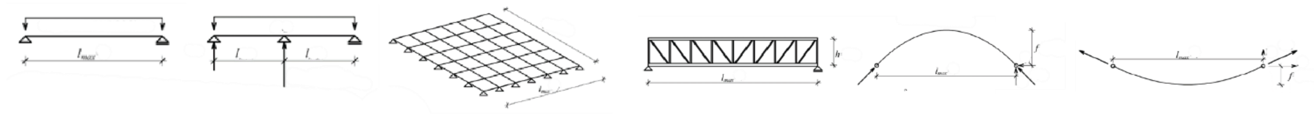
T1/1 - LARGE SPAN STRUCTURES

Background:



	A	B	C	D	E	F
	simply supported	two-span-continuous	grid structure	truss-like stilted IPE330	arch	cable structure
l_{max}	**11**	**14**	**13-14**	**15**	**35**	**146**
load-bearing capacity						x
stability					x	
deformation	x	x	x	x		

Our horizontal loadbearing structures are usually bent (e.g. beams, slabs). The structures are economical only for small spans (it depends on the material: max. 8-10 m for RC, max. 15-18 m pre-casted RC and max. 20-25 m for steel beams). The larger the span, the higher the beam is needed. However, for large spans (over the abovementioned limits) increasing the height of the beam would not be economical, because a significant part of the cross-section would remain unutilized. To increase the loadbearing capacity of the structures, we can change the statical model, the geometry or use solutions such as multi-spanned beams, using lightening holes in the web, truss-like stilted beams, two-way load transferring, arch.

T1/2 – WALL BEAM

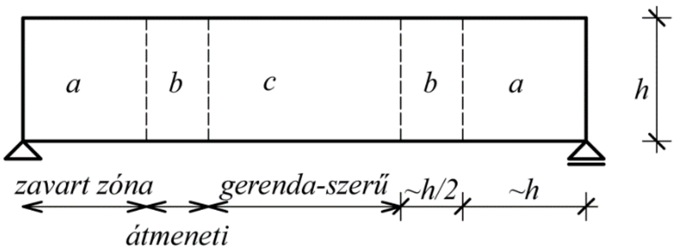
Background:

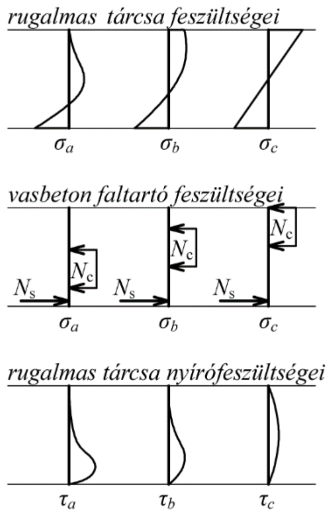
Applying floor height structures can be a convenient and efficient solution in case of large spans: wall beams can fit into the arrangement of the walls and the floors can support the wall beams against lateral-torsional buckling. In the previous semesters, we considered structural elements where the shear deformation could be neglected. In contrary to beams, strains coming from shear deformations and strains caused by bending moment are comparable in magnitude close to the supports. As a result, the Bernoulli-Navier hypothesis is not valid anymore near the supports, where a so-called disturbed zone develops. Calculation of the stresses would be too complicated to carry out by hand; hence we use analogies of the behavior to simplify the problem. The reinforced concrete wall beam is handled as a tied arch, where:

- the tension in the tie-bar is borne by steel reinforcing bars located in the lower part of the wall beam
- the compression in the arch is transferred to the supports by the concrete which behaves as a vault

Shear deformations must be taken into consideration in case of high glued-laminated timber and composite structures as well.

The aim of the practical





The Bernoulli-Navier hypothesis is not valid near the supports, where the cross-sections can not be considered to stay flat any more.

In this practical, we examine a possible construction of a wall beam and its loads. Due to the geometry of the structural element ($l \leq 5h$), only the middle zone can be treated as a regular beam. Reinforcement bars must be continuous from support to support because of the arch analogy and they must carry the normal force. At the point of the maximal bending moment, the upper concrete slab works together with the wall beam to bear compression and a wall opening is possible to create in the middle zone of the wall. However, towards the supports, the compressed concrete zone is in the middle of the wall, therefore it cannot work together with the slab. Although the bending moment is lower near the supports, the effective height is also smaller, therefore the structure carries the same normal force as in the point of the maximal bending moment.

Furthermore, a significant amount of steel fibers is necessary for shear reinforcement for the wall and the slab to work together, that we do not examine in this semester. Being slim, the wall beam can also buckle. Although these effects cannot be neglected, the aim of the practical is only to introduce a simple, approximate method.

Bended RC beam equations: (discussed in previous subjects)

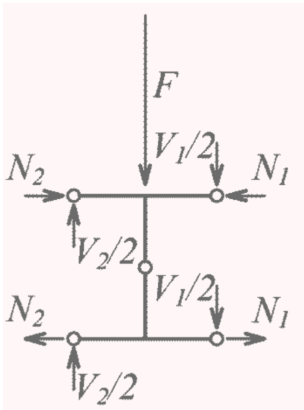
- $N_c = N_s$, $bx_c f_{cd} = A_s f_{yd}$
- $M_{Rd} = bx_c f_{cd} (d - \frac{x_c}{2})$

T2/1 – Vierendeel structure

Background:

In the case of story height structures, opposing architectural and structural requirements could compete against each other. Two structures loaded by the same loads, having the same geometry but a different structural solution might significantly differ economically.

The aim of the practical:



We present a simple approximate calculation of the (statically indeterminate) Vierendeel structure. It assumes, that the bending moment is zero in the middle of the members, provided the columns and beams have the same stiffness. As a result, hinges can be assumed at these points, which reduces the degree of indeterminacy and the internal forces can be calculated. In contrary to a truss, bending moment develops in the members of the Vierendeel structure, therefore the utilization of the cross-section is not uniform (the elements are eccentrically loaded). After determining the load cases with the maximal bending moment or normal force, we carry out an iteration to choose an appropriate cross section. The utilization of the cross-section is given by the Dunkerley formula.

Dunkerley formula: $\frac{N_{Ed}}{N_{Rd}} + k_{yy} \frac{M_{Ed}}{M_{Rd}} \leq 1{,}0$