# TWO-WAY SLAB

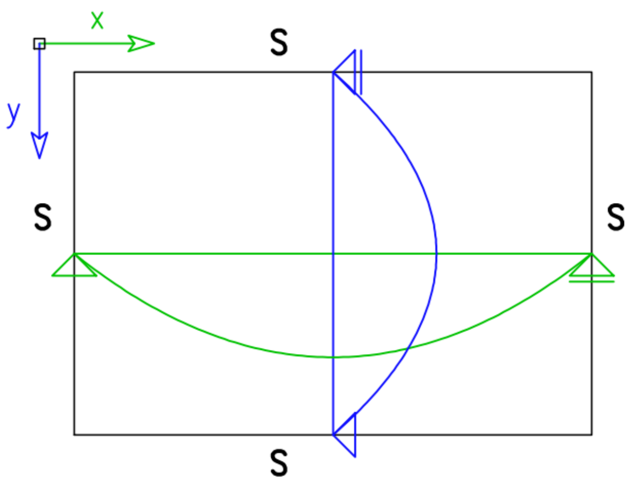
Two-way slabs are surface members acting in a both directions. They are supported on all four sides. The ratio of length to width of one slab should less than 2 otherwise one-way action is obtained, even though supports are provided on all sides. In many cases the slabs are of such proportions and are supported in such way that two-way action results. An optimal plan geometry with all same supports is a square, based on load distribution into both directions.

## Preliminary Design of Slab Thickness

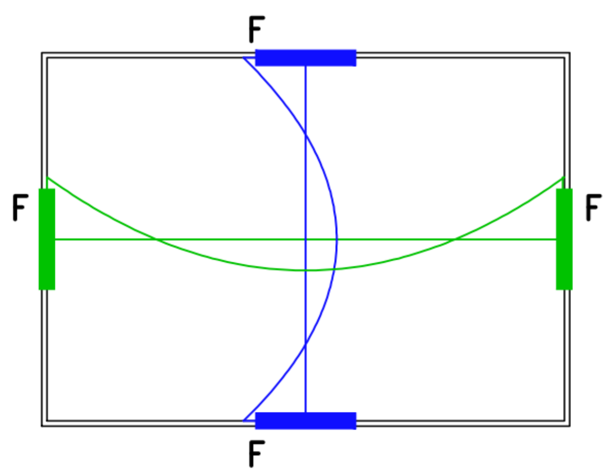
Thickness design depends on boundary conditions (supports). We can distinguish two basic conditions:

- Simple support at all sides (SSSS) → appropriate $h_s = 1.1\ (L_x + L_y)\ /\ 75$,
- fixed support at all sides (FFFF) → appropriate $h_s = 1.2\ (L_x + L_y)\ /\ 105$.

For other boundary conditions is reasonable to keep thickness in range between all fixed and all simply supported edges, but minimum depth is ***80 mm***.




$h_s = 1.1(L_x + L_y)/75$




$h_s = 1.2(L_x + L_y)/105$

## Structure Load

Slabs are loaded by uniform load per square meter (kN/m$^2$) in the mostly cases. It is convenient to think of it as consisting of two sets of parallel strips, in each of the two directions, intersecting each other (mostly perpendicular to each other). Evidently, part of the load is carried by one set and transmitted to one pair of edge support, and the remainder by the other. To obtain internal forces in each way is necessary to compute load for corresponding direction. Because the imaginary strips actually are part of the same monolithic slab, their deflection at the intersection point must be the same. The line load can be obtain by means of split factor $c_x$ based on assumption of the identical center deflection of the short and long strips ($w_x = w_y$).

<u>Example:</u> Task is to derive a split factor $c_x$ for two-way slab with supports in direction $x$ as simple-simple (SS) and in direction $y$ as simple-fixed (SF).

Presumption: $w_x = w_y$ in center of both directions.

$$\frac{5}{384}\frac{f_{d,x}\cdot L_x^4}{EI}=\frac{2}{384}\frac{f_{d,y}\cdot L_x^4}{EI} \quad | \; f_d = f_{d,x} + f_{d,y} \rightarrow \quad f_{d,x}=c_x f_d; \quad f_{d,y}=(1-c_x)c_x f_d$$

$$\frac{5}{384}\frac{c_x f_d\cdot L_x^4}{EI}=\frac{2}{384}\frac{(1-c_x)\, f_d\cdot L_x^4}{EI}$$

$$c_x=\frac{2L_y^4}{5L_x^4+2L_y^4}$$

## Dimensioning Internal Forces

Obtained results are approximate because actual behavior of a slab is more complex than that of the two intersecting strips. Whether is ensured that slab corners cannot heave upward it is allowed to reduce design values of bending moment by coefficient $\kappa$, but <u>only</u> in <u>mid-span</u>.

$$\kappa=\frac{5}{6}\frac{L_x^4+L_y^4}{L_x^2\cdot L_y^2}$$

Reduced bending moments can be obtained as follows:

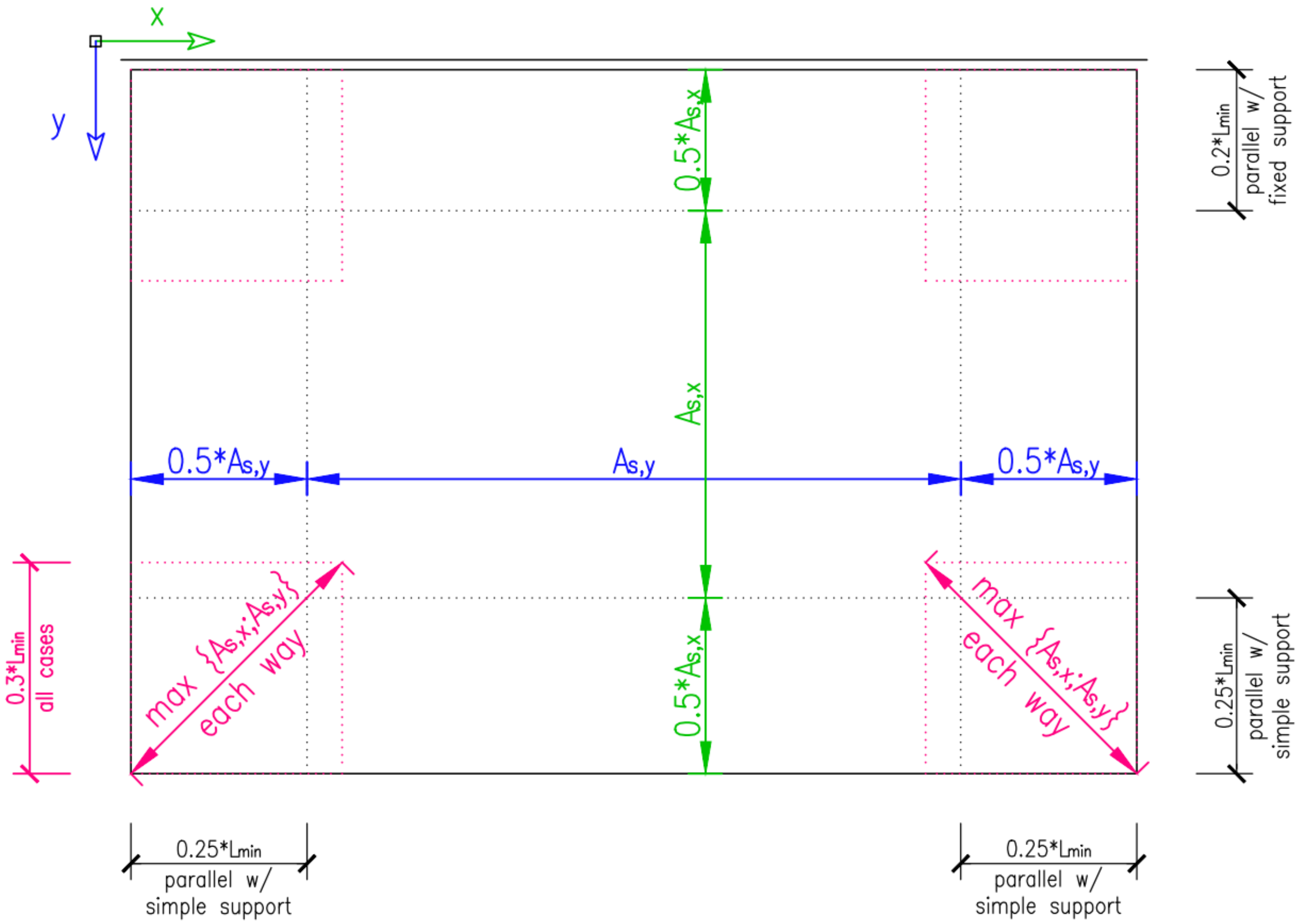
| Boundary Conditions | Reduced Bending Moments |
|---|---|
| Simple-Simple | $m_{red}=m(1-\kappa)$ |
| Simple-Fixed (Fixed-Simple) | $m_{red}=m\left(1-\frac{2}{3}\kappa\right)$ |
| Fixed-Fixed | $m_{red}=m\left(1-\frac{1}{3}\kappa\right)$ |

## Proportioning and Check of Reinforcement

Longitudinal reinforcement must resist to dimensioning bending moments. In the performed analysis were neglected torsion moments in the corners of concrete slab. This simplification must be accounted in arrangement of longitudinal reinforcement according to detailing rules.

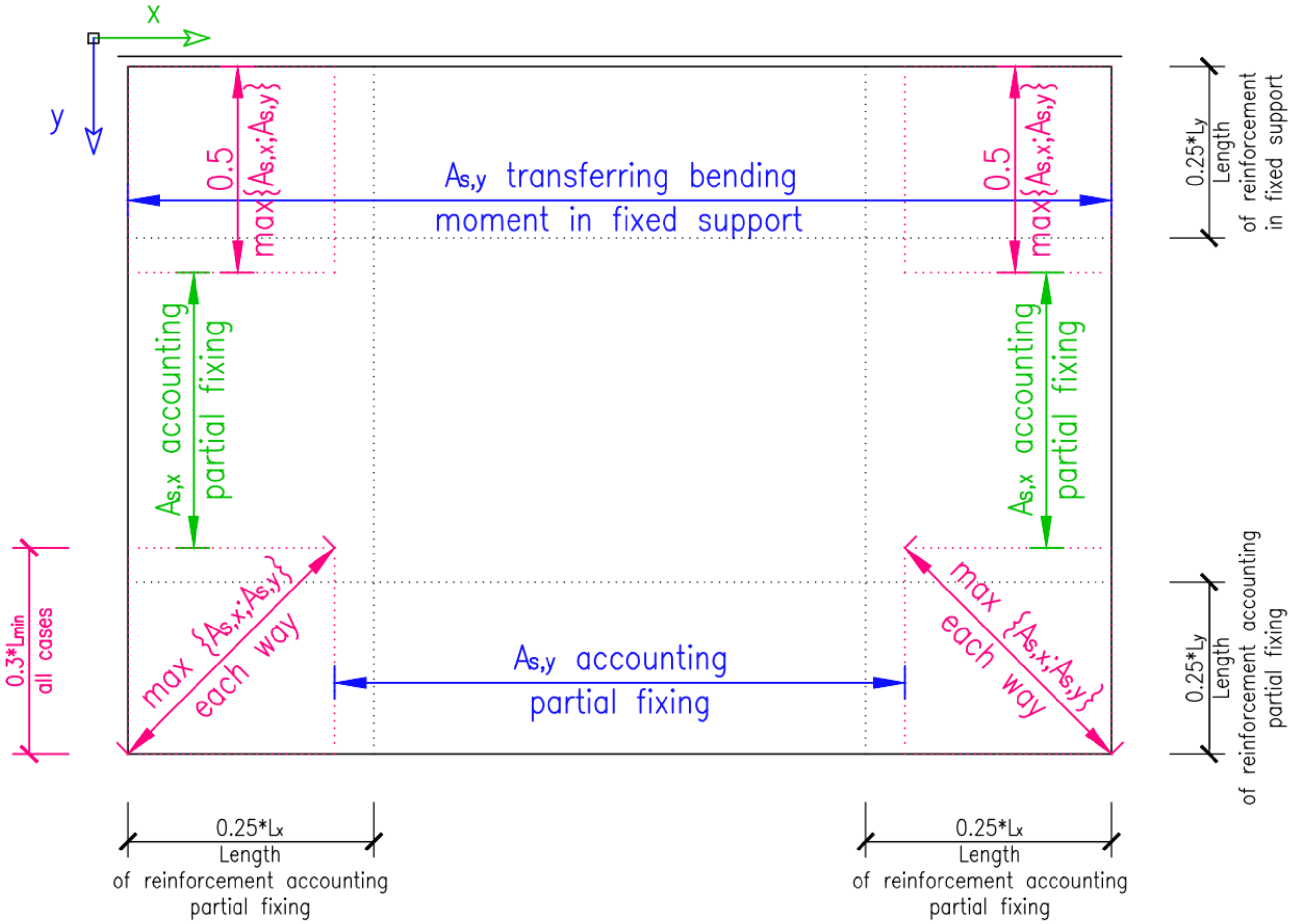
## Reinforcement Arrangement (Detailing Rules)

### *Bottom Reinforcement*




- Longitudinal reinforcement can be reduced in border zones to one half of design area in the middle of span (**green** and **blue** color).
- In the corners where simple supports meet to each other must be reinforcement transferring torsion moments. The minimum area of this reinforcement (in each way) is a maximum from values $A_{s,x}$ and $A_{s,y}$ in mid-span (**pink** color).

*Top Reinforcement*




- Top reinforcement is not reduced anywhere. Slab has to be reinforced by top surface in fixed or partial fixed supports (length of reinforcement is depicted above) - **green** and **blue** color.
- In the corners where simple supports meet to each other must be reinforcement transferring torsion moments. The minimum area of this reinforcement (in each way) is a maximum from values $A_{s,x}$ and $A_{s,y}$ in mid-span - **pink** color.
- In corners where simple support meets fixed support is necessary one half of *max* ($A_{s,x}$; $A_{s,y}$) placed parallel with fixed support- **pink** color.
- In corners where fixed support meets fixed support is not needed reinforcement for torsion moments (this case is not in scheme above)
- All reinforcement must be accompanied by distribution reinforcement.
- No surfaces can be without any reinforcement due to volume changes of concrete (shrinkage). Thereby the surfaces without reinforcement should be accompanied by welded wire mesh.