Banha University
Faculty of Engineering - Shoubra
Civil Engineering Department

Computation of Nonlinear (STR602)

For Master of Engineering Sciences

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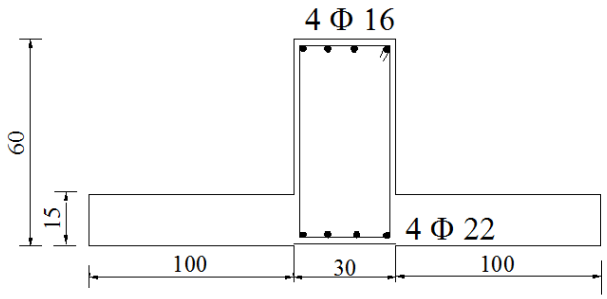
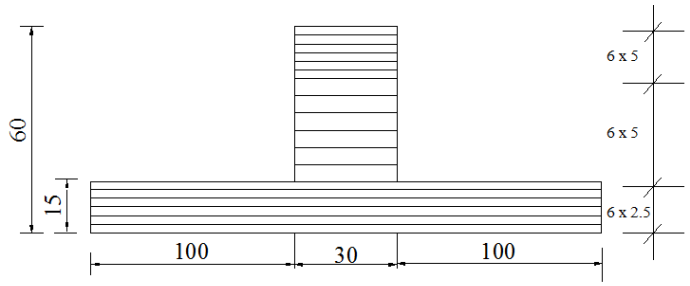
Lecture 4

For the given section shown in Figure 1, the axial strain at mid height of the section ϵ_0 **= -0.0009** and the slope **φ = - 0.0001** (d`= d`` = 2.5 cm). Using the given stress-strain curves for steel and concrete in tension and compression, it is required to:

(a) Calculate and draw the strain distribution;
(b) Calculate and draw the stress distribution;
(c) Calculate axial, coupling and flexural stiffness's (A,B and D) using the secant modulus of elasticity;
(d) Calculate section capacity (M and N);



Beam Section
(d` = d`` = 2.5 cm)



Layered System

BENHA UNIVERSITY
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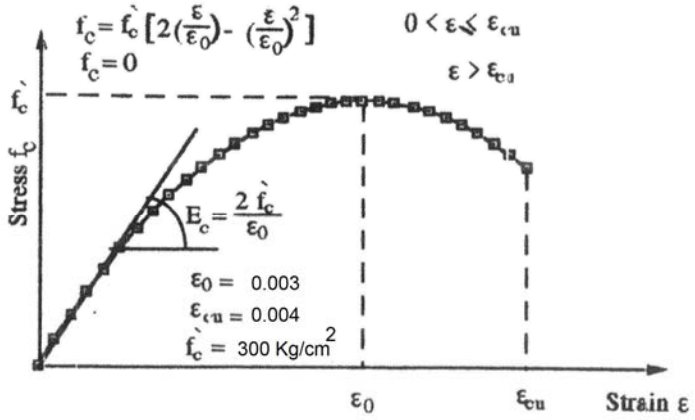
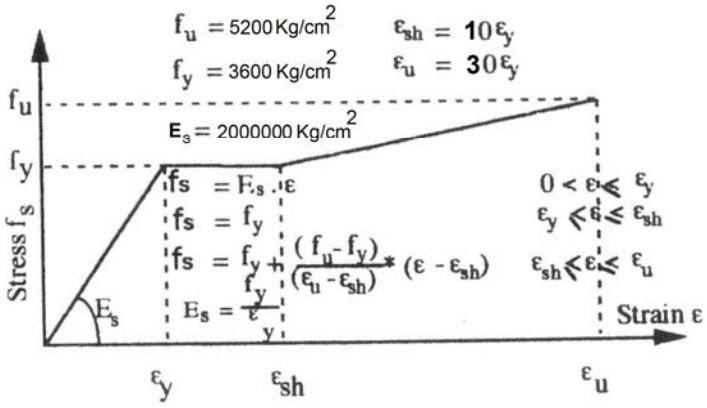
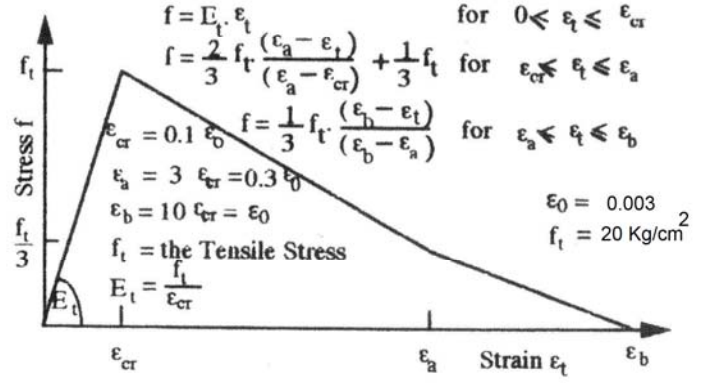


Concrete Stress-Strain Curve in Compression



Trilinear Stress-Strain Cirve for Steel Reinforcement in Tension and Compression



Trilinear Model for Concrete in Tension

Axial stiffness (A) , Coupling stiffness (B) & Flexural stiffness (D)

comp. concrete given		
Fc' =	300	Kg/cm2
Fyst	2400	Kg/cm2
$\epsilon_{0=}$	0.003	
$\epsilon_{cu=}$	0.004	

Tension concrete given		
Fcu =	300	Kg/cm2
Ft =	20	Kg/cm3
$\epsilon_{0=}$	0.003	
$\epsilon_{cr=}$	0.0003	
Et	66666.667	Kg/cm2

Steel given		
St 37	360/520	
Fy	3600	Kg/cm2
Fu	5200	Kg/cm2
Es	2000000	Kg/cm2
ϵ_y=	0.0018	
ϵ_u=	0.054	
ϵ_{sh}=	0.018	

ϵ_{cr}=	0.0003
ϵ_a=	0.0009
ϵ_b=	0.003
Et	66666.66667

axial strain at mid height ϵ_0=	-0.0003
slope =	-0.0001

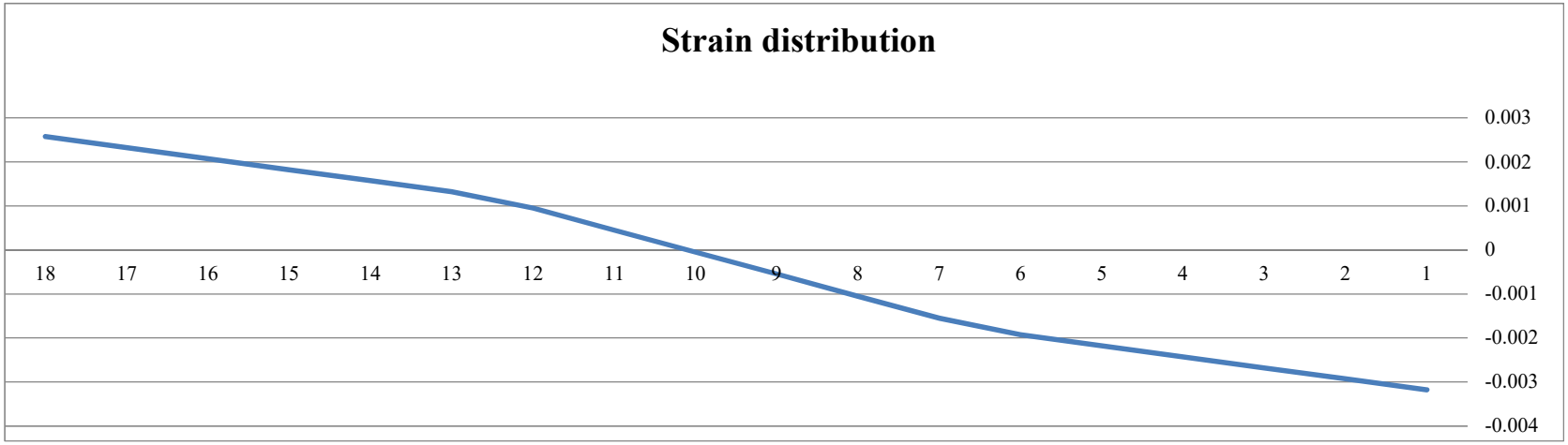
b=	230	cm	t=	60	cm	As=	6.084	cm2	
						As'=	3.218	cm2	

layer no .	layer type	t_l (CM)	b_l (CM)	z_l (CM)	ϵ_l	status	F_l (Kg/CM2)	E secant (Kg/CM2)	A secant (cm2)	B secant (Kg.CM)	D secant (Kg.CM2)	N.F secant (Kg)	B.M secant (Kg.CM)
1	concrete	2.5	230	-28.75	-0.003175	c-comp	-298.9791667	94166.66667	54145833.33	-1556692708	44754915365	-171913.0208	4942499.349
2	steel	2.5	6.083	-26.25	-0.002925	steel	-3600	1230769.231	18716923.08	-491319230.8	12897129808	-54747	1437108.75
3	concrete	2.5	230	-23.75	-0.002675	c-comp	-296.4791667	110833.3333	63729166.67	-1513567708	35947233073	-170475.5208	4048793.62
4	concrete	2.5	230	-21.25	-0.002425	c-comp	-288.9791667	119166.6667	68520833.33	-1456067708	30941438802	-166163.0208	3530964.193
5	concrete	2.5	230	-18.75	-0.002175	c-comp	-277.3125	127500	73312500	-1374609375	25773925781	-159454.6875	2989775.391
6	concrete	2.5	230	-16.25	-0.001925	c-comp	-261.4791667	135833.3333	78104166.67	-1269192708	20624381510	-150350.5208	2443195.964
7	concrete	5	30	-12.5	-0.001550	c-comp	-229.9166667	148333.3333	22250000	-278125000	3476562500	-34487.5	431093.75
8	concrete	5	30	-7.5	-0.001050	c-comp	-173.25	165000	24750000	-185625000	1392187500	-25987.5	194906.25
9	concrete	5	30	-2.5	-0.000550	c-comp	-99.91666667	181666.6667	27250000	-68125000	170312500	-14987.5	37468.75
10	concrete	5	30	2.5	-0.000050	c-comp	-9.916666667	198333.3333	29750000	74375000	185937500	-1487.5	-3718.75
11	concrete	5	30	7.5	0.000450	c-ten	16.66666667	37037.03704	5555555.556	41666666.67	312500000	2500	18750
12	concrete	5	30	12.5	0.000950	c-ten	6.507936508	6850.459482	1027568.922	12844611.53	160557644.1	976.1904762	12202.38095
13	concrete	2.5	30	16.25	0.001325	c-ten	5.317460317	4013.177598	300988.3199	4891060.198	79479728.21	398.8095238	6480.654762
14	concrete	2.5	30	18.75	0.001575	c-ten	4.523809524	2872.260015	215419.5011	4039115.646	75733418.37	339.2857143	6361.607143
15	concrete	2.5	30	21.25	0.001825	c-ten	3.73015873	2043.922592	153294.1944	3257501.631	69221909.65	279.7619048	5944.940476
16	concrete	2.5	30	23.75	0.002075	c-ten	2.936507937	1415.184548	106138.8411	2520797.476	59868940.05	220.2380952	5230.654762
17	steel	2.5	3.217	26.25	0.002325	steel	3600	1548387.097	12452903.23	326888709.7	8580828629	28953	760016.25
18	concrete	2.5	30	28.75	0.002575	c-ten	1.349206349	523.9636308	39297.27231	1129796.579	32481651.64	101.1904762	2909.22619
									ΣA=	ΣB=	ΣD=	ΣN.F=	ΣB.M=
		Σt=	60						480380588.9	-7721711180	1.85535E+11	-916285.2946	20869982.98

C) ***A= 480380588.9*** ***B= -7721711180*** ***D= 1.85535E+11***

d) ***N= -916285.2946*** ***M= 20869982.98***

a) Strain distribution



b) Stress distribution