Title

`konstructive`

A Millimetric, Recursive, base-Twelve Norm for the Construction of Physical Objects

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Abstract

Standardization is a development across many areas of engineering and commerce. Organizations in charge of developing standards can abuse their position by introducing standards that lack technical merit, but are aimed at increasing consumption. Conversely, standardization may avoid consumption if standardized parts are reused and incorporated into new useful objects. Thus, establishing a standard for the construction of physical objects could greatly reduce consumption and the associated use of resources. With this environmental focus as a motivation, I developed `konstructive`, a versatile construction standard. The standard has the millimetre as the base unit and interfaces with standard metric hardware. The base grid dimension is 12 mm. Parts generated on this grid interface with parts that possess half (6 mm) and double (24 mm) the 12 mm base grid size. This factoring can be recursively extended to generate parts that are based on smaller (3 mm, 1.5mm, etc.) and larger (48 mm, 96 mm, etc.) grids. The presented standard is non-proprietary and avoids complexity. Therefore, objects composed of parts that use the standard can be freely shared, manufactured, repaired, maintained, and locally adapted.

Keywords:

- circular economy
- construction system
- conviviality
- planned obsolescence
- reuse
- right to hack
- right to tinker
- right to innovate
- right to repair
- right to reuse
- right to share
- sustainability
- sustainable design
- open innovation
- open technologies
- tools of conviviality
- standardization

Introduction

konstructive is a construction standard that was developed to combat the destruction of our planet and to liberate us from products that ensnare. In order to facilitate rapid adaptation and the freedom to share useful objects, konstructive is non-proprietary, deliberately avoids complexity, and only interfaces with existing non-proprietary standards.

Standards

Standardization has major consequences for our environment and our society. While the motivations for establishing standards are varied, standards are often introduced to encourage consumption and to lower "cost" for developing, producing and distributing products. The method of measuring these costs has varied over time. However, little regard has been given to environmental costs. For a civilization that has reached the Earth's environmental limits, "cost" must align with environmental impact.

Reuse

The reuse of parts is the simplest and most effective construction strategy for limiting environmental degradation. Reusing avoids effects associated with harvesting or mining of resources, as well as energetic expenditures that are required to create products or recycle and redistribute them. Reuse can be optimized if object are designed so they consist of modular parts that follow a common standard.

Non-Proprietary Standards

Why is it necessary to develop an independent standard? Currently, leading companies often band together in consortia to develop standards. This pathway for standardization is profit-driven and results in standards that encourage consumption. Technological advance is only a secondary motivator and environmental and societal impacts are not considered or prioritised. Once created, these new standards force us to acquire a new wave of products and discard the often functional predecessors. Thus, with financial interests driving the creation of standards, it is unlikely that effective standards, which limit consumption and enable repair and maintenance of products, will emerge. Furthermore, the standards enforced by company consortia are often proprietary, or if not proprietary, very complex. Consequently products based on these standards cannot be easily developed, understood, repaired or maintained.

Liberating Standards

Non-proprietary and non-complex standards open a path for technological innovation and provide a shift from profit-centric technologies to human-centric technologies. Non-proprietary and non-complex standards ensure that developed objects can be shared around the world, where they can be locally manufactured, locally repaired, locally maintained, and locally adapted. Having the embedded right to be copied, repaired, maintained and adapted, renders an object developed using a non-proprietary and non-complex standard superior to a product that follows a proprietary or complex standard. Even if the proprietary solution has additional features and initially requires less money to acquire, the embedded ownership, usage and maintenance advantages of the simple and non-proprietary solution will eventually decide in favour of the non-proprietary and non-complex solution. `konstructive` is a non-proprietary and non-complex standard that supports these rights:

- Right to Share
- Right to Reuse
- Right to Repair
- Right to Tinker
- Right to Hack
- Right to Innovate

Materials

The materials that are used to implement `konstructive` must be carefully selected to minimize environmental impact. For this, the materials used should be durable, so parts can be reused many times. However, all parts will eventually lose functionality or structural integrity. Therefore, only materials that can be fully recycled or fully naturally degraded should be used. For naturally degrading materials, examples are wood and material from renewable sources, including plant fibres and biomass-derived plastics. Fossil fuel–based materials should not be used. For recyclable materials, examples are metal and metal alloys, such as aluminium and stainless steel. Composite materials that have to be de-constructed in order to be recycled should not be used.

Voiding patents

In addition to providing all information necessary to design parts and assemble them into useful objects, this document is also written to void any patent claims that may be pursued by other parties. This document ensures that it is not possible to patent parts that conform with the standard (detailed later in this document), or to obtain patents by dimensioning or interfacing objects to conform with the standard. By voiding the potential for patent claims, it is ensured that objects designed and built using `konstructive` can be rapidly implemented by any person, company, or organization. The name `konstructive` has been trademarked to ensure that the standard is not misused or hijacked. An implementation of `konstructive` for 3D-printed parts has been released under a license that allows free and unrestricted use, with the only obligation being to reference the standard and release derived parts under the same license.

Developing the standard

Establishing a construction standard is a non-linear process. In the following section I will provide some historical background, technical information and thoughts that contributed to developing konstructive.

Scales

How can single construction standard cover different scales of size? For example, how can I build a model train bridge and a real train bridge following one standard? Theoretically, I could use many model beams, and many model screws to build a real bridge. However, adapting this construction strategy would be tedious and ineffective.

Recursion is how nature solves the problem of scale. One example for recursion is observable in the form of a fern, where leaves are arranged in fronds, which themselves build larger fronds. Recursion is also the basis for scaling of konstructive. Recursion evolved naturally during the design process. While interfacing parts that covered different dimensional ranges, I realized that I could design and assemble parts in a recursive progression. Consequently, a konstructive part can interface with parts that are scale models of the konstructive part itself. The scale factor is 0.5 for the smaller scale parts and 2 for the larger scale parts, and this factoring can be expanded to additional smaller and larger scales.

The Base Unit

The motivation for establishing the units we use today grew out of the drive for reform in post-revolutionary France. At the beginning of this development was the metre, which was defined as the ten-millionth part of the distance between the North Pole and the Equator. Very careful and lengthy measurements were conducted to approximate this distance, and based on these measurements a platinum metre was created in 1799 as a first reference. The “metre”, together with the “second” and ”gram” formed the basis on which the modern *Système international d'unités* (SI units) is based.

Enshrined as the base unit of science and engineering throughout the world, the metre is unparalleled. Consequently, in all countries, even the United States of America – the last stronghold of imperial units – metric hardware is available. This wide adaptation makes it easy to choose a metre-derived unit for establishing a construction standard. However, starting with a metre, using recursive factoring by the number 2, one ends up with distances in the millimeter range that are complex fractions (e.g $1/2^{10}$ mm = 1/1024 mm = 0.9765625 mm). This length would be impractical as a base length as available tools for measurement are unsuitable and existing hardware could not be used. Therefore, I decided to base konstructive on the millimeter, which allows the use of a wealth of available metric components, such as screws, ball bearings, and rubber rings.

The Base Number System

Amongst the number systems developed by humanity, the base-10 number system is the most common, likely because using one’s fingers is an obvious start for counting the number of things in the world. However, in many societies a base-12 number system emerged with the establishment of trade and construction. The “royal gur-cube” is an example for this development. Measuring 12 x 12 x 1 units (dimensioned about 6 x 6 x 0.5 meters), this standard for volume and length was established around 2130 BCE to facilitate trade throughout the Akkadian Empire. Another common numeral system, is based on the number 2. This system allows easily halving and doubling of distance and weight, and has been common in daily use over millennia. For example, pre-metric units of weights in Germany were based on the unit Pfund, which can be divided into 2 Mark, or 16 Unzen, 32 Lothen, 128 Quinten and 512 Pfennige. In the wake of the French Revolution, all types of systems of measure were decimalized. Some decimalizations introduced in France, such as the 10 hour day and 10 day weeks were short-lived. However, the units for weight and length became fully decimalized, soon replacing traditional base-12 and base-2 numeral systems throughout most of Europe.

Twelve is a very useful number, due to its four divisors (2, 3, 4, 6), whereas the number 10 only has 2 divisors. In addition to dividing a dozen apples between 2, 3, 4 and 6 people without using a knife, a base-12 system also eliminates periodic digits of common fractions we encounter in the base-10 number system. Instead of 0.333.., 0.666... for 1/3 and 2/3 in a base-10 system, the base-12 representation for 1/3 and 1/4 is 0.4 and 0.8, respectively. Given these advantages of the base-12 number systems, it is not surprising that engineering disciplines adapted and kept 12 as a convenient base number, even under the decimal metric pressure. For example, construction materials are often available in 600, 1200, 2400 mm and the imperial foot, which is composed of 12 inches, is still alive and kicking. Furthermore, base-12-derived systems for measuring angles and time remain in use.

I decided to use a base-12 number system for `konstructive.` Thus, given a base length of 1mm, dimensions of a `konstructive` part fit a 12 mm grid. That `konstructive` uses a base-12 numeral system with a millimetre as the base unit is an unexpected outcome, as I initially set out to create a metre-based system with the matching base-10 numeral system. The main advantage for a construction standard is that a base-12 system makes it straight-forward to obtain halves, thirds, quarters and sixths. However, I also considered practical impacts that come from interfacing with existing hardware.

Interfacing with Metric Hardware

A construction system should interface with available metric hardware to allow rapid adaptation. Therefore, I evaluated the practical consequences for implementing a 12 mm, 10 mm and 8 mm grid size in regards to availability and characteristics of metric hardware.

The smallest size screw or threaded rod that is stocked in most hardware stores is the ISO metric M3 (indicating a 3mm nominal shaft diameter). Using an 8-based system, M4 and M8 would be useful for every day applications, while the massive M16 screws would only be relevant when very large objects are constructed. The twelve-based hardware (M12, M6 and M3) and ten-based hardware (M10, M5, M2.5) provides three everyday usable screw sizes, but only the three 12-based screw sizes are commonly found in a hardware store. The reason for this may well be based on the fact that M2 and M2.5 screws are not easy to work with, as they are difficult to align manually.

A screw thread pitch that is a simple fraction of the base unit is required to connect multiple threaded components without gaps. Within the based-12 hardware system (M3, M6, M12), two screws (M3, M6) have thread pitches (1mm and 0.5 mm) that are simple factions of the 1 mm base unit length. These simple fractions are not found for base-8 (M4, M8) screws and base-10 (M2.5, M5, M10) screws, which have thread pitches of 0.7, 1.25 and 0.45, 0.8, 1.5, respectively.

In conclusion, the M3, M6 and M12 hardware (12 mm grid) appears better suited for a construction system than then 10 mm grid-based and 8 mm grid-based hardware components. This assessment is based on the availability and usable scale dimensions covered, and screw threads aligning with the 1mm base unit. Another consideration in favour of the 12 mm grid is that a “double grid” (24 mm) is in the size range of an imperial inch (25.4 mm) and thus may encourage adaptation of the standard in countries and areas of trades that are dominated by imperial units.

Interfacing with π

The constant π rules the geometry of circular objects and poses an interesting challenge for a modular construction system that includes circular objects, such as gears.

Major innovations in gear design were accomplished during the Industrial Revolution, with the current standards only being established towards the end of the 19^{th} century. The most common gear system today is based on a gear tooth in the shape of a involute of a circle. This shape allows the transmission of force between two gears with a constant pressure angle. Involute gears can therefore be combined with other involute gears.

Interacting gears are conveniently constructed by defining the ratio of the number of teeth to the pitch diameter of the gear with a factor, the “gear module”. A gear with 12 mm pitch diameter and a gear module of 1 posesses 12 teeth that are spaced π mm apart. A geared track (rack) system with a gear module of 1 will also feature a distance of π mm between two teeth. Constructing a gear transmissions system using the gear module and involute system allows the use of different gear pairs (e.g 12:12, 13:11, 14:10, etc) with axles that are spaced 12 mm apart.

Adoption of module-based involute gears with the most commonly used pressure angle (20°) makes a large number of existing gear designs available for use with `konstructive`. Gears conforming to `konstructive` have a thickness, as well as axle dimensions, which are simple fractions or multiples of the 12 mm base grid.

`konstructive` **Design *Principles***

Recursive Scaling

`konstructive` provides a framework for the efficient construction of physical objects from reusable standardized parts. Objects can be created by combining parts of the same scale or parts that feature defined scale ratios. The scale ratio is either 0.5 or 2 and can be extended recursively by theses ratios, thus allowing the construction of objects at any scale (Figure 1).

Konstructive Scale Standard

The `konstructive` scale standard is referenced as "`kon`". A prefix indicates the scaling ratio in regard to the base unit of length (1mm) and base grid spacing (12mm), and is denoted as the base of 2 logarithm ($\log_2$) of this scaling ratio (Figure 1-1). Following this convention we can derive the following scale assignments:

`-1kon` (scaling ratio 1:2 or 0.5) has a grid spacing of 6mm (12 times 0.5 mm).
`0kon` (scaling ratio 1:1 or 1) has a grid spacing of 12 mm (12 times 1 mm).
`+1kon` (scaling ratio 2:1 or 2) has a grid spacing of 24 mm (12 times 2 mm).

The prefix range can be extended by integer increments or integer decrements. For example, `-5kon` has a scaling ratio of $1/2^5$ (1/32) and a grid spacing of 1 mm/32*12 (~375 µm), while `5kon` has a scaling ratio of 32/1 and a grid spacing of 1mm*32*12 (384 mm).

Grid Fractions and Part Features

Parts and part features are dimensioned to fit with parts of adjacent scale dimensions. Since `konstructive` uses a base-12 grid that scales recursively by a factor of 0.5 to smaller scales, suitable fractions in reference to the base grid (12 mm at `0kon`) are 6 mm, 3 mm and 1.5 mm. Consequently, this set of dimensions is used for designing `0kon` parts, so they can interface with `-1kon` parts. Structural features with these dimensions include the part holes as well as recessed part surfaces. A secondary set of distances (1mm, 2mm and 4 mm) can also be used to implement part features that, when combined, span the `0kon` grid distance (12 mm).

Half Clearance

Part dimensions will deviate from the ideal dimensions defined by the `konstructive` grid to accommodate manufacturing tolerances, as well as desired clearances between parts. It is assumed that the clearance is divided equally between interfacing parts. This half-clearance can be specified as a postfix that indicates the log 2 of the base dimension (1mm) deviating from the ideal grid dimension.

For example, a desired clearance of 2 mm between parts, results in a half-clearance of 1 mm for each part. This half clearance is indicated by the postfix 0 `(kon0)`. Similarly, a half-clearance of 0.125 mm is indicated by the postfix -3 `(kon-3)`, and a half clearance of 0.01 mm is indicated by the postfix -6.64 `(kon-6.64)`. Indicating the half clearance is optional in many situations.

Parts

“Parts are designed using part dimensions that are recursively scaled”

A single part, the “base plate”, can be considered the foundation of several `konstructive` part families. At `0kon` this base plate features a 12 mm * 12 mm face, 3 mm thickness and a centre hole. The centred hole (Figure 1-2) is either a cuboid (6 mm * 6 mm face, 3 mm height) or a cylinder (3 mm radius, and 3 mm height). This base plate with the centred hole can be used to construct blocks, channels and angles.

A block can be constructed by arranging four base plates perpendicularly around a central square cavity (Figure 1-2). The overall dimension of this base block is 12 mm * 12 mm * 12 mm, while the central cavity covers 6 mm * 6 mm of the faces of the block and extends 12 mm through the block to the opposing face. Each face of the base block possesses such a hole. Similar to the construction of the base block, angles and channels can be constructed using two or three perpendicularly arranged plates (Figure 1-2), all of which can include face features, that allow interfacing with parts of the next smaller scale, while maintaining overall scale dimensions (Figure 1.3).

As they use the same base grid, it is straightforward to combine copies of `0kon` plate, block, channel and angles into composited parts (Figure 1-4). Furthermore, `-1kon` parts can be incorporated within a `0kon` part, as parts are recursively dimensioned and part face features are based on a `-1kon` grid spacing (Figure 1-4).

Plates

Plates with desired dimensions can be constructed from copies of a base plate. For example, a 2 x 2 grid unit plate can be constructed by interfacing four `0kon` plates, with the resulting plate remaining proportionally identical across different `konstructive` scale standards (Figure 2-1). Using recursive 2-based dimensioning, the thickness of the plate at `0kon` may be 6mm, 3mm, and 1.5 mm (Figure 2-1). Furthermore the 12-based grid also facilitates the use of plates with a 1mm, 2mm and 4 mm thickness. Plates with these ranges of thickness can be added in multiple combinations to construct a plate with a 12 mm thickness. Overlapping of plates allows to construct objects that exceed the dimensions of the individual plates used.

Recessing `0kon` plate faces using recursive 2-based dimensioning generates surface features that can interface with `-1kon` parts, while retaining overall part boundaries conforming with `0kon` dimensions. Parts can be recessed on multiple faces (Figure 2-3), (Figure 2-4).

Blocks

Blocks offer functional versatility for construction, as they allow interfacing with other parts in three dimensions. A base block can be constructed by overlapping four rotated base plates. A `0kon` base block has a dimensional boundary of 12 mm * 12 mm * 12 mm, with a centred hole that connects opposite faces forming a central cavity (Figure 1-2).

Composite blocks can be constructed from copies of blocks. For example a 2 * 1 * 1 grid unit block can be constructed by interfacing two 1 * 1 * 1 grid unit blocks (Figure 2-5). Composite blocks can also be generated from base blocks that are arranged in three dimensions (Figure 2-6).

While the block with holes on every face offers a maximum flexibility for interfacing with other blocks through fastener and connectors, it may be useful to reinforce a part by omitting one (Figure 2-7) or two (Figure 2-8) sets of traversing holes.

Recessing of block faces allows interfacing with parts of the next smaller konstructive scale standard. One or several block faces can be recessed (Figure 1-3, Figure 2-9, Figure 2-10) .

Profiles

Beam profiles are the main structural component of framing systems. Beam profiles that conform with konstructive design principles can be readily designed (Figure 2-11). The edge of the groove of these profiles can either be straight, recessed, angled at 45° or have a set of composite features. The function of the groove is to interact with fastener hardware as well as parts that connect beam profiles. The edge of the groove can function as rails for wheels or sliding parts. Composite beam profiles can be designed by combining base profiles (Figure 2-12) to match structural requirements.

Gears and Tracks

Gears and tracks in konstructive conform with metric module-based involute gear standards. A pressure angle of 20° is assumed, unless otherwise specified. The grid spacing of the konstructive scale standard defines the distance of axles between gears.

The cross section of axles can either be circular, square, or in the shape of a rounded cross with dimensions that follow konstructive recursive sizing (Figure 2-13).

The thickness of gears conforms with konstructive recursive sizing for a given scale standard as do additional holes within the gears. These additional holes can be used to connect gears with one another using screws to form additional types of gears, such as double gears.

For building geared tracks out of modular sections it is useful to find a distance, such that the distance between teeth coincides with the base grid of 12 mm. The first multiples of π mm that coincide with a multiple of the 12 mm base grid within less then 1% deviation are 59.69 mm (19 * π mm), and 72.26 mm with (23 * π mm). The distance between teeth covered by 19 teeth over 60 mm is ~3.16 mm, and for 23 teeth over 72 mm is ~3.13 mm. The 72 mm distance possesses advantages that go beyond the smaller numerical deviation form the π mm distance between teeth. When the distance of 72 mm is halved (at the middle of 12^{th} tooth), the resulting 36 mm section has a length that is also a multiple of the base grid. At the implementation level, this means that two identical 36 mm sections of a rack can be combined (by rotating one by 180 degrees) to construct a 72 mm section of a rack.

Objects

"Objects are designed from parts with re-usability in mind"

Useful objects can be constructed by combining `konstructive` parts. It must be ensured that each constructed object can be disassembled into its individual parts. Therefore methods for combining parts that permanently fix them in position, such as gluing, must not be used. Objects consist of parts that are fixed in place by the friction of connectors, by specifically designed fasteners, or by standard metric fasteners.

Connectors

A connector is either a surface feature, such as a knob, which is an integrated component of the part itself (Figure 3-1), or a separate connector that conforms to `konstructive` recursive sizing (Figure 3-2).

Parts themselves can be connectors. For example a `-1kon` block can connect two `0kon` blocks, relying on friction between parts to maintain parts in place (Figure 3-3). Pins that conform to the `konstructive` scaling may provide additional stability between connected parts by taking advantage of chamfers as well as the elasticity of the part material (Figure 3-4).

Fasteners

`konstructive` supports the use of standard metric hardware fasteners. The head dimensions of M3, M6, M12 metric socket head screws are such that the screw heads can be recessed entirely into the square or circular holes of a part (Figure 3-5). Screws can interface with an internally threaded (reinforced) block itself (Figure 3-6), or or with a threaded block of a smaller `konstructive` standard scale that is located inside a block (Figure 3-7) or blocks (Figure 3-8) .

Parts with recessed faces allow screws to interface with threaded parts (with `konstructive` recursive sizing) that are located in the recessed cavities between these parts (Figure 3-9).

In addition, screw head and nuts (M3, M6, M12) can also be located entirely outside the blocks (Figure 3-10).

Future adaptations

konstructive interfaces well with M3, M6 and M12 hardware, however, the hardware may be further adapted:

- The dimensions of the head of socket-head screws may be exactly matched to konstructive dimensions.
- The hexagonal socket head cavities may be changed to square-shaped cavities with konstructive dimensions.
- Square-shaped nuts with konstructive dimensions may add additional functionality for interfacing parts and assembling objects.
- The M12 thread pitch (1.75 mm) is not an integer multiple of 1 mm and a screw with a nominal 12 mm diameter shaft and a 2 mm thread pitch may be a suitable adaptation.
- The dimensions of metric fasteners may be extended to a M1.5 screw, as this size is currently not supported by the ISO metric system.

Glossary

grid

A reference system for placing elements in a three-dimensional Cartesian space.

grid spacing

The spacing at which elements are placed.

`konstructive`

Millimetric, Recursive, base-Twelve Norm for the Construction of Physical Objects. The word “konstructive” refers to a group of people working together.

`konstructive` ***base grid spacing***

A grid spacing of 12 mm.

`konstructive` ***scale standard***

The scale standard of konstructive identified as “`kon`”. A prefix indicates the scaling ratio in regard to the base unit of length (1mm) and base grid spacing (12mm), and is denoted as the base of 2 logarithm ($\log_2$) of this scaling ratio.

scale ratio

The ratio of the dimensions of derived object in relation to the corresponding dimension of the original object.

konstructive

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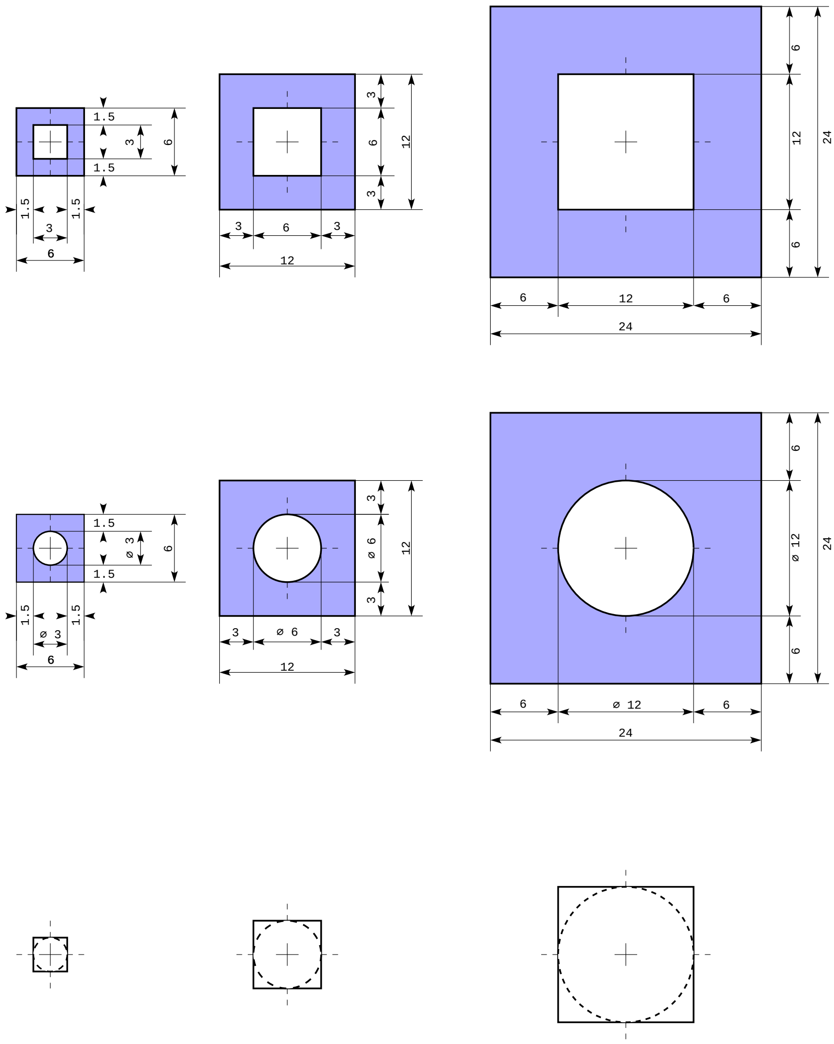
- The manuscript in pdf format was collated using pdftk and pdfcrop


1.5
3
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ø 3
ø 6
ø 12

◄ **Figure 1-1. Recursive scaling.**

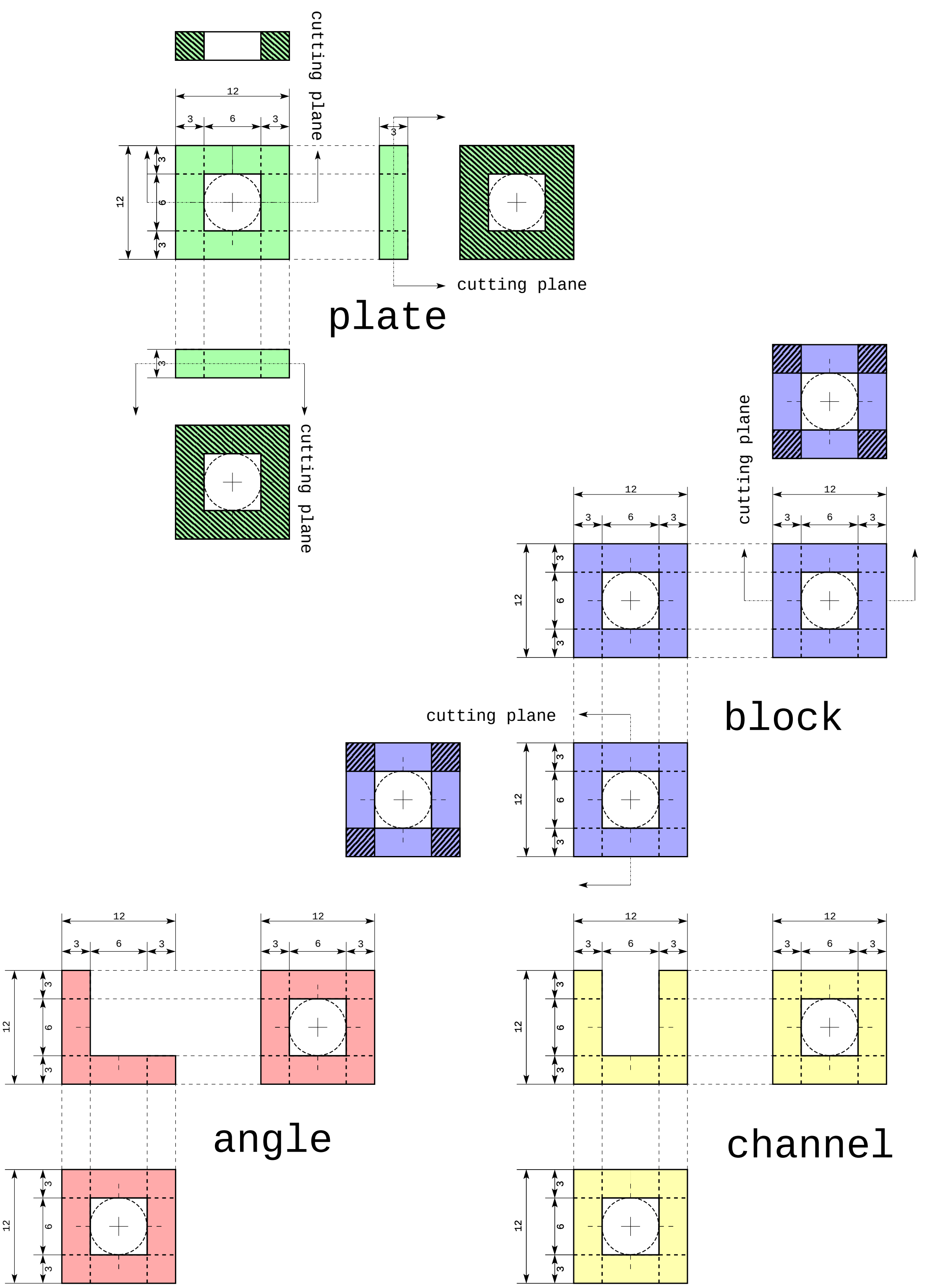
Three `konstructive` scale standard are shown (`-1kon`, left; `0kon`, middle; `+1kon`, right) with a distance between grid units of 6mm, 12mm and 24 mm, respectively.

Centre holes can either be square-shaped (top) or circle-shaped (bottom) and are dimensioned to half the distance between grid units of their respective `konstructive` standard scale.

The symbols indicating holes that are circle-shaped or square-shaped are shown at different scales (middle).

Dimensions are indicated in mm.

konstructive



◄ **Figure 1-2. Base elements.**

Base parts are shown at `0kon`.

A base plate is shown in green (top) including full sectional views. The plate has a central hole.

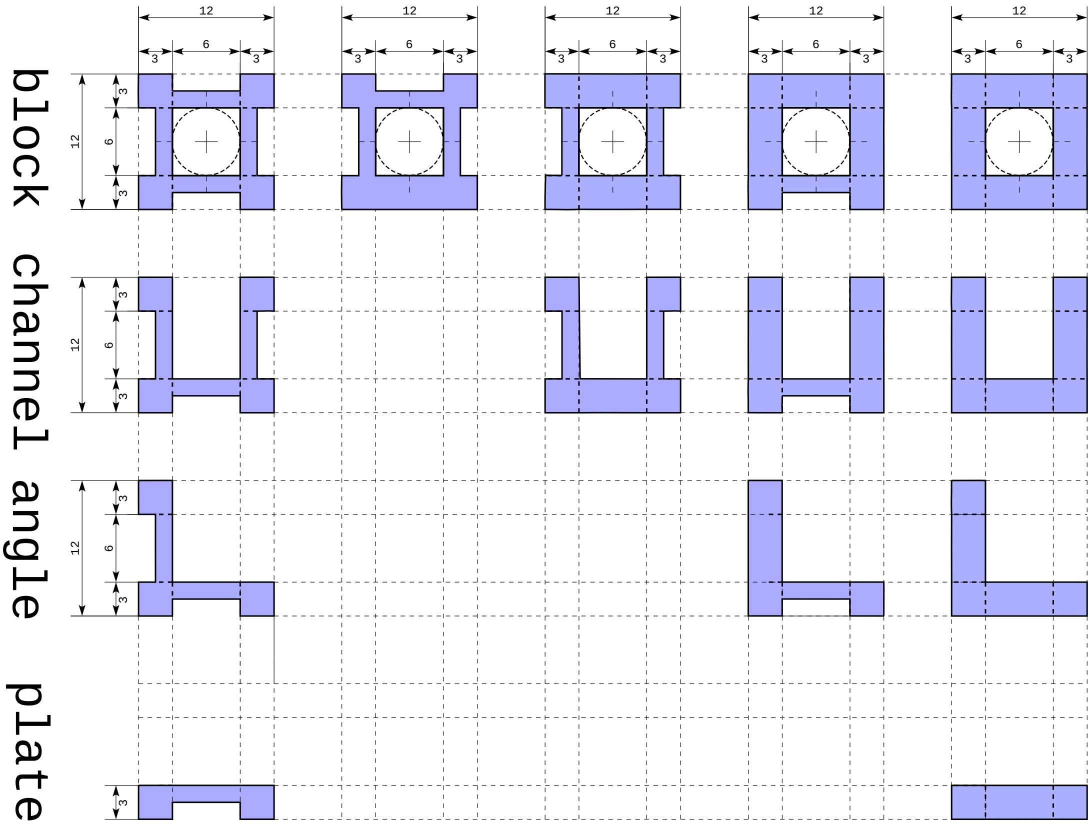
A base block is shown in blue (middle) including full sectional views.
Each face of the block has a central hole that connects opposing faces, thus forming a central cavity.

An base angle is shown in red (bottom left). Each face of the angle has a central hole.

An base channel is shown in orange (bottom right). Each face of the channel has a central hole.

The central hole may be square-shaped (6 mm * 6 mm) or circle-shaped (radius 3mm).

Dimensions are indicated in mm.



block
channel
angle
plate
12
6
3

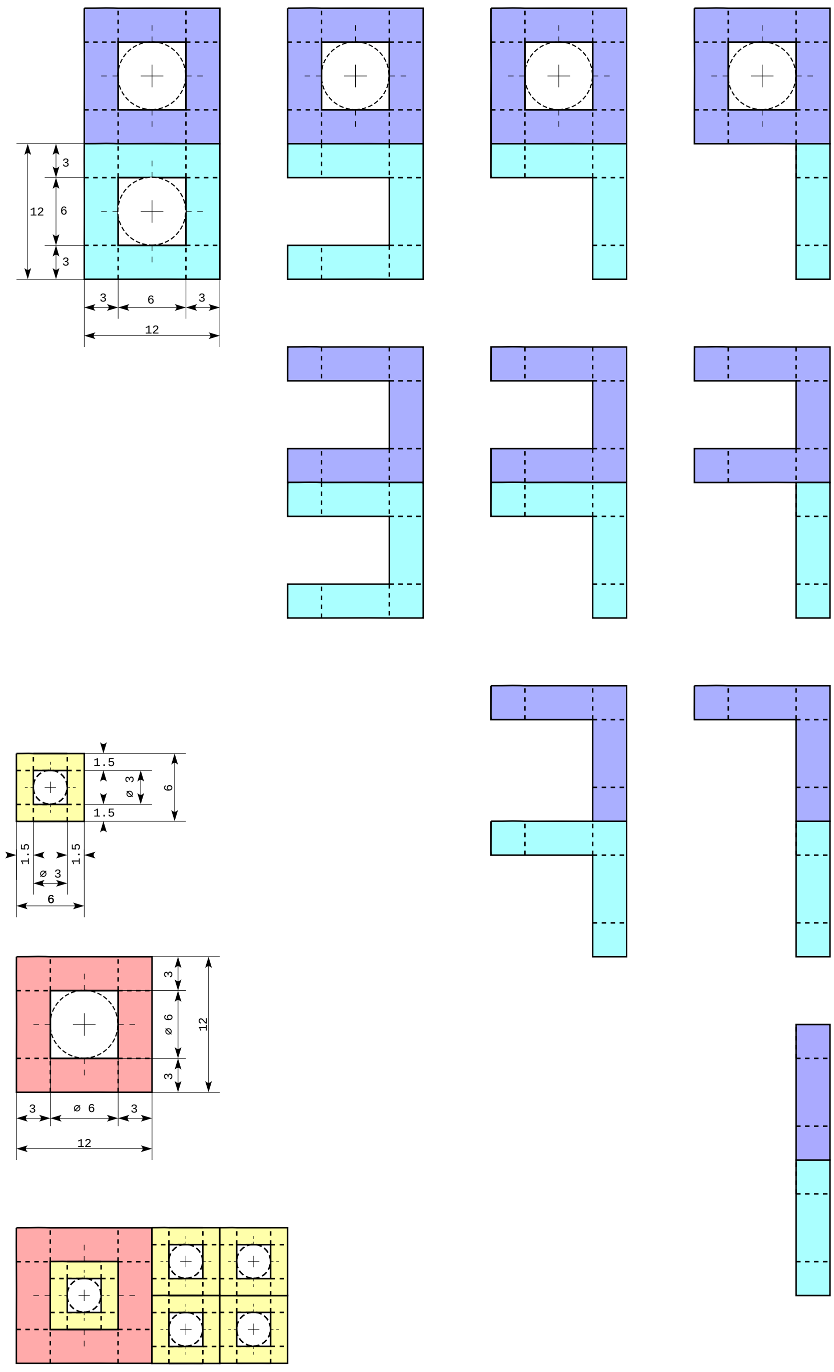
◄ **Figure 1-3. Cross sections of blocks, channels, angles and plates.**

Cross sectional views of `0kon` blocks, channels, angles and plates that are recessed on one or more faces are shown.

The cross sections are not hatched to avoid obscuring of features.

Dimensions are indicated in mm.

konstructive



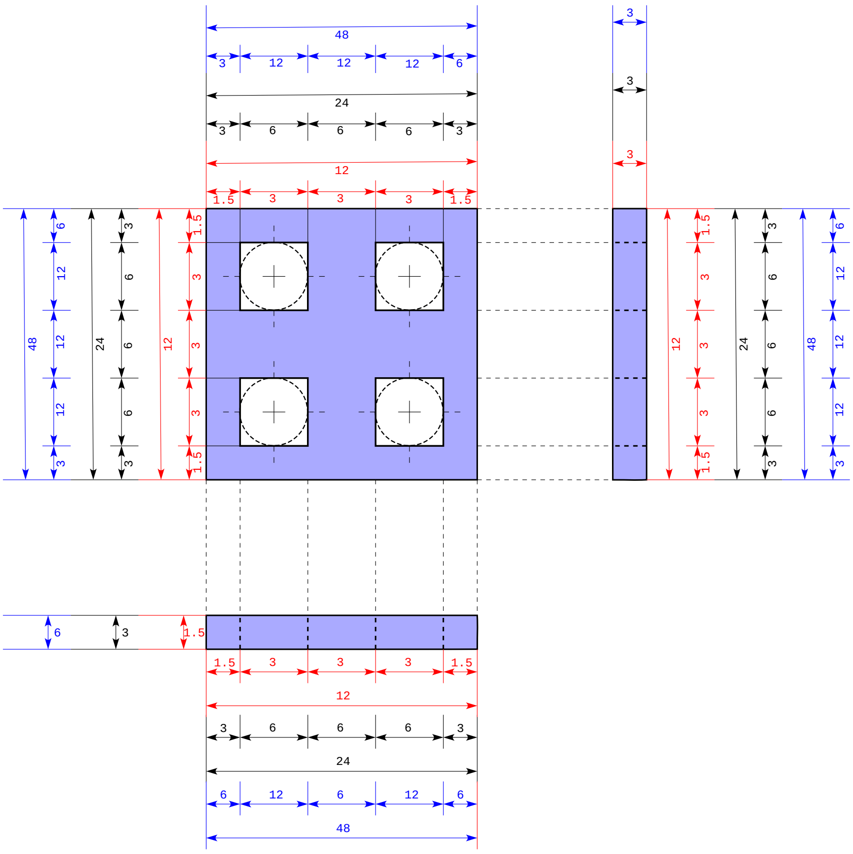
◄ **Figure 1-4. Cross sections of composite parts.**

Examples of `0kon` blocks, channels, angles and plates, which have been combined to obtain composite parts in cross sectional view (blue and cyan).

Examples of a `0kon` block and a `-1kon` block, which have been combined to obtain a composite parts in cross sectional view (red and yellow).

The dimension is indicated in mm for one block.

konstructive



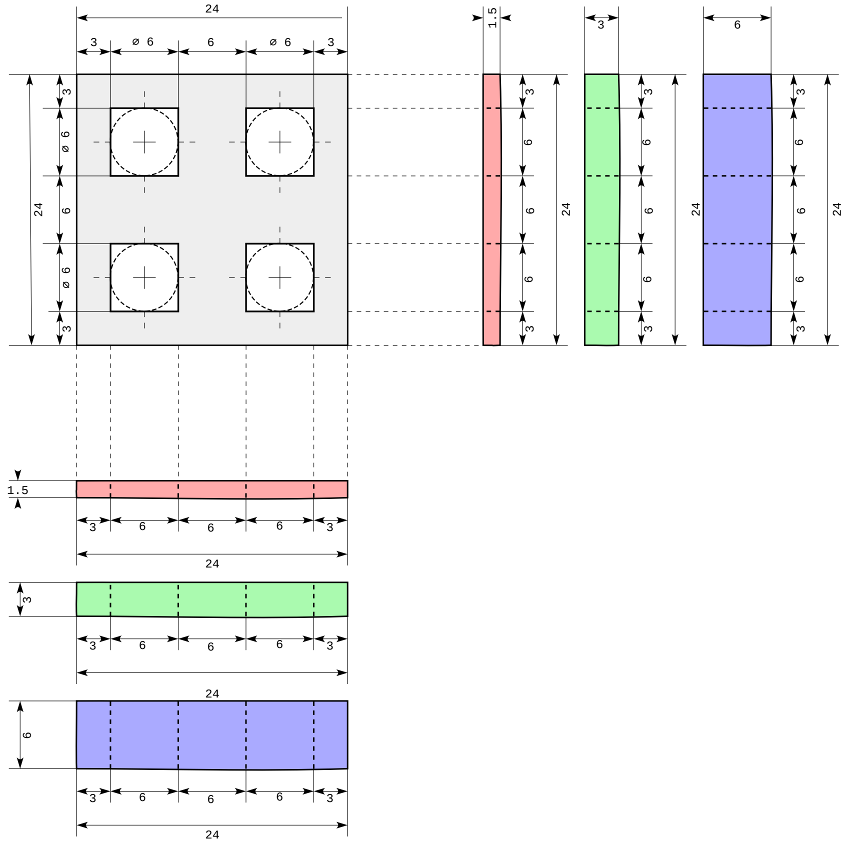
◄ **Figure 2-1. Plate (different** `konstructive` standard scale).

A plate (2 * 2 grid spacing units) is shown in blue.

The dimensions of this plate is shown for `-1kon` (red), `0kon` (black) and `+1kon` (blue).

Dimensions are indicated in mm.

konstructive

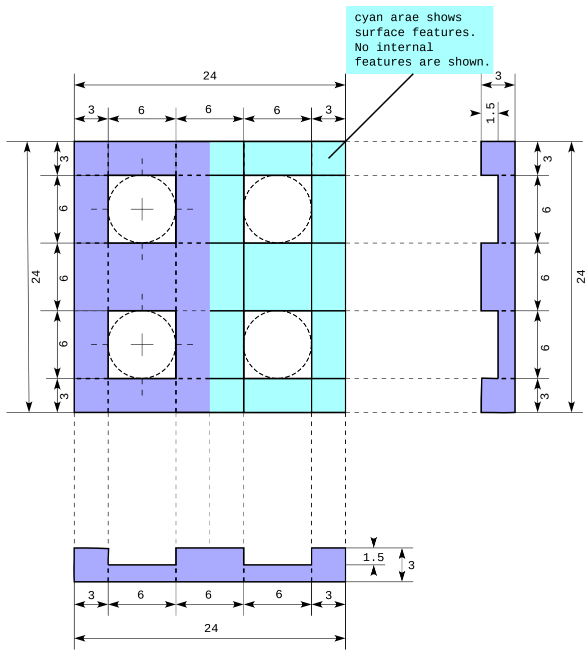


◄ **Figure 2-2. Plate with different thickness.**

A plate (2 * 2 * 0.25 grid spacing units, `0kon`) is shown (grey).

The side views of plates with either 1.5mm (red), 3mm (green), and 6mm (blue) are shown.

Dimensions are indicated in mm.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No internal
features are shown.
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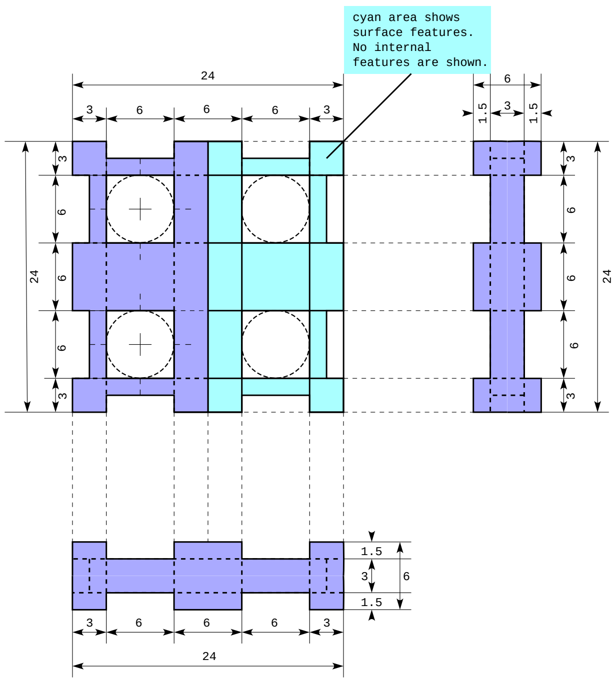
3
24

◄ **Figure 2-3. Plate (single recessed face).**

A plate (2 * 2 * 0.25 grid spacing units, `0kon`) with one recessed surface is shown (blue).

A part of the top view (cyan) shows surface features.

Dimensions are indicated in mm.


cyan area shows
surface features.
No internal
features are shown.
24
3
6
6
6
3
6
1.5
3
1.5
24
24
1.5
3
6
1.5

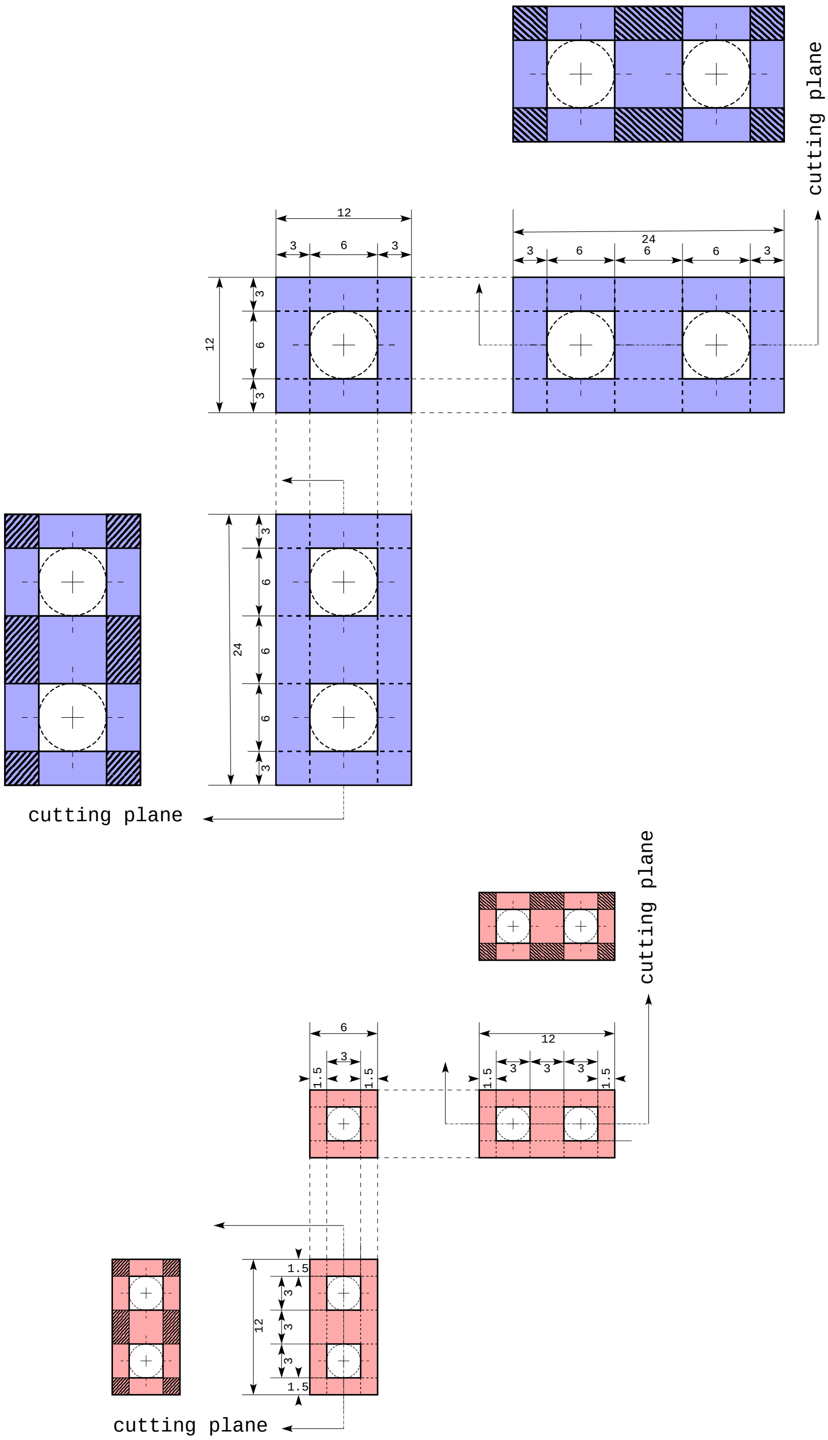
◄ **Figure 2-4. Plate (all faces recessed).**

A plate (2 * 2 * 0.25 grid spacing units, `0kon`) with all faces recessed is shown (blue).

A part of the top view (cyan) shows surface features.

Dimensions are indicated in mm.

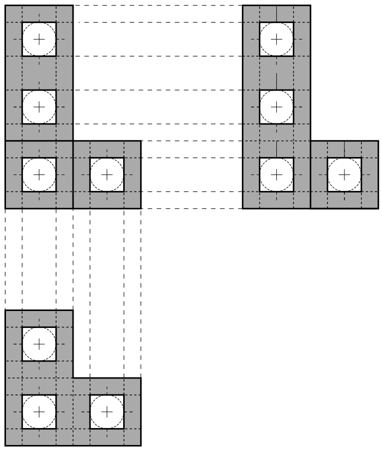
konstructive

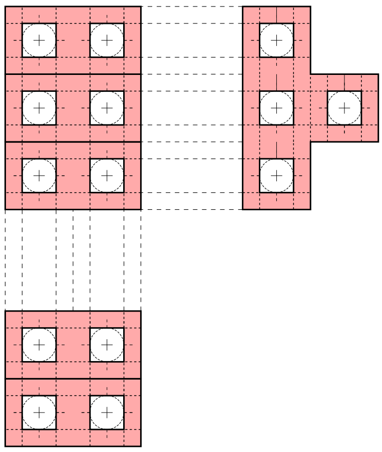


◄ **Figure 2-5. Blocks.**

Blocks (1* 1 * 2 grid spacing units) at `0kon` (blue, top) and at `-1kon` (red, bottom) are shown, including full sectional views.

Dimensions are indicated in mm.





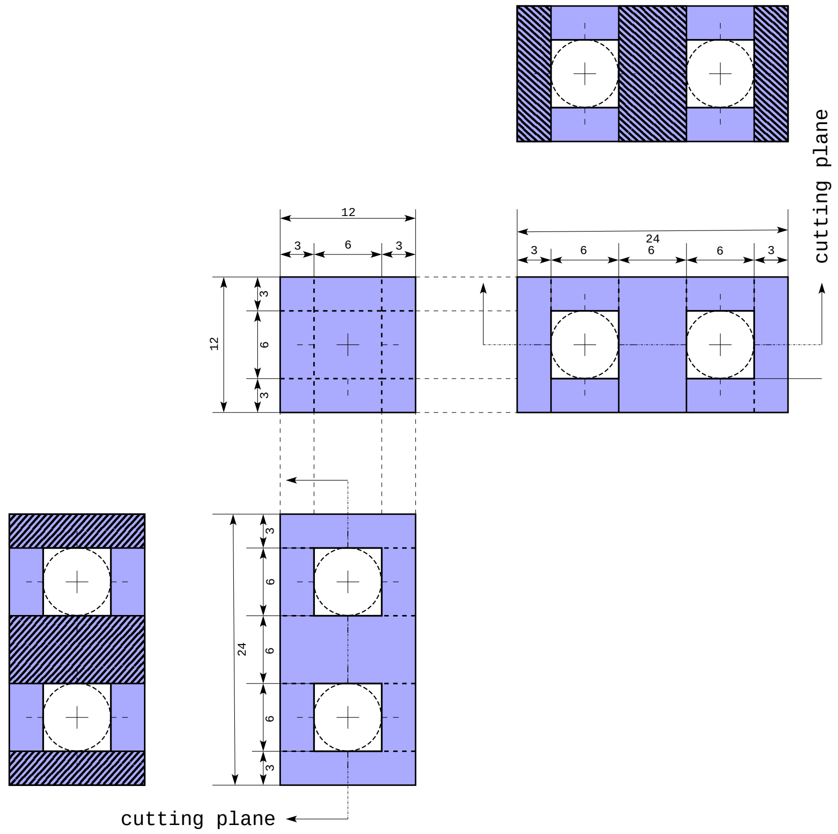
◄ **Figure 2-6. Complex (blocks)**

A complex block (consisting of 5 base blocks) is shown (top, grey)

A complex block (consisting of 8 base blocks) is shown (bottom, red)

No dimensions are indicated; individual base profile components follow `konstructive` dimensioning.

konstructive

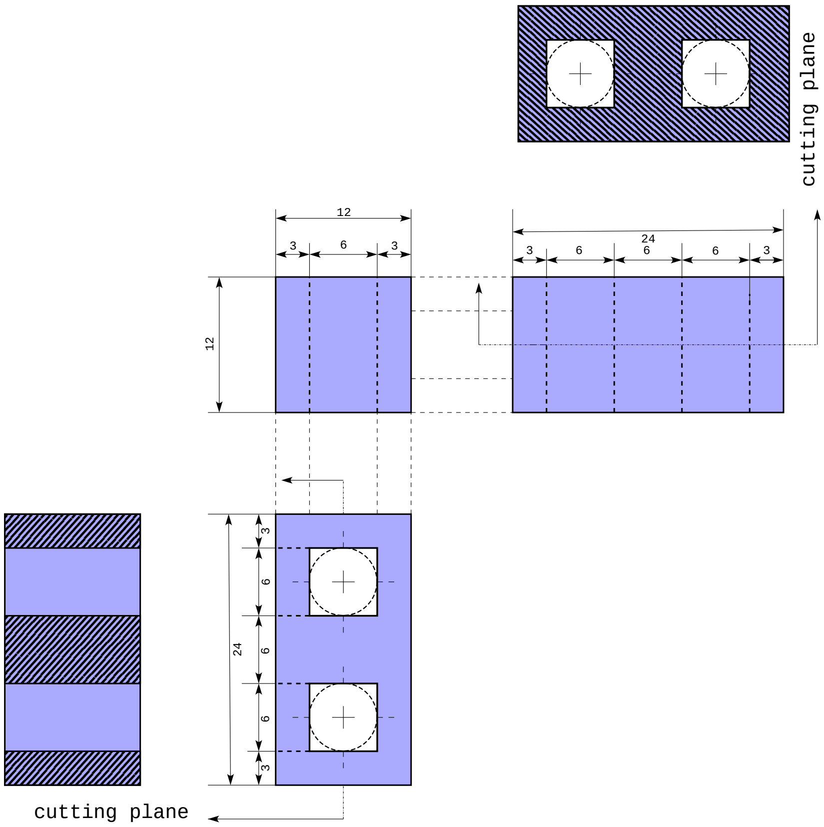


◄ **Figure 2-7. Block, partly reinforced.**

A 0kon partly reinforced block (1* 1 * 2 grid spacing units) is shown (blue), including full section views.

A central hole that traverses the two faces is only present on top/bottom and sides (left/right) and not along the length of the block.

Dimensions are indicated in mm.


cutting plane
12
3
6
3
24
3
6
6
6
3
12
24
3
6
6
6
3
cutting plane

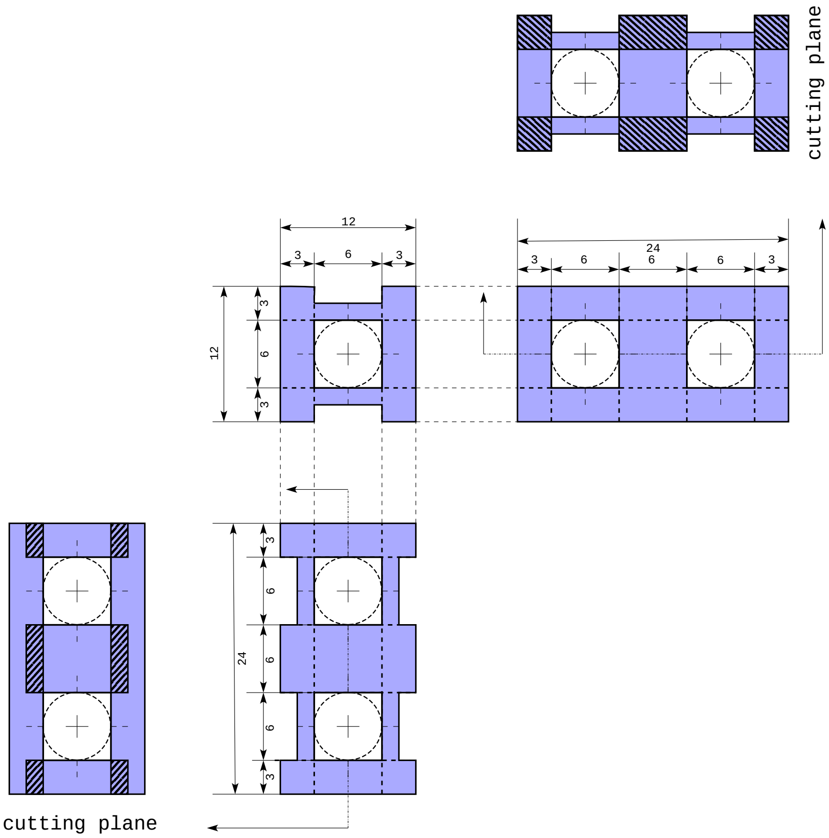
◄ **Figure 2-8. Block, fully reinforced.**

A `0kon` fully reinforced block (1* 1 * 2 grid spacing units) is shown (blue), including full section views.

A single central hole traverses two opposite faces.

The fully reinforced block can also be considered a plate with a thickness of one grid spacing.
Dimensions are indicated in mm.

konstructive

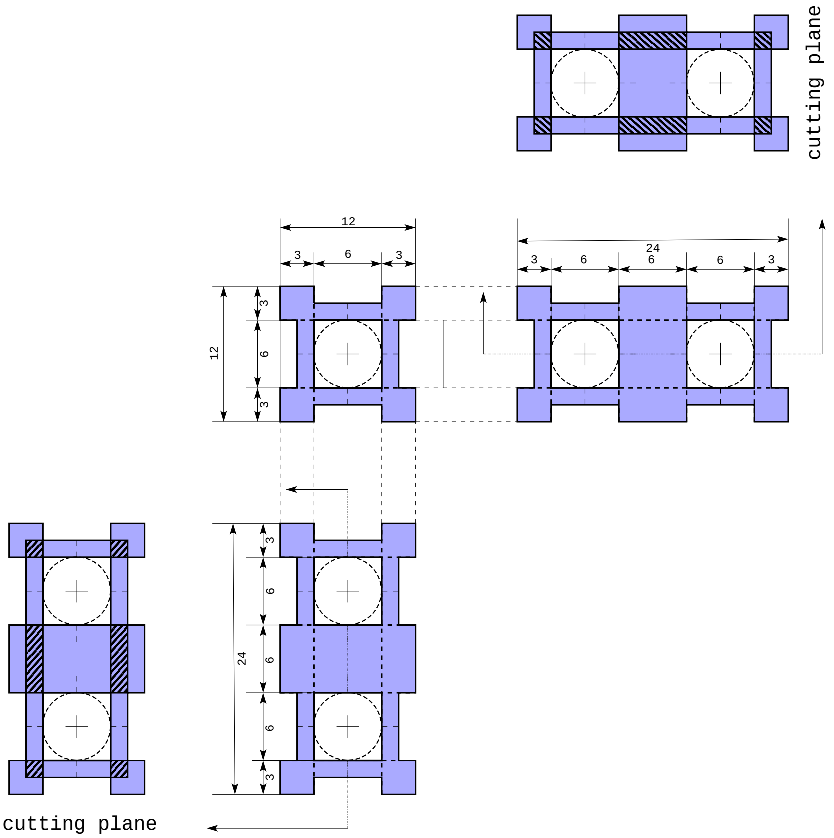


◄ **Figure 2-9. Block (two faces recessed).**

A `0kon` block (1* 2 * 2 grid spacing units) with tow recessed faces is shown (blue), including full section views.

Two opposite faces are recessed to accommodate interfacing with `-1kon` parts.

Dimensions are indicated in mm.


cutting plane
12
3
6
3
24
3
6
6
6
3
12
3
6
3
24
3
6
6
6
3
cutting plane

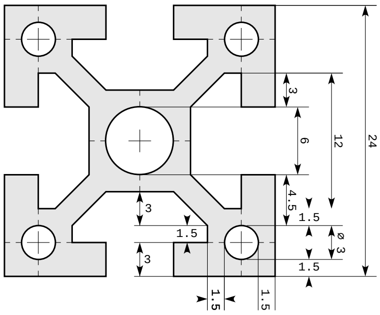
◄ **Figure 2-10. Block (all faces recessed).**

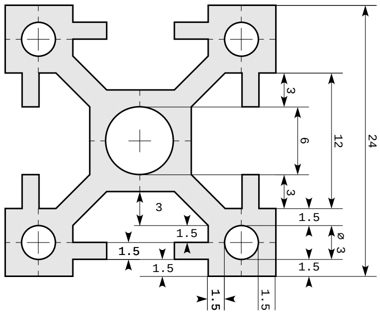
A fully recessed `0kon` block (1* 1 * 2 grid spacing units) is shown (blue), including full section views.

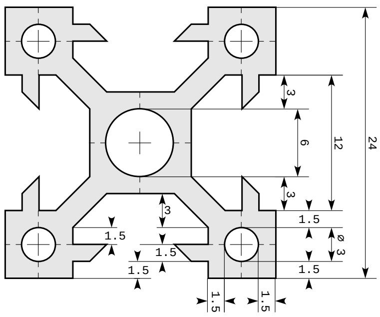
All faces are recessed to accommodate interfacing with `-1kon` parts.

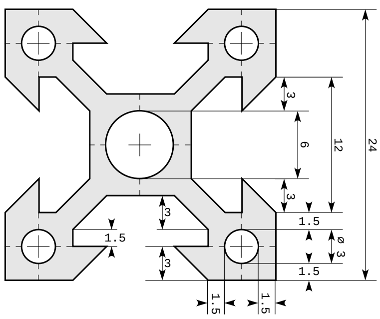
Dimensions are indicated in mm.

konstructive









◄ **Figure 2-11. Beam profiles**

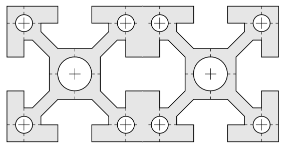
The beam profiles (cross section) are shown at `0kon`.

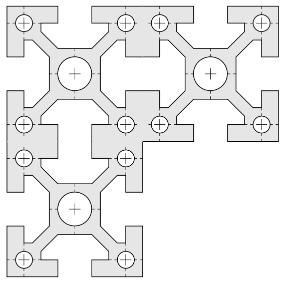
The beam profiles possess a groove that is 12 mm wide, and a grove cavity, which has the same dimensions for all profile implementations.

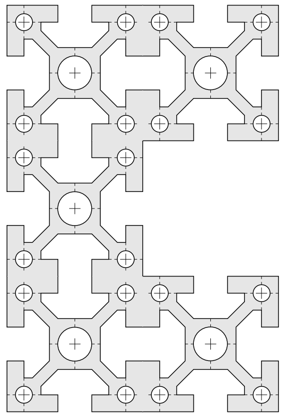
Four different implementations are shown, which feature differently shaped . The profile can either possess a straight edge (top), a recessed edge (second from top), recessed edge with a section that is angled at 45° (second from bottom), or an edge that is angled at 45° (bottom).

The cross sections are nor hatched to avoid obscuring of dimension indicators.

Dimensions are indicated in mm.





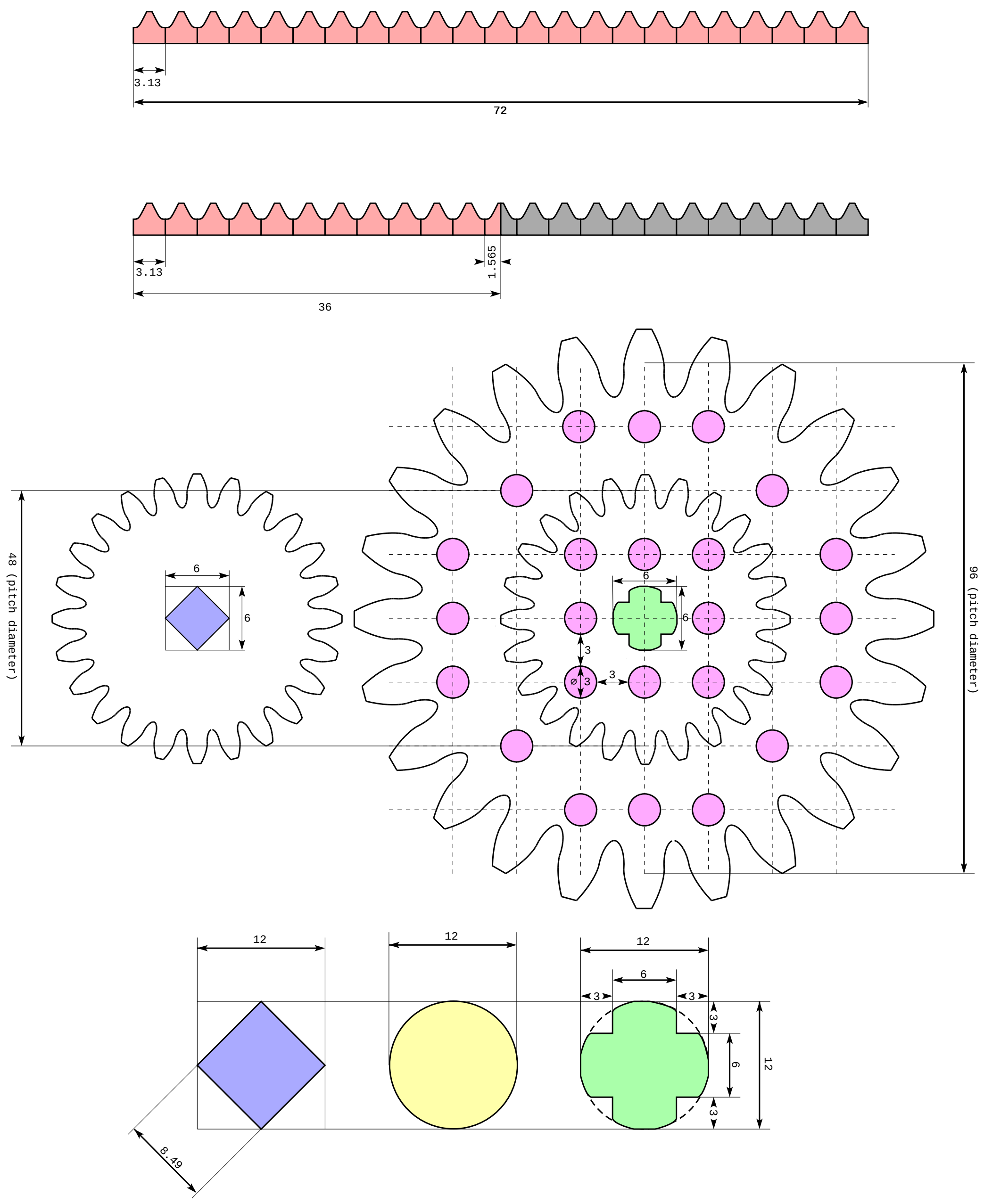


◄ **2-12 Composite beam profiles**

Examples for composite profiles (with straight edges) include a linear composite of two base profiles (top), an angle-shaped composite of three base profiles (middle), and a channel shaped composite of five base profiles (bottom)

No dimensions are indicated; individual base profile components follow `konstructive` dimensioning.

konstructive



◄ **Figure 2-13. Tracks, gears and axles holes.**

An part that approximates the module 1 distance (3.13 mm) within a multiple of the base grid system (`0kon`) at 72 mm is shown (top, red). The 72 mm track can be divided into tow equal parts (top, red and grey).

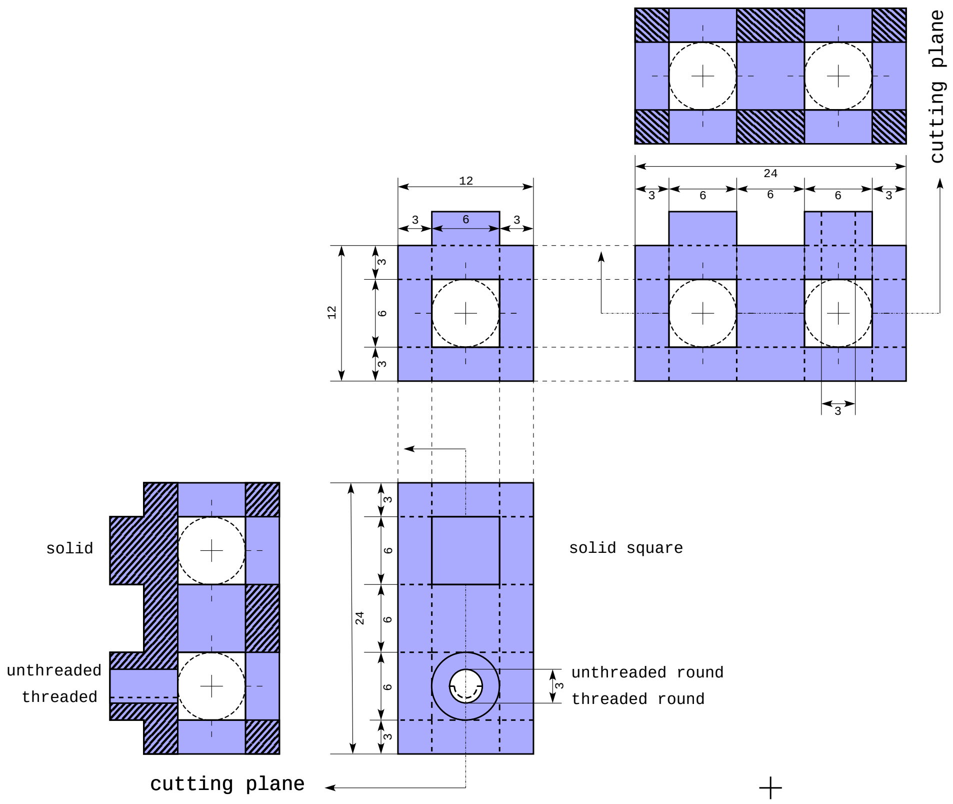
Top view of a 24 tooth involute gear with module 1 (pitch diameter of 48 mm), featuring a square shaped axle hole (blue), is shown (middle left).

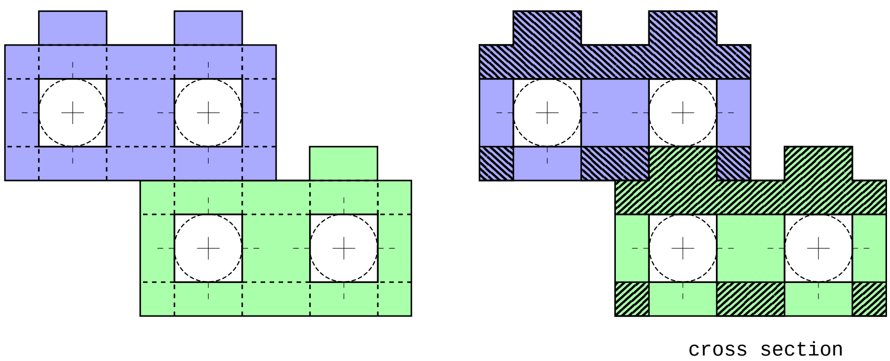
Top view of a composite gear composed of two 24 teeth involute gears (with module 1 and module 2), featuring a rounded cross shaped axle hole (blue), is shown (middle right). Holes (purple) that are dimensioned and located based on a `konstructive` scale standard and grid can be used to connect gears with one another through fasteners or connectors (middle, right).

The dimensions of a square shaped axle (blue, bottom left) and circular-shaped axle (yellow, bottom middle) and a rounded cross-shaped axle (green, bottom right) at `0kon` are shown.

Dimensions are indicated in mm.

konstructive





◄ **Figure 3-1. Assembly of blocks (integrated connector).**

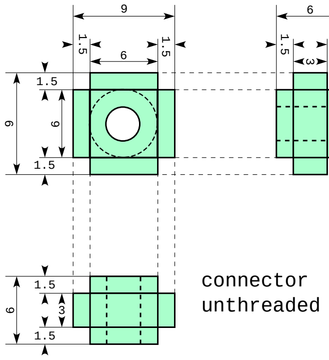
A `0kon` block (featuring an integrated connector) is shown (top, blue).

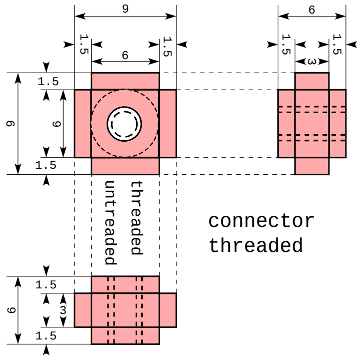
The connecting element is either cylinder-shaped or cube-shaped, and may be solid or possess a central hole, which may be unthreaded (allowing the passing of a screw) or threaded (interacting with a screw).

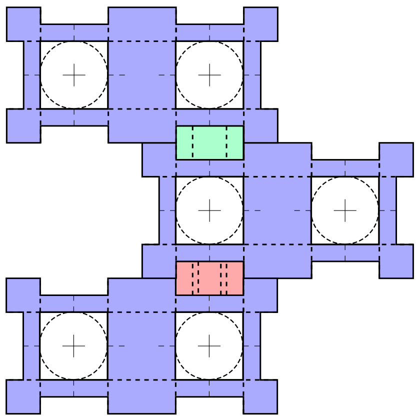
Surface view of the two `0kon` connector blocks without a central hole (blue and green) are shown (bottom left).

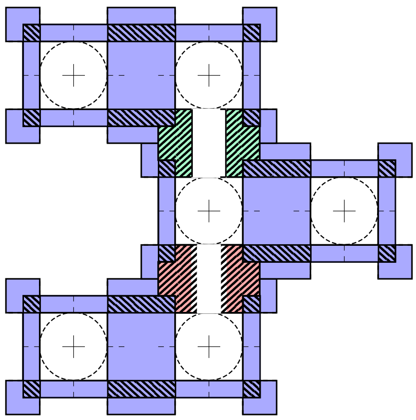
A cross sectional view of this assembly is shown (bottom right).

Dimensions are indicated in mm.


9
6
1.5
3
connector
unthreaded


9
6
1.5
3
threaded
untreaded
connector
threaded





◄ **Figure 3-2. Assembly blocks (external connector).**

A `0kon` connector is shown (top, green).

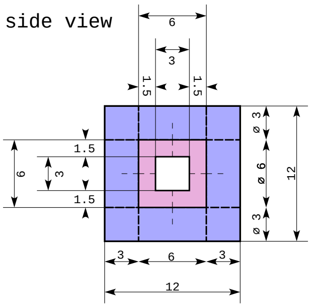
The connector may be solid or possess a central hole, which may be unthreaded (allowing the passing of a screw) or threaded (interacting with a screw).

A cross sectional view of this assembly is shown (bottom).

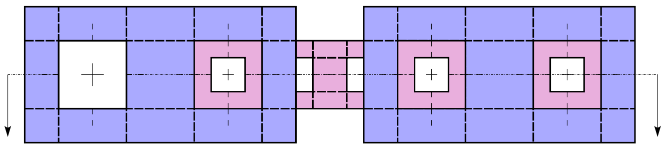
Dimensions are indicated in mm.

konstructive

side view

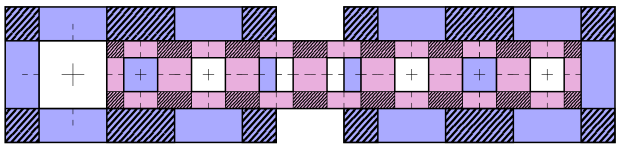


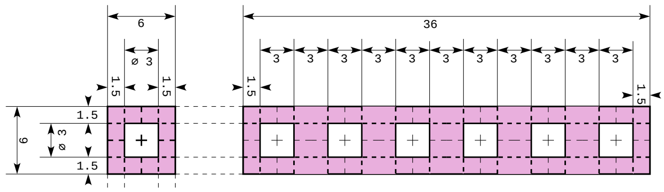
top view

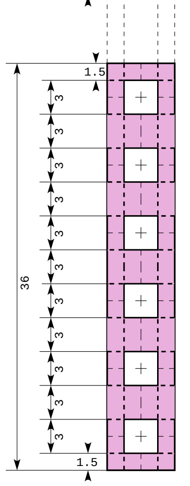


cutting plane

side view (full section)







internal connector block

◄ **Figure 3-3. Assembly of blocks (internal blocks).**

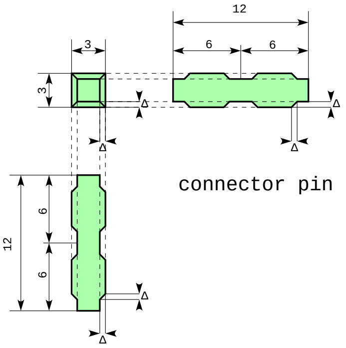
A `-1kon` block functioning as a connector is shown (bottom, red).

An assembly of two `0kon` blocks (blue) connected by a `-1kon` block (red) are shown (top).

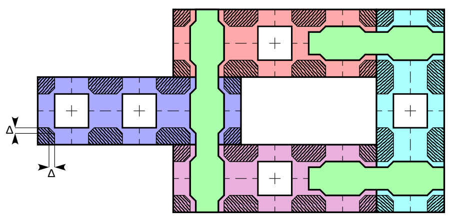
A cross sectional view of this assembly is shown below.

Dimensions are indicated in mm.

konstructive

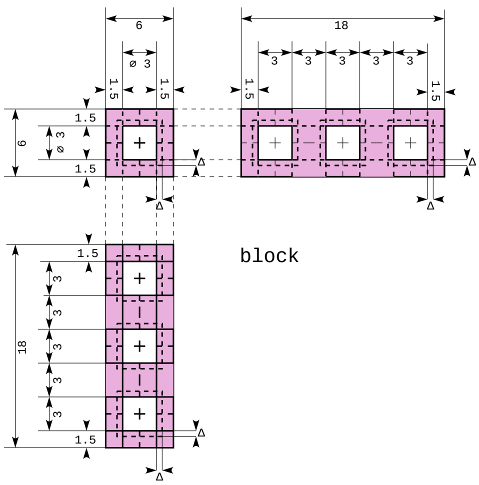


connector pin



assembly

full section



block

◄ **Figure 3-4. Assembly of blocks (internal pins).**

A `-2kon` pin (1 * 1 * 2 grid spacing units) functioning as a connector is shown (top, green).

A `0kon` block (1 * 1 * 3) is shown (bottom, purple).

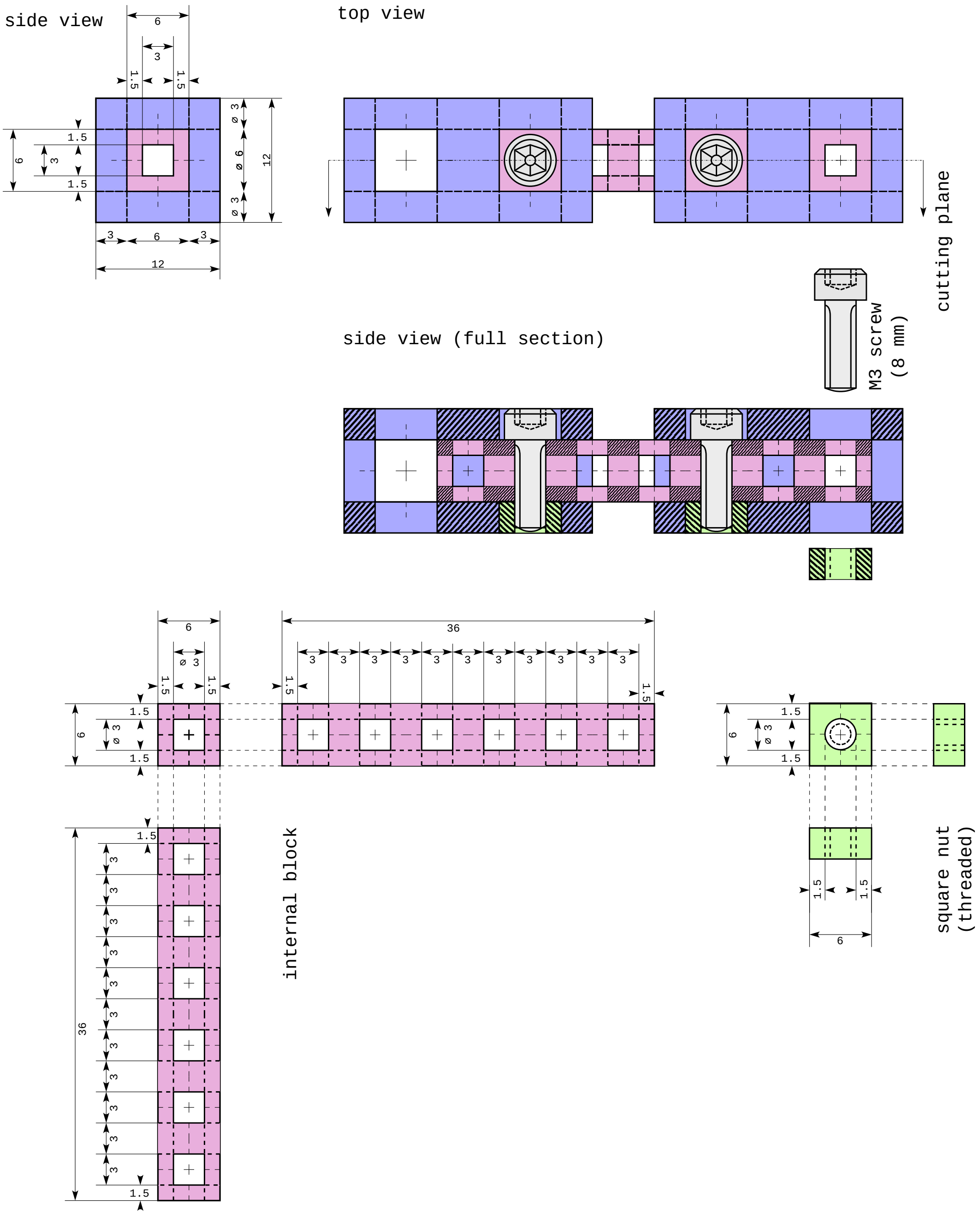
An assembly of `-1kon` blocks (blue, red, green, cyan and purple) connected by `-1kon` pins (green) is shown (middle).

A cross sectional view of this assembly is shown below.

The delta symbol (Δ) indicates a small distance, which depends on manufacturing tolerances and material properties.

Dimensions are indicated in mm.

konstructive



◄ **Figure 3-5. Assembly of blocks (internals block, square nut, and screw).**

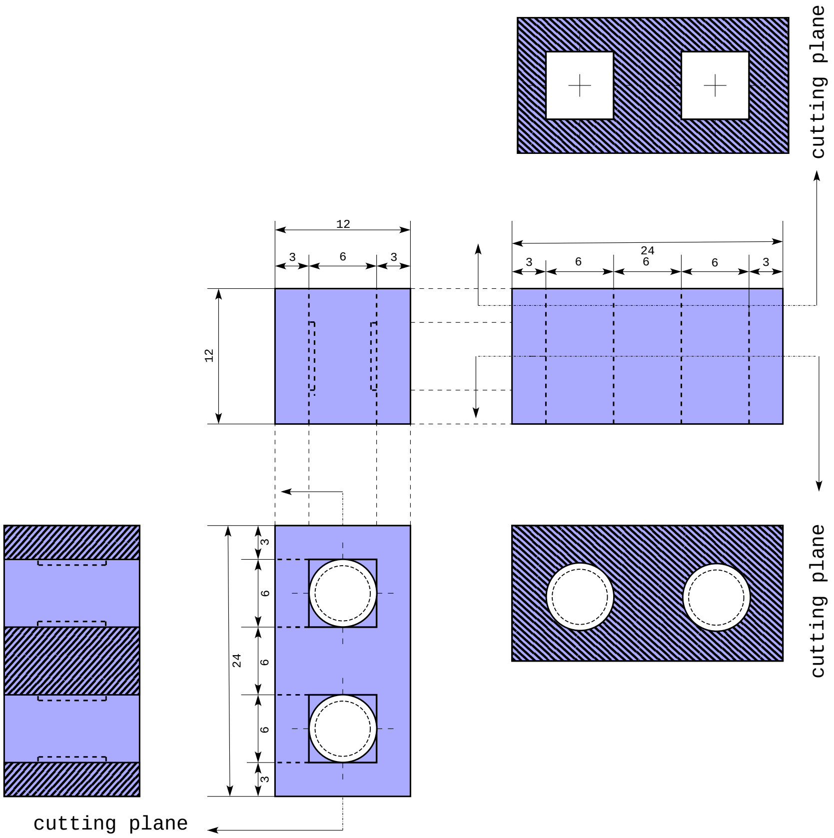
Top view, side view (top) and cross sectional view (middle) of an assembly consisting of two `0kon` blocks (blue), fastened by an internal `-1kon` block (red), a M3 screw (grey) and a threaded square nut (green).

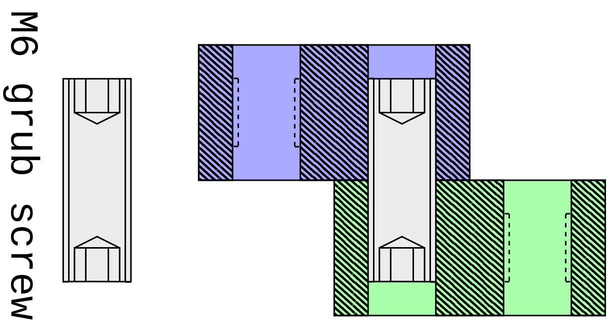
Top and side views of the internal `-1kon` block (red) are shown (bottom left).

Top and side views of a `-1kon` the M3-threaded square nut are shown (bottom right).

Dimensions are indicated in mm.

konstructive





◄ **Figure 3-6. Assembly of blocks (threaded, screws)**

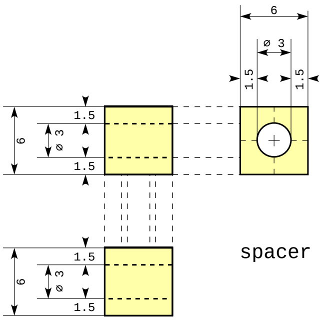
A 0kon threaded, fully reinforced block (1* 2 * 2 grid spacing units) is shown (blue), including full section views.

A M6 grub screw (grey) is shown (bottom).

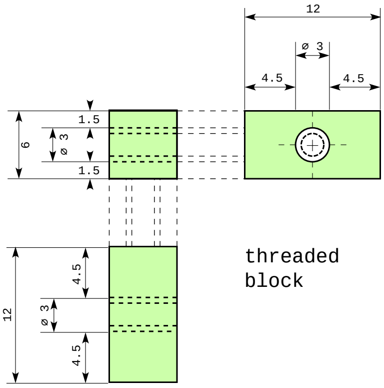
A single central hole traverses two opposite faces. The hole is square-shaped towards the face of the block and circle-shaped and M3-threaded at the centre to allow interfacing with M6 screws.
The fully reinforced block can also be considered a threaded plate with a thickness of one grid spacing.

Dimensions are indicated in mm.

konstructive

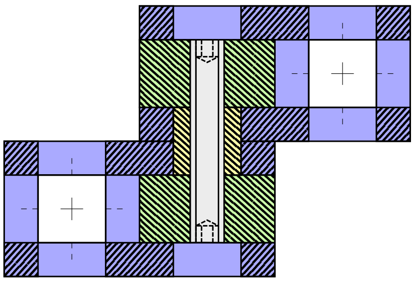


spacer

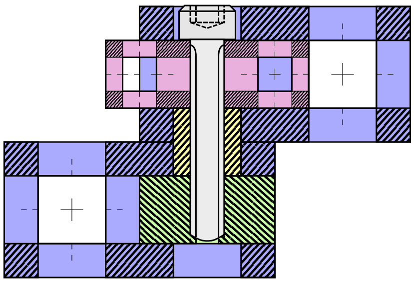


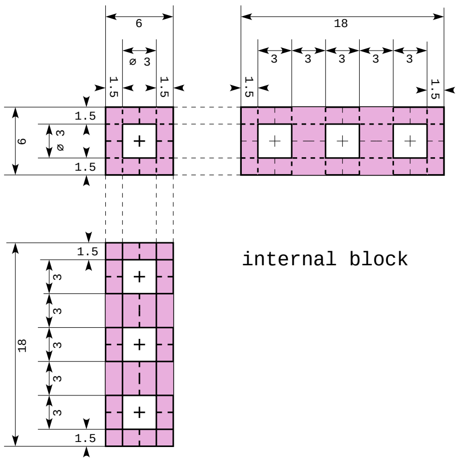
threaded block

side view (full section)



side view (full section)





internal block

◄ **Figure 3-7. Assembly of blocks (spacer, threaded block, screw).**

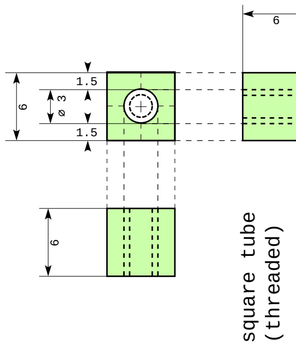
A `-1kon` spacer is shown (top left, yellow).
A `-1kon` threaded block is shown (top middle, green).
A `-1kon` internal block is shown (bottom, red).

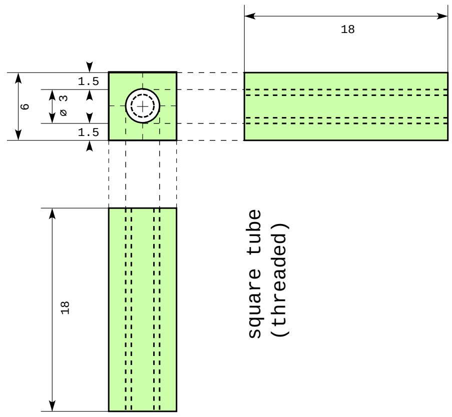
Cross sectional view of an assembly of two `0kon` blocks (blue) fastened by an M3 grub screw, interfacing and two `-1kon` threaded blocks (green) and passing through a `-1kon` spacer (yellow) is shown (middle left).

Cross sectional view of an assembly of two `0kon` blocks (blue) fastened by an M3 socket head screw interfacing with a `-1kon` internal block (red), a `-1kon` threaded block (green) and passing through a `-1kon` spacer (yellow) is shown (middle right).

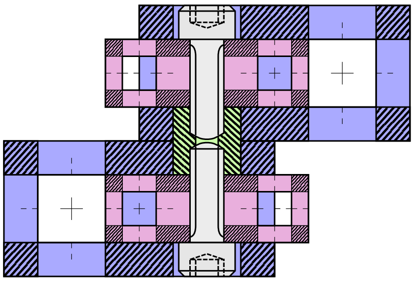
Dimensions are indicated in mm.

konstructive

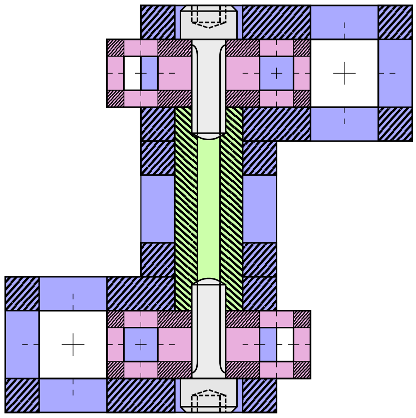


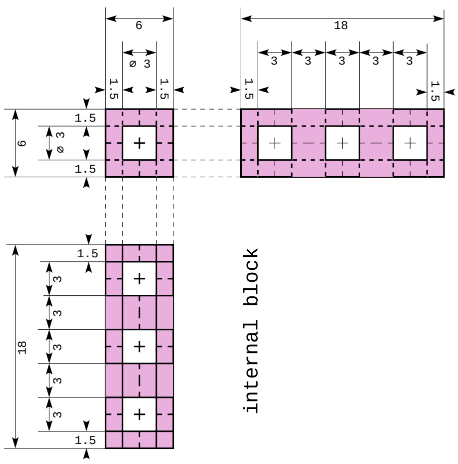


side view (full section)



side view (full section)





◄ **Figure 3-8. Assembly of blocks (internal block, coupling nut, and screw).**

A `-1kon` coupling nut (1 * 1 * 1 grid distance units) and a `-1kon` coupling nut (1 * 1 * 3 grid distance units) are shown (top, green).

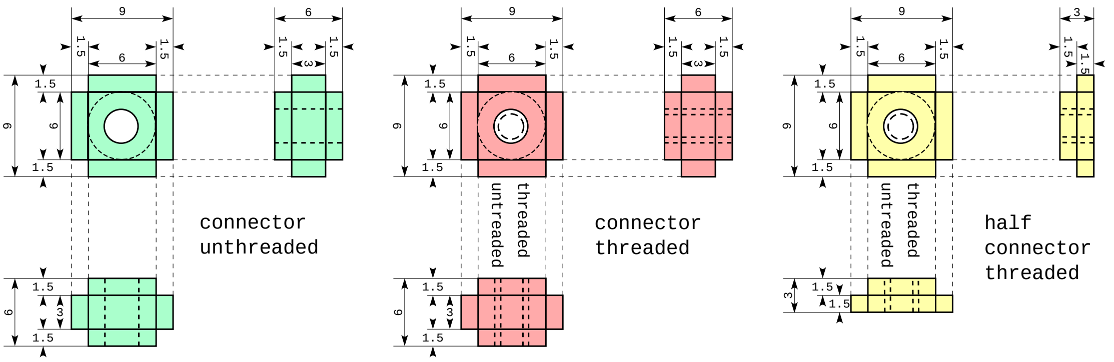
A `-1kon` block (1 * 1 * 3) is shown (bottom, purple).

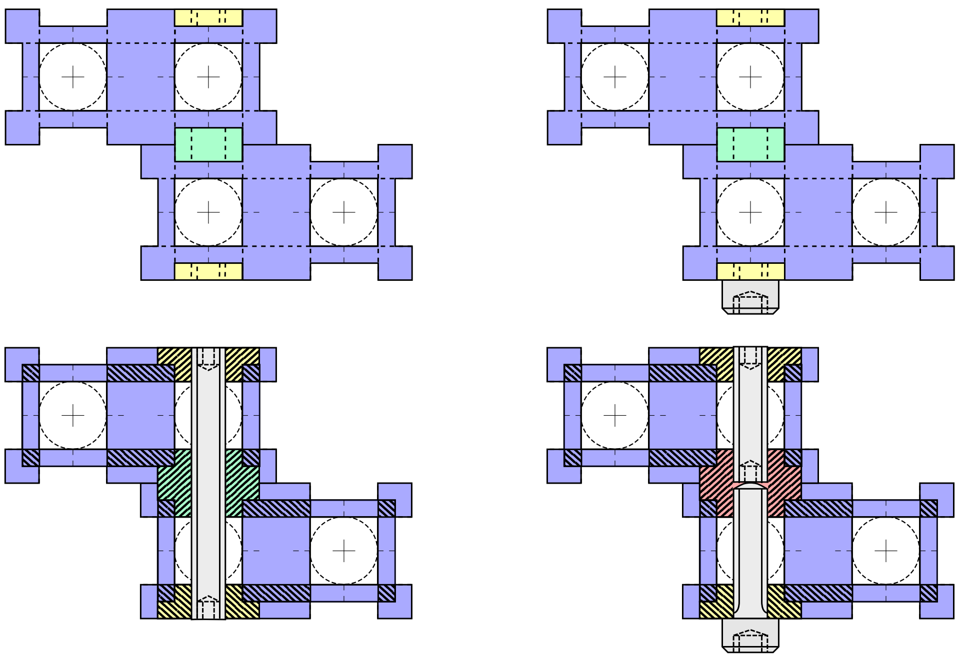
A cross sectional view of an assembly consisting of two `0kon` blocks (blue) fastened by an M3 screw (grey) and a threaded fastener (green) passing through tow internal `-1kon` blocks (red) is shown (middle left).

A cross sectional view of an assembly consisting of three `0kon` blocks (blue) fastened by an M3 screw (grey) and a M3-threaded fastener is shown (middle right).

Dimensions are indicated in mm.

konstructive





◀ **Figure 3-9. Assembly of blocks (external connector, screws).**

A -1kon unthreaded connector is shown (top, green).

A -1kon threaded connector is shown (top, red).

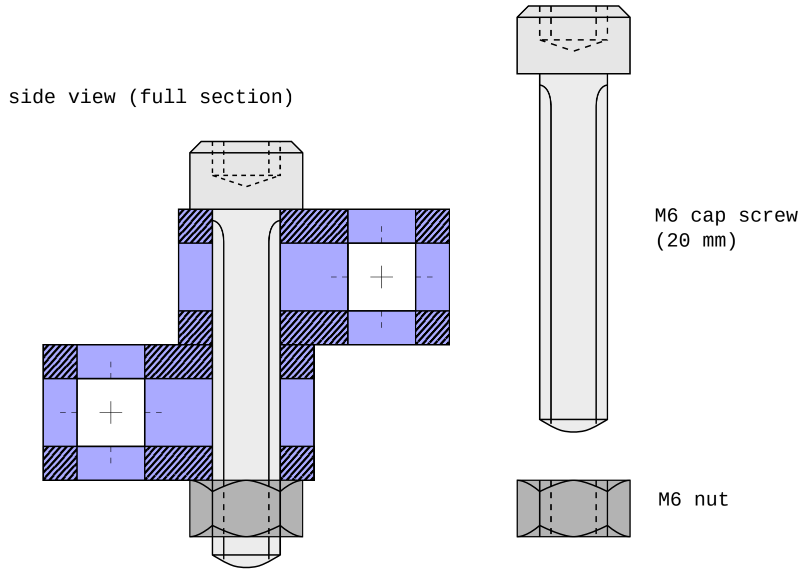
A -1kon threaded half connector is shown (top, yellow).

Assembly of two fully recessed 0kon blocks (blue) mediated by an M3 grub by interfacing with two -1kon threaded half connectors (yellow) and passing through and a -1kon unthreaded connector (green) is shown (middle left).

Assembly of two fully recessed 0kon blocks (blue) mediated by an M3 grub screw and M3 socket head screw interfacing with two -1kon threaded half connectors (yellow) and a -1kon threaded connector (red) is shown (middle right).

Cross sectional views of this assemblies are shown (bottom).

Dimensions are indicated in mm.


side view (full section)
M6 cap screw
(20 mm)
M6 nut

◄ **Figure 3-10. Assembly of blocks (screw).**

Full sectional side view of an assembly consisting of an 0kon block (blue), an M6 screw (grey), and an M6 nut (grey) is shown.

Dimensions are indicated in mm.