INTERNATIONAL UNIVERSITY OF AFRICA
CIVIL ENGINEERING DEPARTMENT

ANALYSIS AND DESIGN OF STEEL WORKS

GRADE 4

7TH SEMESTER

Lecture No 2

BEAMS

PART 3

NUMERICAL EXAMPLE

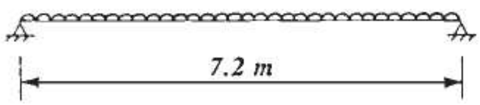
PREPARED BY Dr i TALAAT

Worked example

The Steel Construction Institute Silwood Park, Ascot, Berks SL5 7QN	Subject ***BEAM EXAMPLE 1 LATERALLY RESTRAINED UNIVERSAL BEAM***		Chapter ref. ***16***
	Design code ***BS 5950: Part 1***	Made by ***DAN*** Checked by ***GWO***	Sheet no. ***1***

Problem

Select a suitable UB section to function as a simply supported beam carrying a 140 mm thick solid concrete slab together with an imposed load of 7.0 kN/m². Beam span is 7.2 m and beams are spaced at 3.6 m intervals. The slab may be assumed capable of providing continuous lateral restraint to the beam's top flange.



Due to restraint from slab there is no possibility of lateral-torsional buckling, so design beam for:

i) ***Moment capacity***
ii) ***Shear capacity***
iii) ***Deflection limit***

Loading

D.L. $= (2.4 \times 9.81 \times 0.14)$	$= 3.3\,kN/m^2$	
I.L.	$= 7.0\,kN/m^2$	
Total serviceability loading	$= 10.3\,kN/m^2$	*Table 2*
Total load for ultimate limit state		
$= 1.4 \times 3.3 + 1.6 \times 7.0$	$= 15.8\,kN/m^2$	
Design ultimate moment	$= (15.8 \times 3.6) \times 7.2^2/8$	
	$= 369\,kN\,m$	
Design ultimate shear	$= (15.8 \times 3.6) \times 7.2/2$	
	$= 205\,kN$	

Assuming use of S275 steel and no material greater than 16 mm thick, — *Table 9*

take $p_y = 275\,N/mm^2$

Required $S_x = 369 \times 10^6/275$
$= 1.34 \times 10^6\,mm^3 = 1340\,cm^3$

A $457 \times 152 \times 67$ *UB has a value of* S_x *of* $1440\,cm^3$ — *Steelwork Design Guide Vol 1*

$T = 15.0 < 16.0\,mm$

$\therefore\ p_y = 275\,N/mm^2$

Check section classification — *3.5.2*

Actual $b/T = 5.06 \quad d/t = 44.7$

$\varepsilon = (275/p_y)^{1/2} = 1$ — *Table 11*

Limit on b/T for plastic section $= 9 > 5.06$

Limit on d/t for shear $= 80 > 44.7$

$\therefore$ ***Section is plastic***

Actual $M_c = 275 \times 1440 \times 10^3$ — *4.2.5*
$= 396 \times 10^6\,N\,mm$
$= \underline{396\,kN\,m} > \underline{369\,kN\,m}$ *OK*

Vertical shear capacity

$P_v = 0.6\,p_y A_v$ — *4.2.3*

where $A_v = tD$

$\therefore\quad P_v = 0.6 \times 275 \times 9.1 \times 457.2 = 686 \times 10^3\,N$

$= \underline{686\,kN} > \underline{205\,kN}$ *OK*

Check serviceability deflections under imposed load **2.5.1**

$$\delta = \frac{5 \times (7.0 \times 3.6) \times 7200^4}{384 \times 205000 \times 32400 \times 10^4}$$

$$= 13.3mm \quad = \quad span/541$$

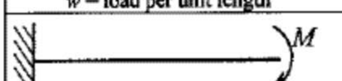
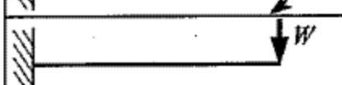
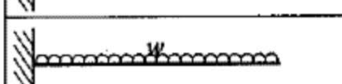
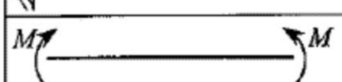
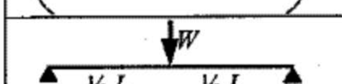
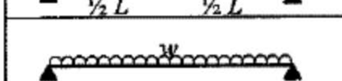
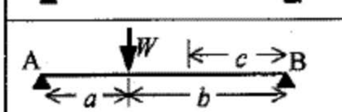
From Table 8 limit is span/360 $\therefore$ δ *OK*

$\therefore$ ***Use 457 × 152 × 67UB Grade 43***

Table 8 — Suggested limits for calculated deflections

a) *Vertical deflection of beams due to imposed load*	
Cantilevers	Length/180
Beams carrying plaster or other brittle finish	Span/360
Other beams (except purlins and sheeting rails)	Span/200
Purlins and sheeting rails	See **4.12.2**
b) *Horizontal deflection of columns due to imposed load and wind load*	
Tops of columns in single-storey buildings, except portal frames	Height/300
Columns in portal frame buildings, not supporting crane runways	To suit cladding
Columns supporting crane runways	To suit crane runway
In each storey of a building with more than one storey	Height of that storey/300
c) *Crane girders*	
Vertical deflection due to static vertical wheel loads from overhead travelling cranes	Span/600
Horizontal deflection (calculated on the top flange properties alone) due to horizontal crane loads	Span/500

BEAM BENDING

L = overall length W = point load, M = moment w = load per unit length	End Slope	Max Deflection	Max bending moment
	$\frac{ML}{EI}$	$\frac{ML^2}{2EI}$	M
	$\frac{WL^2}{2EI}$	$\frac{WL^3}{3EI}$	WL
	$\frac{wL^3}{6EI}$	$\frac{wL^4}{8EI}$	$\frac{wL^2}{2}$
	$\frac{ML}{2EI}$	$\frac{ML^2}{8EI}$	M
	$\frac{WL^2}{16EI}$	$\frac{WL^3}{48EI}$	$\frac{WL}{4}$
	$\frac{wL^3}{24EI}$	$\frac{5wL^4}{384EI}$	$\frac{wL^2}{8}$
 $a \le b, \quad c = \sqrt{\frac{1}{3}b(L+a)}$	$\theta_B = \frac{Wac^2}{2LEI}$ $\theta_A = \frac{L+b}{L+a}\theta_B$	$\frac{Wac^3}{3LEI}$ (at position c)	$\frac{Wab}{L}$ (under load)