Budapest University of Technology and Economics

Department of Mechanics, Materials and Structures
English courses
Reinforced Concrete Structures
Code: BMEEPSTK601

Lecture no. 7:

DETAILING OF BEAMS

Content:

1. Approximate design of the cross-sectional dimensions
2. Principles of constructing the envelope resistance shear and moment diagrams
3. Detailing the reinforcement system of a simple supported beam with cantilever
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   3.3 Data and list of bars
4. Choosing the concrete cover and grade (ambiental conditions)
5. Some further constructional rules
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   b. Anchorage of links and bent-up bars
   c. Reinforcement designed for torsion

1. Approximate design of the cross-sectional dimensions

Adopting *b* , capacity conditions for shear and flexure result in *d* as follows:

$$V_{Rd,max} = \frac{1}{2} bd\nu f_{cd} \geq V_{Ed} \rightarrow \qquad bd \geq 4\frac{V_{Ed}}{f_{cd}}$$

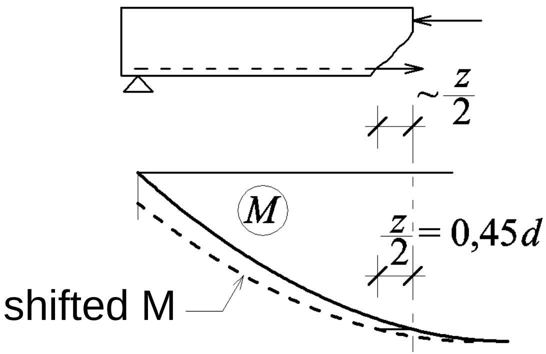
$$M_{Rd} \cong b0{,}4df_{cd}0{,}7d \geq M_{Ed} \rightarrow \qquad bd^2 \geq 4\frac{M_{Ed}}{f_{cd}}$$

$$\rightarrow \frac{M_{Ed}}{V_{Ed}} \cong d$$

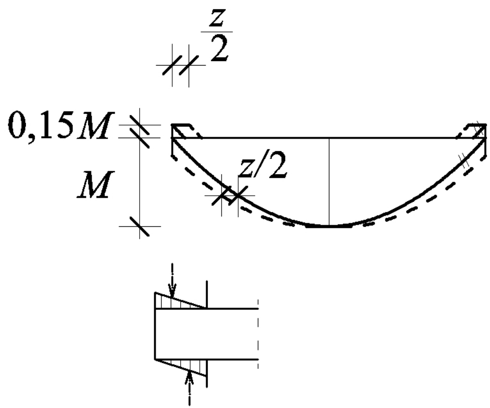
Value of ℓ / d can then be checked for deflection, and adjusted if necessary

2. Principles of constructing the envelope resistance shear and moment diagrams

The reason of parallel shifting of the diagram of applied moments

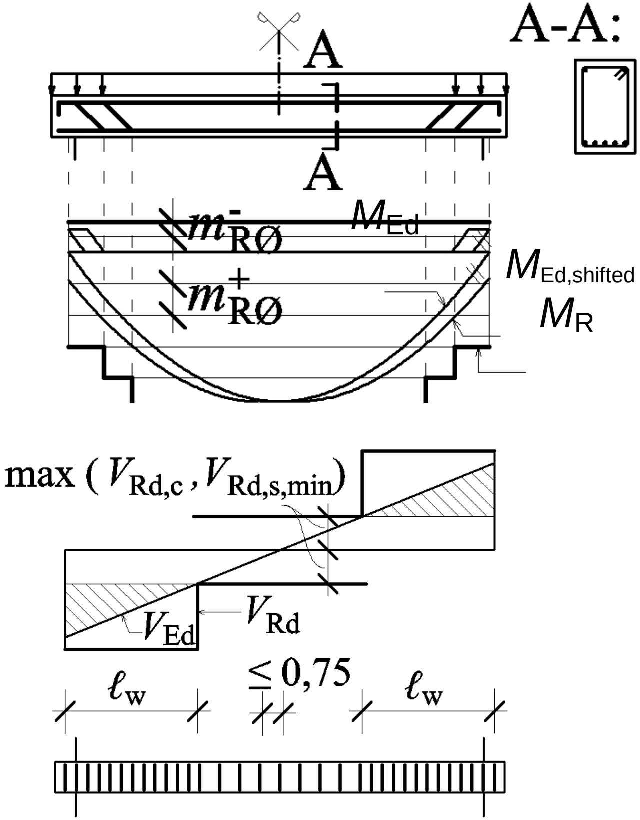


The extent of shifting is *z,* if no shear reinforcement is applied, 0,25*z*, at bent-up bars



Effect of partial restraint at extreme support:

Enveloping the moment and shear diagrams of a simple supported beam



$m^-_{R\phi}$ and $m^+_{R\phi}$

capacity moments attributed to a top and bottom bar respectively of diameter ϕ

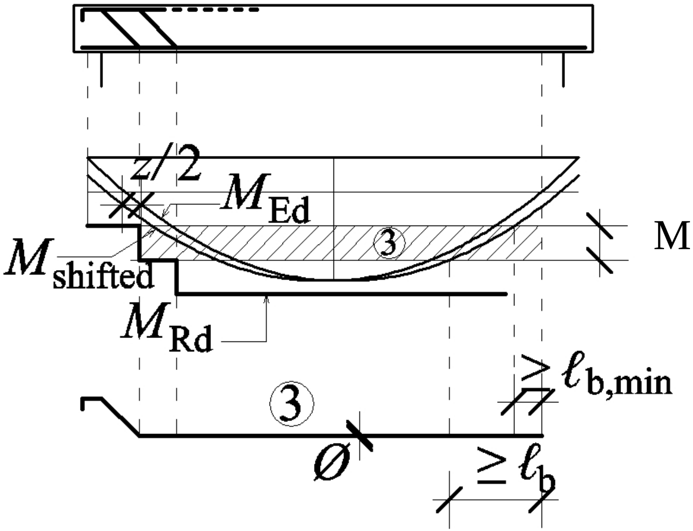
2 bars are bent-up from 5 on bottom (it is possible)

Design of shear reinforcement (here links) is necessary for the dashed area

Use of minimum links along the Interior part af the beam

Graphical presentation of the capacity moment attributed to each of the longitudinal bars of an rc beam

-Example of the bar id. no. 3, bent-up on left and finished in the span on right :



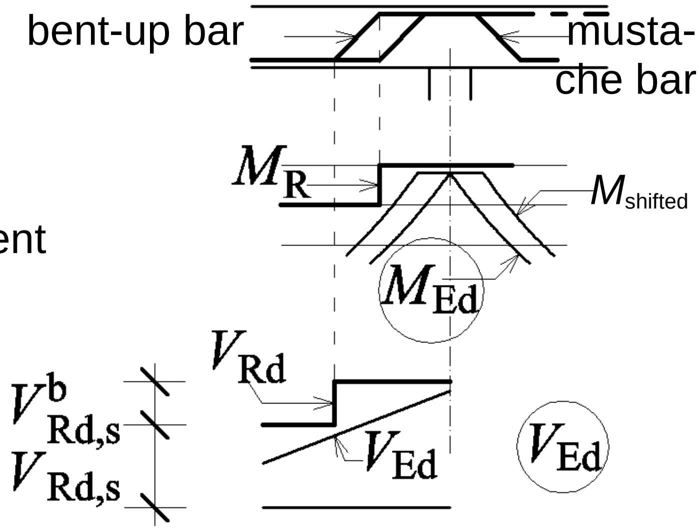
$$M_{Rd,3} = \frac{\phi_3^2 \pi}{4} f_{yd} z$$

Reason of using bent-up bar +,,mustache bar,, at intermediate supports

Detail of the side view of the beam

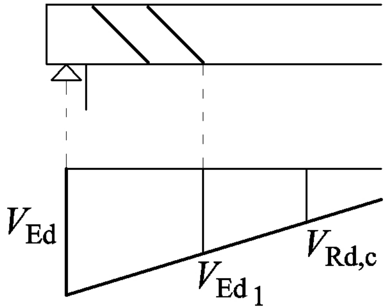
Detail of the shifted moment diagram and the envelope moment diagram at intermediate support

Detail of the shear force diagrams



Shear design strategies

-Using bent-up bars



-the ,,simple grading system,, (geom. order) of bent-up bars

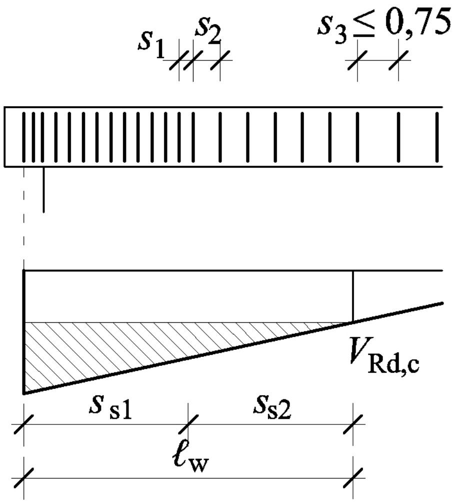
-design of links for max($V_{Ed,1}$, 0,5$V_{Ed,max}$) and maintaining its intensity in support direction

-design of min. links from section of $V_{Rd,c}$

-When designing only links, if

$$\ell_w = \frac{V_{Ed,\max} - V_{Rd,c}}{p_d}$$ is long

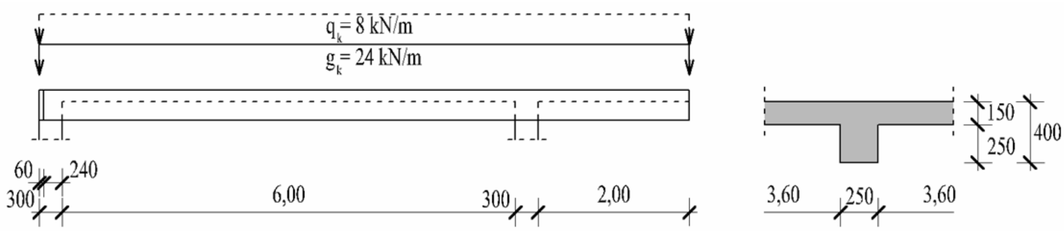
(greater than ≈1,2 m), it is more economic to design two link intensities – spacing s_1 and s_2 - along ℓ_w:



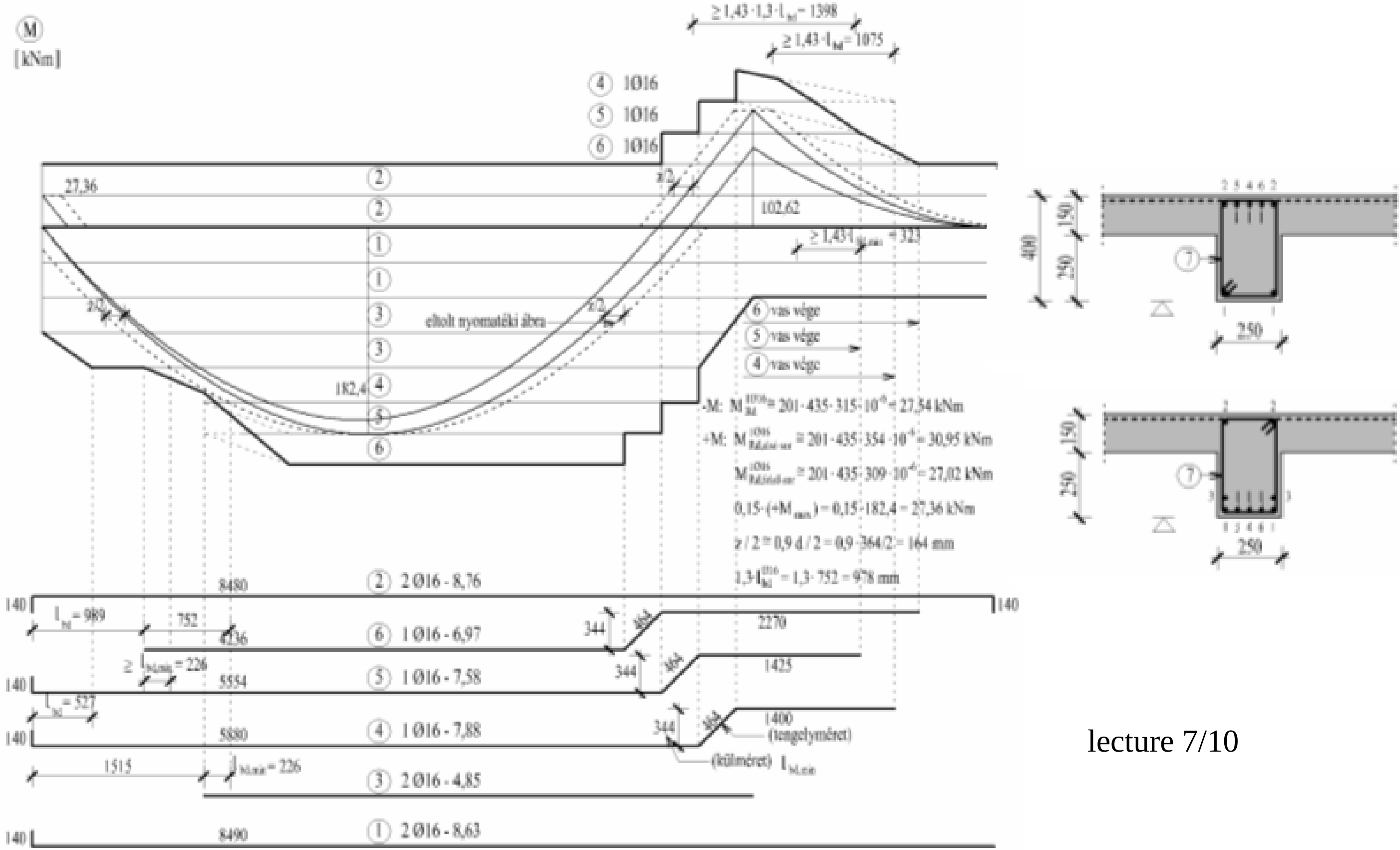
3. Detailing the reinforcement system of a simple supported beam with cantilever

(example treated numerically in the practical lessons)

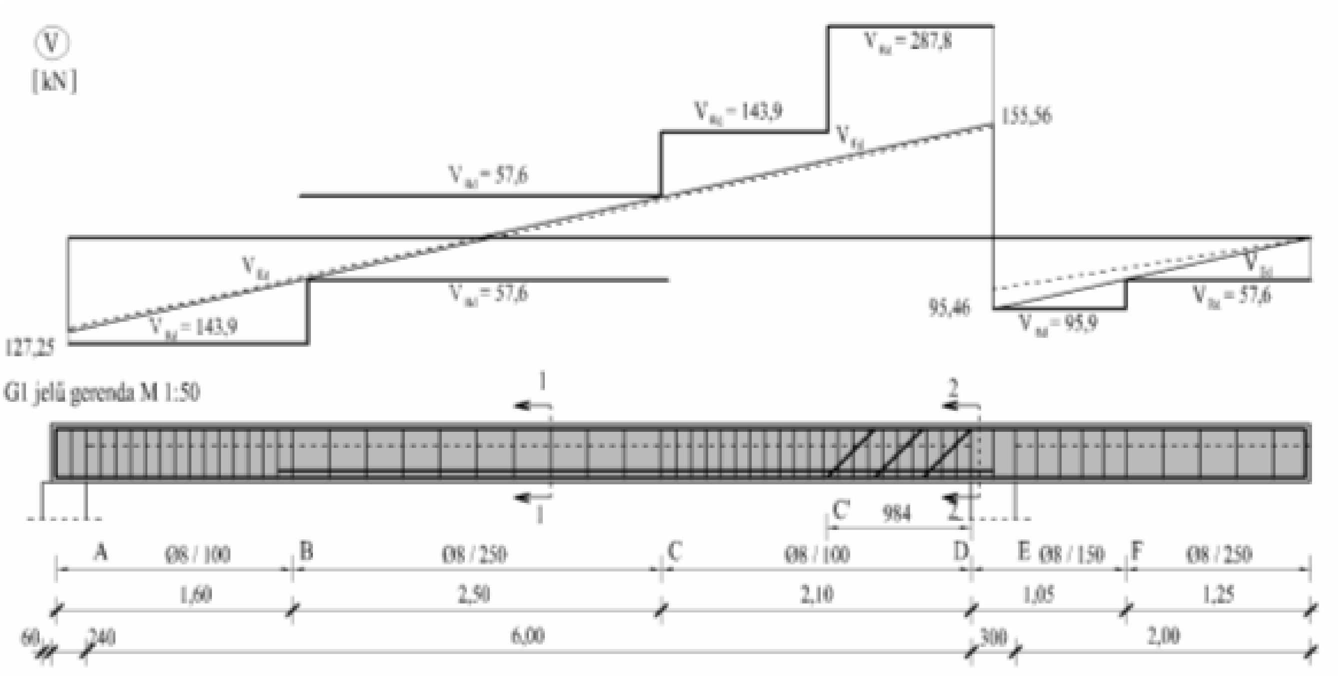
Geometrical data and loads



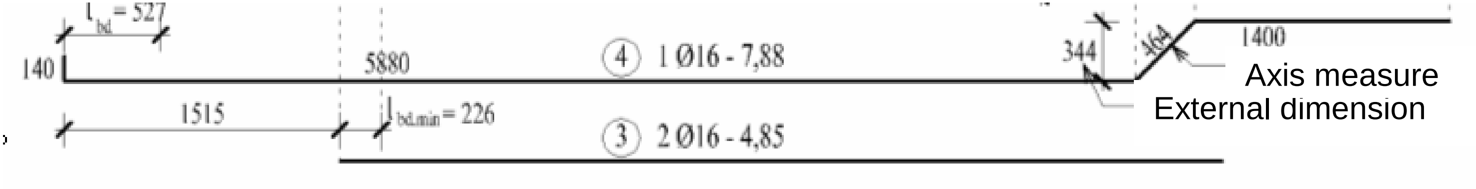
3.1 The shifted extreme moment diagram and the envelope resistance moment diagram



3.2 The extreme shear diagram and the envelope shear resistance diagram



3.3 Bar data and list of bars



List of bars for beam G1 Reinforcement quality: B60.50

Id. no.	pcs.	Ø	length	Σ length (m)	
		mm	m	Ø8	Ø16
1	2	16	8,63		17,26
…	…	…	…	…	…
7	62	8	1,26	78,12	
Total length (m)				78,12	64,1
Specific mass (kg/m)				0,395	1,58
Total mass (kg)				30,9	101,3

4. Choosing the concrete cover and grade (ambiental conditions)

$$c_{nom} \geq 10 \text{ mm} + \max\begin{Bmatrix} c_{min,b} \\ c_{min,dur} \\ 10 \text{ mm} \end{Bmatrix}$$

$c_{min,b}$ is the minimum concrete cover conditioned by adequate bound (1 to 3 bar diameter)

$c_{min,dur}$ depends from conditions of the ambiente, as given in the table below

Ambiental conditions corresponding to EN 206			Min. concrete strength grade	Min. cement-content kg/m^3	Max. w/c ratio %	Values of $c_{min,dur}$ (mm)
Sign	Ambiental conditions	Examples				
X0	Dry ambient	Dry indoor spaces	C12/ 15	260	65	10
XC1	Carbonization in dry or constantly wet ambient	Indoor spaces with medium air humidity content, underwater structures	C20/ 25	260	65	15

XC2, XC3	Carbonization in wet, rarely dry ambient, or by moderate air humidity content	Water reservoirs, foundation structures. Structures of open-air halls, garages, indoor spaces of high humidity	C25/30 C30/37	280	60 55	25
XC4	Carbonization in variable dry and humid space	Structures exposed to rain	C30/37	300	50	30
XD1	Chloride corrosion by limited air humidity content	Structures exposed to atmospheric chloride corrosion	C30/37	300	55	35
XD2	Chloride corrosion in humid, rarely dry ambient	Water-side surface of non-insulated basins, structures subjected to the effect of industrial water with chloride content	C30/37	300	55	40

XD3	Chloride corrosion in variable humid or dry ambient	Structures of bridges, pavements, parking house floors effected by chlorine containing chemicals	C35/ 45	320	45	45
XS2	Permanent effect of seawater	Basin filled with seawater	C35/ 45	300	50	40
XF1	Moderate water saturation without anti-freeze	Vertical surfaces exposed to rain and frost	C30/ 37	300	55	**
XF3	High water saturation without anti-freeze	Horizontal surfaces exposed to rain and frost	C30/ 37	320	50	**
XA1 XA2 XA3	Slightly, moderately and strongly aggressive ambient	Structures exposed to sulphate containing soils and groundwater	C30/ 37 C30/ 37 C35/ 45	300 + 320 + 360 +	55 50 45	**

5.Some further constructional rules

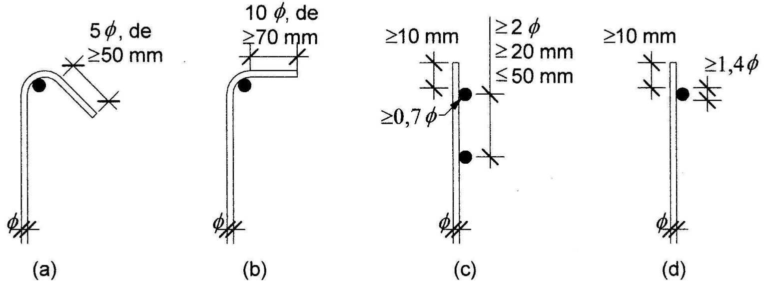
a) The minimum anchorage length

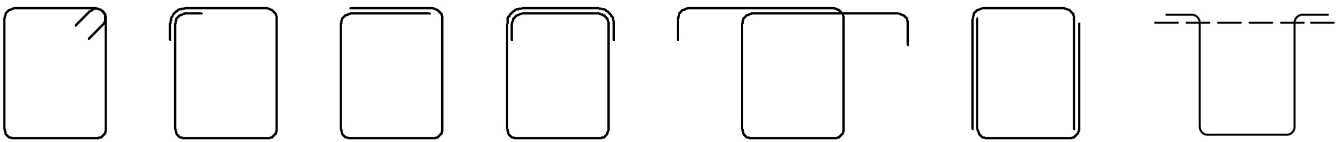
$$l_{b,min} = \max\{10\phi;\ 100\text{ mm},\ \alpha_{min}\ l_b \frac{\sigma_s}{f_{yd}}\}$$

α_{min}= 0,3 for bars working in tension
α_{min}= 0,6 for bars working in compression

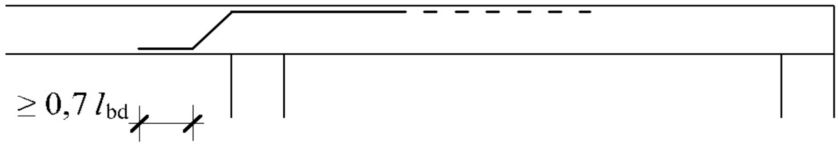
b) Anchorage of links and bent-up bars

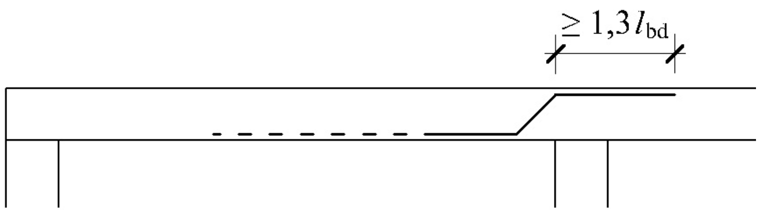
Anchorage of links





Anchorage of bent-up bars in the compression and tension zone respectively





c) Reinforcement designed for torsion

For better anchorage, use links of the type indicated below!

Longitudinal bars should ba uniformly distributed along all sides of the section: