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

- Multi-storey buildings
- Purpose, advantages and disadvantages
- Historical review and examples
- Lay-out
- Spatial structural stiffness
- Load
- Floor structure
- Conclusions

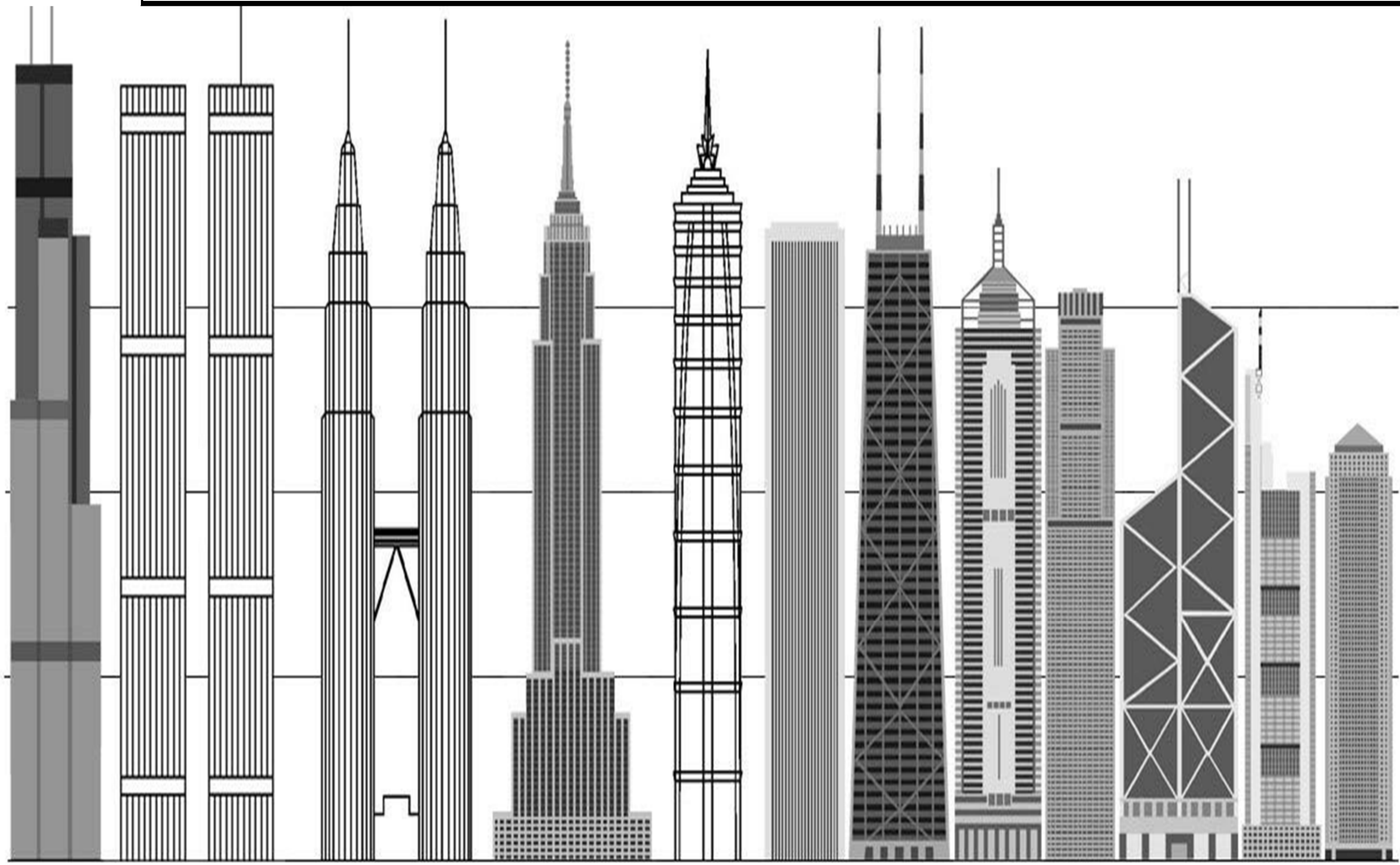
Multi-storey buildings

- Purpose: administration, public, residential, hotels
- Advantages of „steel solution“: large spans, shallow floors, small dimensions of columns, speed of erection, lower weight, smaller footings, ready for re-construction, after the end of its useful time easy to removing and re-cycling
- Disadvantages: higher acquisition costs, additional fire protection
- Tall buildings: premium of height

Historical review

- 1885: Chicago – Home Insurance Building, the first building with iron columns and 10 storeys
- 1899: New York – Park Row 119 m, 29 storeys
- 1931: New York – Empire State Building 381 m, 102 storeys
- 1971: New York – WTC 417 m, 110 storeys
- 1974: Chicago – Sears 443 m, 110 storeys
- 2004: Taipei 101 – 509 m, 101 storeys
- 2010: Dubai 828 m (predominantly concrete)
- Under construction: New York – Freedom Tower 1776 ft (542m), etc.

Tallest buildings in the world



New York, Empire State 381 m

- Open at 1931
- 102 storeys
- Constructional time 18 months
- Steel riveted structure
- 60 000 t
- Survived crash of B25 Mitchell at 1945
- Iconic for N.Y.

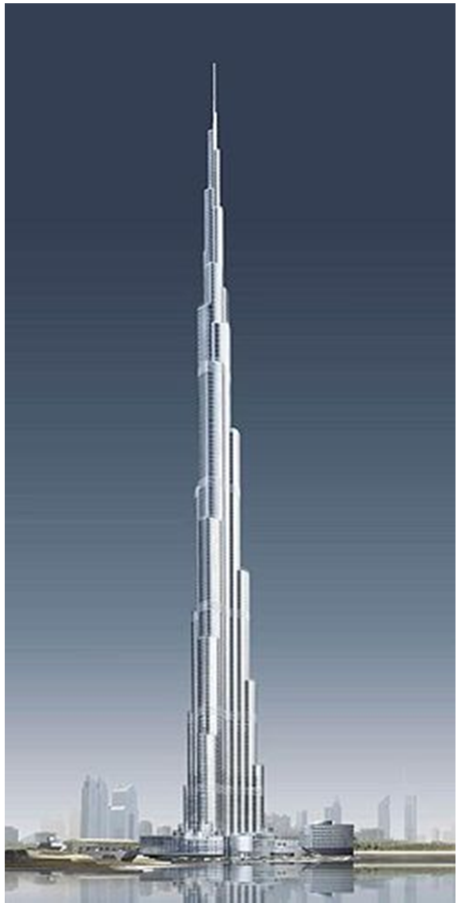
New York, World Trade Center 417 m, collapsed 2001

Tajvan, Taipei 101

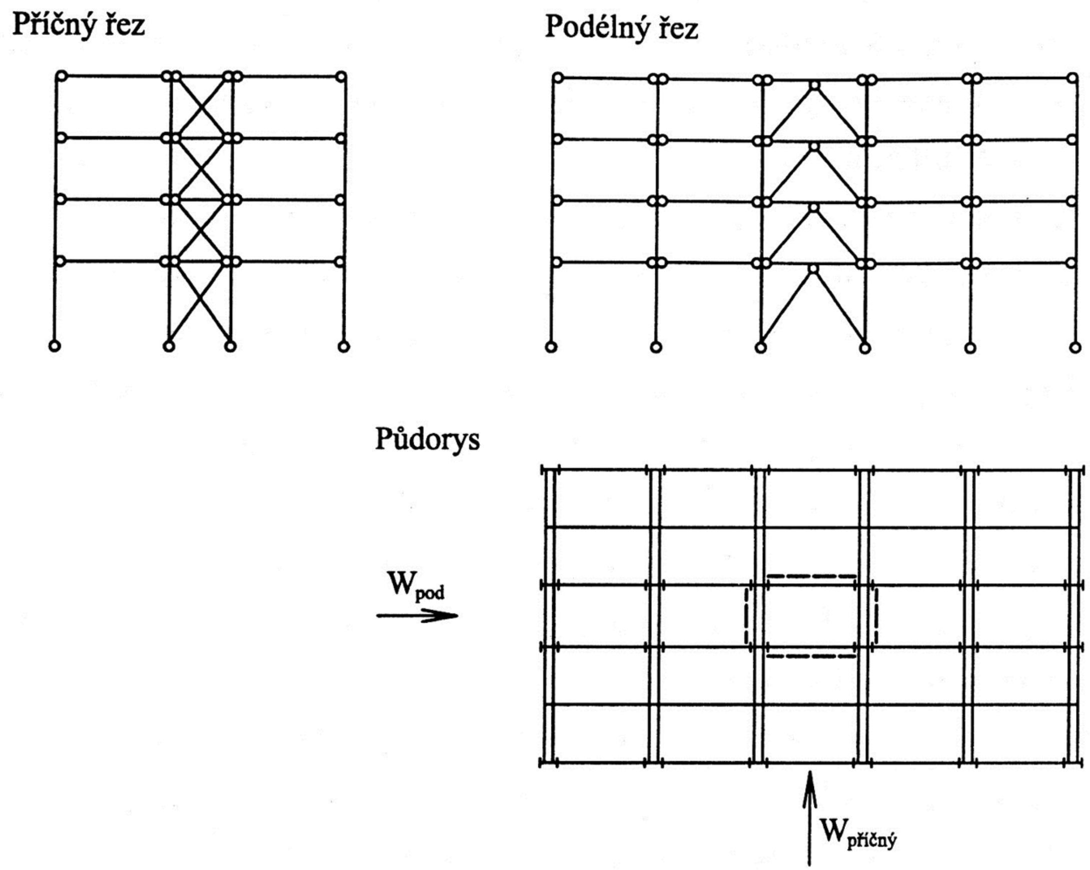
- Open at 2004
- 101 storeys
- 509 m
- Composite steel and concrete megastructure
- Hollow steel columns 2400x3000x80 mm filled by concrete
- Steel 650 t ball as a damper suspended in 88. storey
- Traditional bamboo shape
- Happy number 8

Dubai Burj Tower (828 m)

- Main concrete part 586 m
- Upper steel part 130 m
- Steel needle 112 m
- Finished 2009
- Open 2010
- Design: Skidmore, Owings and Merrill (U.S.A.)
- Actual name: Burj Khalifa Tower



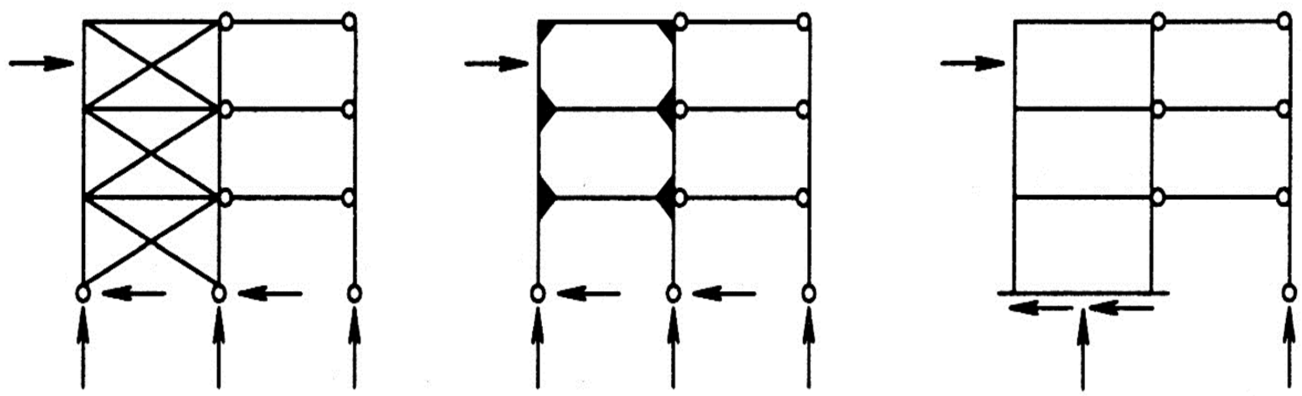
Spatial stiffness



Stiffened and non-stiffened frames

- Stiffened frames and non-stiffened (hinged) frames: functionality of the system is ensured by (horizontally) very rigid floor tables
- Stiffened frames:

- Truss structures: cost effective, but disturbing the lay-out
- Rigid frames: lesser stiffness, not disturbing the lay-out
- Stiffening walls (concrete or masonry): good for not too high buildings



Load

- according to standards (ČSN EN 1991 in Czech Rep.) and demands of client
- permanent: commonly the same in all floors
- variable:

- imposed load: 2 to 5 kN/m^2
- wind pressure: depends on wind velocity at site, height of building, aerodynamic properties,
- snow: depends on conditions at site, for multi-storey buildings not so important
- technical equipment: for example heating, air condition
- seismic effects: not significant in Czech Republic

Floor structure

- Floor deck with two functions:
- to spread the vertical load into primary and secondary floor beams
- to spread the horizontal load into stiffened frames
- System of primary and secondary floor beams: different arrangement, see below, common distance between primary beams is 2 - 3 m
- Hot-rolled I beams preferred
- Bolted joints preferred