1C2
Conceptual Design of Buildings

Prof. Jiří Studnička

List of lectures

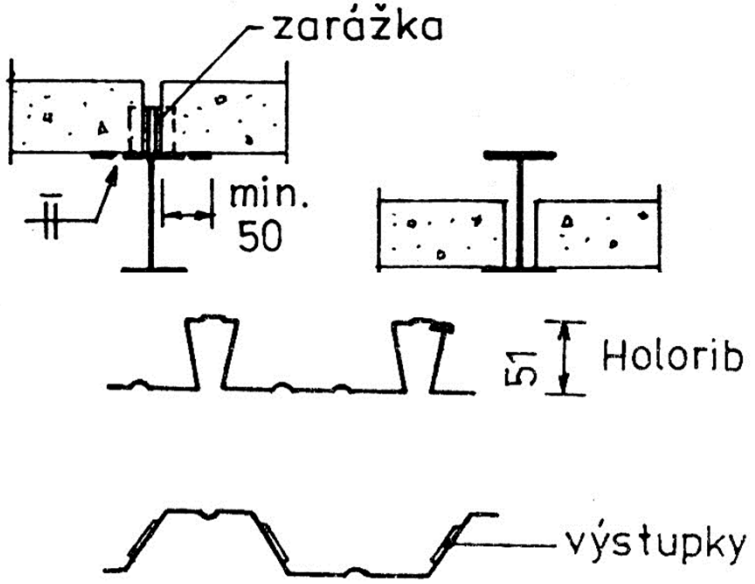
1) Multi-storey buildings
2) Floor slabs, primary and secondary beams
3) Joints of floor beams and columns
4) Cellular beams, slim floors
5) Composite floors
6) Steel columns
7) Base plates
8) Composite beams and columns
9) Composite frames
10) Frame bracing
11) Advanced models for frame bracing
12) Design tools
13) Conceptual design, repetition

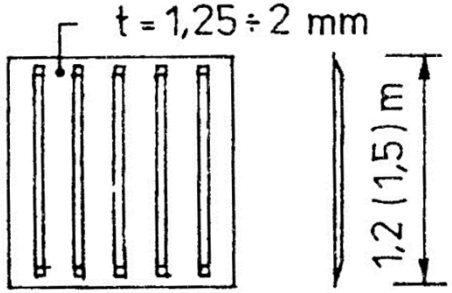
Objectives of the lecture

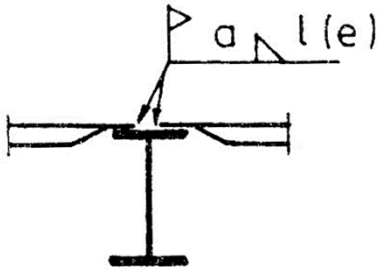
- Floor decks
- Primary floor beams
- Secondary floor beams
- Edge beams
- Simple and continuous beams
- Bolted joints

Floor deck

- Concrete decks (fabricated or cast-in-situ)
- Steel profiled sheeting filled with concrete (composite or non-composite)
- Steel sheeting with longitudinal stiffeners (pressed)



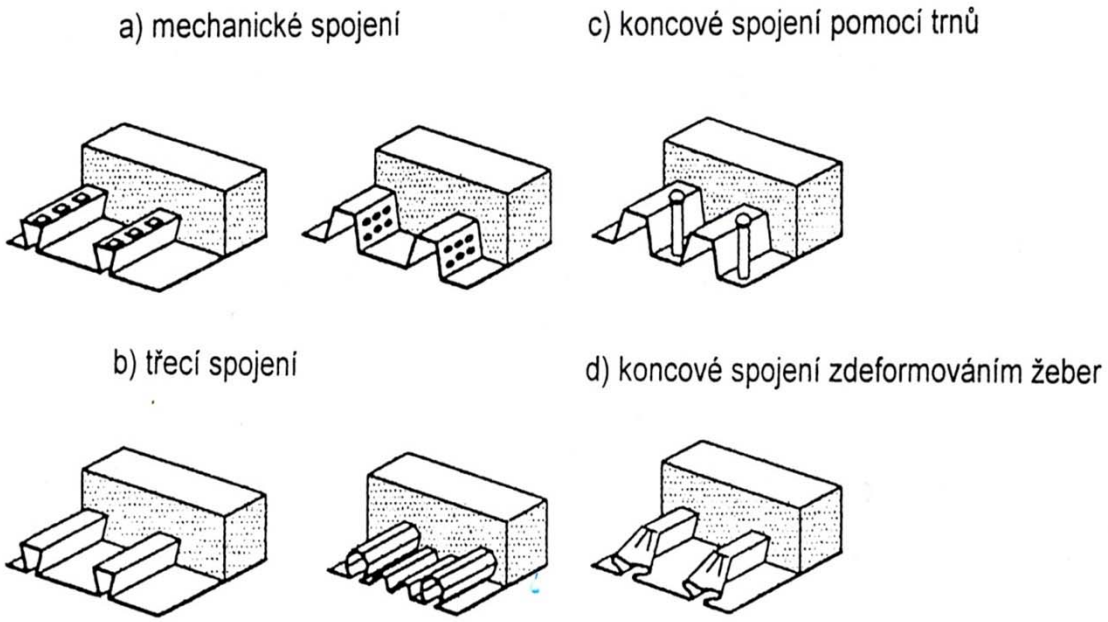




Slabs with profiled steel sheeting

- Design calculation:

- all load is transmitted by steel sheeting only
- steel sheeting as shuttering (loaded by wet concrete only), but variable load is transmitted by concrete ribbed deck
- composite slab: sheeting with embossments or mechanical end anchorage is connected with concrete without any slip and composite function is ensured (most effective design)

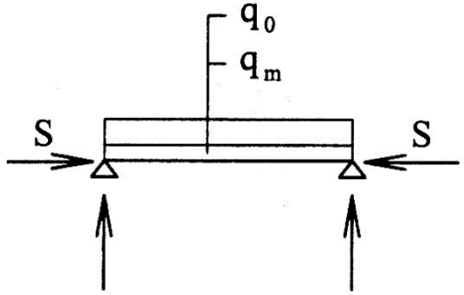


Sheeting with stiffeners acting as a membrane

- The first step of calculation: load q is splitted into beam part q_0 and membrane part q_m
- determine the deflection δ_0 and δ_m for beam and membrane, respectively
- splitting of load is correct, if

  $\delta_0 = \delta_m$

  (iterative procedure is inevitable)
- stress in steel sheeting may be calculated from expressions below



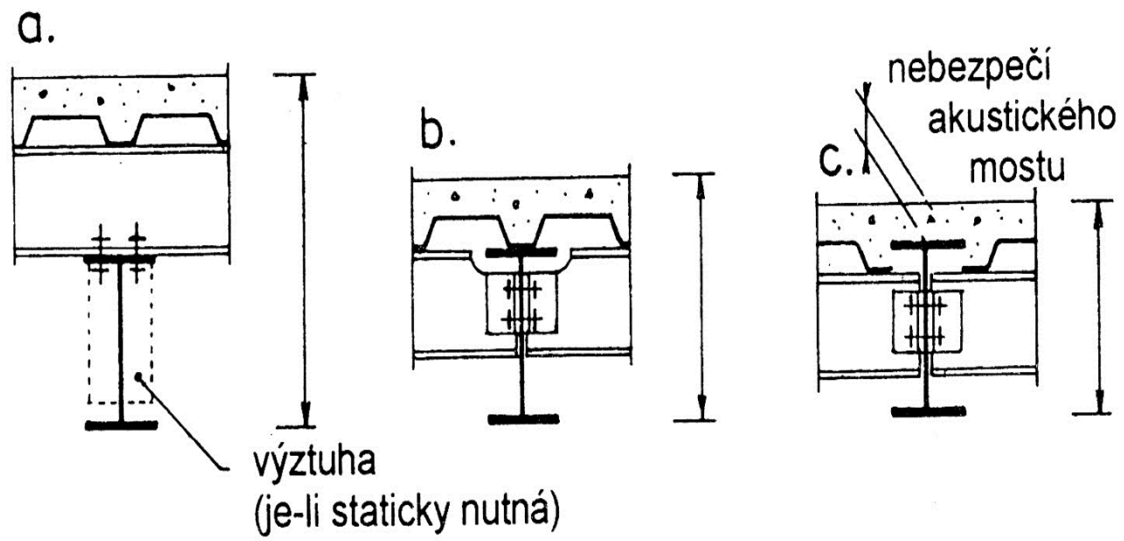
$$q = q_0 + q_m \qquad q_m = \frac{8S\delta}{L^2} \qquad \delta = \delta_0 = \delta_m$$

$$\delta_0 = \frac{5}{384}\frac{q_0 L^4}{EI} \qquad \delta_m = L\sqrt{\frac{3S}{8EA}}$$

$$\sigma_0 = \frac{M_0}{W_{eff}}, \qquad \sigma_m = \frac{S}{A}$$

Design of the floor beams

- Primary beam: simple or continuous, hot rolled profile, composite where possible, plastic design, check the deflections (elastic approach) L/250
- Secondary beam: large spans, rolled or welded profile, composite where possible, plastic design, deflection limit L/400, mutual position of primary and secondary beams, see figure below, option c) is most frequent (because of shallow appearance)

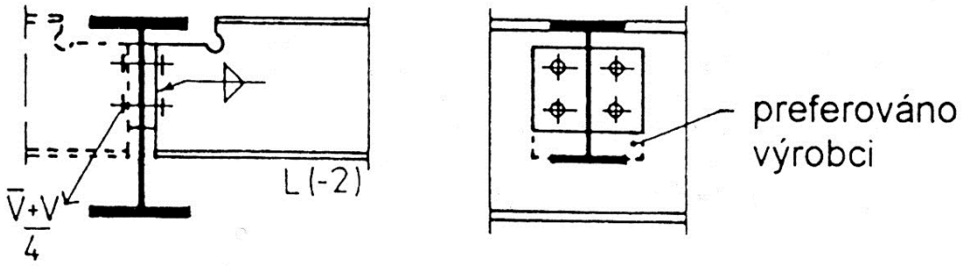


Details of design

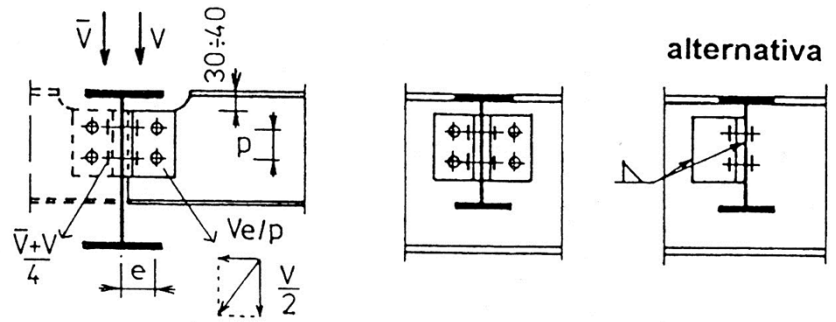
- Composite steel and concrete beams with steel profiled sheeting are heavily preferred
- Profiled sheeting: perpendicular or parallel to beam
- Determine the effective width of concrete slab
- Choice between simple and continuous beam (depends on joints)
- Choice the grade of steel and strength of concrete
- Choice the type of shear connector (studs are more frequent)
- Calculate the design resistance of beam (plastic theory)
- Determine the number and spacing of shear connectors
- Decision should be made between propped or un-propped construction for deflection calculation (elastic theory)
- Check of deflections (pre-cambering is recommended)
- Eigenfrequence f_1 of beam should be higher than 3Hz
- $f_1 = (\alpha(EI/m)^{-0,5}) /(2\pi L^2)$ coefficient α depends on support conditions (for simple beam α = 9,89), L is span, m mass, I second moment of area

Hinge (simple) joint of primary to secondary floor beam

- With contact plate



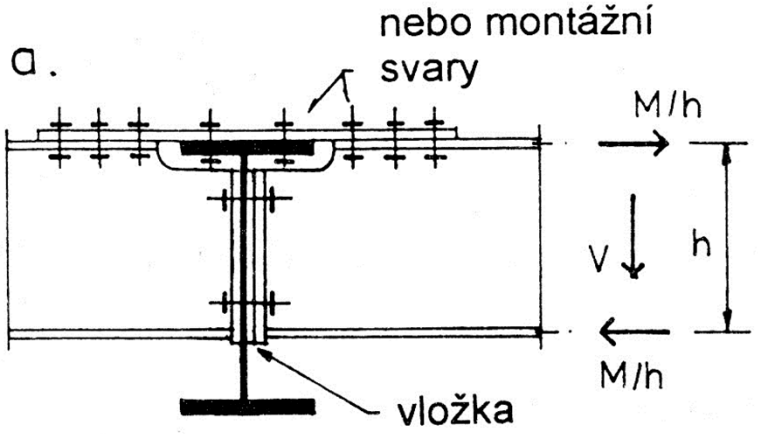
- With angles

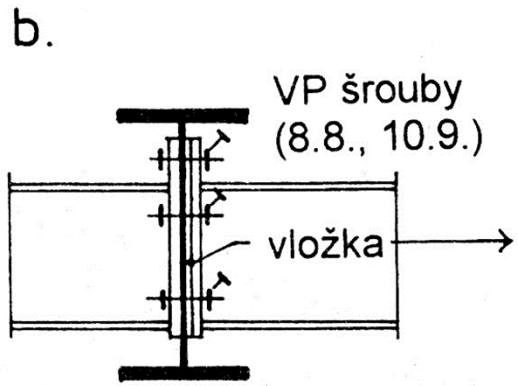


Stiff (frame) joint of primary to secondary floor beam

a) Bolt heads obstruct to floor deck

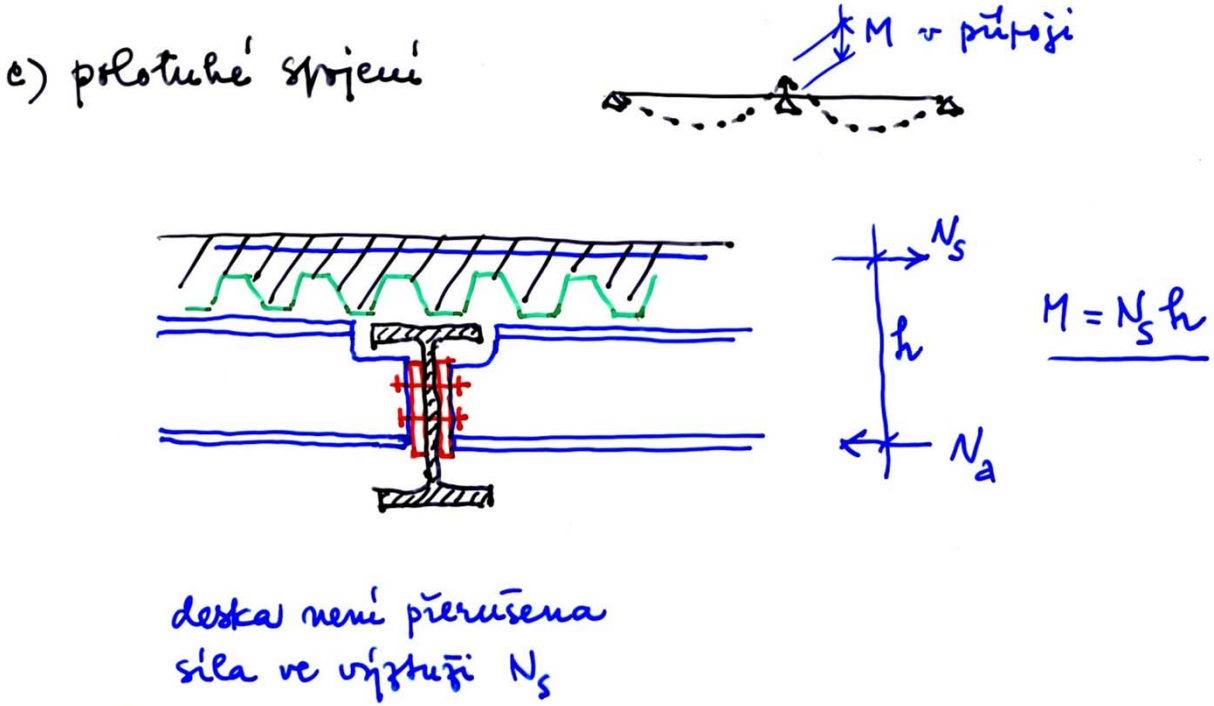
b) Thick plate should be used because of bolts are in tension





Semi-rigid joint

- The reinforcement in concrete slab (with resistance N_s) create the natural bending moment in joint



Joint with contact plate, bolted connection