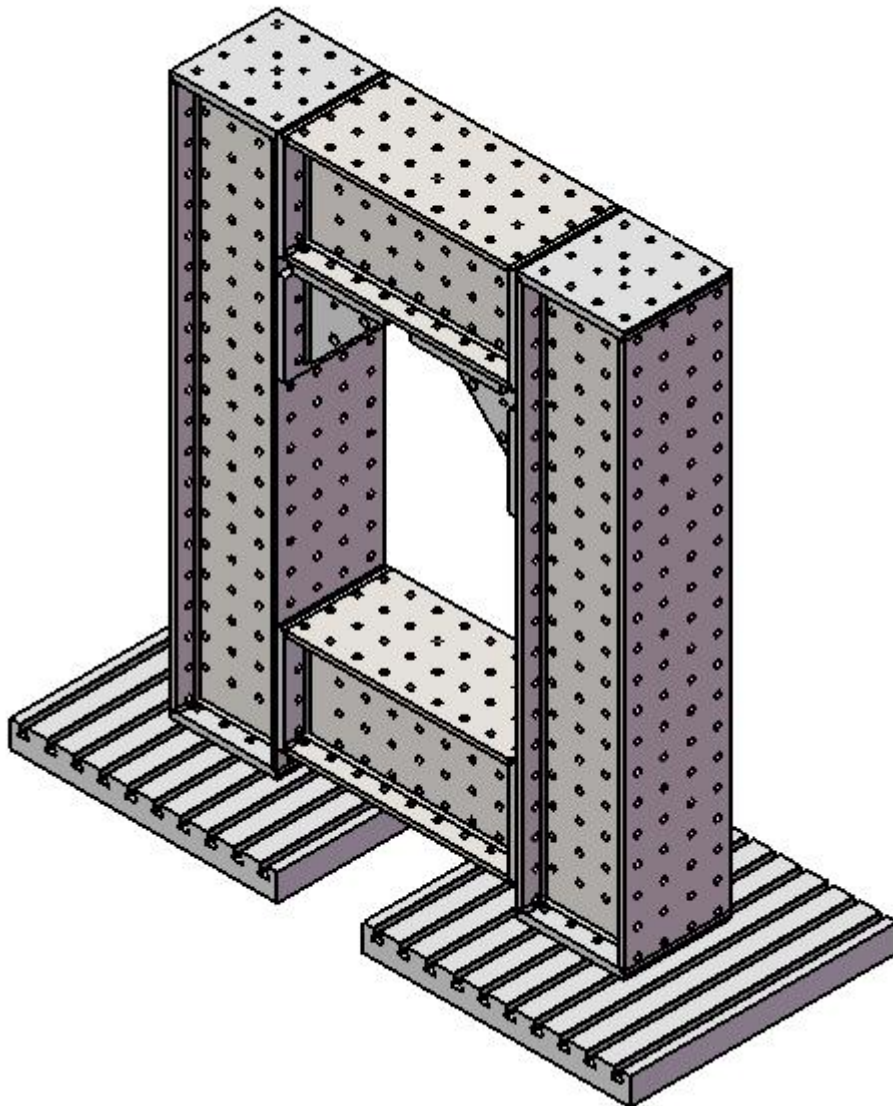


Additionally, screws and tension rods M20 are offered in selectable lengths, as well as nuts and screws in highly resistant quality.

If a certain measure is to remain constantly adjusted, spacer plates of various thicknesses can be used instead of sliding elements.

Picture 11 shows a portal that was produced out of elements of the construction kit SPR 400.

portal out of SPR400 elements



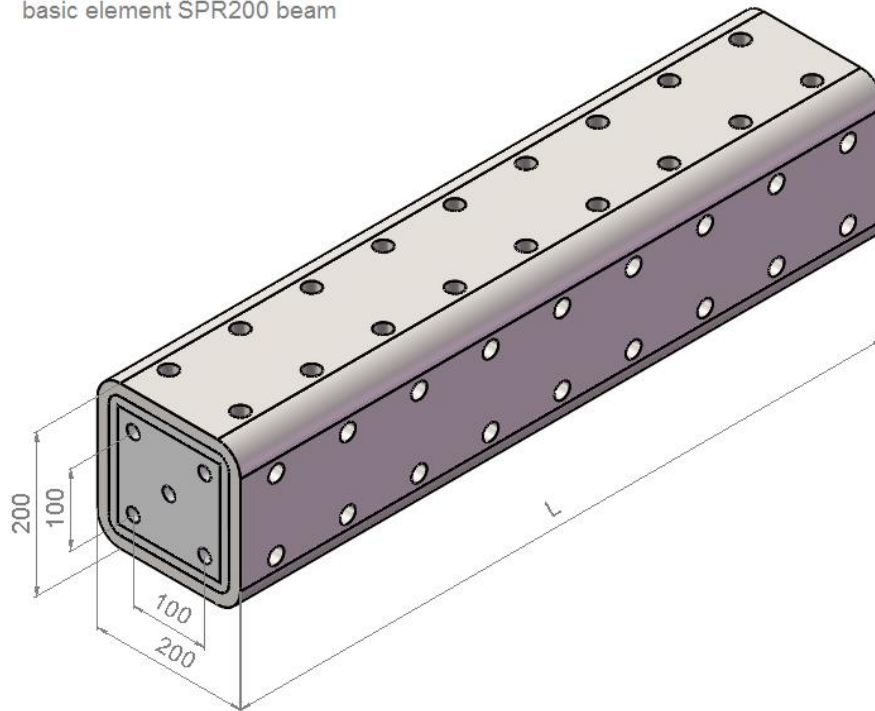
**Picture 11: Portal out of SPR400 elements**

## CONSTRUCTION KIT SPR200

From the basis of the construction kit SPR400, the construction kit SPR200 was developed. It has the same hole pattern 100 mm x 100 mm for screws M20 and the same elements are used. Since it was resorted to a large extent to semi-finished products in its design (e. g. box section), it is very inexpensive.

Basic elements of the construction kit are beams out of hollow profiles according to DIN 59410 with outer measures 200 mm x 200 mm (picture 12).

basic element SPR200 beam



**Picture 12: Basic element of the construction kit SPR200 beam**

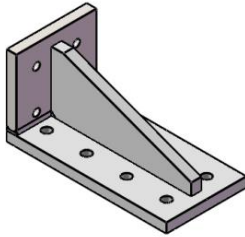
On the narrow side of the beam, threaded holes were installed to enable a flexible use.

The beams are preferably supplied in lengths  $l = 500, 900, 1300, 1700, 2100, 2500$  and  $2900$  mm. Intermediate lengths in 100 mm increments are possible.

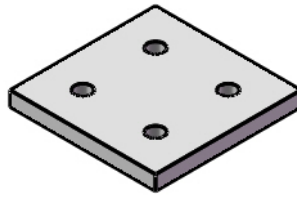
Picture 13 shows more elements of the construction kit. Their function is explained with the construction kit SPR400. The selectable frame plates in length, width and thickness are identical with those of the construction kit SPR400 (see picture 5).

In this construction kit, screws and tension rods M20 as well as nuts and washers in selected and high strength design are offered as accessories, too.

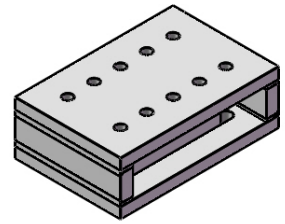
90° angle, long



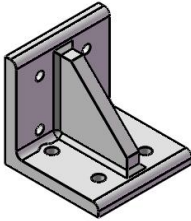
spacer plate



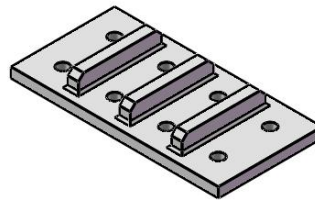
sliding element



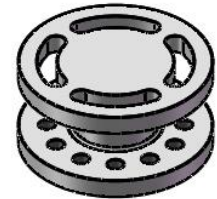
90° angle



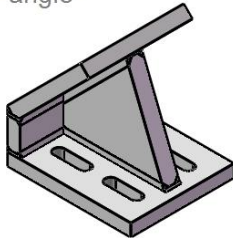
double counter plate



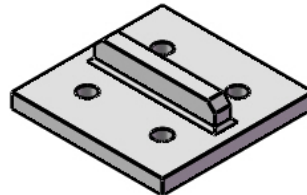
rotary element



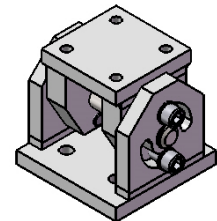
45° angle



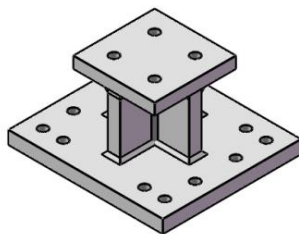
counter plate



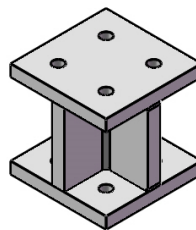
adjusting angle



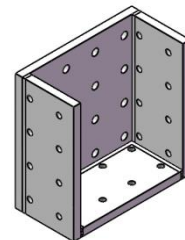
foundation coupler



coupler



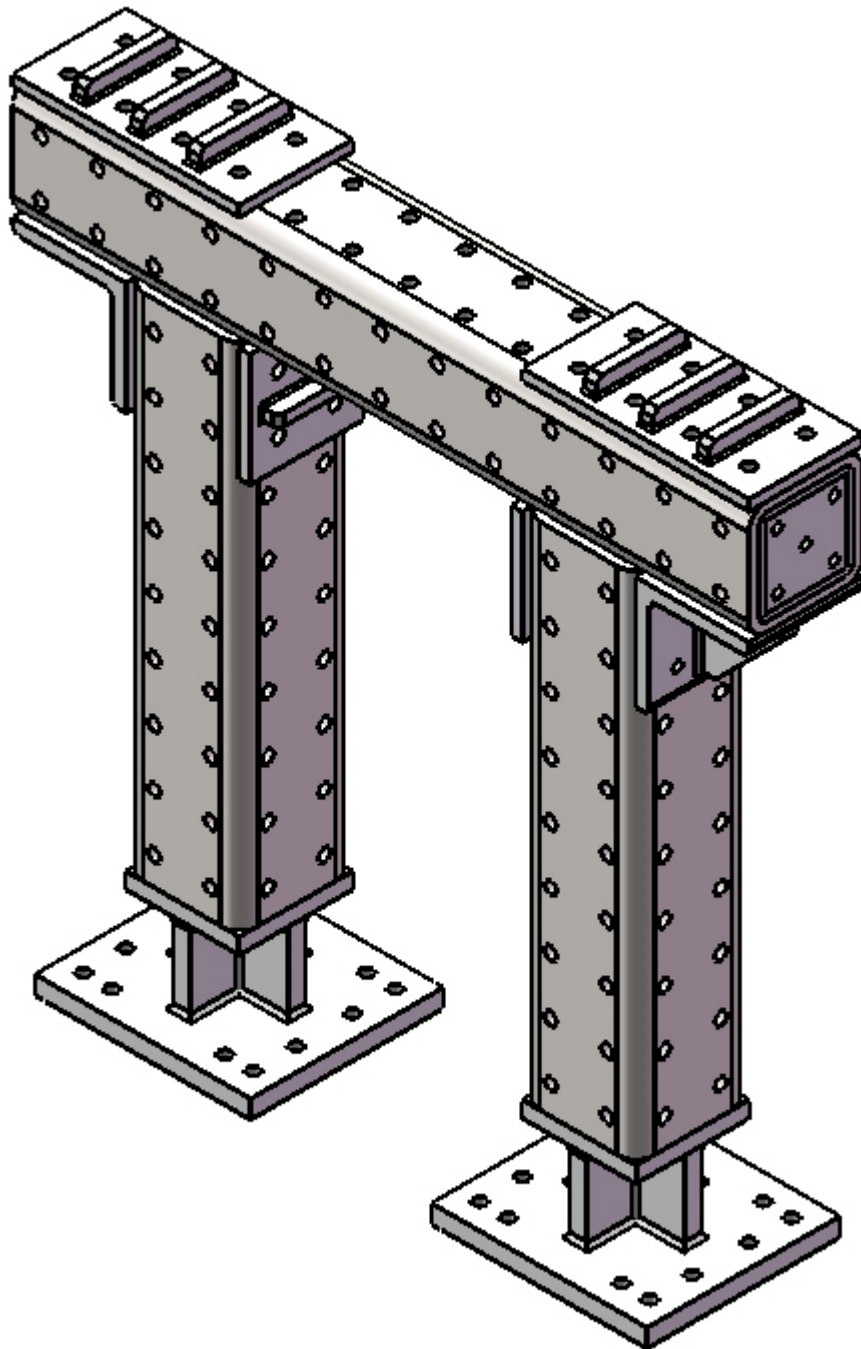
bracket



**Picture 13: Elements of the construction kit SPR200**

Picture 14 shows a portal, consisting of the elements of the construction kit SPR200.

portal out of SPR200 elements



**Picture 14: Portal out of the elements of the construction kit SPR200**

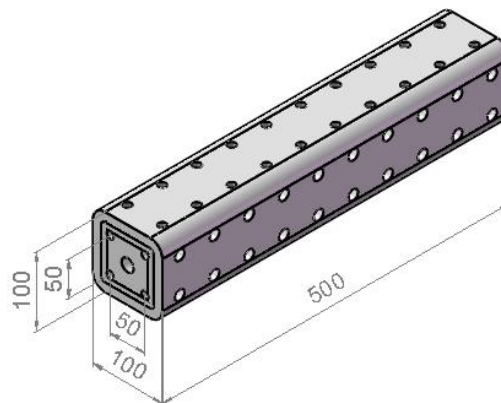
## CONSTRUCTION KIT SPR100

The construction kit SPR100 has diverse applications in machine and vehicle construction.

Compared with the kits SPR400 and SPR200, it is characterized by the fact that its elements have lower measures, so the supporting structures can be largely assembled without lifting equipment.

Basic elements of the construction kit are beams out of box profiles (picture 15) with outer sizes 100 mm x 100 mm. This and all other elements of the construction kit have a hole pattern 50 mm x 50 mm for screws M12. The two opposite sides of the beam have through holes for M12 screws. The two other opposite beam sides have threaded holes M12. The fronts have threaded holes M12, too.

basic element SPR100 beam

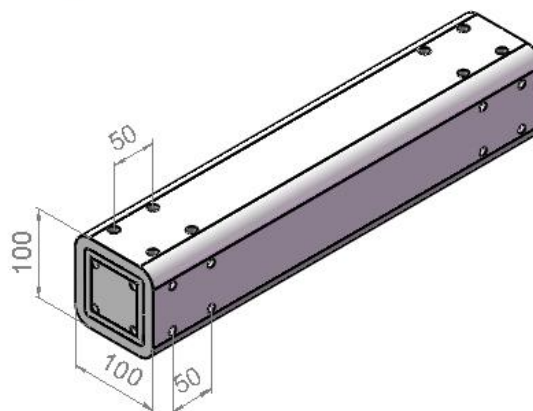


**Picture 15: Basic element of the construction kit SPR100 beam**

The carrier`s lengths in the construction kit are intended to be  $l = 200, 500, 900, 1300, 1700$  and  $2100$  mm. Intermediate lengths in 100 mm increments can also be supplied.

If only tensile forces are transmitted or if the whole hole pattern is not necessary, bars were included in the construction kit. They have the outer measures of the beam and wear the hole pattern only at their ends. In the middle area they have a considerably lower wall thickness and thus a significant lower mass (picture 16).

bar

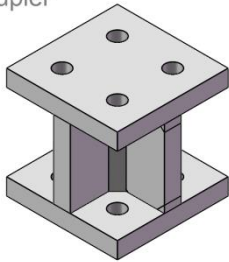


**Picture 16: Bar**

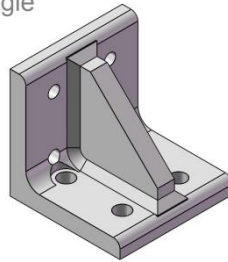
Picture 17 shows the elements coupler, angle and counter plate. Their function is already explained in the construction kit SPR400.



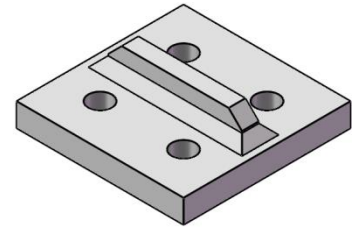
coupler



90° angle

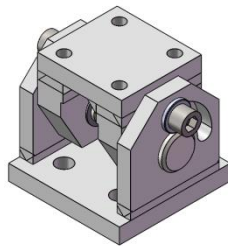


counter plate

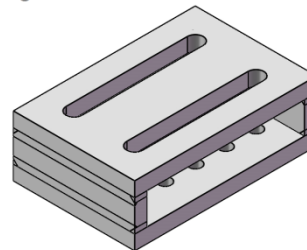


**Picture 17: Coupler, angles and counter plate**

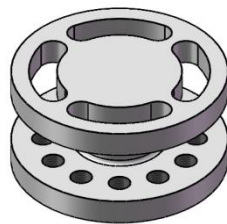
adjusting angle



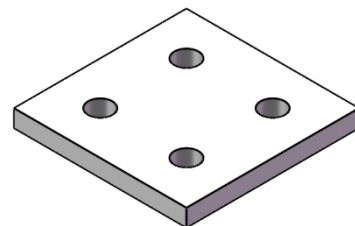
sliding element



rotary element



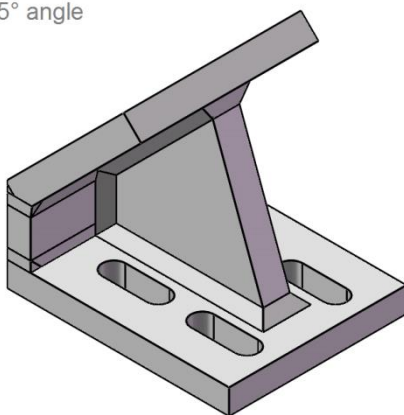
spacer plate



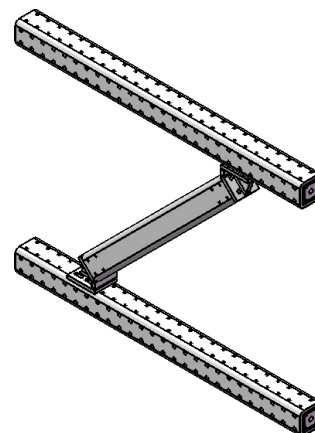
**Picture 18: Other elements of the construction kit SPR100**

Furthermore, a 45° angle is offered. This angle allows e. g. bracings like the one shown in picture 19.

45° angle



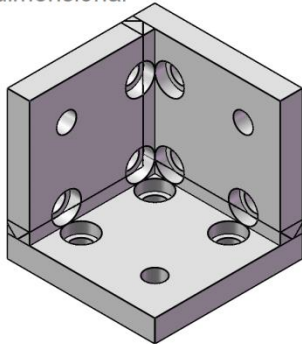
example of use of 45° angle



**Picture 19: 45° angle and example of use**

A three-dimensional angle was included in the construction kit as well (picture 20). With that, spatial frame corners can be assembled.

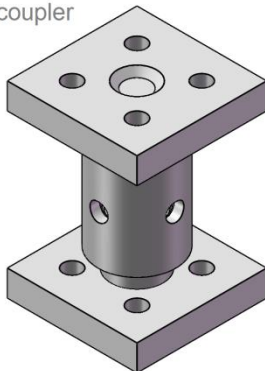
three-dimensional angle



**Picture 20: Three-dimensional angle**

A balancing in longitudinal direction can be realized with an adjusting coupler, shown in picture 21.

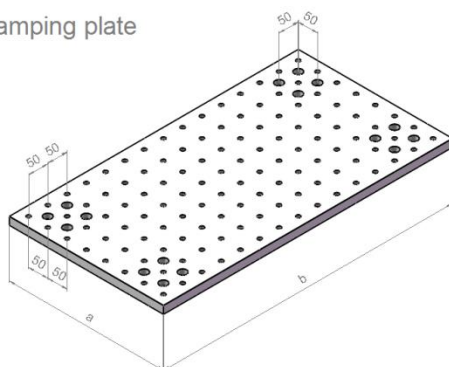
adjusting coupler



**Picture 21: Adjusting coupler**

The clamping plates of the construction kit SPR100 support the 50 mm pattern (picture 22). The measures a and b are freely selectable, too. Anchor points are offered analogous to picture 6.

clamping plate



**Picture 22: Clamping plate**

In the construction kit SPR100 screws and tension rods M12 in selected length as well as nuts and washers in high strength design are offered as accessories.

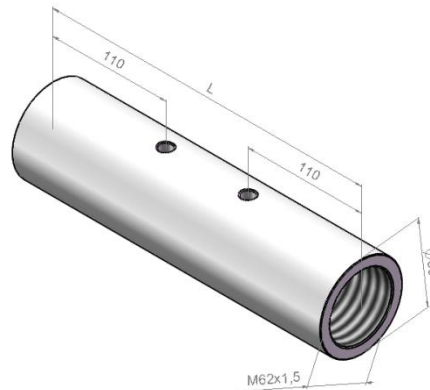


## CONSTRUCTION KIT SPS80

With only few elements, the construction kit SPS80 achieves a maximum of flexibility concerning the supporting structures which are to be developed.

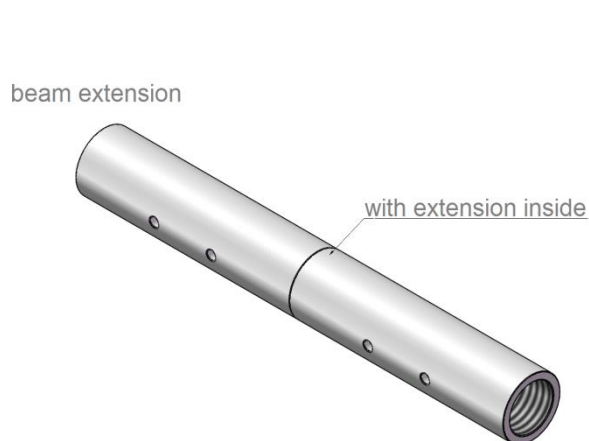
Beams out of pipes with an outer diameter of 80 mm are basic elements (picture 23). These pipes are hard chrome-plated. They have a wall thickness of 12.5 mm. They are supplied in lengths  $l = 200, 300, 500, 900, 1300, 1700$  and 2100 mm.

basic element SPS80 beam



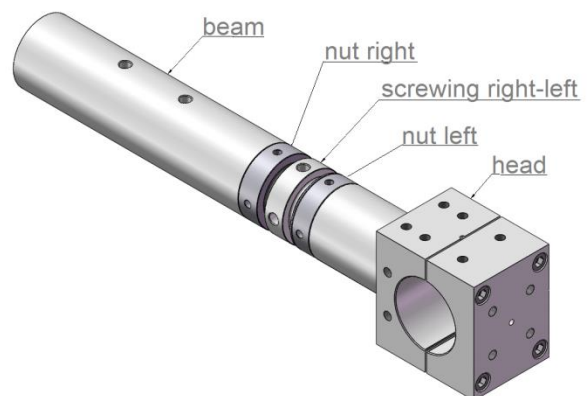
**Picture 23: Basic element of the construction kit SPS80 beam**

The beams have right-hand female thread on their ends. With an extension, beams can be lengthened. The screwing has a right-left female thread and makes it possible to connect them with construction kit elements, which have left female thread. So, an infinitely variable longitudinal adjustment in the frame assembly is possible. Right and left female nuts enable the partners to counter to produce the backlash. The outer diameter of the screwing and the nuts correspond to the one of the beam, so this area has no restriction in possible connections (picture 24 and 25).



**Picture 24: beam extension**

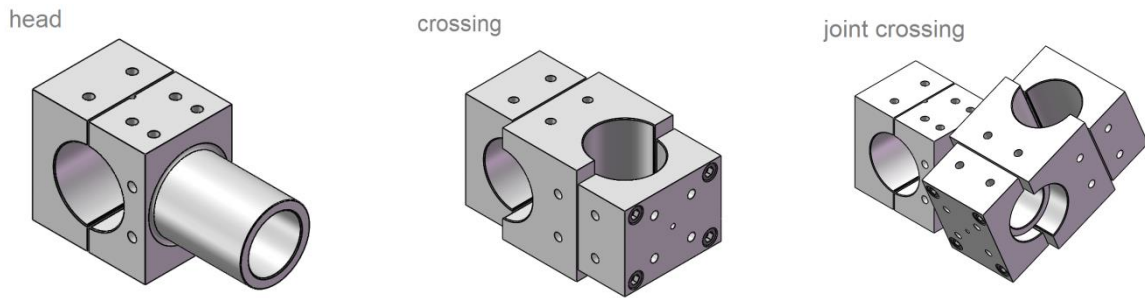
connection beam and head



**Picture 25: Connection beam and head**

Also pipes with 4 mm wall thickness without female thread -bars- are offered. They cannot be extended the way shown in picture 24. They allow the construction of support structures with low dead weight.

Picture 26 shows the elements to produce pipe connections.

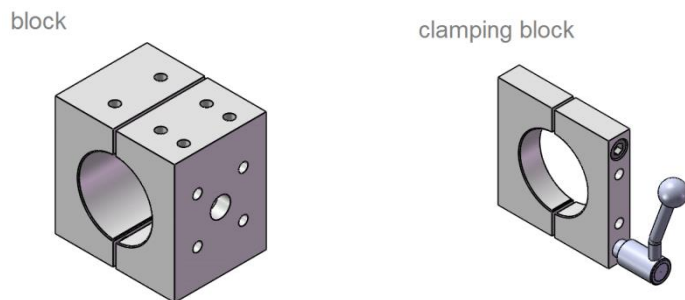


**Picture 26: Elements for pipe connections**

The head can be connected to the supporter bluntly (picture 26). This way, T-joints of two pipes are producible. With the crossing cross joints can be produced, and with the element joint crossing, pipe crossings can be realized with any angle.

The blocks shown in picture 27 can be attached on the pipes. On the blocks, more components can be connected. The clamping block has to be attached before installing the pipes, whereas the block can also be attached to a finished supporting structure.

All node elements like heads, crossings, blocks and plate elements support the hole grid 50 mm x 50 mm for M12 screws.

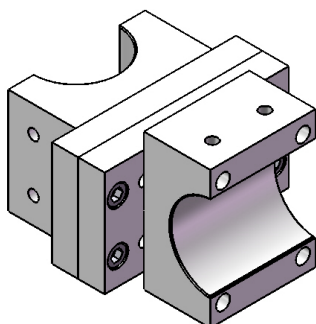


**Picture 27: Blocks**

The clamping plates correspond to those of the construction kit SPR100.

If the elements are to be interconnected among each other according to picture 28, spacer plates can be used.

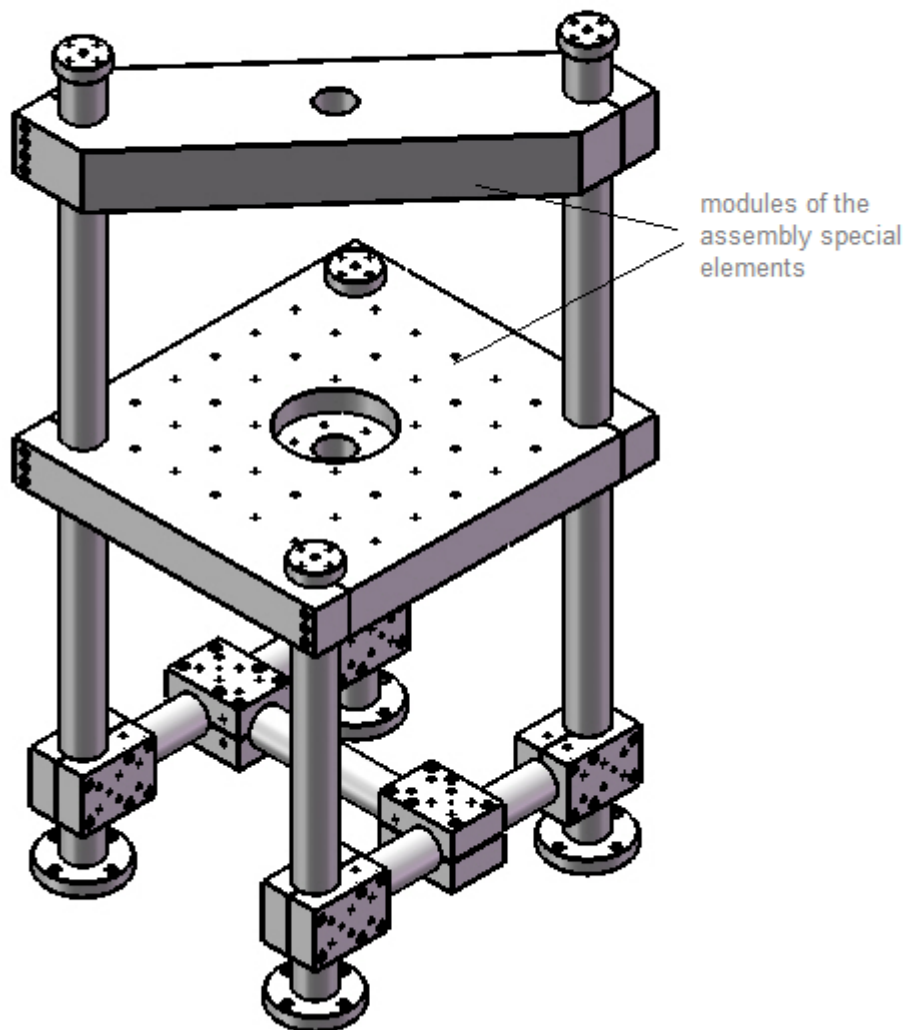
application spacer plate couple



**Picture 28: Application spacer plate couple**

A test frame – assembled from elements of the clamping construction kit SPS80 – shown in picture 29.

test frame



**Picture 29: Test frame**

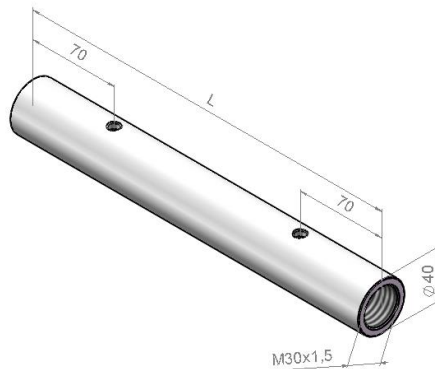
As accessories screws and armatures in selected length and also internal nuts and washers in high strength version are offered.

## CONSTRUCTION KIT SPS40

This construction kit was created based on SPS80.

Beams made of pipes with an outside diameter of 40 mm are the basic elements (picture 29). These pipes are hard chrome-plated. They have a wall thickness of 6 mm. They are supplied with lengths  $l = 200, 300, 500, 900, 1300$  and  $1700$  mm.

basic element  
SPS40 beam

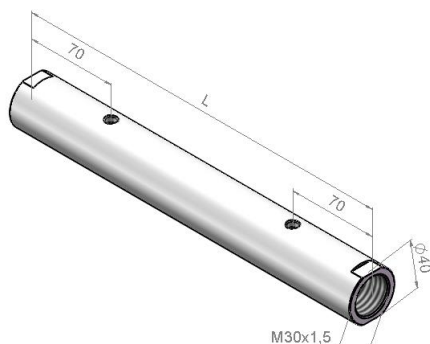


**Picture 30: Basic element of the construction kit SPS40 beam**

At the ends the beams have right-left female thread. Therefore an axial connection of the beams is possible, analogous to the construction kit SPS80 (see picture 24).

To realize the movement functions, this construction kit provides surface hardened shafts with an outside diameter of 40 mm.

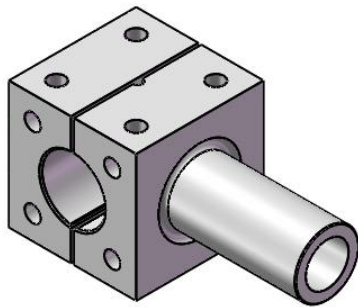
shaft



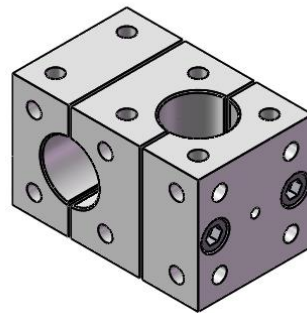
**Picture 31: Shaft**

In this construction kit, head, crossing, joint crossing, block and clamping block are offered as well (picture 32). They support the hole pattern  $500 \text{ mm} \times 50 \text{ mm}$  for M12 screws, too.

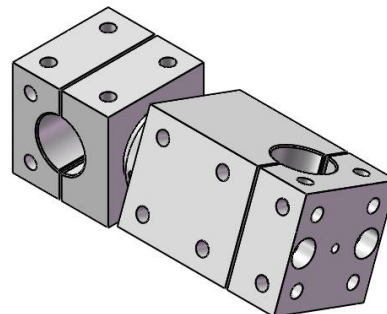
head



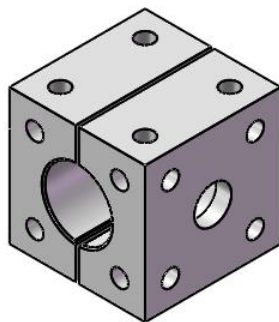
crossing



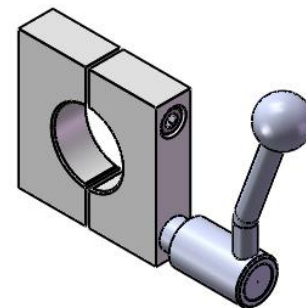
joint crossing



block



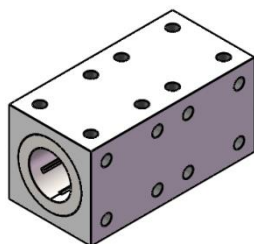
clamping block



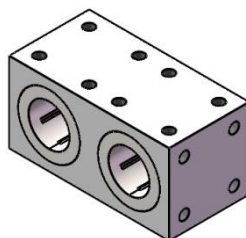
**Picture 32: Elements of the construction kit SPS40**

In addition, movable elements are offered in this construction kit (picture 33).

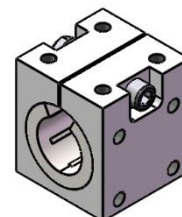
row bearing



double bearing



linear bearing,  
adjustable

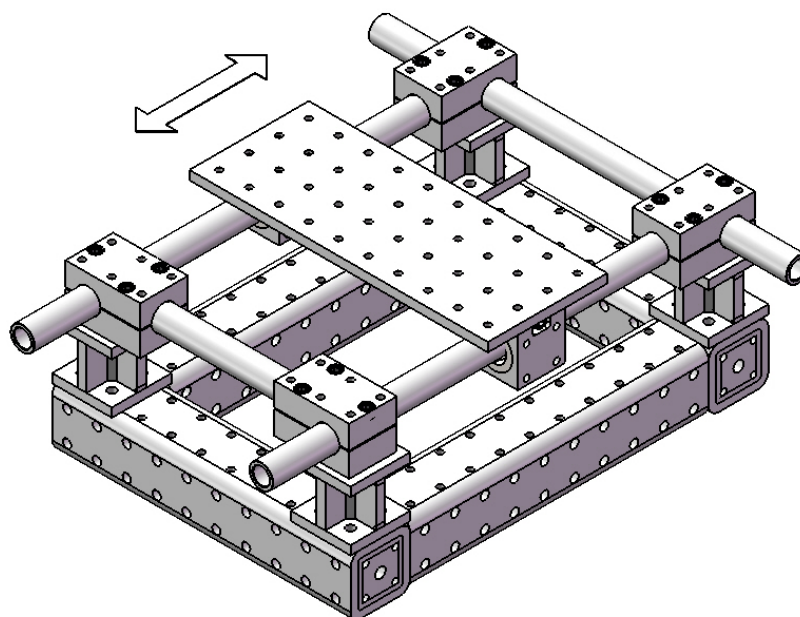


**Picture 33: Movable elements**

The movable elements can be installed where certain translations are to be made und where certain static support conditions are to be realized.

Picture 34 shows an example of application of the construction kit SPS40 in connection with the construction kit SPR100.

device out of SPS40



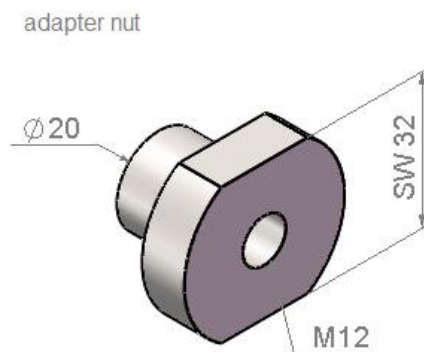
**Picture 34: Device of construction kit SPS40**

As accessories to the construction kit SPS40, screws and tension rods M12 are offered in selected length as well as internal nuts and washers in high strength version.

## INTERACTION OF THE CONSTRUCTION KITS

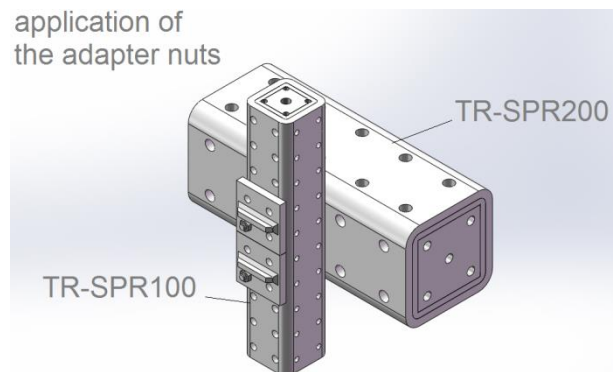
The five described construction kits cannot only be used individually, but also in combination, increasing the diversity of possible application. The construction kits SPR400 and SPR200 can be combined with each other without restrictions as both have the hole pattern 100 mm x 100 mm for M20 screws.

Likewise, the construction kits SPR100, SPS80 and SPS40 can be combined with each other as they have a hole pattern of 50 mm x 50 mm for screws M12. To connect both pattern holes, the construction kits contain special elements, for example the adapter nuts according to picture 35.



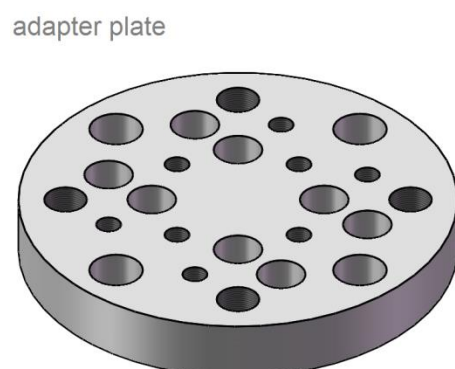
**Picture 35: Adapter nut**

Picture 36 shows the application of the adapter nuts when connecting a beam with the hole pattern for M20 with a beam with the hole pattern for M12.



**Picture 36: Application of the adapter nuts**

Picture 37 shows an adapter plate, which is provided with both hole patterns. So, connections between different construction kits can be established.



**Picture 37: Adapter plate**



## DESIGN NOTES FOR SUPPORTING STRUCTURES

When designing supporting structures for strength test facilities, manufacturing devices or measuring devices, certain guidelines have to be considered. When doing so, the supporting structures are predictable and become little distorted under particular stresses. Little distortions mean high manufacturing and measuring precision as well as low energy demand with swing strength tests.

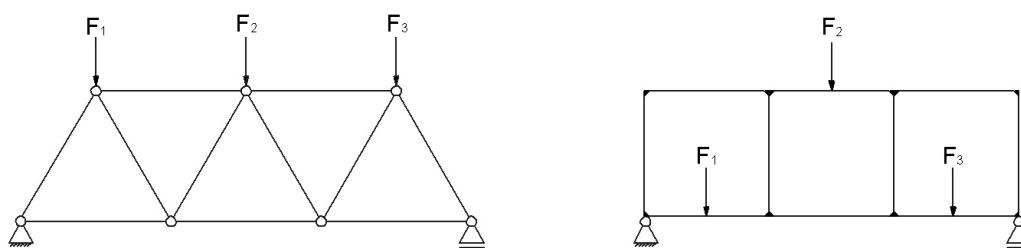
To make a supporting structure predictable, it should correspond to the supporting structure in its structure, treated in statics.

As the construction kits mainly consist of bar-shaped elements, clear bar supporting structures should be constructed, if possible.

Picture 38 shows a classification of the bar supporting structures.

Bar supporting structures are divided into: trusses (a) and frames (b).

classification of the supporting structures



**Picture 38: Classification of the supporting structures**

Only tensile-pressure stresses occur in the truss bars. The stresses are introduced in nodes. The system lines of the bars overlap in the truss nodes. In the nodes, the bars are linked together in a flexible way. Frames can also be loaded outside the nodes. Also bending and torsion moments occur in the bars.

In general, a truss requires a higher amount of elements in comparison to a corresponding frame supporting structure. That means, a frame supporting structure can be established faster, whereas the truss has smaller deformations.

In the bar supporting structures, forces should be introduced the way that the effective lines of the forces go through the center of gravity and through the shear center of the bar cross-sections.

As in all construction kits profiles are used where the center of gravity and the shear center concur, the construction kits correspond to the requirement mentioned above.

The cross-section of the basic elements of the construction kits are presented in a selection table on the last page.

The shear center is located in the center of gravity in all basic elements.

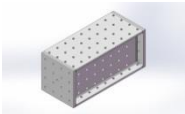
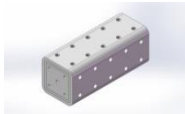


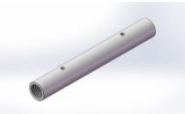
The requirement to connect trusses in a flexible way can be well met by the construction kits SPS80 and SPS40 with their tubular carriers. If frame supporting structures are built, the corners need to be strengthened to reduce deformations. Therefore, each singular construction kit contains appropriate elements. The corresponding elements of all construction kits have appropriate connection options, so the system lines of the bars can cross.

## SELECTION OF A MODULAR CONSTRUCTION KIT

Which of the five construction suits best in a concrete case, can be determined by comparing the basic elements. The basic elements are compared with in the following table.

First, the cross-section of the basic elements is described. The load-bearing capacity can be calculated on the basis of the resistance moments for each of the applicable stress cases. With the help of the stated dead weights it can be decided, whether hoists are necessary and if so, which ones.

Furthermore, it is shown, which connecting elements are needed within a construction kit and between the construction kits, and there are also hints for connecting the construction kits among each other.

Parameter		Construction kit							
		SPR400	SPR200	SPR100	SPS80	SPS40			
Profile		Welded structure	hollow profile	hollow profile	pipe	pipe			
			200 x 200 x 16	100 x 100 x 12,5	80 x 10	40 x 8			
Sketch									
Section modulus	Bending	2500 cm <sup>3</sup>	608 cm <sup>3</sup>	108 cm <sup>3</sup>	35 cm <sup>3</sup>	5 cm <sup>3</sup>			
	Torsion	3300 cm <sup>3</sup>	1080 cm <sup>3</sup>	191 cm <sup>3</sup>	69 cm <sup>3</sup>	11 cm <sup>3</sup>			
Mass		220 kg/m	100 kg/m	33 kg/m	18 kg/m	5 kg/m			
Max. test force (standard value)		250 (400)* kN	100 kN	30 kN	25 kN	5kN			
Raster/adjustability		100 x 100 mm / in steps	100 x 100 mm / in steps	50 x 50 mm / in steps	50 x 50 mm of the node elements stepless	50 x 50 mm of the node elements stepless			
Connection element in the construction kit		tie rod M20	tie rod M20	screw M12 & tie rod M12	screw M12 clamping connection	screw M12 clamping connection			
Combination possibilities → without adapter → → with adapter			→	→→	→→	→→			
			←	→→	→→	→→			
	SPR400	←←	SPR200	←←	SPR100	→	SPS80	→	SPS40
		←←		←←		←		→	
		←←		←←		←		←	

\*for short lever arms

**Table: Comparison of the construction kits**