Slabs

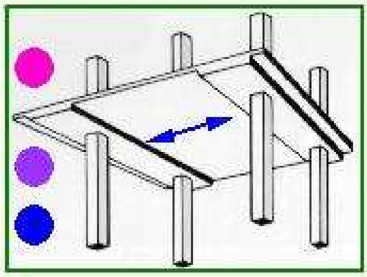
Six types of reinforced concrete slab are shown below. They can

be supported by beams or walls on one or more sides,

or be supported directly by columns, known as flat slab or flat plate construction;

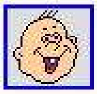
be solid or consist of a number of ribs to reduce weight;

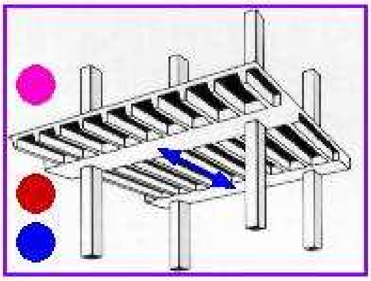
span in either one or two directions.

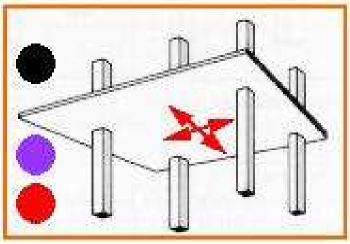


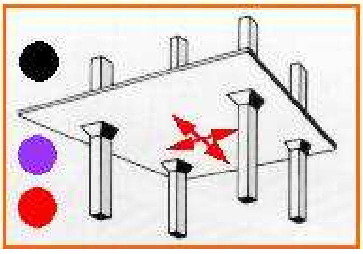
Click on the 2 slabs which will always span in one direction.

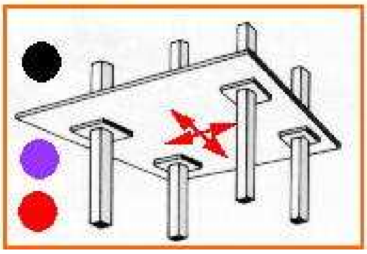
Well done, you have correctly chosen both

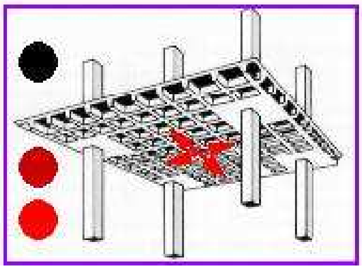








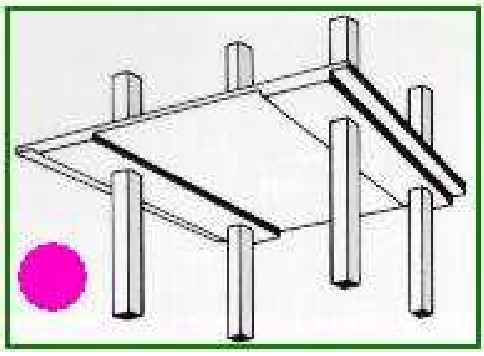




One way slab

A 1-way beam and solid slab system is best suited to a rectangular column grid with long beam spans and shorter slab spans. 2-way beam systems tend to complicate formwork, reinforcement details and the provision of services.

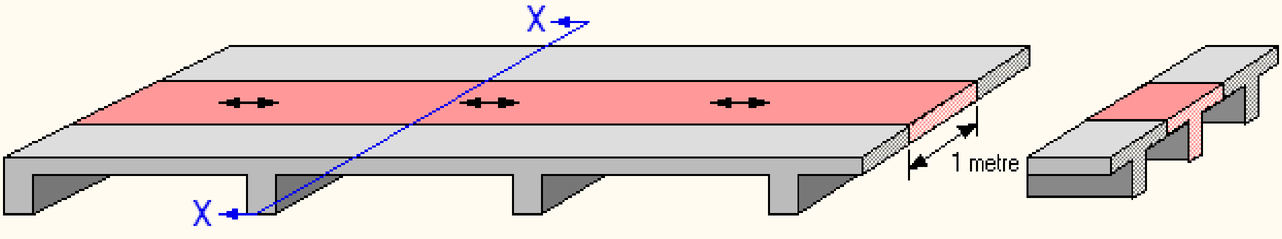
This is a band beam and slab construction, where shallow band beams are used to minimise the depth.



Span up to 8 m, $h \sim l / 26$, až 0,30 m

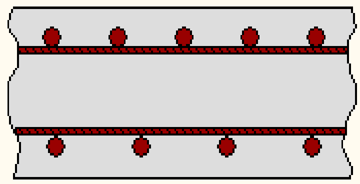
One way slab

Generally, 1-way spanning slabs are analysed as a continuous beam strip (see Part 1 Analysis of Structures) subject to the most unfavourable arrangements of load. The continuous slab spans between the transverse beam supports.



Rather than analyse the full width of the slab, it is common practice to analyse a 1 metre wide strip or a single rib. The resulting moments may be redistributed.

The main reinforcement is placed in the outer layer in the direction of spanning to provide the maximum lever arm. In solid slabs secondary or distribution reinforcement, generally a minimum percentage, is placed in the transverse direction to form a reinforcement mesh.

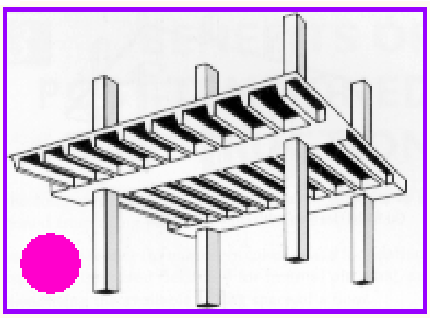


section X - X

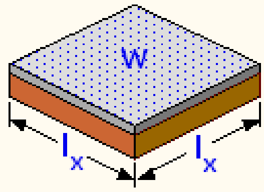
One way ribbed slab

One-way spanning ribbed slabs, or trough slabs, are best suited to a rectangular column grid with long slab spans and shorter beam spans. A lightly reinforced structural topping is provided, within which openings for services are easily formed.

Here the ribs span between beams within the depth of the slab to provide a level soffit.



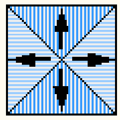
Two way slab



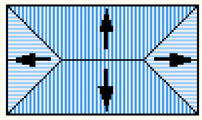
A square, unrestrained, simply supported slab of effective span l_x, continuously supported on all four sides is subjected to a uniform distributed load of w per unit area. The mid span moment per unit width in each direction is $\beta w l_x^2$.

For a 1-way spanning, simply supported slab the value of β is 0.125, but being supported on all four sides reduces the mid-span deflection and hence the bending moment. In this case by exactly a half to 0.0625.

The load on the slab is shared equally between the four sides, thus

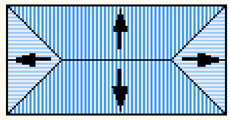


but as the aspect ratio (longer side to shorter side) of the slab is increased, the amount of load transferred to the shorter sides remains the same, while the increased load is transferred to the longer sides, thus



The value of β increases in the shorter direction and decreases in the longer direction, tending to 0.125 and 0 respectively as the aspect ratio tends to infinity.

When the aspect ratio exceeds ---- the slab can be considered to be 1-way spanning. What is this value ? 2

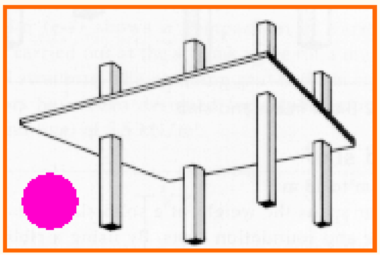


That's right.

Span up to 10 m, $h \sim l_x / 38$

Flat slab

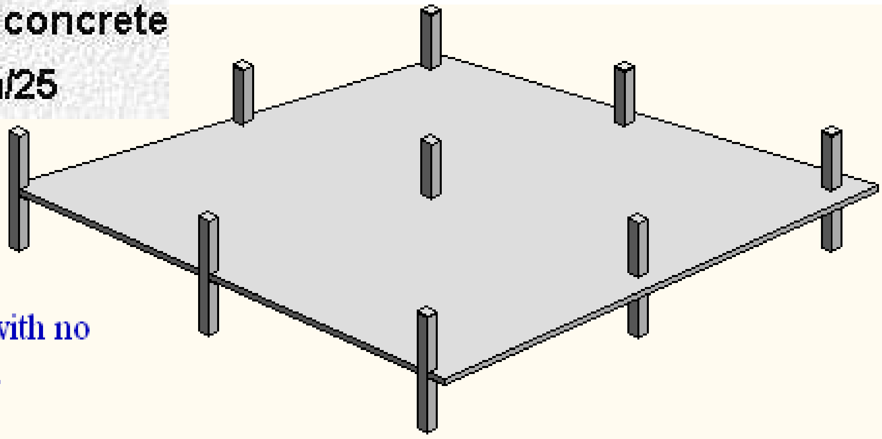
Flat slabs are best suited, but not limited, to a square column grid. Solid slabs of constant thickness are easy to construct and make routing of horizontal services very easy. Shear reinforcement may have to be provided around the column heads to avoid punching failures.



Span Range:

- up to 8m for reinforced concrete
- up to 10m for prestressed concrete
- overall depth around span/25

Flat slab



A flat slab floor is a reinforced concrete slab supported directly by the columns with no intermediate beams. Because of this it ....

- is simple to construct, requiring the minimum of formwork,
- minimises construction depths, and
- provides a clear soffit for routing services.

However, the absence of beams means that the slab has to ....

- carry the shear forces, which are concentrated around the column,
- transmit the moment to the edge and corner columns,
- suffer greater deflections.

Flat slab

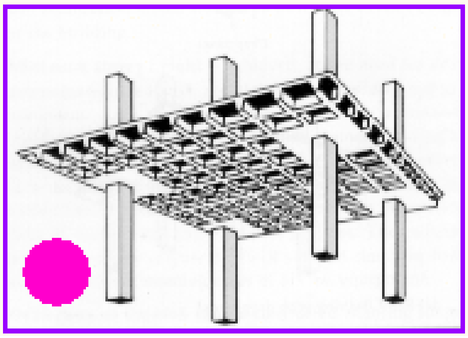
Punching shear

A laboratory test for punching shear failure.

Two way ribbed slab

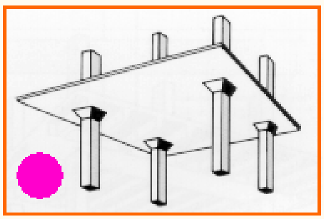
Two-way spanning ribbed slabs, or waffle slabs, are best suited, but not limited, to a square column grid arrangement of larger dimensions than for a solid slab. Solid sections are provided around the columns to resist punching shear.

Here solid beam strips are provided between the columns.



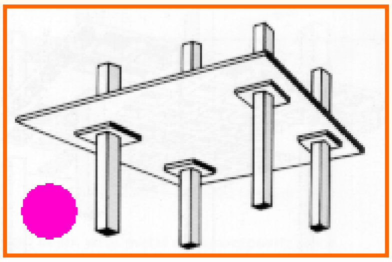
Enlarged column heads

In flat slabs, shear reinforcement around the column heads can be avoided, or reduced, by providing enlarged column heads, also called mushroom heads or column capitals. These complicate the construction process, but enable longer spans to be provided.



Drop panels

Providing drop panels around the column heads enables flat slabs to carry large shear forces without the need for shear reinforcement. Although longer spans can be provided, the drops complicate the construction process and can interfere with the routing of services.



Analysis of slab

Theoretically all slabs are two-dimensional systems with bending in two orthogonal directions. In practice, however, some slabs are continuously supported just on two opposite, parallel sides, such that bending effectively occurs only in one direction, the bending moments in the transverse direction being negligible.

According to classical plate theory, in addition to bending moments M_x and M_y there are also twisting moments M_{yx} and M_{xy}, as well as the plate shears V_x and V_y. In general,for reinforced concrete floor slabs it is only necessary to design for M_x and M_y and sometimes to provide restraint against the twisting moments at external slab corners.

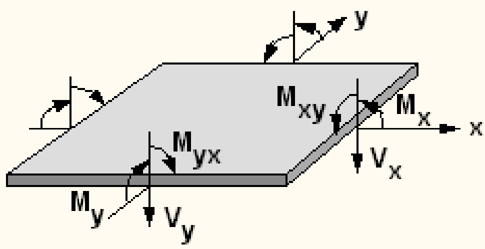


plate element

Any system of floor slabs can be analysed as a grillage or a finite element plate by any number of computer programs. These methods are not examined in this package.

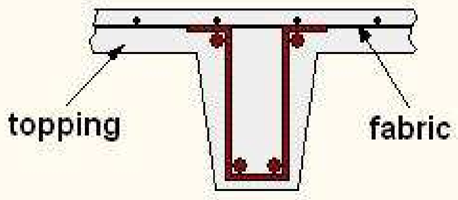
Simpler methods can be adopted for most floor layouts subject to uniform loading, and these are discussed for various slab types on the next few pages. Concentrated loads can produce severe bending moments and shear forces requiring special attention.

A plastic analysis such as yield line theory or the strip method may be used for single panels. Both these methods are discussed at the end of this topic.

Shear reinforcement

Traditionally shear reinforcement is not provided in solid slabs to resist direct shear forces. If the shear force exceeds the shear resistance of the slab then the design parameters are altered, say by increasing the depth of the slab.

However, this is not the case with ribbed slabs which are designed to carry heavier loads, and where it is normal practice to provide shear reinforcement in each rib. The typical link arrangement below also shows the common practice of providing a nominal percentage of fabric reinforcement in the structural topping.



Shear reinforcement is usually required around the supporting columns in flat slab construction to resist the effects of punching shear. This can be in the form of links as shown, but there are alternative solutions which are discussed in the topic 'Punching Shear'.

Indicative dimensions of slabs

Slabs

One way spanning slabs h_{min}

– simple supported................. $l_1/25 – l_1/20$ (50 mm)

– continuous and fixed .... . $l_1/33 – l_1/30$ (50 mm up to 1 m)

(60 mm up to 1,5 m)

(70 mm obove 1,5 m)

– cantilevered .... $l_1/10$ (50 mm)

Indicative dimensions of slabs

Slabs

Two way slabs

		h_{min}
– simply supported…………….	$l_1/33$	(100 mm)
– partially fixed ……………...	$l_1/40$	
- fully fixed …	$1{,}2\ (l_1 + l_2)/105$	(100 mm)

Indicative dimensions of slabs

		h_{min}
Two ways lighten (ribbed) slabs		
– simply supported……………………..	$l_1/20$	
– partially or fully fixed …………….....	$l_1/25$	
Locally supported slabs		
– flat slab …………………………….	$l_2/33$	(160 mm)
– enlarged heads………………… ...	$(l_2 - 2c/3)/35$	(120 mm)

l_2 is a greater span, c effective width of the head

Indicative dimensions of concrete beams

	h	b
Simply supported and continuous beams		
– with imposed loads …………	$l_1/15 - l/_1 12$	(0,33 – 0,4) h
– roof … ………………………………	$l_1/17 - 1_1/14$	(0,33 – 0,4) h
Cantilever beams		
– withy imposed loads ………….	$l/5$	(0,33 – 0,4) h
– roof ………………… ………………	$l/10$	(0,33 – 0,4) h

Indicative dimensions of concrete components

	h	b
Beams		
– with imposed loads …… …..	$l/12$ – 1/8	(0,3 – 0,5) h
– roofs ………………… …	$l/14$- $l/12$	(0,3 – 0,5) h

Columns

– middle column of a multistorey building

$$A_s = \frac{\sum N_d}{0{,}8 f_{cd} + \rho_s\, f_{yd}}$$

Minimum dimensions:
- 200 mm, cast in situ
- 140 mm, prefabricated columns