



KLS
Vishwanathrao Deshpande Institute of Technology
Haliyal - 581329

DESIGN OF RCC STRUCTURES

LAB MANUAL

[BCV601]

for

VI Semester B.E.

As prescribed by

**VISVESVARAYA TECHNOLOGICAL UNIVERSITY,
BELAGAVI - 590014**

(From Academic Year: 2025-26)

Prepared by

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Department of Civil Engineering

Index

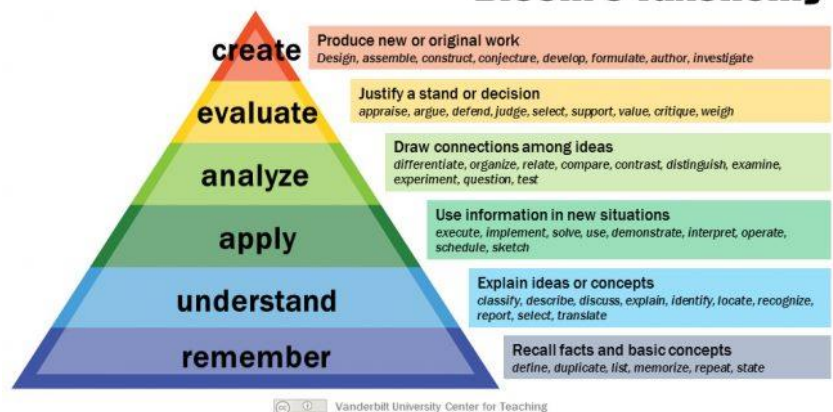
Sl. No.	Content	Page No.
1	Calculation of deflection of singly reinforced beam using Excel	1
2	Design of a simply supported RCC singly reinforced beam using Excel and draw the reinforcement details	2
3	Design of a simply supported RCC doubly reinforced beam using Excel and draw the reinforcement details	5
4	Design of singly reinforced beams with check for shear, check for development length and other Checks using excel.	9
5	Design of a cantilever beam using excel and draw the reinforcement	12
6	Design a simply supported rcc one way slab with intermediate support and draw the reinforcement Details	18
7	Design a two-way slab for the given data and prepare bar bending schedule	20
8	Design a short axially loaded RC column using Excel	25
9	Design the reinforcement for RCC square column with isolated square footing	27
10	Design the reinforcement for RCC circular column with isolated square footing	31
11	Creation of models related to RC Structural elements. (Demonstration)	33

PROGRAM OUTCOMES(POs)

Program Outcomes as defined by NBA (PO) Engineering Graduates will be able to:

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Bloom's Taxonomy



Vision (College)	
To nurture talent and enrich society through excellence in technical education, research and innovation.	
Mission (College)	
<ul style="list-style-type: none"> ➤ To augment innovative pedagogy and kindle quest for interdisciplinary learning and to enhance conceptual understanding. ➤ To build competence, professional ethics and develop entrepreneurial Thinking. ➤ To strengthen industry institute partnership and explore global collaborations. ➤ To inculcate culture of socially responsible citizenship. ➤ To focus on holistic and sustainable development. 	
Vision (Dept)	
<i>To excel in imparting Civil Engineering knowledge of global standards in meeting societal and environmental challenges with professional ethics</i>	
Mission (Dept)	
<ul style="list-style-type: none"> ➤ To develop entrepreneurial and skill and team work among students. ➤ To inculcate basics of civil engineering knowledge to meet the professional challenges through research and innovation in collaboration with industries. ➤ To cultivate qualities of professional ethics and commitment towards welfare of the society and environment. 	
Program Educational Objectives (PEO)	
PEO1	To design and utilize new materials, processes, and projects through research and development for the welfare of society.
PEO2	To communicate feasible technical solutions for civil engineering problems faced by public through presentations and demonstrations.
PEO3	To participate in lifelong learning activities through constructive interactions with stake holders.
Program Specific Outcomes (PSO)	
PSO 1	Graduates will be able to plan, analyse and design in order to execute and maintain civil engineering structures using alternative materials and innovative construction practices for sustainable infrastructural development of the nation.
PSO 2	Graduates will be able to pursue career opportunities for personal and professional growth by demonstrating leadership skill, professional integrity and solve issues related to civil engineering and allied fields.

CO's And PO's Mapping Chart**Subject with code: Design of RCC Structures (BCV601)****AY:2024-25****Semester: 6th**

S.No	Description	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	Understand the design philosophy and principles	2	1												
2	Solve engineering problems of RC elements subjected to flexure, shear and torsion.		2	3									2	1	
3	Demonstrate the procedural knowledge in designs of RC structural elements such as slabs, stair case, columns and footings.		2	3										1	
4	Owens professional and ethical responsibility.								1						

Degree of compliance

Low:1

Medium:2

High:3

Mapping of Experiments with CO, PO and PSO

Experiment Details		CO	PO	PSO
PART – A : CONCRETE LAB				
Module – 1: Tests on Cement				
1	Calculation of deflection of singly reinforced beam using Excel	2	2,5	
2	Design of a simply supported RCC singly reinforced beam using Excel and draw the reinforcement details	3	3,5	1
3	Design of a simply supported RCC doubly reinforced beam using Excel and draw the reinforcement details	3	3,5	1
4	Design of singly reinforced beams with check for shear, check for development length and other Checks using excel.	3	3,5	1
5	Design of a cantilever beam using excel and draw the reinforcement	3	3,5	1
6	Design a simply supported rcc one way slab with intermediate support and draw the reinforcement Details	3	3,5	1
7	Design a two-way slab for the given data and prepare bar bending schedule	3	3,5	1
8	Design a short axially loaded RC column using Excel	3	3,5	1
9	Design the reinforcement for RCC square column with isolated square footing	3	3,5	1
10	Design the reinforcement for RCC circular column with isolated square footing	3	3,5	1
11	Creation of models related to RC Structural elements. (Demonstration)	3	5	

EXPERIMENT WISE LESSON PLAN

Experiment No.1	
Name	Calculation of deflection of singly reinforced beam using Excel [L ₃ , L ₄]
Objectives	<ul style="list-style-type: none"> To learn excel tools and functional formulas and to calculate deflection using excel
Experiment No.2	
Name	Design of a simply supported RCC singly reinforced beam using Excel and draw the reinforcement details [L ₄ , L ₅ .L ₆]
Objectives	<ul style="list-style-type: none"> To learn excel tools and functional formulas and to design SS RCC singly reinforced beam using excel
Experiment No.3	
Name	Design of a simply supported RCC doubly reinforced beam using Excel and draw the reinforcement details [L ₄ , L ₅ , L ₆]
Objectives	<ul style="list-style-type: none"> To learn excel tools and functional formulas and to design SS RCC doubly reinforced beam using excel
Experiment No.4	
Name	Design of singly reinforced beams with check for shear, check for development length and other Checks using excel.. [L ₂ , L ₃]
Objectives	<ul style="list-style-type: none"> To learn excel tools and functional formulas to design Singly reinforced beam with all the necessary checks.
Experiment No.5	
Name	Design of a cantilever beam using excel and draw the reinforcement[L ₄ , L ₅ .L ₆]
Objectives	<ul style="list-style-type: none"> To learn excel tools and functional formulas and to design cantilever beam using excel
Experiment No.6	
Name	Design a simply supported rcc one way slab with intermediate support and draw the reinforcement Details [L ₄ , L ₅ .L ₆]
Objectives	<ul style="list-style-type: none"> To learn excel tools and functional formulas and to design one way slab using excel
Experiment No.7	
Name	Design a two-way slab for the given data and prepare bar bending schedule [L ₄ , L ₅ .L ₆]
Objectives	<ul style="list-style-type: none"> To learn excel tools and functional formulas and to design two way slab using excel
Experiment No.8	
Name	Design a short axially loaded RC column using Excel [L ₄ , L ₅ .L ₆]
Objectives	<ul style="list-style-type: none"> To learn excel tools and functional formulas and to design short axially loaded column using excel
Experiment No.9	
Name	Design the reinforcement for RCC square column with isolated square footing

	[L ₄ , L ₅ .L ₆]
Objectives	<ul style="list-style-type: none">To learn excel tools and functional formulas and to design RCC square column with isolated footing using excel
Experiment No.10	
Name	Design the reinforcement for RCC circular column with isolated square footing [L ₄ , L ₅ .L ₆]
Objectives	<ul style="list-style-type: none">To learn excel tools and functional formulas and to design RCC circular column with isolated footing using excel
Experiment No.11	
Name	Creation of models related to RC Structural elements. (Demonstration) [L ₄ , L ₅ .L ₆]
Objectives	<ul style="list-style-type: none">To create RCC structural models with all the theoretical knowledge and practical observations.

EXPERIMENT 1

Calculation of deflection of singly reinforced beam using Excel

A beam 6 m long, simply supported at its ends, is carrying a point load of 50 KN at its centre. The moment of inertia of the beam is $78 \times 10^6 \text{ mm}^4$. If E for the material of the beam = $2.1 \times 10^5 \text{ N/mm}^2$. calculate deflection at the centre of the beam and slope at the supports.

Solution:

GIVEN DATA:

$$L = 6 \text{ m}$$

$$W = 50 \text{ KN} = 50 \times 10^3 \text{ N}$$

$$I = 78 \times 10^6 \text{ mm}^4$$

$$E = 2.1 \times 10^5 \text{ N/mm}^2$$

SOLUTION:

DEFLECTION AT THE CENTRE OF THE BEAM,

$$y_c = WL^3 / 48 EI$$

$$= 50000 \times 60003 / (48 \times 2.1 \times 10^5 \times 78 \times 10^6) = 13.736 \text{ mm.}$$

SLOPE AT THE SUPPORTS,

$$\Theta_A = \Theta_B = - WL^2 / 16 EI = 50000 \times 60002 / (16 \times 2.1 \times 10^5 \times 78 \times 10^6) = 0.06868 \text{ radians.}$$

Deflection Calculation

		Simply supported beam with UDL	Simply supported beam with Point Load	Cantilever beam with UDL	Cantilever beam with Point Load
Load	W	8 KN/m	70 KN/m	1400 KN/m	10 KN/m
Length	l	2.60 m	3.00 m	3.80 m	5.00 m
Elasticity of Concrete = 5000(vfck)	Ec	22000000 MPa	22000000 MPa	22000000 MPa	22000000 MPa
Width	b	0.20 m	0.20 m	1.50 m	0.20 m
Depth	d	0.45 m	0.60 m	1.10 m	0.60 m
Moment	M	8.66 m	82.13 m	2601.46 m	40.63 m
Reaction	R	13.33 m	109.50 m	2738.38 m	32.50 m
Moment of Inertia = $bd^3/12$	Ixx	0.0015 mm ⁴	0.0036 mm ⁴	0.1664 mm ⁴	0.0036 mm ⁴
Deflection	dy	0.1 mm	0.5 mm	10.0 mm	5.3 mm
Formula		$5WI^4/384EI$	$WI^3/48EI$	$WI^4/8EI$	$WI^3/3EI$

EXPERIMENT 2

Design of a simply supported RCC singly reinforced beam using Excel and draw the reinforcement details

A Reinforced concrete beam is to be designed over an effective span of 5m to support a service load of 8 KN/m. adopts M20 grade concrete and Fe 415 HYSD bars

Step 1

Given Data		
Effective length	=	5 m
f_{ck}	=	20 N/mm ²
f_y	=	415 N/mm ²
span to effective depth ratio	=	18
unit weight	=	25 kN/m ³

Step 2

Dimensions		
Span/Effective=18, depth	=	0.27777778 m
	=	277.777778 mm
Considering depth d	=	300 mm
Effective cover	=	50 mm
cover d'	=	50 mm
Overall depth D	=	350 mm
	=	0.35 m
Provide breadth b	=	230 mm
	=	0.23 m

Step 3

Load calculations		
DL=Self Weight	=	$b \cdot D \cdot \gamma_{RCC}$
DL	=	2.0125 kN/m
LL	=	8 kN/m
Total load W	=	10.0125 kN/m
Factored load $W_u=1.5 \times W_u$	=	15.01875 kN/m

Step 4

Ultimate Moment and Ultimate shear		
M_u	=	$W_u l^2 / 8$
	=	46.9335938 kNm
v_u	=	$(W_u l) / 2$
	=	37.546875 kN

Step 5

Limiting Moment of Resistance		
$M_{u\text{lim}}$	=	$0.138 \cdot f_{ck} \cdot b \cdot d^2$
	=	57132000 Nmm
		57.13 kNm

$M_{u\text{lim}} > M_u$
The beam can be designed as singly reinforced beam

Step 6

Tensile Reinforcement		
A_{st}	=	$\left(\frac{0.5 \cdot f_{ck} \cdot b \cdot d}{f_y} \right) \cdot \left(1 - \sqrt{1 - \frac{4.6 \cdot M_u \cdot 10^6}{f_{ck} \cdot b \cdot d^2}} \right)$
	=	512.13 mm ²
$A_{st\text{min}}$	=	$(0.85 \cdot b \cdot d) / f_y$
	=	141.3253012 mm ²
$A_{st\text{max}}$	=	$(0.04 \cdot b \cdot D)$
	=	3220 mm ²

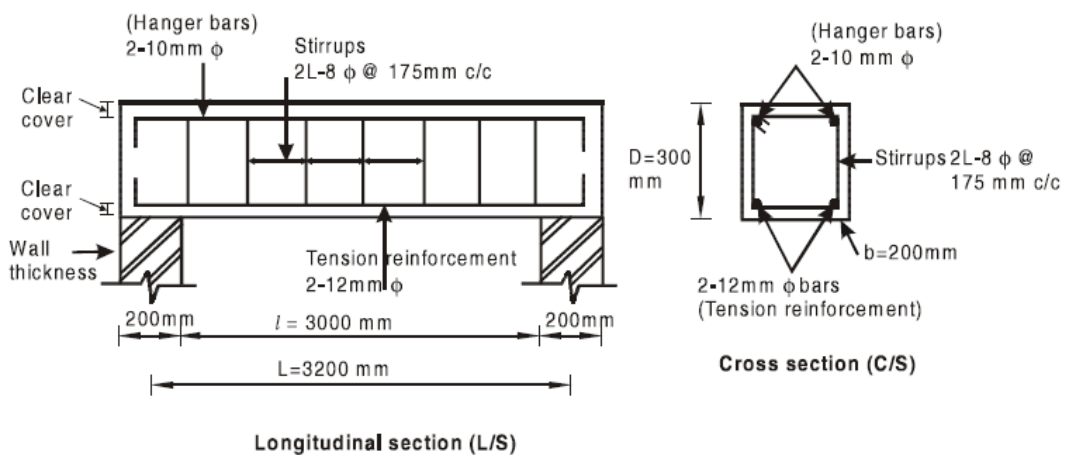
$A_{st\text{min}} < A_{st} < A_{st\text{max}}$
--

Step 7

Using 16mm diameter bars		
No of bars	=	(A_{st} / a_{st})
a_{st}	=	$\pi / 4 \cdot 16^2$
	=	201.088 mm ²
No of bars	=	2.54679543
	=	3
Provide 3 no'r of 16mm dia bars as tesion reinforcement		
Provide 2 no'r of 10mm dia bars as hanger bars		

Step 8

Shear Reinforcement		
Nominal shear stress τ_v	=	$V_u/(b*d)$
	=	0.544 N/mm ²
$A_{st_{pro}}$	=	$3*(\pi/4)*16^2$
	=	603.264 mm ²
P_t	=	$100A_{st_{pro}}/b*d$
	=	0.87429565
Design shear stress τ_c	=	0.58 N/mm ²
$\tau_v < \tau_c$		
Hence provide the nominal shear reinforcement		
Consider 2 leg 6mm dia vertical stirrups		
A_{sv}	=	$2*(\pi/4)*6^2$
	=	56.556 mm ²
S_v	=	$(0.87*f_y*A_{sv})/(0.4*b)$
	=	221.951563 mm
	=	200 mm
Provide 2 legged 6mm diameter vertical stirrups at a distance of 200mm c/c		



EXPERIMENT 3

Design of a simply supported RCC doubly reinforced beam using Excel and draw the reinforcement details

Design a Reinforced concrete beam of Rectangular cross section to carry a Live load of 20KN/m. The clear span of the beam is 5.5m. The bearing at each end is 300mm. use M20 grade concrete and Fe415 steel.

Step 1

Given Data			
Clear length	=	5.5	m
f_{ck}	=	20	N/mm ²
f_y	=	415	N/mm ²
span to effective depth ratio	=	18	
unit weight	=	25	KN/m ³
Bearing at each end	=	300	mm
LL	=	20	KN/m

Step 2

Dimensions			
Span/Effective depth, Depth=	=	0.30555556	m
	=	305.555556	mm
Considering depth d	=	350	mm
	=	0.35	m
Effective cover	cover d'	=	50 mm
Overall depth D	=	400	mm
	=	0.4	m
Provide breadth b	=	230	mm
	=	0.23	m
Effective span			
C/C distance bet the support	=	5.8	m
Clear span + d	=	5.85	m
L_{eff}	=	5.8	m

Step 3

Load calculations			
DL=Self Weight	=	$b \cdot D \cdot \gamma_{RCC}$	
DL	=	2.3	kN/m
LL	=	20	kN/m
Total load	W	=	22.3 kN/m
Factored load W_u	=	33.45	kN/m

Step 4

Ultimate Moment and Ultimate shear		
M_u	=	$W_u l^2 / 8$ 140.65725 kNm
V_u	=	$(W_u l) / 2$ 97.005 kN

Step 5

Limiting Moment of Resistance		
$M_{u,lim}$	=	$0.138 * f_{ck} * b * d^2$
	=	77763000 Nmm 77.7 kNm

$M_{u,lim} < M_u$ The beam can be designed as doubly reinforced beam

Step 6

Tensile Reinforcement		
$A_{st} = A_{st1} + A_{st2}$		
A_{st1}	=	$((X_u/d)_{lim} * 0.36 * b * d) / (0.87 * f_y)$
	=	770.552555 mm ²
$(M_u = M_{u,lim}) = f_{sc} * A_{sc} * (d - d')$		
ϵ_s	=	$2 * 10^5$ N/mm ²
$X_{u,max}$	=	$0.48 * d$
	=	168 mm
f_{sc}	=	$(0.0035 * (X_{u,max} - d') * \epsilon_s) / X_{u,max}$
	=	491.666667 N/mm ²
f_{sc}	=	361.05 N/mm ²
A_{sc}	=	580.62 mm ²
$A_{sc} = A_{st2}$	=	580.62 mm ²
$A_{st} = A_{st1} + A_{st2}$	=	1351.17256 mm ²
$A_{st,req}$	=	1351.17256 mm ²
$A_{sc,req}$	=	580.62 mm ²

Step 7

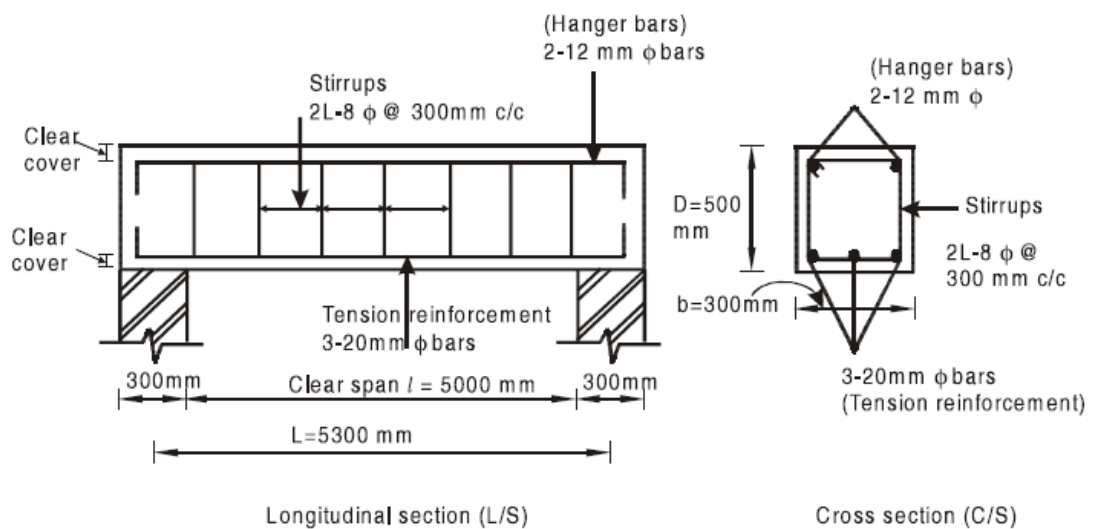
Using 25mm diameter bars	(Tesion R/F)	
No of bars	=	(Ast/ast)
ast	=	$\pi/4*25^2$
	=	490.9375 mm ²
No of bars	=	2.75222928
	=	3
Using 16mm diameter bars	(Compression R/F)	
No of bars	=	(Ast/ast)
ast	=	$\pi/4*16^2$
	=	201.088 mm ²
No of bars	=	2.88739258
	=	3
Provide 3 bars of 25mm dia bars as tesion reinforcement		
Provide 3 bars of 16mm dia bars as compression reinforcement		

Step 8

Shear Reinforcement		
Nominal shear stress τ_v	=	$V_u/(b*d)$
	=	1.2 N/mm ²
$A_{st_{pro}}$	=	$3*(\pi/4)*25^2$
	=	1472.8 mm ²
$A_{sc_{pro}}$	=	$3*(\pi/4)*16^2$
	=	603.26 mm ²
P_t	=	$100A_{st_{pro}}/b*d$
	=	1.829
Design shear stress τ_c	=	0.76 N/mm ²
		$\tau_v > \tau_c$
Hence design for shear reinforcement		
$V_u = V_{uc} + V_{us}$		
V_{uc}	=	$\tau_c * b * d$
	=	61180 N
		61.1 KN
V_{us}	=	$V_u - V_{uc}$
		35.905 KN
Using 2 leg 6mm diameter		
A_{sv}	=	$2*(\pi/4)*6^2$
	=	56.55 mm ²
S_v	=	$(0.87*f_y*A_{sv}*d)/V_{us}$
		199027.493
		199 mm
	=	175 mm
Provide 2 legged 6mm diameter vertical stirrups at a distance of 175mm		

Step 9

Deflection Calculation		
$(L/d)_{act}$	=	0.01657143
	=	16.5714286
$(L/d)_{permissible}$	=	$(L/d)_{max} * K_t * K_c * K_f$
f_s	=	$0.58f_y(Ast_{req}/Ast_{pro})$
	=	220.83 N/mm ²
K_t	=	0.9
P_c	=	$(100Asc_{pro})/(b*d)$
	=	0.75
K_c	=	1.2
K_f	=	1
$(L/d)_{permissible}$	=	21.6
	$(L/d)_{act}$	< $(L/d)_{permissible}$
Hence the design is safe		



EXPERIMENT 4

Design of singly reinforced beams with check for shear, check for development length and other checks using Excel.

A Reinforced concrete beam is to be designed over an effective span of 5m to support a service load of 8 KN/m. adopts M20 grade concrete and Fe 415 HYSD bars

Step 1

Given Data		
Effective length	=	5 m
f_{ck}	=	20 N/mm ²
f_y	=	415 N/mm ²
span to effective depth ratio	=	18
unit weight	=	25 kN/m ³

Step 2

Dimensions		
Span/Effective=18, depth	=	0.27777778 m
	=	277.777778 mm
Considering depth d	=	300 mm
Effective cover	=	50 mm
cover d'	=	50 mm
Overall depth D	=	350 mm
	=	0.35 m
Provide breadth b	=	230 mm
	=	0.23 m

Step 3

Load calculations		
DL=Self Weight	=	$b \cdot D \cdot \gamma_{RCC}$
DL	=	2.0125 kN/m
LL	=	8 kN/m
Total load W	=	10.0125 kN/m
Factored load $W_u=1.5 \times W_u$	=	15.01875 kN/m

Step 4

Ultimate Moment and Ultimate shear		
M_u	=	$W_u l^2 / 8$
	=	46.9335938 kNm
v_u	=	$(W_u l) / 2$
	=	37.546875 kN

Step 5

Limiting Moment of Resistance		
$M_{u\text{lim}}$	=	$0.138 \cdot f_{ck} \cdot b \cdot d^2$
	=	57132000 Nmm
		57.13 kNm

$M_{u\text{lim}} > M_u$
The beam can be designed as singly reinforced beam

Step 6

Tensile Reinforcement		
A_{st}	=	$\left(\frac{0.5 \cdot f_{ck} \cdot b \cdot d}{f_y} \cdot \left(1 - \sqrt{1 - \frac{4.6 \cdot M_u \cdot 10^6}{f_{ck} \cdot b \cdot d^2}} \right) \right)$
	=	512.13 mm ²
$A_{st\text{min}}$	=	$(0.85 \cdot b \cdot d) / f_y$
	=	141.3253012 mm ²
$A_{st\text{max}}$	=	$(0.04 \cdot b \cdot D)$
	=	3220 mm ²

$A_{st\text{min}} < A_{st} < A_{st\text{max}}$
--

Step 7

Using 16mm diameter bars		
No of bars	=	(A_{st} / a_{st})
a_{st}	=	$\pi / 4 \cdot 16^2$
	=	201.088 mm ²
No of bars	=	2.54679543
	=	3
Provide 3 no'r of 16mm dia bars as tesion reinforcement		
Provide 2 no'r of 10mm dia bars as hanger bars		

Step 8

Shear Reinforcement		
Nominal shear stress τ_v	=	$V_u/(b*d)$
	=	0.544 N/mm ²
$A_{st_{pro}}$	=	$3*(\pi/4)*16^2$
	=	603.264 mm ²
P_t	=	$100A_{st_{pro}}/b*d$
	=	0.87429565
Design shear stress τ_c	=	0.58 N/mm ²
$\tau_v < \tau_c$		
Hence provide the nominal shear reinforcement		
Consider 2 leg 6mm dia vertical stirrups		
A_{sv}	=	$2*(\pi/4)*6^2$
	=	56.556 mm ²
S_v	=	$(0.87*f_y*A_{sv})/(0.4*b)$
	=	221.951563 mm
	=	200 mm
Provide 2 legged 6mm diameter vertical stirrups at a distance of 200mm c/c		

EXPERIMENT 5

Design of a cantilever beam using Excel and draw the reinforcement

Design a cantilever beam of clear span 3.25m, service load 15kN/m. Use Fe415 steel, M20 concrete. Sketch the reinforcement details.

Given : clear span, $l = 3.25$ m, live load = 15 kN/m

$$f_{ck} = 20 \text{ N/mm}^2 \text{ and } f_y = 415 \text{ N/mm}^2$$

Step : 1 Selection of cross - sectional dimensions

(a) Effective depth of beam (d)

$$d = \frac{\text{clear span}}{7} = \frac{l}{7} = \frac{3250}{7} = 464.28 \text{ mm}$$

say, $d = 500$ mm or 0.5 m [$\therefore d_{\text{provided}} = 500$ mm]

(b) Overall depth of beam (D)

$$D = d + d' \text{ (Assume } d' = 50 \text{ mm)}$$

$$\therefore D = 500 + 50 = 550 \text{ mm or } 0.55 \text{ m}$$

(c) Width of beam (b)

$$b = \frac{1}{3} \times d \text{ to } \frac{2}{3} \times d$$

$$\therefore b = \frac{1}{3} \times 500 = 166.66 \text{ mm}$$

$$b = \frac{2}{3} \times 500 = 333.33 \text{ mm}$$

\therefore Provide $b = 250$ mm or 0.25 m

$$\text{Beam size} = b \times D = 250 \times 550 \text{ mm}$$

Step : 2 Calculation of effective span (L)

$$\text{Effective span } (L) = \text{clear span } (l) + \frac{\text{effective depth } (d)}{2}$$

$$\therefore L = 3.25 + \frac{0.5}{2} = 3.5 \text{ m}$$

Step : 3 Load calculation

1. Self weight of beam = $b \times D \times \text{density of RCC}$
 $= 0.25 \times 0.55 \times 25 = 3.437 \text{ kN/m}$
 $\approx 3.44 \text{ kN/m}$
 2. Live load (Given) = 15.0 kN/m
- Total load, W = 18.44 kN/m
- \therefore Factored W_u = $1.5 \times W = 1.5 \times 18.44 = 27.66 \text{ kN/m}$

Step : 4 Calculation of Maximum bending moment

$$M_u = \frac{W_u L^2}{2} = \frac{27.66 \times 3.5^2}{2} = 169.41 \text{ kN.m or } 169.41 \times 10^6 \text{ N.mm}$$

Step : 5 Check for effective depth

$$M_{u_{lim}} = 0.138 f_{ck} b d^2 \quad \text{--- For Fe 415 steel}$$

Equating, $M_u = M_{u_{lim}}$

$$\therefore d_{req} = \sqrt{\frac{M_u}{0.138 f_{ck} b}} = \sqrt{\frac{169.41 \times 10^6}{0.138 \times 20 \times 250}} = 495.50 \text{ mm}$$

$d_{req} < d_{provided}$ (500 mm), Design is safe, (ok)

Step : 6 Calculation of main reinforcement

$$M_{u_{lim}} = 0.138 f_{ck} b d^2 = 0.138 \times 20 \times 250 \times 500^2 = 172.5 \text{ kN.m}$$

$\therefore M_{u_{lim}} > M_u$ --- Section is under reinforced

Hence singly reinforced section is to be designed

Refer IS:456-2000, G-1.1(b)

$$M_u = 0.87 f_y A_{st} d \left[1 - \left(\frac{f_y A_{st}}{f_{ck} b d} \right) \right]$$

$$169.41 \times 10^6 = 0.87 \times 415 \times 500 A_{st} \left[1 - \left(\frac{415 A_{st}}{20 \times 250 \times 500} \right) \right]$$

$$29.96 A_{st}^2 - 180525 A_{st} + 169.41 \times 10^6 = 0$$

$$\therefore A_{st} = 1162.84 \text{ mm}^2$$

- Check for minimum reinforcement - clause 26.5.1.1(a)

$$A_{st_{min}} = \frac{0.85 b d}{f_y} = \frac{0.85 \times 250 \times 500}{415} = 256.02 \text{ mm}^2$$

$\therefore A_{st} > A_{st_{min}}$, Hence (ok)

Now Assume 20 mm ϕ bars

$$\therefore \text{Area of one bar, } a_{st} = \frac{\pi}{4} \phi^2 = \frac{\pi}{4} \times 20^2 = 314.15 \text{ mm}^2$$

$$\text{No. of bars} = \frac{A_{st}}{a_{st}} = \frac{1162.84}{314.15} = 3.70 \text{ say } 4$$

$$A_{st_{provided}} = 4 \times 314.15 = 1256.6 \text{ mm}^2$$

\therefore Provide 4-20 mm ϕ bars at tension reinforcement (Top) and 2-12 mm ϕ bars at compression reinforcement (Bottom) [Assume]

Step : 7 Design of shear reinforcement

- Design of shear force

$$V_u = W_u L = 27.66 \times 3.5 = 96.81 \text{ kN}$$

- Nominal shear stress, $\tau_v = \frac{V_u}{b d} = \frac{96.81 \times 10^3}{250 \times 500} = 0.77 \text{ N/mm}^2$

- Percentage of tensile steel reinforcement, $p_t = \frac{100 A_{st_{provided}}}{b d} = \frac{100 \times 1256.6}{250 \times 500}$

$$\therefore p_t = 1\%$$

- Calculation of τ_v , Refer IS:456-2000, table No. 19

using $p_t = 1\%$ and $f_{ck} = 20 \text{ N/mm}^2$

$$\tau_v = 0.62 \text{ N/mm}^2$$

- Design shear strength, ' $\tau_{v_{max}}$ ', Refer table No.-20

using $f_{ck} = 20 \text{ N/mm}^2$

$$\therefore \tau_{v_{max}} = 2.8 \text{ N/mm}^2$$

- Comparisons

(a) $\tau_v > \tau_v$ --- Hence shear reinforcement is required

(i) Calculate shear carried by concrete, $V_{uc} = \tau_v b d = 0.62 \times 250 \times 500 = 77500 \text{ N}$

$$\therefore V_{uc} = 77.5 \text{ kN}$$

- (ii) Calculate shear carried by stirrups, $V_{ur} = V_u - V_{uc} = 96.81 - 77.5 = 19.31$ kN
spacing of stirrups should be least of the following three

$$1. S_v = \frac{0.87 f_y A_{sv} d}{V_{ur}}$$

Assume 2L – 8mm ϕ vertical stirrups

$$\therefore A_{sv} = 2 \times \frac{\pi}{4} \times 8^2 = 100.53 \text{ mm}^2$$

$$\therefore S_v = \frac{0.87 \times 415 \times 100.53 \times 500}{19.31 \times 10^3} = 939.83$$

$$2. S_v \geq 0.75 d, \therefore S_v = 0.75 \times 500 = 375 \text{ mm}$$

$$3. S_v \geq 300 \text{ mm}, \therefore S_v = 300 \text{ mm}$$

say $S_v = 300 \text{ mm}$

\therefore Provide 2L–8mm ϕ bars @ 300 mm c/c

- (b) $\tau_{c_{max}} > \tau_v$, —Design is safe (ok)

Step : 8 Check for deflection control

- (a) Note down the percentage of steel provided, $p_t = 1\%$
(b) stress in steel, Refer IS:450-2000, Fig 4

$$f_s = 0.58 f_y \left[\frac{A_{st_{req}}}{A_{st_{prov}}} \right] = 0.58 \times 415 \times \frac{1162.84}{1256.6} = 222.74 \text{ N/mm}^2$$

read out the modification factor (k_t)

$$\therefore k_t = 1.15$$

$$1. \left(\frac{L}{d} \right)_{\max} = 7 \times k_t \times k_c \times k_f \quad k_c = k_f = 1$$

$$\therefore \left(\frac{L}{d} \right)_{\max} = 7 \times 1.15 \times 1 \times 1 = 8.05$$

$$2. \left(\frac{L}{d} \right)_{\text{provided}} = \frac{3500}{400} = 7$$

$$\therefore \left(\frac{L}{d} \right)_{\max} > \left(\frac{L}{d} \right)_{\text{provided}}$$

Hence deflection control is satisfied, (ok)

Step : 9 Development length or Anchorage length at supports

Refer IS:456–2000, clause 26.2.1

$$L_d = \frac{\phi \sigma_s}{4 \tau_{bd}} \quad \text{where } \sigma_s = 0.87 f_y$$

$$\therefore L_d = \frac{0.87 f_y \phi}{4 \tau_{bd}}$$

$$\tau_{bd} = 1.2 \text{ N/mm}^2 \text{ — from clause 26.2.1.1}$$

For deformed bars increased by 60%

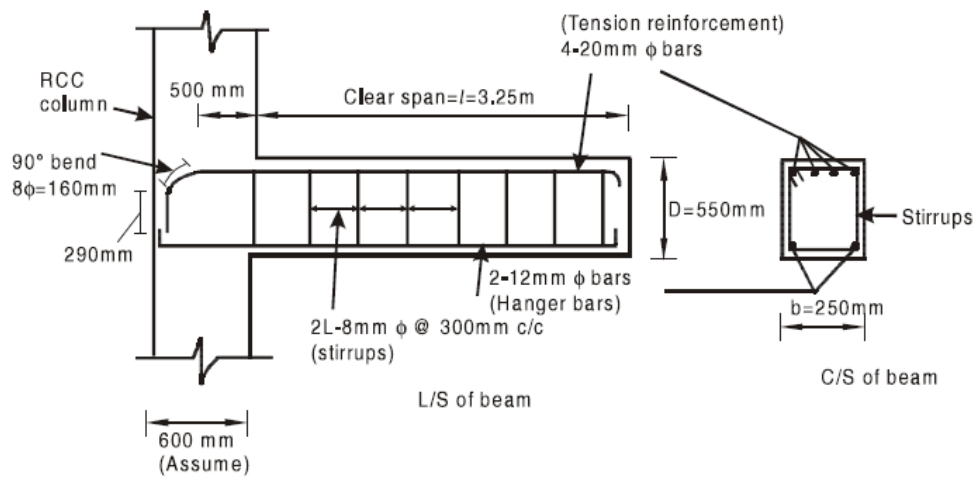
$$\text{i.e., } \tau_{bd} = 1.2 \times 1.6$$

$$\text{Now, } L_d = \frac{0.87 \times 415 \times 20}{4 \times 1.2 \times 1.6} = 940.23 \text{ mm say } 950 \text{ mm}$$

The main tension reinforcement is extended into the column to a length of 500 mm and bent down at 90° and extended upto 8 ϕ and 290 mm

$$\text{i.e., } L_d = 500 + 8 \times 20 + 290 = 950 \text{ mm}$$

Step : 10 Reinforcement details



EXPERIMENT 6

Design a simply supported RCC one way slab with intermediate support and draw the reinforcement details

Design a Simply supported slab for the following parameters clear dimension of slab in plan 9m x 4m. The slab is simply supported along 2 long edges. Live load = 4.5 kN/m², Finishing load = 0.5 kN/m², Materials used M20 and Fe415, width of support 300 mm.

Step 1

Given Data			
f_{ck}	=	20	N/mm ²
f_y	=	415	N/mm ²
unit weight	=	25	kN/m ³
Width of support	=	300	mm
l_y	=	9	m
l_x	=	4	m
l_y/l_x	=	2.25	
LL	=	4.5	kN/m ²
Span to effective depth ratio	=	20	

Step 2

Type of slab
$(l_y/l_x) = 2.25 > 2$
Hence the slab is to be designed as one way slab

Step 3

Dimensions			
Span/Effective depth	=	0.2	m
	=	200	mm
Considering depth d	=	200	mm
	=	0.2	m
Effective cover d'	=	25	mm
Overall depth D	=	225	mm
	=	0.225	m
Provide breadth b	=	1000	mm
		1	m
Effective span (l_x)			
C/C distance bet the support	=	4.3	m
Clear span + d	=	4.2	m
Effective span (l_y)	=		
C/C distance bet the support	=	9.2	m
Clear span + d	=	9.3	m

$l_{x\text{eff}}$	=	4.2 m
$l_{y\text{eff}}$	=	9.2 m

Step 4

Load calculations		
DL=Self Weight	=	$D \cdot \gamma_{\text{RCC}}$
DL	=	5.625 KN/m ²
LL	=	4.5 KN/m ²
FL	=	0.5 KN/m ²
Total load W	=	10.625 KN/m
Factored load W_u	=	15.9375 KN/m

Step 5

Ultimate Moment and Ultimate shear		
M_u	=	$W_u l^2 / 8$ 35.142188 kNm
v_u	=	$(W_u l) / 2$ 33.46875 kN

Step 6

Limiting Moment of Resistance		
$M_{u\text{lim}}$	=	$0.138 \cdot f_{ck} \cdot b \cdot d^2$ 110400000 Nmm 110.4 kNm

$M_{u\text{lim}} > M_u$
Hence the depth provided is sufficient

Step 7

Tensile Reinforcement		
A_{st}	=	$\left(\frac{0.5 \cdot f_{ck} \cdot b \cdot d}{f_y} \right) \cdot \left(1 - \sqrt{1 - \frac{4.6 \cdot M_u \cdot 10^6}{f_{ck} \cdot b \cdot d^2}} \right)$
	=	514.09 mm ²
$A_{st\text{min}}$	=	0.12% $\cdot b \cdot D$
	=	270 mm ²
Considering 12mm diameter bars		
Spacing	=	$\left(\frac{\pi \cdot 4 \cdot 102}{A_{st\text{req}}} \right) \cdot 1000$
	=	220.02 mm
	=	200 mm
Provide 12mm diameter bars at a spacing of 200mm c/c		

Step 8

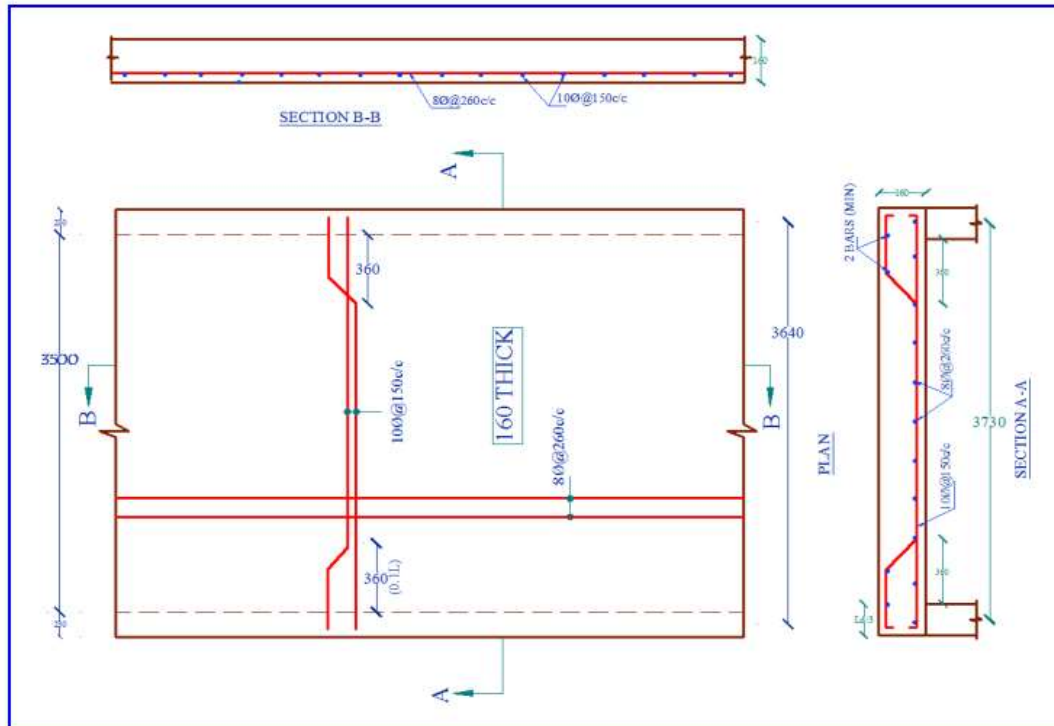
Distribution Reinforcement	
Ast _{min} should be considered	
Using 8mm diameter	
Spacing	= $((\pi/4 * 8^2) / Ast_{min}) * 1000$
	= 186.19259 mm
Provide 8mm diameter bars at a spacing of 175mm c/c	

Step 9

Shear Reinforcement	
Nominal shear stress τ_v	= $V_u / (b * d)$
	= 0.167 N/mm ²
Ast _{pro}	= $((\pi/4 * 8^2) / Spacing) * 1000$
	= 565.56 mm ²
P _t	= $100 Ast_{pro} / b * d$
	= 0.2827
Design shear stress τ_c	= 0.375 N/mm ²
K	= 1.15
$\tau_v < K \tau_c$	
No shear reinforcement should be provided	

Step 10

Deflection Calculation	
(L/d) _{act}	= 0.021
	= 21
(L/d) _{permissible}	= $(L/d)_{max} * K_t * K_c * K_f$
f _t	= $0.58 f_y (Ast_{req} / Ast_{pro})$
	= 218.19 N/mm ²
K _t	= 1.75 N/mm ²
(L/d) _{permissible}	= 33
$(L/d)_{act} < (L/d)_{permissible}$	
Hence the design is safe	



Reinforcement Detail of One way slab

EXPERIMENT 7

Design a two-way slab for the given data and prepare Bar bending schedule

Design the Slab for a room of clear dimensions 4mx5m,width of support 300mm,Two adjacent edges are discontinuous LL = 3KN/m²,FF = 1KN/ m².Materials used M20 and Fe415.Show reinforced details.

Step

1

Given Data			
f_{ck}	=	20	N/mm ²
f_y	=	415	N/mm ²
unit weight	=	25	KN/m ³
l_y	=	5	m
l_x	=	4	m
l_y/l_x	=	1.25	
FF	=	1	KN/m ²
LL	=	3	KN/m ²
Span to effective depth ratio	=	35*0.8	

Step

2

Type of slab
$(l_y/l_x) = 1.25 < 2$
Hence the slab is to be designed as two way slab

Step

3

Dimensions			
Span/Effective depth	=	0.1425	m
	=	142.5	mm
Considering depth d	=	125	mm
	=	0.125	m
Effective cover d'	=	25	mm
Overall depth D	=	150	mm
	=	0.15	m
Provide breadth b	=	1000	mm
	=	1	m
Effective span (l_x)			
C/C distance bet the support	=	4.3	m
Clear span + d	=	4.125	m
Effective span (l_y)	=		
C/C distance bet the support	=	5.3	m
Clear span + d	=	5.125	m

l_{xeff}	=	4.125 m
l_{yeff}	=	5.125 m

Step

3

Load calculations		
DL=Self Weight	=	$D \cdot \gamma_{RCC}$
DL	=	3.75 KN/m ²
LL	=	3 KN/m ²
FL	=	1 KN/m ²
Total load	W	= 7.75 KN/m ²
Factored load W_u/m run	=	11.625 KN/m

Step

4

Ultimate Bending Moment and Shear		
l_{yeff}/l_{xeff}	=	1.24242424
+ve α_x	=	0.062
-ve α_x	=	0.0466
+ve α_y	=	0.035
-ve α_y	=	0.047
$M_x(-ve)$	=	$\alpha_x \cdot W_u \cdot l_x^2$
	=	12.2640117 KN/m
$M_y(-ve)$	=	$\alpha_y \cdot W_u \cdot l_x^2$
	=	9.29691211 KN/m
$M_x(+ve)$	=	$\alpha_x \cdot W_u \cdot l_x^2$
	=	9.21778945 KN/m
$M_y(+ve)$	=	$\alpha_y \cdot W_u \cdot l_x^2$
	=	6.92323242 KN/m

Step

5

Limiting Moment of Resistance		
$M_{u,lim}$	=	$0.138 \cdot f_{ck} \cdot b \cdot d^2$
	=	43125000 Nmm
		43.125 kNm

$M_{u,lim} > M_u$ Hence the depth provided is sufficient

Step

6

Tesion Reinforcement

Ast _x (+ve)	=	$((0.5 * f_{ck} * b * d) / f_y) * (1 - \text{SQRT}(1 - ((4.6 * \mu * 10^6) / f_{ck} * b * d^2)))$
	=	211.77 mm ²
Ast _x (-ve)	=	$((0.5 * f_{ck} * b * d) / f_y) * (1 - \text{SQRT}(1 - ((4.6 * \mu * 10^6) / f_{ck} * b * d^2)))$
	=	285.29 mm ²
Ast _y (+ve)	=	$((0.5 * f_{ck} * b * d) / f_y) * (1 - \text{SQRT}(1 - ((4.6 * \mu * 10^6) / f_{ck} * b * d^2)))$
	=	157.59 mm ²
Ast _y (-ve)	=	$((0.5 * f_{ck} * b * d) / f_y) * (1 - \text{SQRT}(1 - ((4.6 * \mu * 10^6) / f_{ck} * b * d^2)))$
	=	213.65 mm ²
Ast _{min}	=	0.12% * b * D
		180 mm ²
Using 8mm diameter bars		
Ast _x (+ve)		
Spacing	=	$((\pi / 4 * 8^2) / Ast_{req}) * 1000$
		237.38 mm
Ast _x (-ve)		
Spacing	=	$((\pi / 4 * 8^2) / Ast_{req}) * 1000$
		176.21 mm
Ast _y (+ve)		
Spacing	=	$((\pi / 4 * 8^2) / Ast_{req}) * 1000$
	=	279.28 mm
Ast _y (-ve)		
Spacing	=	$((\pi / 4 * 8^2) / Ast_{req}) * 1000$
	=	235.3 mm
Ast _{pro}	=	$((\pi / 4 * 8^2) / Spacing) * 1000$
	=	287.2686 mm ²
Ultimate Shear		
V _u	=	$((W_u * (r^4 / (1 + r^4)) * (l_x / 2)))$
		16.85 KN

Step
8

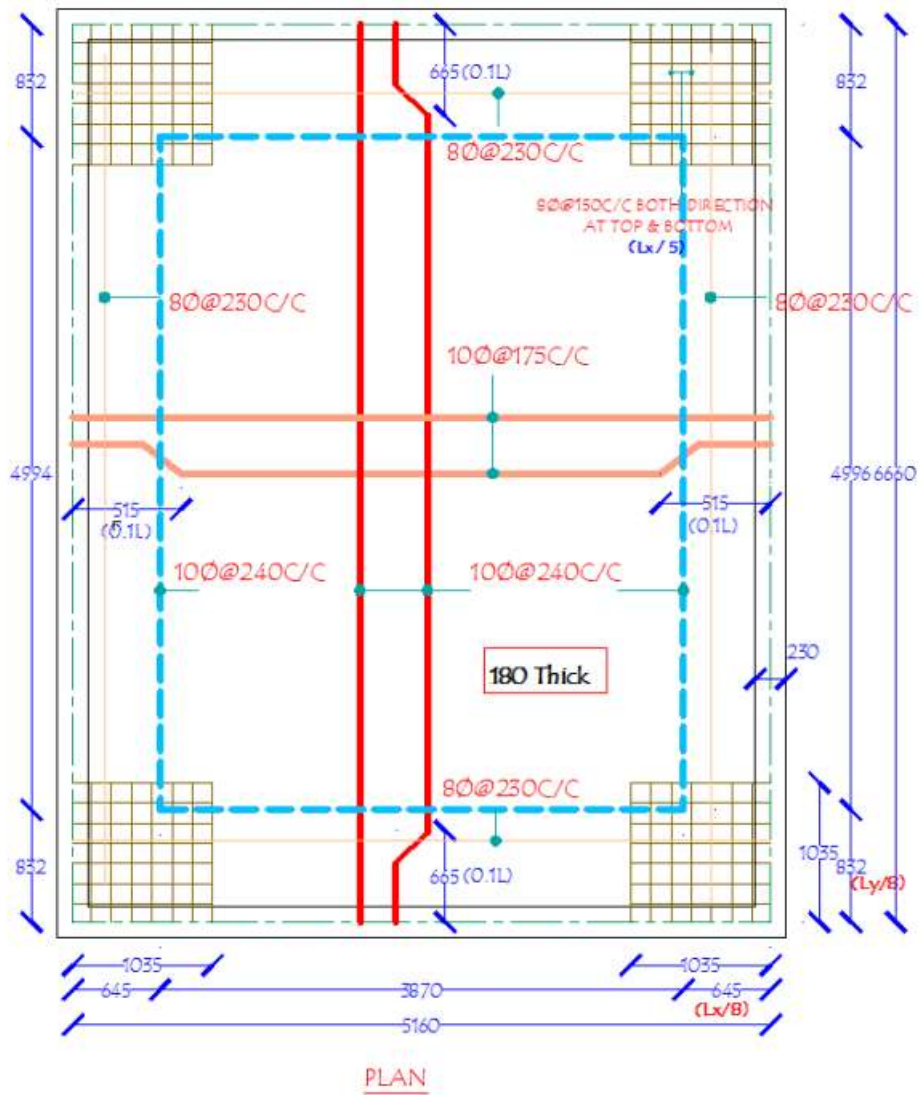
Shear Reinforcement		
Nominal shear stress τ_v	=	$V_u / (b * d)$
	=	0.1348 N/mm ²
P _t	=	$100 Ast_{pro} / b * d$
	=	0.229
Design shear stress τ_c	=	0.3432 N/mm ²
K	=	1.3
$\tau_v < K \tau_c$		
No shear reinforcement should be provided		

Step
9

Deflection Calculation			
$(L/d)_{act}$	=		33
$(L/d)_{permissible}$	=	$(L/d)_{max} * K_t * K_c * K_f$	
f_s	=	$0.58f_y(Ast_{req}/Ast_{pro})$	
	=	239.56	N/mm ²
K_t	=	1.5	N/mm ²
$(L/d)_{permissible}$	=		42
		$(L/d)_{act}$	< $(L/d)_{permissible}$
Hence the design is safe			

Step
10

Torsion	
Continuous edge	$3/8 * Ast_{max}$ 106.9838 mm ²
Discontinuous edge	$3/4 * Ast_{max}$ 213.9675 mm ²



EXPERIMENT 8

Design a short axially loaded RC column using Excel

Design the reinforcement in a column of size 400 mm x 600 mm subjected to an axial load of 2000 kN under service dead load and live load. The column has an unsupported length of 4.0 m and effectively held in position and restrained against rotation in both ends. Use M 25 concrete and Fe 415 steel.

Step 1: To check if the column is short or slender

Given

$l = 4000 \text{ mm}$, $b = 400 \text{ mm}$ and $D = 600 \text{ mm}$.

Table 28 of IS 456 = $l_{ex} = l_{ey} = 0.65(l) = 2600 \text{ mm}$.

So, we have

$l_{ex}/D = 2600/600 = 4.33 < 12$ $l_{ey}/b = 2600/400 = 6.5 < 12$

Hence, it is a short column.

Step 2: Minimum eccentricity

$e_{x \text{ min}} = \text{Greater of } (l_{ex}/500 + D/30) \text{ and } 20 \text{ mm} = 25.2 \text{ mm}$

$e_{y \text{ min}} = \text{Greater of } (l_{ey}/500 + b/30) \text{ and } 20 \text{ mm} = 20 \text{ mm}$

$0.05 D = 0.05(600) = 30 \text{ mm} > 25.2 \text{ mm} (= e_{x \text{ min}})$

$0.05 b = 0.05(400) = 20 \text{ mm} = 20 \text{ mm} (= e_{y \text{ min}})$

Hence, the equation given in cl.39.3 of IS 456 (Eq.10.4) is applicable for the design here.

Step 3: Area of steel

$P_u = 0.4 f_{ck} A_c + 0.67 f_y A_{sc}$

$3000(103) = 0.4(25)\{(400)(600) - A_{sc}\} + 0.67(415) A_{sc}$

$A_{sc} = 2238.39 \text{ mm}^2$

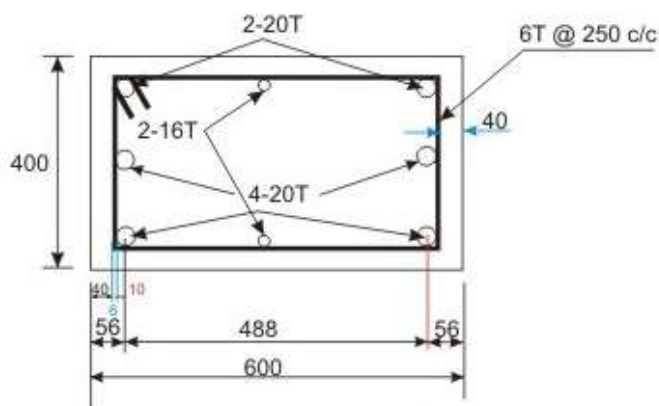
Provide 6-20 mm diameter and 2-16 mm diameter rods giving $2287 \text{ mm}^2 (> 2238.39 \text{ mm}^2)$ and $p = 0.953$ per cent, which is more than minimum percentage of 0.8 and less than maximum percentage of 4.0. Hence, o.k.

Step 4: Lateral ties

The diameter of transverse reinforcement (lateral ties) is determined from cl.26.5.3.2 C-2 of IS 456 as not less than (i) $\phi / 4$ and (ii) 6 mm. Here, ϕ = largest bar diameter used as longitudinal reinforcement = 20 mm. So, the diameter of bars used as lateral ties = 6 mm.

The pitch of lateral ties, as per cl.26.5.3.2 C-1 of IS 456, should be not more than the least of

- (i) the least lateral dimension of the column = 400 mm
- (ii) sixteen times the smallest diameter of longitudinal reinforcement bar to be tied = $16(16) = 256$ mm
- (iii) 300 mm



EXPERIMENT 9

Design the reinforcement for RCC square column with isolated square footing

Design an isolated footing for an R.C. column of size 300 mm x 300 mm which carries a vertical load of 800 kN together with an uniaxial moment of 40 kN-m. The safe bearing capacity of soil is 250 kN/m². Use M25 concrete and Fe 415 steel.

Step 1: Size of footing

Load on column = 800 kN

Extra load at 10% of load due to self weight of soil = 80 kN

Hence, total load, P = 880 kN

Let us provide a square isolated footing, where L=B

Equating the maximum pressure of the footing to SBC of soil,

$$\frac{P}{A} + \frac{M}{Z} = \text{SBC}$$

i.e., $\frac{880}{B^2} + \frac{40 \times 6}{B^3} = 250$

On solving the above equation, and taking the least and feasible value, B = 2 m

Hence, provide a square footing of size 2 m x 2 m

The maximum and minimum soil pressures are given by

$$p_{max} = \frac{800}{2^2} + \frac{40 \times 6}{2^3} = 230 \frac{kN}{m^2} < 250 \frac{kN}{m^2} \text{ O.K.}$$

$$p_{min} = \frac{800}{2^2} - \frac{40 \times 6}{2^3} = 170 \frac{kN}{m^2} > \text{Zero O.K.}$$

Hence, factored upward pressures of soil are,

$p_{u,max} = 345 \text{ kN/m}^2$ and $p_{u,min} = 255 \text{ kN/m}^2$

Further, average pressure at the center of the footing is given by

$p_{u,avg} = 300 \text{ kN/m}^2$

and, factored load, $P_u = 900 \text{ kN}$, factored uniaxial moment, $M_u = 60 \text{ kN-m}$

Step 2: Two way shear

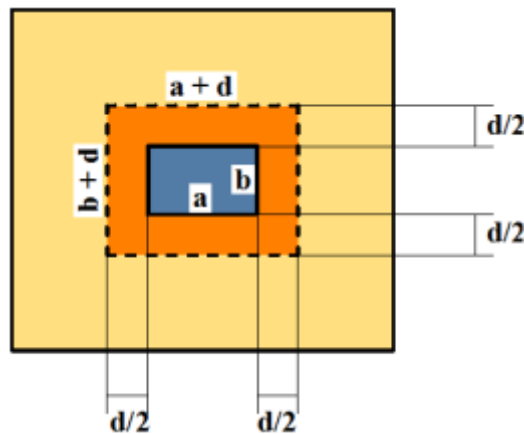
Assume an uniform overall thickness of footing, D = 450 mm

Assuming 16 mm diameter bars for main steel, effective thickness of footing 'd' is

$$d = 450 - 50 - 16 - 8 = 376 \text{ mm}$$

The critical section for the two way shear or punching shear occurs at a distance of d/2 from the face

of the column , where a and b are the dimensions of the column.



Hence, punching area of footing = $(a + d)^2 = (0.30 + 0.376)^2 = 0.457 \text{ m}^2$

where $a = b =$ side of column

Punching shear force = Factored load - (Factored average pressure x punching area of footing)

$$= 1200 - (300 \times 0.457)$$

$$= 1062.9 \text{ kN}$$

Perimeter along the critical section = $4(a + d) = 4(300 + 376)$

$$= 2704 \text{ mm}$$

Therefore, nominal shear stress in punching or punching shear stress ζV is computed as

$$\begin{aligned} \zeta_v &= \frac{\text{Punching shear force}}{\text{perimeter} \times \text{effective thickness}} \\ &= \frac{1062.9 \times 1000}{2704 \times 376} = 1.05 \text{ N/mm}^2 \end{aligned}$$

Allowable shear stress = $k_s \cdot \zeta_c$

$$\text{where } \zeta_c = 0.25 \sqrt{f_{ck}} = 0.25 \sqrt{25} = 1.25 \text{ N/mm}^2$$

$$\text{and, } k_s = (0.5 + \beta_c) = \left(0.5 + \frac{0.30}{0.30}\right) = 1.0 \text{ ; Hence, adopt } k_s = 1$$

$$\text{Thus, Allowable shear stress} = k_s \cdot \zeta_c = 1 \times 1.25 = 1.25 \text{ N/mm}^2$$

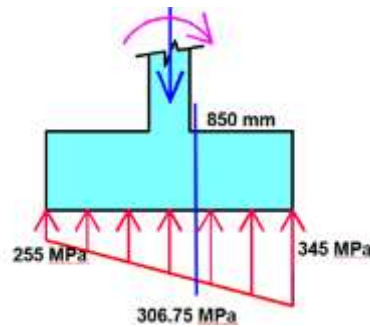
Since the punching shear stress (1.05 N/mm²) is less than the allowable shear stress (1.25 N/mm²), the assumed thickness is sufficient to resist the punching shear force.

Hence, the assumed thickness of footing $D = 450 \text{ mm}$ is sufficient.

The effective depth for the lower layer of reinforcement, $d = 450 - 50 - 8 = 392 \text{ mm}$, and

the effective depth for the upper layer of reinforcement, $d = 450 - 50 - 16 - 8 = 376 \text{ mm}$.

Step 3: Design for flexure The critical section for flexure occurs at the face of the column



The projection of footing beyond the column face is treated as a cantilever slab subjected to factored upward pressure of soil.

Factored maximum upward pressure of soil, $p_{u,max} = 345 \text{ kN/m}^2$

Factored upward pressure of soil at critical section, $p_u = 306.75 \text{ kN/m}^2$

Projection of footing beyond the column face, $l = (2000 - 300)/2 = 850 \text{ mm}$

Bending moment at the critical section in the footing is

$$M_u = [\text{Total force}] \times [\text{Distance of CG from critical section}]$$

$$M_u = \left[\left(\frac{345 + 306.75}{2} \right) 0.85 \right] \times \left[\left(\frac{2 \times 345 + 306.75}{345 + 306.75} \right) \times \frac{0.85}{3} \right]$$

$$M_u = 119.11 \text{ kN-m/m width of footing}$$

The area of steel A_{st} can be determined using the following moment of resistance relation for under reinforced condition given in Annex G – 1.1 b of IS 456 :2000.

$$M_u = 0.87 f_y A_{st} d \left[1 - \frac{f_y A_{st}}{b d f_{ck}} \right]$$

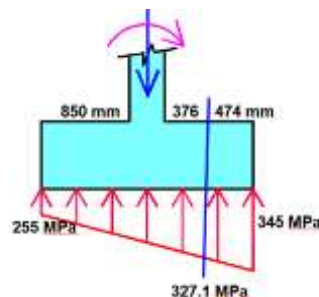
$$119.11 \times 10^6 = 0.87 \times 415 \times A_{st} \times 376 \left[1 - \frac{415 \times A_{st}}{1000 \times 376 \times 25} \right]$$

$$A_{st} = 914.30 \text{ mm}^2$$

The corresponding value of $p_t = 0.24 \%$ Hence from flexure criterion, $p_t = 0.24 \%$

Step 4: One way shear

The critical section for one way shear occurs at a distance of 'd' from the face of the column



Factored maximum upward pressure of soil, $p_{u,max} = 345 \text{ kN/m}^2$

Factored upward pressure of soil at critical section, $p_u = 327.1 \text{ kN/m}^2$

For the cantilever slab, total Shear Force along critical section

considering the entire width B is

$$V_u = [\text{Total force}] \times [(1 - d) \times B]$$

$$V_u = \left[\frac{345 + 327.1}{2} \right] \times [(0.85 - 0.376) \times 2]$$

$$V_u = 318.58 \text{ kN}$$

The nominal shear stress is given by

$$\zeta_v = \frac{V_u}{B d} = \frac{318.58 \times 1000}{2000 \times 376} = 0.42 \text{ N/mm}^2$$

From 19 of IS 456 :2000, find the p_t required to have a minimum design shear strength $\zeta_C = \zeta_V = 0.42 \text{ N/mm}^2$ with $f_{ck} = 25 \text{ N/mm}^2$.

For $p_t = 0.365 \%$ the design shear strength ζ_C is $0.42 \text{ N/mm}^2 = \zeta_V = 0.42 \text{ N/mm}^2$.

Hence from one way shear criterion, $p_t = 0.365 \%$ Comparing p_t from flexure and one way shear criterion, provide $p_t = 0.365 \%$ (larger of the two values)

$$\text{Hence, } A_{st} = \frac{p_t}{100} b d = \frac{0.365}{100} 1000 \times 376 = 1372.4 \text{ mm}^2$$

Provide ϕ 16 mm dia bars at 140 mm c/c. Therefore, A_{st} provided = $1436 \text{ mm}^2 > A_{st}$ required (1372.4 mm^2).

Hence O.K.

EXPERIMENT 10

Design the reinforcement for RCC circular column with isolated square footing

Design a circular column of 400 mm diameter with helical reinforcement subjected to an axial load of 1500 kN under service load and live load. The column has an unsupported length of 3 m effectively held in position at both ends but not restrained against rotation. Use M 25 concrete and Fe 415 steel.

Step 1: To check the slenderness ratio

Given data are: unsupported length $l = 3000$ mm, $D = 400$ mm.

Table 28 of Annex E of IS 456 gives effective length $l_e = l = 3000$ mm.

Therefore, $l_e/D = 7.5 < 12$ confirms that it is a short column.

Step 2: Minimum eccentricity

$e_{min} = \text{Greater of } (l/500 + D/30) \text{ or } 20 \text{ mm} = 20 \text{ mm}$

$0.05 D = 0.05(400) = 20 \text{ mm}$

As per cl.39.3 of IS 456, e_{min} should not exceed $0.05D$ to employ the equation given in that clause for the design. Here, both the eccentricities are the same. So, we can use the equation given in that clause of IS 456 i.e., Eq.10.8 for the design.

Step 3: Area of steel

From Eq.10.8, we have

$$P_u = 1.05(0.4 f_{ck} A_c + 0.67 f_y A_{sc}) \dots (10.8)$$

$$A_c = A_g - A_{sc} = 125714.29 - A_{sc}$$

$$1.5(1500)(10^3) = 1.05\{0.4(25)(125714.29 - A_{sc}) + 0.67(415) A_{sc}\}$$

$$A_{sc} = 3304.29 \text{ mm}^2.$$

Provide 11 nos. of 20 mm diameter bars ($= 3455 \text{ mm}^2$) as longitudinal reinforcement giving $p = 2.75\%$. This p is between 0.8 (minimum) and 4 (maximum) per cents.

Hence o.k.

Step 4: Lateral ties

It has been mentioned in sec.10.22.4 that the pitch p of the helix determined from Eq.10.11 automatically takes care of the cl.39.4.1 of IS 456. Therefore, the pitch is calculated from Eq.10.11 selecting the diameter of helical reinforcement from cl.26.5.3.2 d-2 of IS 456. However, automatic satisfaction of cl.39.4.1 of IS 456 is also checked here for confirmation.

Diameter of helical reinforcement (cl.26.5.3.2 d-2) shall be not less than greater of

- (i) one-fourth of the diameter of largest longitudinal bar, and
- (ii) 6 mm.

Therefore, with 20 mm diameter bars as longitudinal reinforcement, the diameter of helical reinforcement = 6 mm.

From Eq.10.11, we have

$$\text{Pitch of helix } p \leq 11.1(D_c - sp\phi) a_{sp} f_y / (D_c^2 - \dots) \quad (10.11) \quad c k c f D^2$$

where $D_c = 400 - 40 - 40 = 320$ mm, $sp\phi = 6$ mm, $a_{sp} = 28$ mm², $f_y = 415$ N/mm², $D = 400$ mm and $f_{ck} = 25$ N/mm².

$$\text{So, } p \leq 11.1(320 - 6) (28) (415) / (400^2 - 320^2) (25) \leq 28.125 \text{ mm}$$

As per cl.26.5.3.2 d-1, the maximum pitch is the lesser of 75 mm and $320/6 = 53.34$ mm and the minimum pitch is lesser of 25 mm and $3(6) = 18$ mm. We adopt pitch = 25 mm which is within the range of 18 mm and 53.34 mm. So, provide 6 mm bars @ 25 mm pitch forming the helix.

Checking of cl. 39.4.1 of IS 456

Volume of helical reinforcement in one loop = 27632 mm³ and

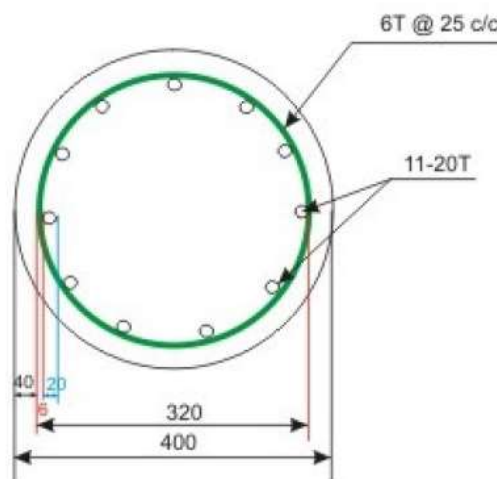
Volume of core in one loop = 2011428.571 mm³.

Their ratio = $27632 / 2011428.571 = 0.0137375$

$$0.36(A_g/A_c - 1) (f_{ck}/f_y) = 0.012198795$$

It is, thus, seen that the above ratio (0.0137375) is not less than $0.36(A_g/A_c - 1) (f_{ck}/f_y)$.

Version



EXPERIMENT 11

Creation of models related to RC Structural elements. (Demonstration)

RC structural Model of Slab

RC structural Model of Column

RC structural Model of Beam Column Joint

RC structural Model of Beams



KLS
Vishwanathrao Deshpande Institute of Technology
Haliyal - 581329

Software Application Lab

LAB MANUAL

[BCVL606]

for

VI Semester B.E.

As prescribed by

**VISVESVARAYA TECHNOLOGICAL UNIVERSITY,
BELAGAVI - 590014**

(From Academic Year: 2025-26)

Prepared by

Prof. Laxmi G Hattiholi

Department of Civil Engineering

Index

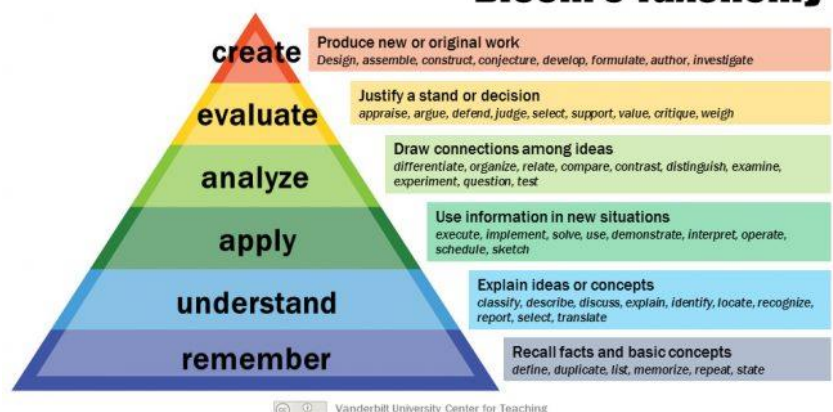
Sl. No.	Content	Page No.
1	Analysis of plane trusses, continuous beams using software	1
2	Analysis of portal frames using software	19
3	Understanding basic features of Project management software. Constructing Project: create. WBS, Activities, and tasks and Computation Time using Excel spread sheet and transferring the same to Project management software.	21
4	Identification of Predecessor and Successor activities with constrain. Constructing Network diagram (AON Diagram) and analyzing for Critical path,	
5	Critical activities and Other non-Critical paths, Project duration, Floats. Study on various View options available	
6	Basic understanding about Resource Creation and allocation g. Understanding about Splitting the activity, Linking multiple activity, assigning Constrains, Merging Multiple projects, Creating Baseline Project	
7	GIS applications using open source software: To create shape files for point, line and polygon features with a map as reference. To create decision maps for specific purpose.	20
8	Computation of earthwork, Design of horizontal curve by offset method, Design of super elevation Using Excel	25
9	Creating structural model and analysis of high rise structures	27
10	Creating a model of building and the effect of earth quake	31
11	Create a model of large span roof and analyse	33
12	Crate a plan and set of structural drawings for a multi-storied building	

PROGRAM OUTCOMES(POs)

Program Outcomes as defined by NBA (PO) Engineering Graduates will be able to:

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Bloom's Taxonomy



Vision (College)	
To nurture talent and enrich society through excellence in technical education, research and innovation.	
Mission (College)	
<ul style="list-style-type: none"> ➤ To augment innovative pedagogy and kindle quest for interdisciplinary learning and to enhance conceptual understanding. ➤ To build competence, professional ethics and develop entrepreneurial Thinking. ➤ To strengthen industry institute partnership and explore global collaborations. ➤ To inculcate culture of socially responsible citizenship. ➤ To focus on holistic and sustainable development. 	
Vision (Dept)	
<i>To excel in imparting Civil Engineering knowledge of global standards in meeting societal and environmental challenges with professional ethics</i>	
Mission (Dept)	
<ul style="list-style-type: none"> ➤ To develop entrepreneurial and skill and team work among students. ➤ To inculcate basics of civil engineering knowledge to meet the professional challenges through research and innovation in collaboration with industries. ➤ To cultivate qualities of professional ethics and commitment towards welfare of the society and environment. 	
Program Educational Objectives (PEO)	
PEO1	To design and utilize new materials, processes, and projects through research and development for the welfare of society.
PEO2	To communicate feasible technical solutions for civil engineering problems faced by public through presentations and demonstrations.
PEO3	To participate in lifelong learning activities through constructive interactions with stake holders.
Program Specific Outcomes (PSO)	
PSO 1	Graduates will be able to plan, analyse and design in order to execute and maintain civil engineering structures using alternative materials and innovative construction practices for sustainable infrastructural development of the nation.
PSO 2	Graduates will be able to pursue career opportunities for personal and professional growth by demonstrating leadership skill, professional integrity and solve issues related to civil engineering and allied fields.

CO's And PO's Mapping Chart**Subject with code: Design of RCC Structures (BCV601)****AY:2024-25****Semester: 6th**

S.No	Description	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	Use software for modelling, analysis and design of structural elements		1			3								1	
2	Use of Project Management software for Project planning and scheduling of a building project	2				2			1				2		2
3	Use of open source software for GIS applications and to create shape files.					2									
4	Design using excel spread sheet.			3		1								1	

Degree of compliance

Low:1

Medium:2

High:3

Mapping of Experiments with CO, PO and PSO

Experiment Details		CO	PO	PSO
LAB				
1	Analysis of plane trusses, continuous beams using software	1	2,5	1
2	Analysis of portal frames using software	1	2,5	1
3	Understanding basic features of Project management software. Constructing Project: create. WBS, Activities, and tasks and Computation Time using Excel spread sheet and transferring the same to Project management software.	2	1,5,8,12	2
4	Identification of Predecessor and Successor activities with constrain. Constructing Network diagram (AON Diagram) and analyzing for Critical path,	2	1,5,8,12	2
5	Critical activities and Other non-Critical paths, Project duration, Floats. Study on various View options available	2	1,5,8,12	2
6	Basic understanding about Resource Creation and allocation g. Understanding about Splitting the activity, Linking multiple activity, assigning Constrains, Merging Multiple projects, Creating Baseline Project	2	1,5,8,12	2
7	GIS applications using open source software: To create shape files for point, line and polygon features with a map as reference. To create decision maps for specific purpose.	3	5	
8	Computation of earthwork, Design of horizontal curve by offset method, Design of super elevation Using Excel	4	3,5	1
9	Creating structural model and analysis of high rise structures	1	2,5	1
10	Creating a model of building and the effect of earth quake	1	2,5	1
11	Create a model of large span roof and analyse	1	2,5	1
12	Crate a plan and set of structural drawings for a multi-storied building	1	2,5	1

EXPERIMENT WISE LESSON PLAN

Experiment No.1	
Name	Analysis of plane trusses, continuous beams using software[L3,L4]
Objectives	<ul style="list-style-type: none"> To learn Structural analysis software and analyse the plane truss and continues beam
Experiment No.2	
Name	Analysis of portal frames using software [L3,L4]
Objectives	<ul style="list-style-type: none"> To learn Structural analysis software and analyse the portal frame
Experiment No.3,4,5,6	
Name	Project Management Software[L3,L4,L5]
Objectives	<ul style="list-style-type: none"> To understand and learn Project Management software tools and create a baseline project and to analyse critical activities
Experiment No.7	
Name	Design of singly reinforced beams with check for shear, check for development length and other Checks using excel.. [L2 , L3]
Objectives	<ul style="list-style-type: none"> To learn excel tools and functional formulas to design Singly reinforced beam with all the necessary checks.
Experiment No.5	
Name	Design of a cantilever beam using excel and draw the reinforcement[L4, L5.L6]
Objectives	<ul style="list-style-type: none"> To learn excel tools and functional formulas and to design cantilever beam using excel
Experiment No.6	
Name	Design a simply supported rcc one way slab with intermediate support and draw the reinforcement Details [L4, L5.L6]
Objectives	<ul style="list-style-type: none"> To learn excel tools and functional formulas and to design one way slab using excel
Experiment No.7	
Name	GIS applications using open source software: To create shape files for point, line and polygon features with a map as reference. To create decision maps for specific purpose. [L3,L4]
Objectives	<ul style="list-style-type: none"> To learn QGIS software tools and to create shape files.
Experiment No.8	
Name	Computation of earthwork, Design of horizontal curve by offset method, Design of super elevation Using Excel [L3,L4,L5]
Objectives	<ul style="list-style-type: none"> To learn excel tools and functional formulas and to compute earthwork , horizontal curve and super elevation.

Experiment No.9	
Name	Creating structural model and analysis of high rise structures [L1,L2]
Objectives	<ul style="list-style-type: none"> To understand creating structural model and analysis of high rise structures using staad pro.
Experiment No.10	
Name	Creating a model of building and the effect of earth quake [L1,L2]
Objectives	<ul style="list-style-type: none"> To understand creating structural model of building and effect of earthquake using staad pro.
Experiment No.11	
Name	Create a model of large span roof and analyse [L1,L2]
Objectives	<ul style="list-style-type: none"> To understand creating structural model of large span roof and its analysis using staad pro.
Experiment No.12	
Name	Crate a plan and set of structural drawings for a multi-storied building [L1,L2]
Objectives	<ul style="list-style-type: none"> To understand and to create a plan of structural drawings for multi storied building using staad pro.

Structural Analysis Using STAAD

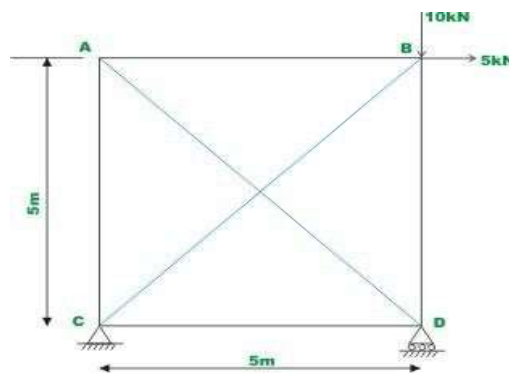
Introduction to STAAD pro: It is a structural analysis and design computer program originally developed by Research Engineers International at Yorba Linda, California in 1997. In late 2005, Research Engineers International was bought by Bentley Systems

The commercial version, STAAD.Pro, is one of the most widely used structural analysis and design software products worldwide. It supports several steel, concrete and timber design codes.

Experiment No. : 1

Analysis of plane trusses:

1. (a) Analyze the given truss using STAAD pro software.



Problem study: The given truss has a 5m span between two supports and a height of 5m. Two forces (vertical and horizontal) are acting at point B.

Aim: To find the reactions at the supports and draw the bending moment, shear force, and axial force diagrams using STAAD pro.

Tools Required: STAAD Pro Software, Microsoft Word Software, Paint Software, and Printer.

Procedure:

1. Open STAAD software.
2. A new project is started with unit's m & KN and structure type as Plane.
3. The given structure is drawn in the workspace using the graphical user interface of the software according to given dimensions.

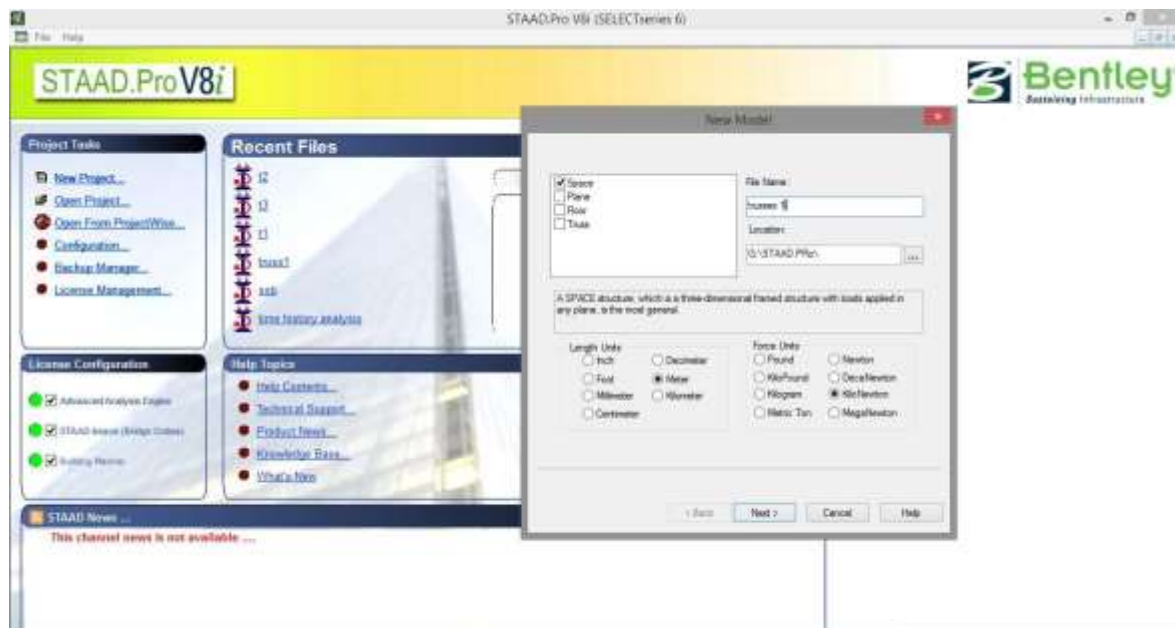
4. Define the material property as steel, assign defined property to drawn truss using commands.
5. Define Supports and assign to specified nodes of the structure.
6. Define load as nodal load and assign to specified nodes in trusses member by using node cursor.
7. Perform analysis command was given.
8. The file was saved and run analysis command was executed.
9. It is made sure that there is no error is indicated in the output window.
10. Post processing mode was selected.
11. The results were properly arranged using the tools.
12. Printouts were taken.

Results:

1. Reaction at support A =
2. Reaction at support B =
3. Shear force, bending moment and member force diagrams are attached.

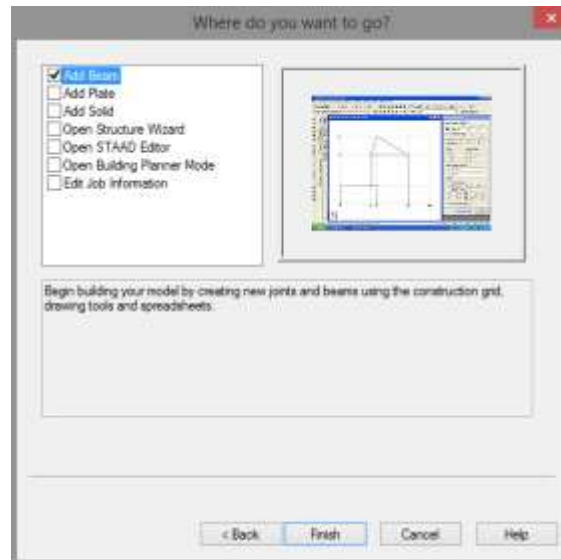
Step-by-step operation on software:

Step: 1 Open STAAD pro software and set units.



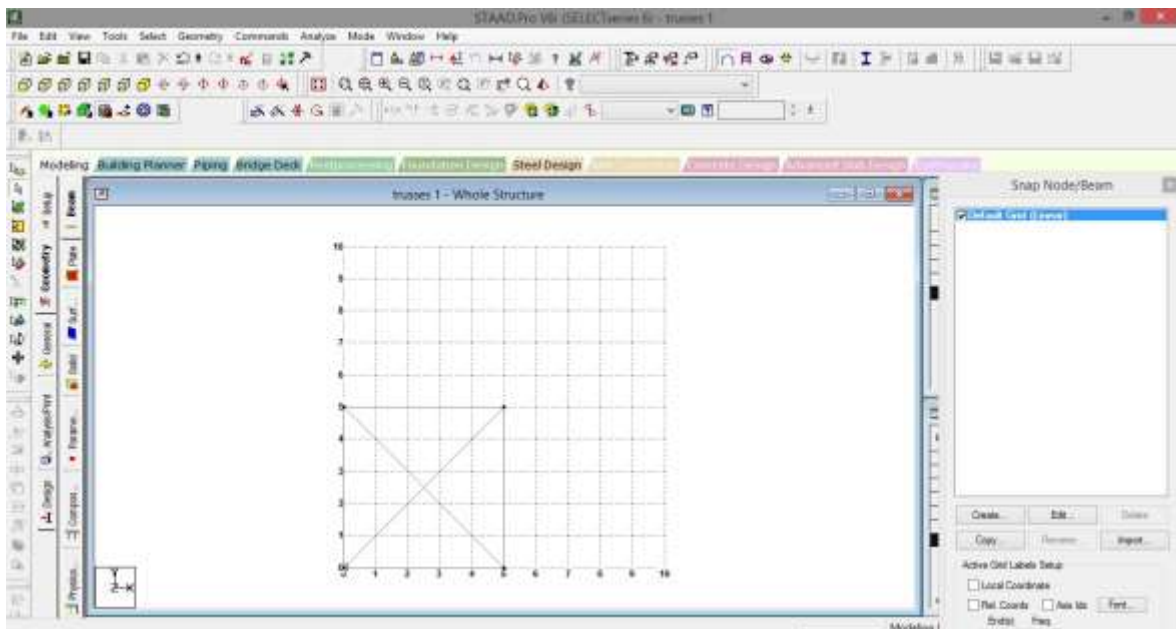
Start with new project > select space option in new model window > Type file name > choose storage location > set units to meter and kilo newton.

Step: 2 Choose add beams option.



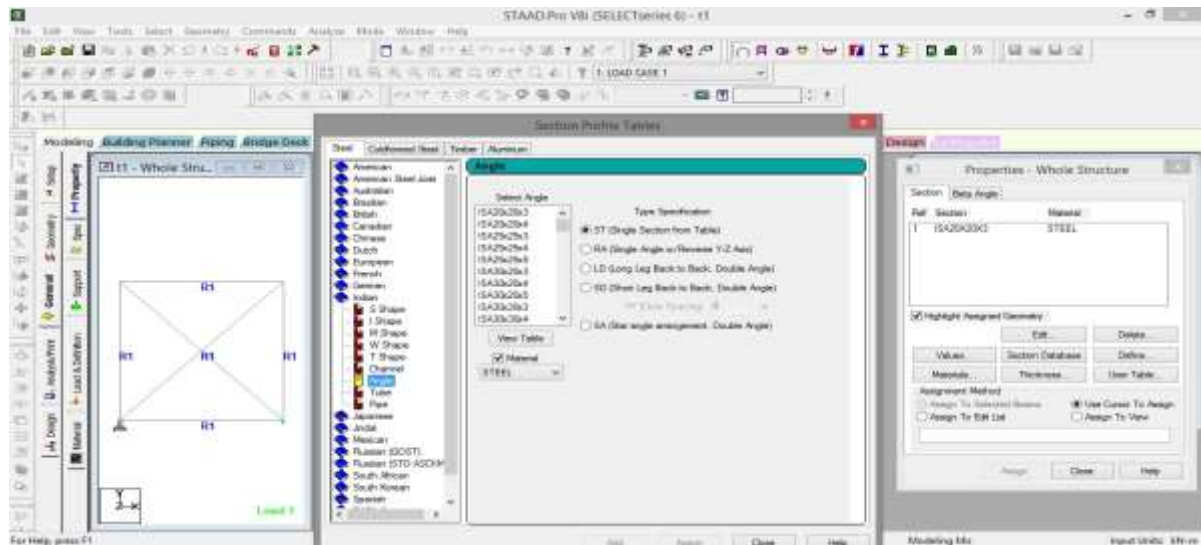
Choose add beam options to draw model.

Step: 3 Open STAAD pro to make model by using snap node or beam option.



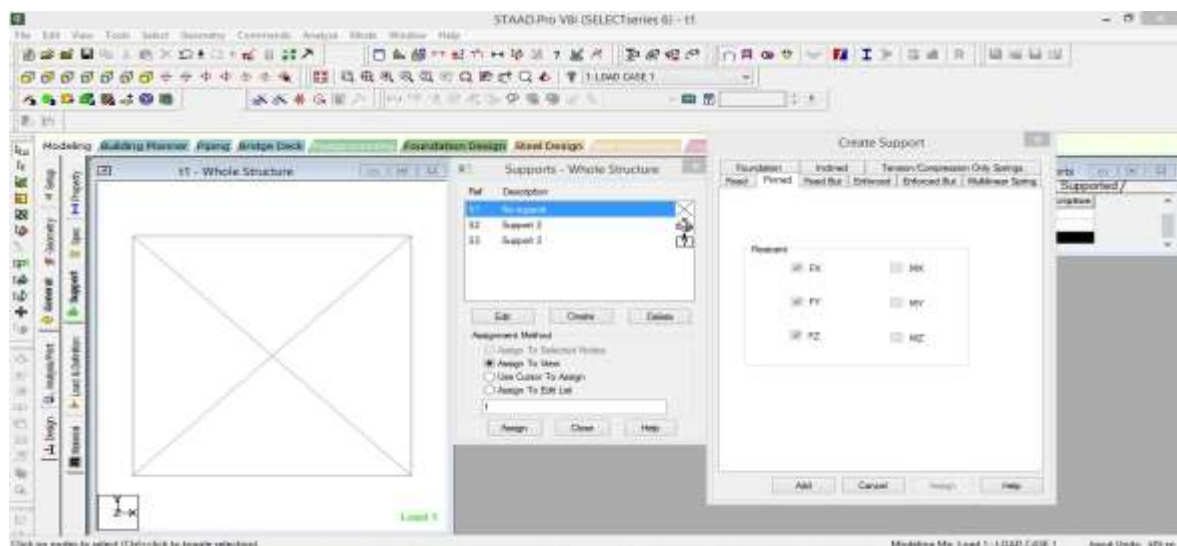
The above figure shows that the truss drawn according to given question. If you want to increase grid spacing use edit command.

Step: 4 Defining of material and assign material to truss.



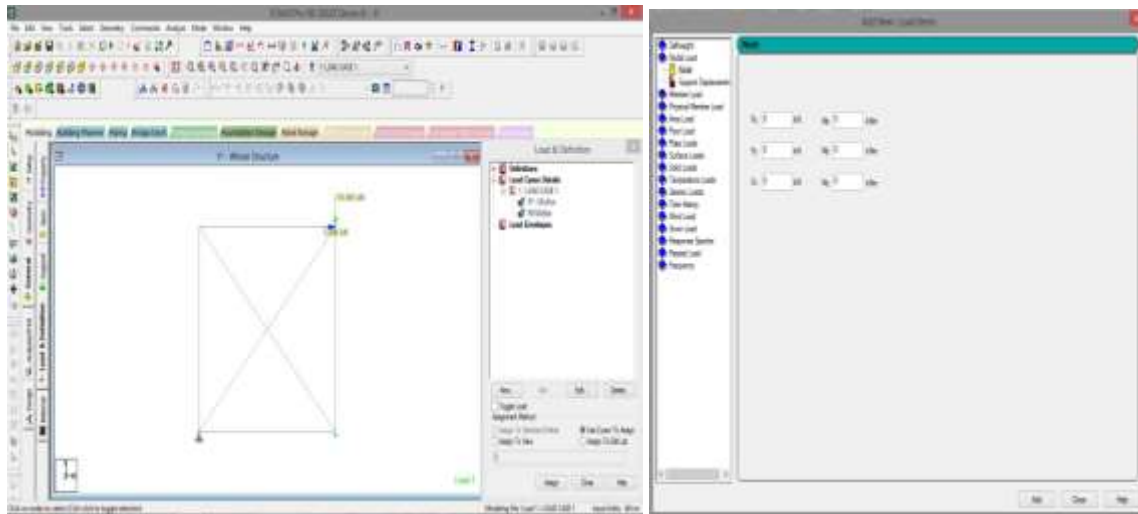
Go to General > property > section database > select Indian angle > assign by using assign to view option

Step: 5 Create support condition and assign to nodes.



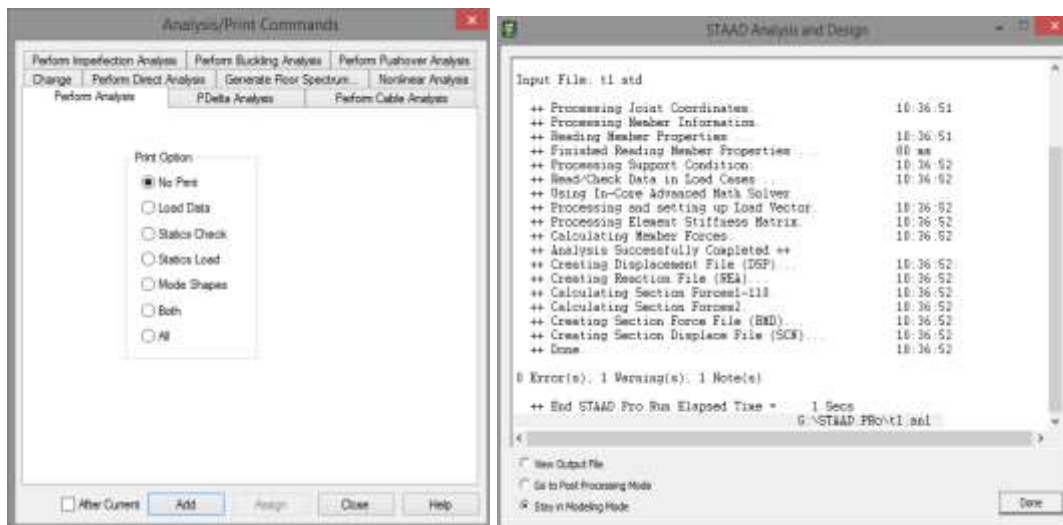
Go to support > create support as pinned (MX, MY, MZ are released), and roller support (FX, FZ, MX, MY, MZ are released) by considering fixed but option > assign support to model by using node cursor and assign to selected node option.

Step: 6 Define load case and assign load cases.



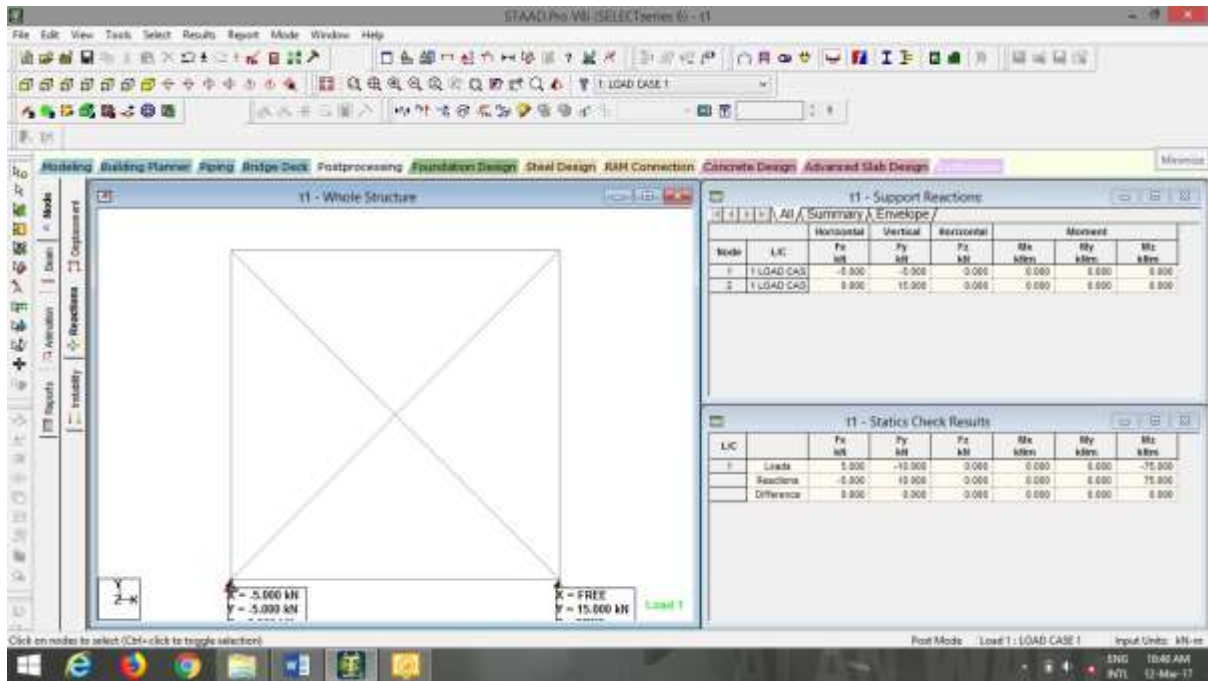
Go to loads and definition > Click on load case details add load case1 > Click on load case 1 add nodal load as $FY = -10\text{kN}$, $FX = 5\text{kN}$ add > select defined loads and assign to truss.

Step: 7 Analysis/print.

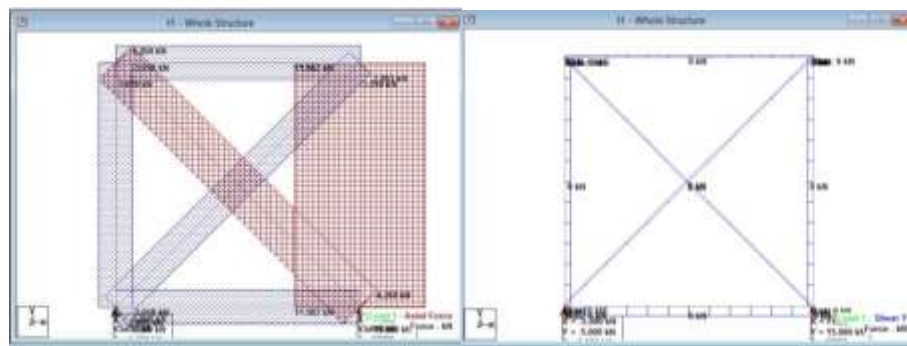


Go to analysis/print > select all add > go to analyze > run analysis > If no error found go to post processing mode.

Step: 8 Results.

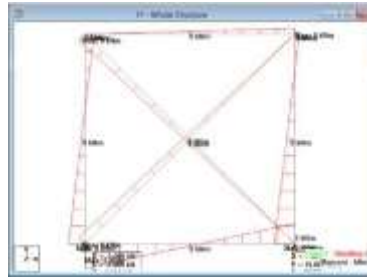


In post processing mode > go to reactions to get support reactions (in this problem the support reaction is -5 , -5 at fixed support and 15 at pinned support).



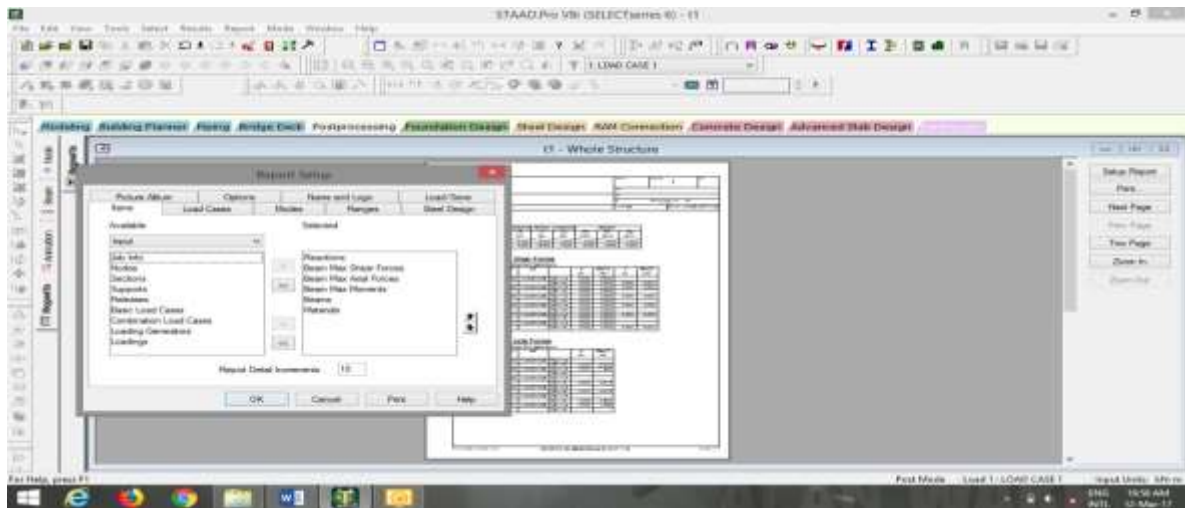
Axial force diagram

Shear force diagram



Bending moment diagram

Step: 8 Report extraction.



In Post processing mode go to report > select input and output parameters should be extracted > ok > go to file > export report > MS WORD.

Reactions

Node	L/C	Horizontal	Vertical	Horizontal	Moment		
		FX (kN)	FY (kN)	FZ (kN)	MX (kNm)	MY(kNm)	MZ(kNm)
1	1:LOAD CASE 1	-5.000	-5.000	0.000	0.000	0.000	0.000
2	1:LOAD CASE 1	0.000	15.000	0.000	0.000	0.000	0.000

Beam Maximum Shear Forces

Distances to maxima are given from beam end A.

Beam	Node A	Length h (m)	L/C		d (m)	Max Fz (kN)	d (m)	Max Fy (kN)
1	1	5.000	1:LOAD	Max		0.000		

				Max -ve		0.000		-0.000
2	2	5.000	1:LOAD	Max		0.000		0.000
				Max -ve		0.000		
3	3	5.000	1:LOAD	Max		0.000		0.000
				Max -ve		0.000		
4	4	5.000	1:LOAD	Max		0.000		0.000
				Max -ve		0.000		
5	1	7.071	1:LOAD	Max		0.000		0.000
				Max -ve		0.000		
6	4	7.071	1:LOAD	Max		0.000		
				Max -ve		0.000		-0.000

Beam Maximum Axial Forces

Distances to maxima are given from beam end A.

Beam	Node A	Length (m)	L/C		d (m)	Max Fx (kN)
1	1	5.000	1:LOAD CASE 1	Max +ve		
				Max -ve	0.000	-3.018
2	2	5.000	1:LOAD CASE 1	Max +ve	0.000	11.982
				Max -ve		
3	3	5.000	1:LOAD CASE 1	Max +ve		
				Max -ve	0.000	-3.018
4	4	5.000	1:LOAD CASE 1	Max +ve		
				Max -ve	0.000	-3.018
5	1	7.071	1:LOAD CASE 1	Max +ve		
				Max -ve	0.000	-2.803
6	4	7.071	1:LOAD CASE 1	Max +ve	0.000	4.268
				Max -ve		

Beam Maximum Moments

Distances to maxima are given from beam end A.

Beam	Node A	Length (m)	L/C		d (m)	Max My (kNm)	d (m)	Max Mz (kNm)
1	1	5.000	1:LOAD CASE 1	Max +ve	0.000	0.000	5.000	0.000
				Max -ve	0.000	0.000	0.000	-0.000
2	2	5.000	1:LOAD CASE 1	Max +ve	0.000	0.000	0.000	0.000
				Max -ve	0.000	0.000	5.000	-0.000
3	3	5.000	1:LOAD CASE 1	Max +ve	0.000	0.000	0.000	0.000
				Max -ve	0.000	0.000	5.000	-0.000
4	4	5.000	1:LOAD CASE 1	Max +ve	0.000	0.000	0.000	0.000
				Max -ve	0.000	0.000	5.000	-0.000
5	1	7.071	1:LOAD CASE 1	Max +ve	0.000	0.000	0.000	0.000
				Max -ve	0.000	0.000	7.071	-0.000
6	4	7.071	1:LOAD CASE 1	Max +ve	0.000	0.000	7.071	0.000
				Max -ve	0.000	0.000	0.000	-0.000

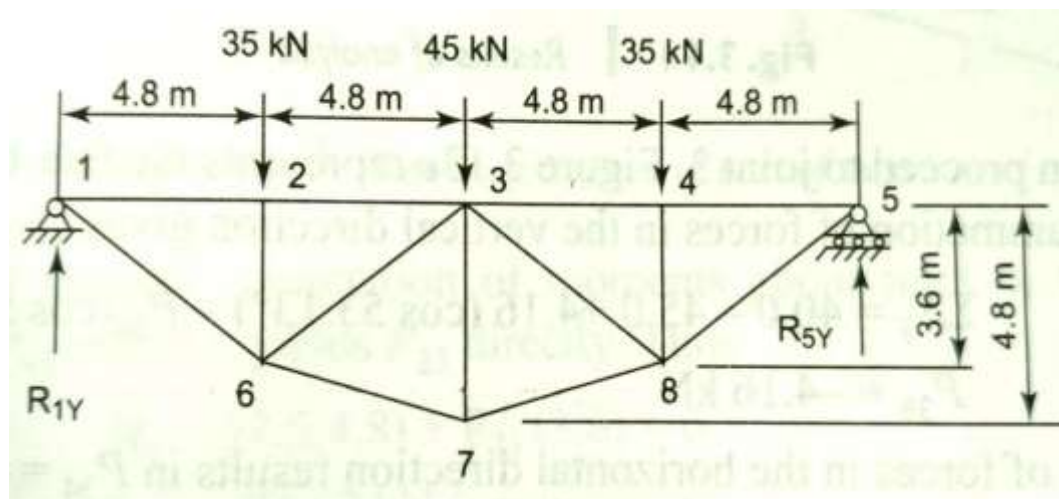
Beams

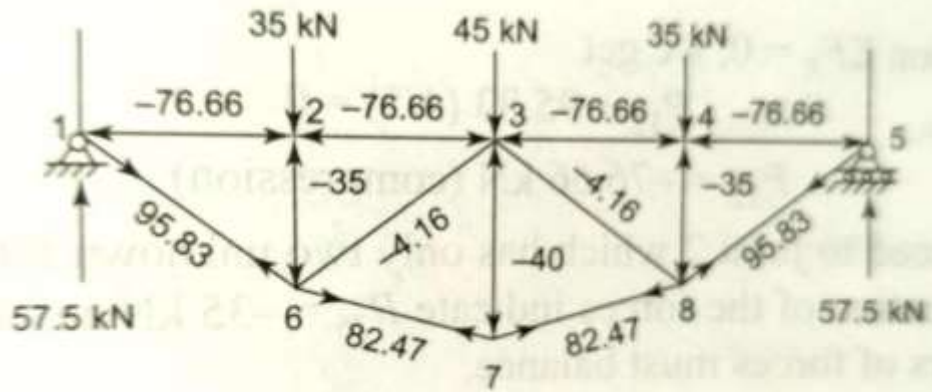
Beam	Node A	Node B	Length (m)	Property	- (degrees)
1	1	2	5.000	1	0
2	2	3	5.000	1	0
3	3	4	5.000	1	0
4	4	1	5.000	1	0
5	1	3	7.071	1	0
6	4	2	7.071	1	0

Materials

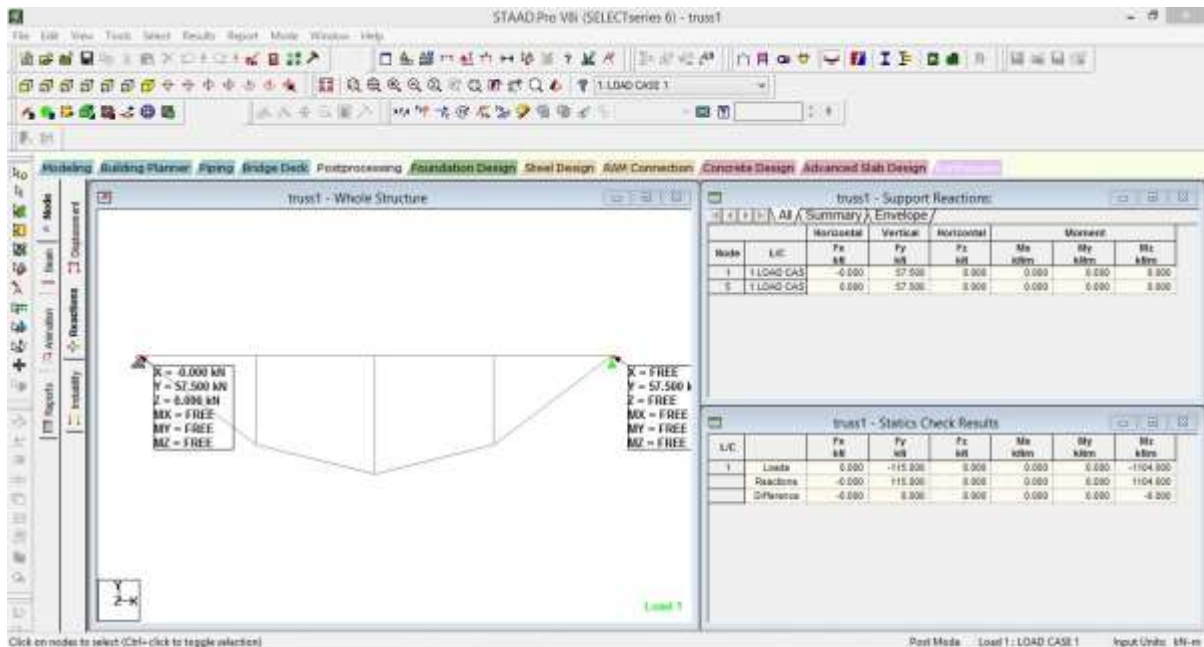
Mat	Name	E (kN/mm ²)	-	Density (kg/m ³)	- (°C)
3	STEEL	205.000	0.300	7.83E 3	12E -6
4	STAINLESSSTEEL	197.930	0.300	7.83E 3	18E -6
5	ALUMINUM	68.948	0.330	2.71E 3	23E -6
6	CONCRETE	21.718	0.170	2.4E 3	10E -6

(b) Analyze the given truss using STAAD pro software.

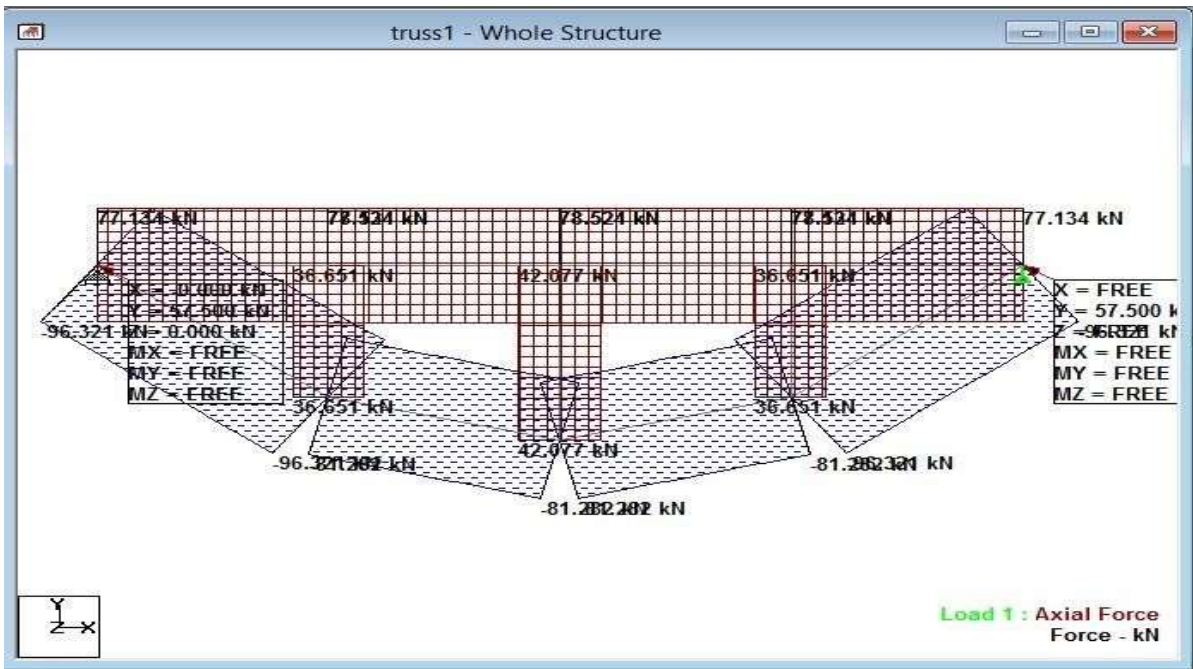




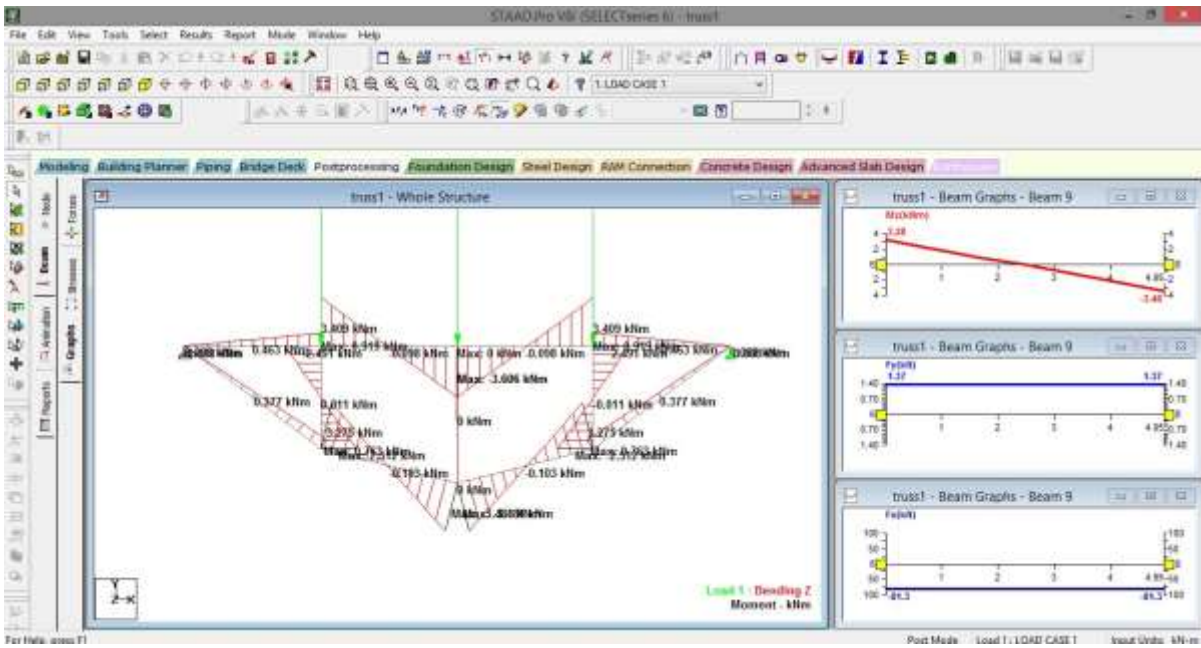
Forces in members obtained from manual calculation.



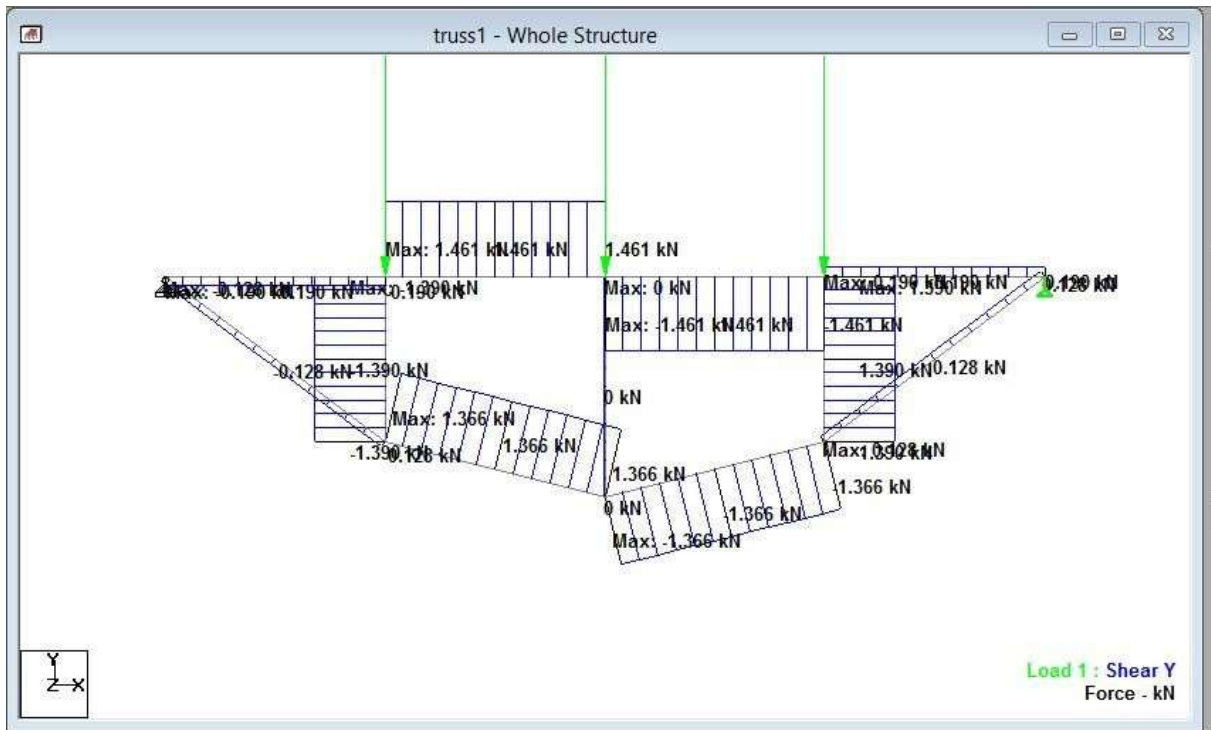
Support reactions obtained in software is matching with manual calculations.



Forces in members obtained from software.



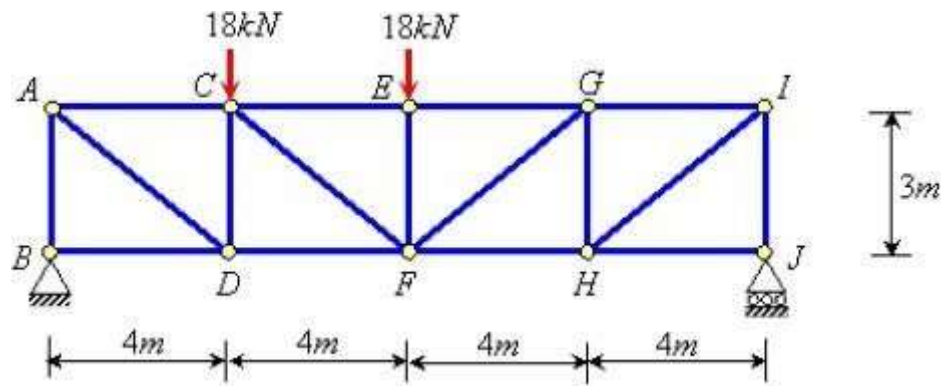
Bending moment diagram with graphs



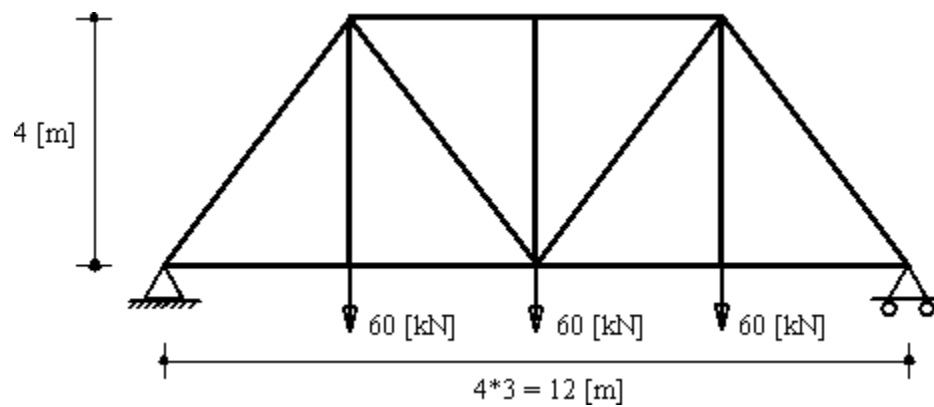
Shear force diagram.

Examples to solve.

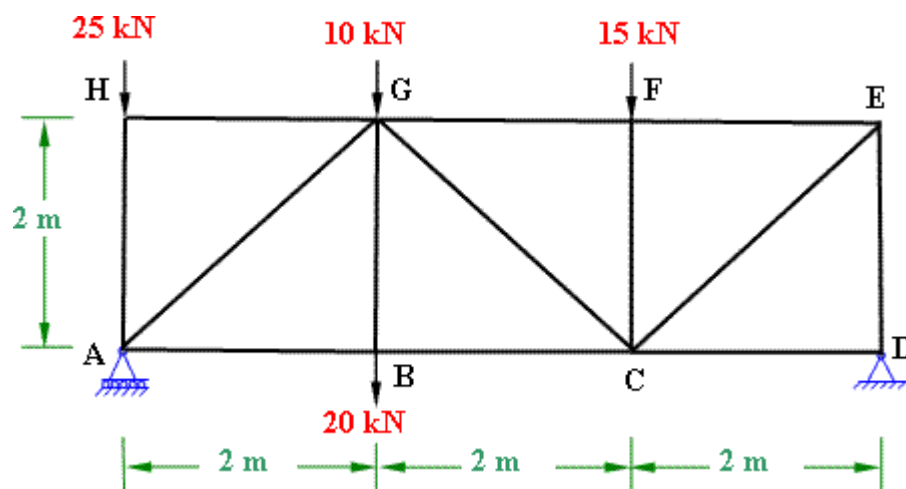
1.



2.

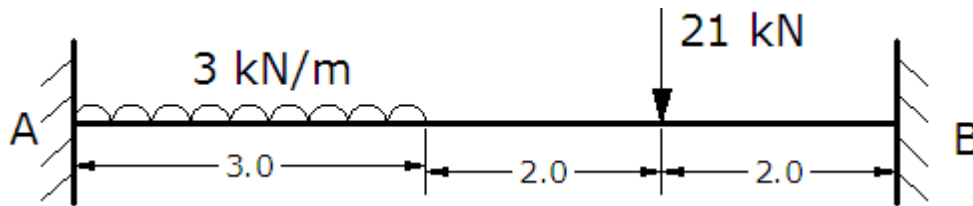


3.



1(b) Analysis of Continues Beam

Analysis of a Fixed Beam Using STAAD pro software.



Aim: To find the reactions at the supports and draw the bending moment and shear force diagram using STAAD.

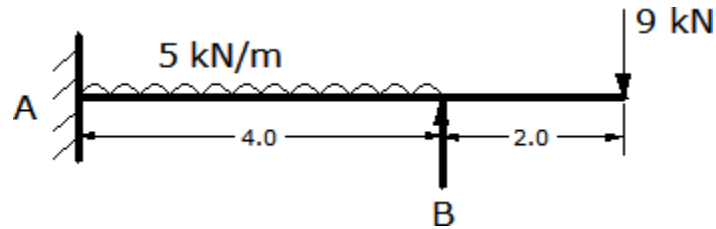
Tools Required: STAAD Pro Software, Microsoft Word Software, Paint Software, Printer

Procedure:

- 1) Open STAAD pro software.
- 2) Start with new project set unit's to m & KN and structure type as Plane.
- 3) The given structure is drawn in the workspace using the graphical user interface of the software.
- 4) Define section property as rectangular assume suitable dimension assigned to the members drawn by using assign to view option.
- 5) Create support condition as fixed assign to the beam at required nodes.
- 6) Define load cases in a single load case, as concentrated force of 21kn and uniform force of 3kn/m and assign on beam member.
- 7) Perform analysis command was given, the file was saved and run analysis command was executed.
- 8) It is made sure that there is no error is indicated in the output window.
- 9) Post processing mode was selected.
- 10) The results were properly arranged using the tools.
- 11) Printouts were taken.

Results:

1. Reaction at support A =
2. Reaction at support B =
3. Shear force and bending moment diagrams are attached.

(b) Analysis of a Propped Cantilever Beam Using STAAD

Aim: To find the reactions at the supports and draw the bending moment and shear force diagram using STAAD.

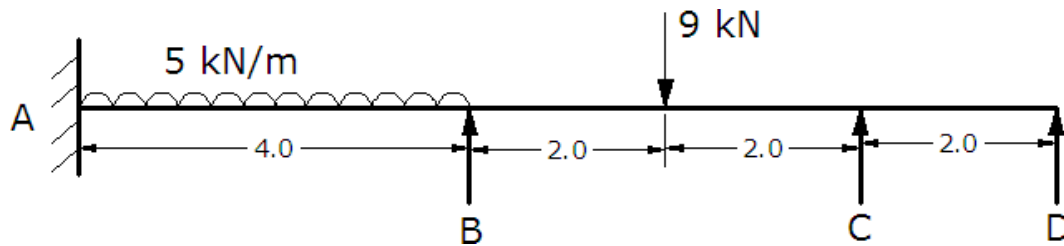
Tools Required: STAAD Pro Software, Microsoft Word Software, Paint Software, Printer

Procedure:

- 1) Open STAAD pro software.
- 2) Start with new project set unit's to m & KN and structure type as Plane.
- 3) The given structure is drawn in the workspace using the graphical user interface of the software.
- 4) Define section property as rectangular assume suitable dimension assigned to the members drawn by using assign to view option.
- 5) Create support condition as fixed and simply supported assign to the beam at required nodes.
- 6) Define load cases in a single load case, as concentrated force of 9kn at 6m distance and uniform force of 5kn/m and assign on beam member.
- 7) Perform analysis command was given, the file was saved and run analysis command was executed.
- 8) It is made sure that there is no error is indicated in the output window.
- 9) Post processing mode was selected.
- 10) The results were properly arranged using the tools.
- 11) Printouts were taken.

Results:

1. Reaction at support A =
2. Reaction at support B =
3. Shear force and bending moment diagrams are attached.

(c) Analysis of a Continuous Beam Using STAAD

Aim: To find the reactions at the supports and draw the bending moment and shear force diagram using STAAD.

Tools Required: STAAD Pro Software, Microsoft Word Software, Paint Software, Printer

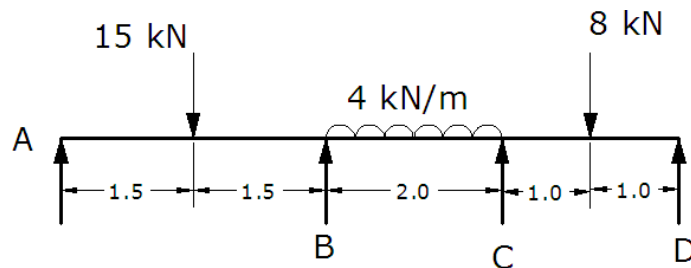
Procedure:

- 1) Open STAAD pro software.
- 2) Start with new project set unit's to m & KN and structure type as Plane.
- 3) The given structure is drawn in the workspace using the graphical user interface of the software.
- 4) Define section property as rectangular assume suitable dimension assigned to the members drawn by using assign to view option.
- 5) Create support condition as fixed and simply supported assign to the beam at required nodes.
- 6) Define load cases in a single load case, as concentrated force of 9kn at 6m distance and uniform force of 5kn/m and assign on beam member.
- 7) Perform analysis command was given, the file was saved and run analysis command was executed.
- 8) It is made sure that there is no error is indicated in the output window.
- 9) Post processing mode was selected.
- 10) The results were properly arranged using the tools.
- 11) Printouts were taken.

Results:

1. Reaction at support A =
2. B=..... ,
3. C=..... ,
4. D=.....
5. Shear force and bending moment diagrams are attached.

d) Analysis of a Continuous Beam Using STAAD



Aim: To find the reactions at the supports and draw the bending moment and shear force diagram using STAAD.

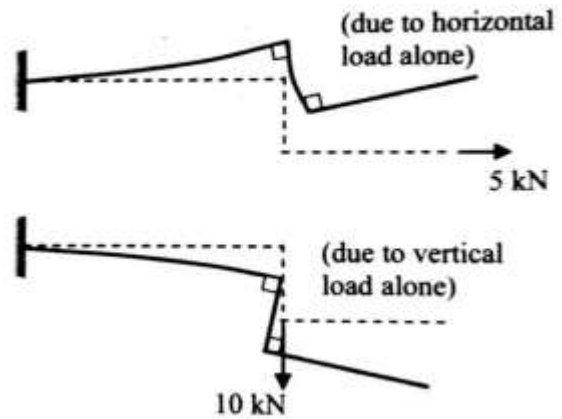
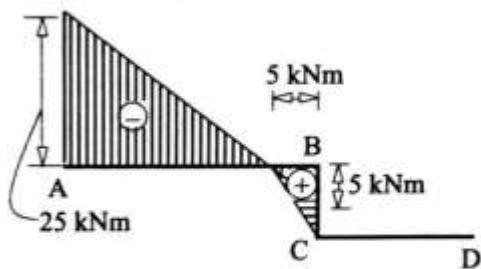
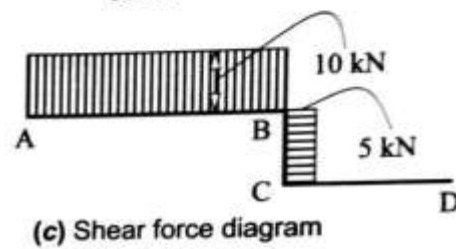
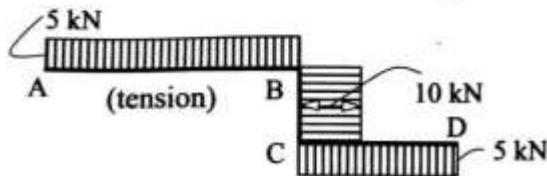
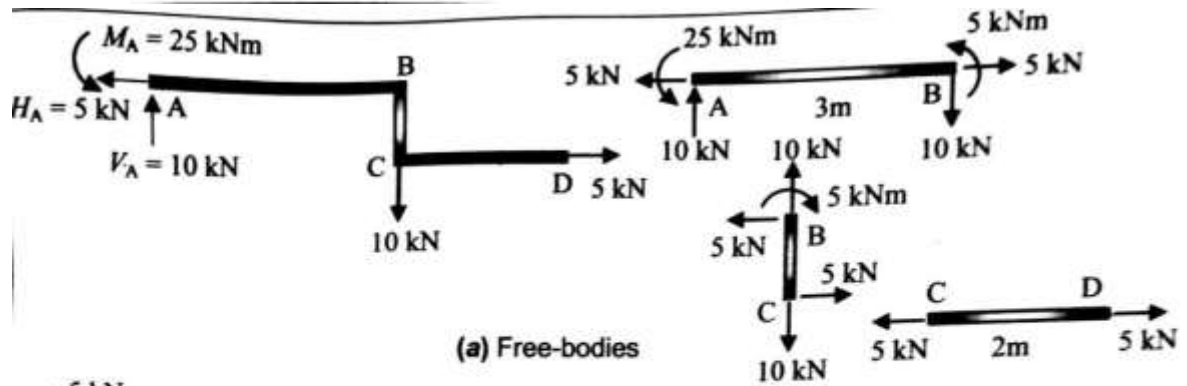
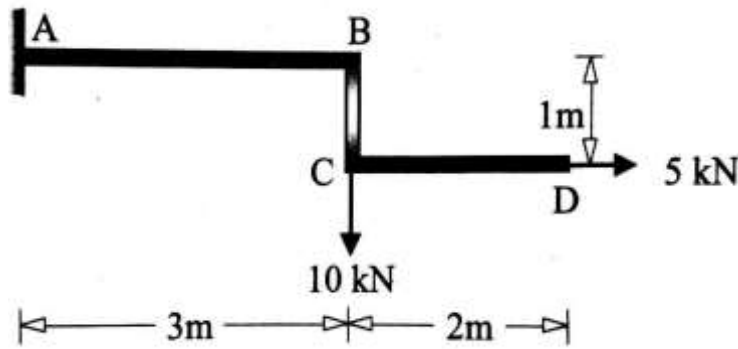
Tools Required: STAAD Pro Software, Microsoft Word Software, Paint Software, Printer

Procedure:

- 1) Open STAAD pro software.
- 2) Start with new project set unit's to m & KN and structure type as Plane.
- 3) The given structure is drawn in the workspace using the graphical user interface of the software.
- 4) Define section property as rectangular assume suitable dimension assigned to the members drawn by using assign to view option.
- 5) Create support condition as fixed and simply supported assign to the beam at required nodes.
- 6) Define load cases in a single load case, as concentrated force of 9kn at 6m distance and uniform force of 5kn/m and assign on beam member.
- 7) Perform analysis command was given, the file was saved and run analysis command was executed.
- 8) It is made sure that there is no error is indicated in the output window.
- 9) Post processing mode was selected.
- 10) The results were properly arranged using the tools.
- 11) Printouts were taken.

Results:

1. Reaction at support A =
2. B=..... ,
3. C=..... ,
4. D=.....
5. Shear force and bending moment diagrams are attache



EXPERIMENT 2

Analysis of portal frames using software

2(a) Analysis of a Single storied 2D Portal Frame Using STAAD

Aim: To find the reactions at the supports and draw the bending moment and shear force diagram using STAAD.

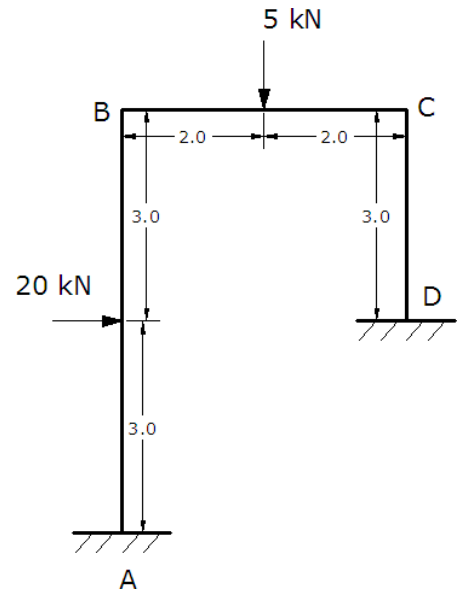
Tools Required: STAAD Pro Software, Microsoft Word Software, Paint Software, Printer

Procedure:

1. Open STAAD Pro software.
2. Start with new project set unit's to m & KN and structure type as Plane.
3. The given structure is drawn in the workspace using the graphical user interface of the software.
4. Define section property as rectangular concrete section with suitable dimensions assumed..
5. Create Supports as fixed and assign to required node.
6. Loading is defined in a single load case and concentrated force of 5kn and 20kn assign to the frame at suitable distance.
7. Perform analysis command was given
8. Post analysis print options were selected suitably.
9. The file was saved and run analysis command was executed.
10. It is made sure that there is no error is indicated in the output window.
11. Post processing mode was selected.
12. The results were properly arranged using the tools.
13. Printouts were taken.

Results:

1. Reaction at support A =
2. Reaction at support D =
3. Shear force and bending moment diagrams are attached.



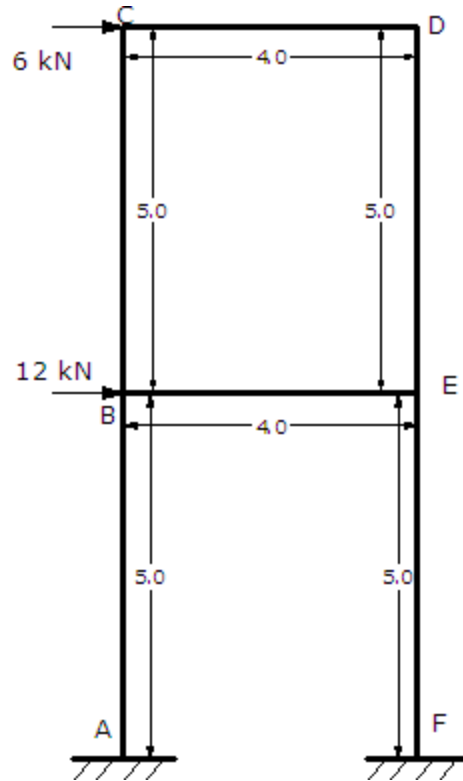
(b) Analysis of a Double storied 2D Portal Frame Using STAAD

Aim: To find the reactions at the supports and draw the bending moment and shear force diagram using STAAD.

Tools Required: STAAD Pro Software, Microsoft Word Software, Paint Software, Printer

Procedure:

1. Open STAAD Pro software.
2. Start with new project set unit's to m & KN and structure type as Plane.
3. The given structure is drawn in the workspace using the graphical user interface of the software.
4. Define section property as rectangular concrete section with suitable dimensions assumed.
5. Create Supports as fixed and assign to required node.
6. Loading is defined in a single load case and concentrated force of 6kn and 12kn assign to the frame at suitable distance.
7. Perform analysis command was given
8. Post analysis print options were selected suitably.
9. The file was saved and run analysis command was executed.
10. It is made sure that there is no error is indicated in the output window.
11. Post processing mode was selected.
12. The results were properly arranged using the tools.
13. Printouts were taken.

**Results:**

1. Reaction at support A =
2. Reaction at support F =
3. Shear force and bending moment diagrams are attached.

Project Management Software

Experiment 3,4,5,6

Understanding basic features of Project management software.

1. PLANNING AND SCHEDULING
2. COLLABORATION.
3. DOCUMENTATION
4. REPORTING
5. RESOURCE MANAGEMENT
6. MANAGING THE PROJECT BUDGET SUMMING IT UP

What is a project?

Project is a temporary effort undertaken to create a unique product or a new service. It might take one week, months or many years but must have some finish date.

Must Remember:

1. Project manager must have complete knowledge of product (product specifications) to be developed before defining the scope (cost, time, resources) of the project.
2. A good Manager is one who completes the project intime, within budget and as per customer satisfaction.

Why to use MS Project? MS Project helps to track the information about project goals cost deadlines and resources.

SOME OF THE IMPORTANT VIEWS IN MS PROJECT:

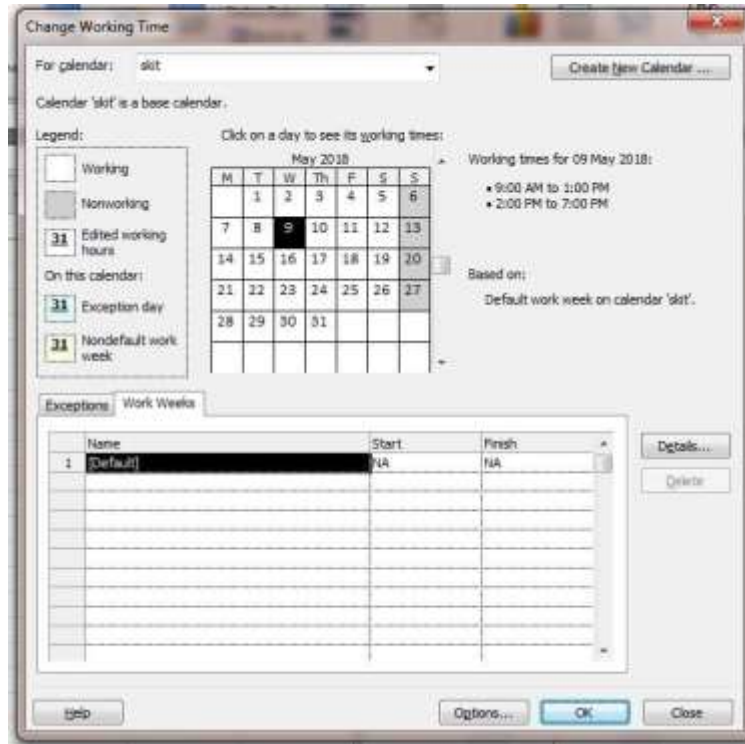
- **Gantt chart view** is a default view gives information about tasks, duration of each task, starting and finishing dates and resources allocated to that specific task.
- **Resource sheet view** elaborates all available resources allocated to a project in a sheet format. It doesn't tell which tasks are assigned to which resource.
- **Resource Usage view** groups the tasks against each resource.
- **Task usage view** shows details about each task that which task is assigned to whom and working schedule of each resource.
- **Calendar view** Task bars appear on the days are scheduled to start.
- **Network Diagram view** shows relationship among tasks and also dependencies.

CALENDAR

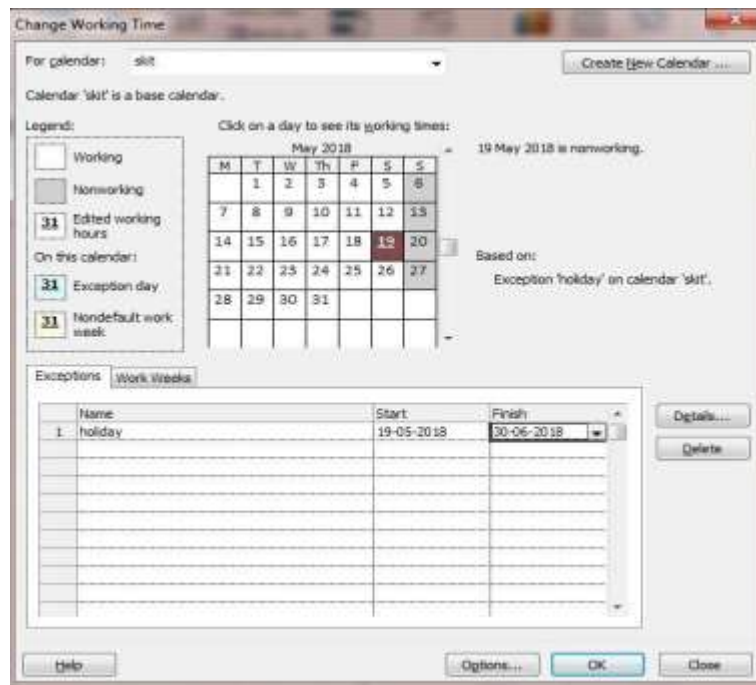
AIM: To create a new base calendar that has 6 working days per week and 10 hours between. The calendar should include holidays on the third Saturday of the month. Assign the new base calendar as project calendar.

PROCEDURE:

1. Go to project menu > properties > change working time.
2. Click create new calendar.
3. If we want to begin with a default calendar, click create new base calendar.
4. Else you want to create a new calendar based on existing calendar, click make a copy of and then click calendar name in the calendar bar.
5. In the “name box”, type your name of a new base calendar.
6. Click ok.
7. On the calendar, select the days You want to change.
8. Click the “detail” tab and set working time for the next working sheet. Click ok.
9. Now the “option” tab has to be clicked > calendar option for project set working time.
10. For editing calendar, refer “work weeks” and “exceptions”.



Working days



















Non-working day

TASK & ITS RELATIONSHIP

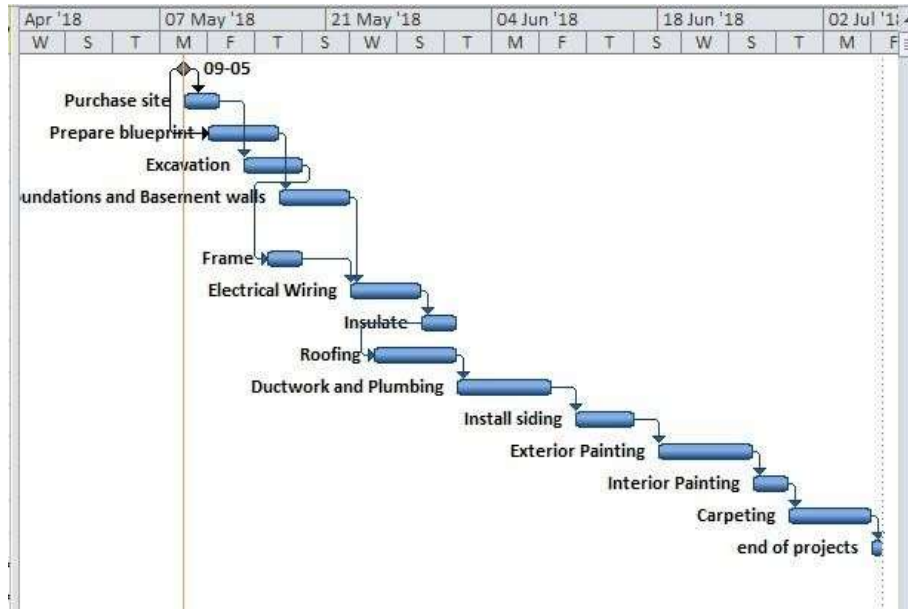
AIM: - To construct a network diagram & critical path

PROCEDURE:-

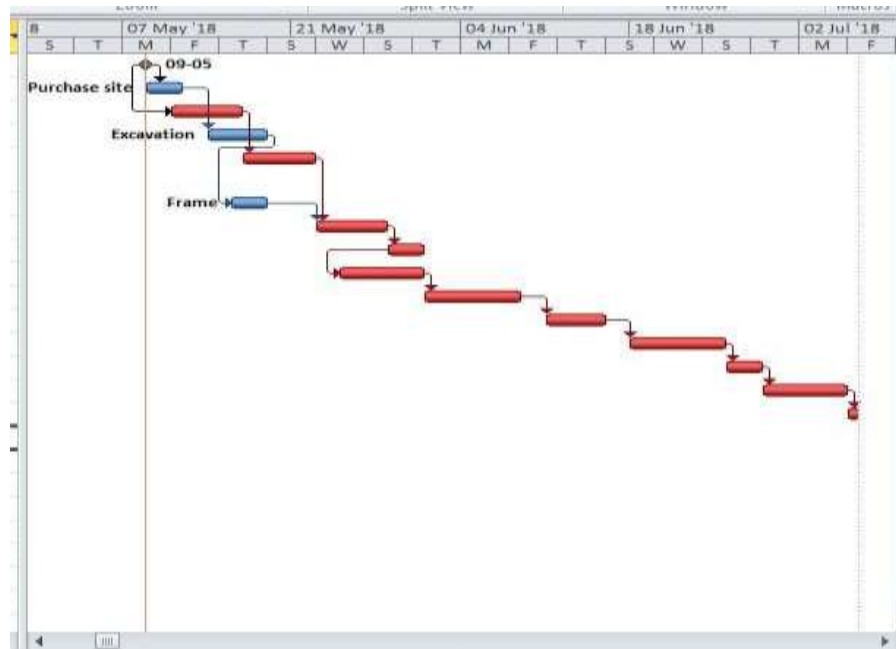
1. Click the task mode as auto schedule.
2. Enter the activities or task name in the task name column.
3. Enter the duration of each activities in the duration column.
4. In the entry table enter predecessor's numbers in the predecessor column.
5. Right click on gantt chart & then click on show /hide bar styles.
6. Then press critical path.

	 Task Mode	Task Name	Duration	Start	Finish	Predecessors
1		Start of project	0 days	Wed 09-05-18	Wed 09-05-18	
2		Purchase site	3 days	Wed 09-05-18	Fri 11-05-18	1
3		Prepare blueprint	4 days	Fri 11-05-18	Wed 16-05-18	1SS+2 days
4		Excavation	5 days	Mon 14-05-18	Fri 18-05-18	2
5		Foundations and Basement walls	4 days	Thu 17-05-18	Tue 22-05-18	3
6		Frame	3 days	Wed 16-05-18	Fri 18-05-18	4FS-3 days
7		Electrical Wiring	4 days	Wed 23-05-18	Mon 28-05-18	5,6
8		Insulate	3 days	Tue 29-05-18	Thu 31-05-18	7
9		Roofing	5 days	Fri 25-05-18	Thu 31-05-18	8SS-2 days
10		Ductwork and Plumbing	6 days	Fri 01-06-18	Fri 08-06-18	9
11		Install siding	5 days	Mon 11-06-18	Fri 15-06-18	10
12		Exterior Painting	6 days	Mon 18-06-18	Mon 25-06-18	11
13		Interior Painting	3 days	Tue 26-06-18	Thu 28-06-18	12
14		Carpeting	5 days	Fri 29-06-18	Thu 05-07-18	13
15		end of projects	1 day	Fri 06-07-18	Fri 06-07-18	14

Entering of Tasks



Gantt Chart



Critical Path

RESOURCE DEFINING & ASSIGNING

AIM: - To define and assign the resource to complete the task in your project.

There are three types of resources to be assigned

1. Work Resources.
2. Cost Resources.
3. Material Resources.

PROCEDURE:-DEFINING OF RESOURCES

1. Go to view bar and then select resource sheet.
2. In resource sheet enter the resources in the resource name column.
3. Mention the type of resources in the type column.

ASSIGNING OF RESOURCES

1. In view bar select Gantt chart and double click on particular activities or task.
2. A dialog box will open then select resources.
3. Finally then add resources.

Example 1:-

ID	Activities	Duration	Predecessor
1	Start	0	-
2	DPP	3	1
3	Land Acquisition & Requisition	5	2
4	Tender Document Preparation	7	3
5	Tender	9	4
6	Bid Evaluation	7	5
7	Tender Award	5	5
8	Procurement	4	6,7

9	Mobilization	3	8
---	--------------	---	---

10	Clearing, Grading And Stringing	15	9
11	Trenching, Lowering And Back Filling	20	9,10
12	Hydrostatic Testing	4	11
13	Cleaning	3	12
14	Commissioning	4	13
15	Operation	6	14
16	End	0	15

ENTRYING OF RESOURCES

ID	Resource Name	Max. units	Std. rate
1	Project Manager	2	400/day
2	Site Engineer	2	350/day
3	Surveyor	1	300/day
4	Workers	20	250/day
5	Equipment	-	500/machine

ASSIGNING THE RESOURCES

TASK	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Project manager	-	1	-	1	1	-	1	-	1	-	1	-	-	1	1	-
S E	-	1	1	-	-	1	-	1	-	1	1	-	-	-	1	-
Surveyor	-	-	1	1	1	-	1	-	1	-	-	1	1	1	-	-
Workers	-	2	5	-	2	10	5	-	5	9	5	5	18	5	5	-
equipment	-	1	3	-	-	5	9	5	1	-	1	5	6	2	3	-

Task ID	Task Name	Duration	Start	Finish	Predecessors
1	Start	0 days	Wed 09-05-18	Wed 09-05-18	
2	DPP	3 days	Wed 09-05-18	Fri 11-05-18	1
3	Land Acquisition & Requisition	5 days	Mon 14-05-18	Fri 18-05-18	2
4	Tender Document Preparation	7 days	Mon 21-05-18	Tue 29-05-18	3
5	Tender	9 days	Wed 30-05-18	Mon 11-06-18	4
6	Bid Evaluation	7 days	Tue 12-06-18	Wed 20-06-18	5
7	Tender Award	5 days	Tue 12-06-18	Mon 18-06-18	5
8	Procurement	4 days	Thu 21-06-18	Tue 26-06-18	6,7
9	Mobilization	3 days	Wed 27-06-18	Fri 29-06-18	8
10	Clearing, Grading And Stringing	15 days	Mon 02-07-18	Fri 20-07-18	9
11	Trenching, Lowering And Back Filling	20 days	Mon 23-07-18	Fri 17-08-18	9,10
12	Hydrostatic Testing	4 days	Mon 20-08-18	Thu 23-08-18	11
13	Cleaning	3 days	Fri 24-08-18	Tue 28-08-18	12
14	Commissioning	4 days	Wed 29-08-18	Mon 03-09-18	13
15	Operation	6 days	Tue 04-09-18	Tue 11-09-18	14
16	End	0 days	Tue 11-09-18	Tue 11-09-18	15

Entry Table

Resource ID	Resource Name	Type	Material	Initials	Group	Max.	Std. Rate	Ovt. Rate	Cost/Use	Accrue At	Base Calendar
1	project engineer	Work		p			2 ₹ 400.00/day	₹ 0.00/hr	₹ 0.00	Prorated	Standard
2	site engineer	Work		s			2 ₹ 350.00/day	₹ 0.00/hr	₹ 0.00	Prorated	Standard
3	surveyor	Work		s			1 ₹ 300.00/day	₹ 0.00/hr	₹ 0.00	Prorated	Standard
4	workers	Work		w			20 ₹ 250.00/day	₹ 0.00/hr	₹ 0.00	Prorated	Standard
5	equipment	Material	nos	e			₹ 500.00		₹ 0.00	Prorated	

Resource Sheet

Task Information

General | Predecessors | Resources | Advanced | Notes | Custom Fields

Name: Duration: 3 days Estimated

Resources:

Resource Name	Assignment Owner	Units	Cost
project engineer		2.00	₹ 2,400.00
site engineer		2.00	₹ 2,100.00
workers		2.00	₹ 1,500.00
equipment		1 nos	₹ 500.00

Help OK Cancel

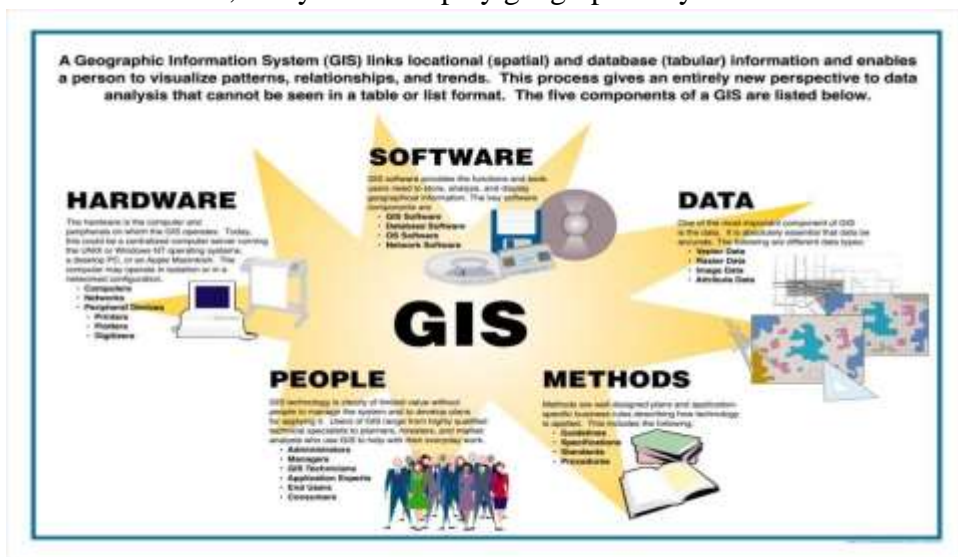
Assigning of Resource

GIS applications using open source software

Experiment 7

What is a Geographic Information System (GIS)?

A Geographical Information System (GIS) is an organized collection of computer **hardware**, **software** and **data** used to link, analyze and display geographically referenced information.



The foundation of GIS is the ability to locate objects and events (streams, villages, disease cases) and link them with appropriate information in order to identify patterns and provide a basis for map making and analysis. Key types of geographical data, represented as separate map layers in a GIS, are outlined in the table below.

Sr. No	Data Type	Example	Layer on Map	
1	POINT	Building, Hospital, City, Well.	Points	
2	LINE	River, Road	Lines	
3	POLYGON	Administrative Boundaries, Census facts.	Areas	

4	RASTER	Pixel or grid data	
---	--------	--------------------	--

Vector data: A representation of the world using points, lines, and polygons. Vector models are useful for storing data that has discrete boundaries, such as country borders, land parcels, and streets.

Point features: A map feature that has neither length nor area at a given scale, such as a city on a world map or a building on a city map.

Line features: A map feature that has length but not area at a given scale, such as a river on a world map or a street on a city map.

Polygon features: A map feature that bounds an area at a given scale, such as a country on a world map or a district on a city map.

Raster data. A representation of the world as a surface divided into a regular grid of cells. Raster models are useful for storing data that varies continuously, as in an aerial photograph, a satellite image, a surface of chemical concentrations, or an elevation surface.

With a GIS application you can open digital maps on your computer, create new spatial information to add to a map, create printed maps customised to your needs and perform spatial analysis.

Understanding QGIS

What is Quantum GIS?

Quantum GIS (QGIS) is a user friendly Open Source GIS application licensed under the GNU General Public License. QGIS is an official project of the Open Source Geospatial Foundation (OSGeo). It runs on Linux, Unix, Mac OSX, Windows and Android and supports numerous vector, raster, and database formats and functionalities.

Like all GIS applications, QGIS provides a graphical user interface allowing display of map layers and manipulation of data for analyses and map-making.

A Geographical Information System (GIS) is a collection of software that allows you to create, visualize, query and analyze geospatial data. Geospatial data refers to information about the geographic location of an entity. This often involves the use of a geographic coordinate, like a latitude or longitude value. Spatial data is another commonly used term, as are: geographic data, GIS data, map data, location data, coordinate data and spatial geometry data. Applications using geospatial data perform a variety of functions. Map production is the most easily understood function of geospatial applications. Mapping programs take geospatial data and render it in a form that is viewable, usually on a computer screen or printed page. Applications can present static maps(a simple image) or dynamic maps that are customized by the person viewing the map through a desktop program or a web page.

Many people mistakenly assume that geospatial applications just produce maps, but geospatial data analysis is another primary function of geospatial applications. Some typical types of analysis include computing:

1. Distances between geographic locations
2. The amount of area (e.g., square meters) within a certain geographic region
3. What geographic features overlap other features?
4. The amount of overlap between features
5. The number of locations within a certain distance of another
6. and so on...

These may seem simplistic, but can be applied in all sorts of ways across many disciplines. The results of analysis may be shown on a map, but are often tabulated into a report to support management

decisions. The recent phenomena of location-based services promises to introduce all sorts of other features, but many will be based on a combination of maps and analysis. For example, you have a cell phone that tracks your geographic location. If you have the right software, your phone can tell you what kinds of restaurants are within walking distance. While this is a novel application of geospatial technology, it is essentially doing geospatial data analysis and listing the results for you.

System Requirements

Windows OS:

Minimum: Pentium III / 256 MB RAM.

Recommended: 1 GB of RAM and 1.6 GHz processor.

Operation System: Platforms Windows and Linux (Win XP or newer, Linux Suse 8.2/9.0/9.2, Linux Debian (Lliurex))

MAC OS:

PC/Desktop with at least Pentium IV

Tiger OS, Leopard OS.

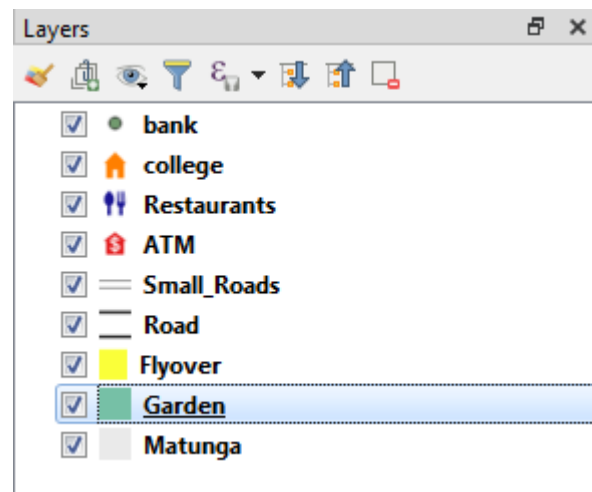
PRACTICAL - 1

AIM : - Creating and Managing Vector Data:

- a) Adding vector layer
- b) Setting properties
- c) Vector Layer Formatting

Procedure:

- a. Adding vector layers (Polygon, Line, Points)
 - Polygon layers (We have taken 2 layers Matunga, Garden)
 - Line layers (We have taken 3 layers Small_Roads, Road, Flyover)
 - Point layers (We have taken 4 layers bank,college,Restaurants,ATM)
- b. Setting properties (Labeling, Symbolism)

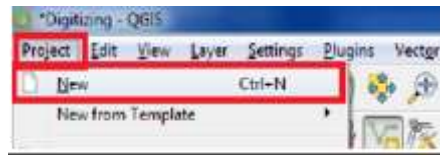


Our aim is to create map representing a location and its surrounding as follows:



a. Creating Polygon vector layer

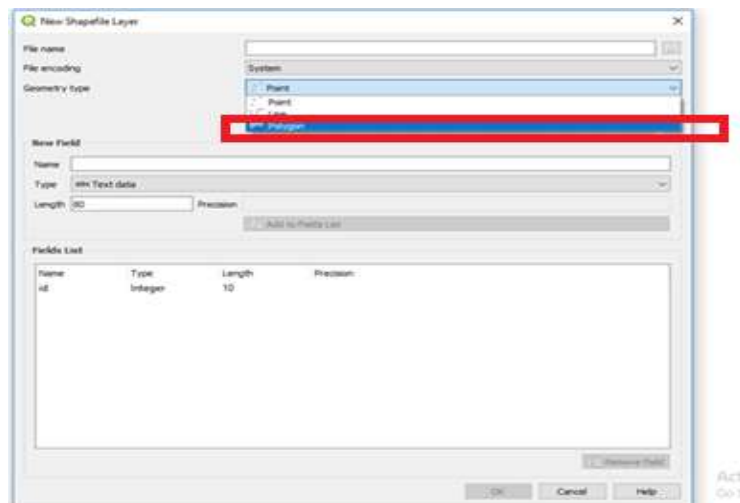
- Select **Project**→**New**



- Select **Layer**→**Create Layer**→**New Shapefile Layer**

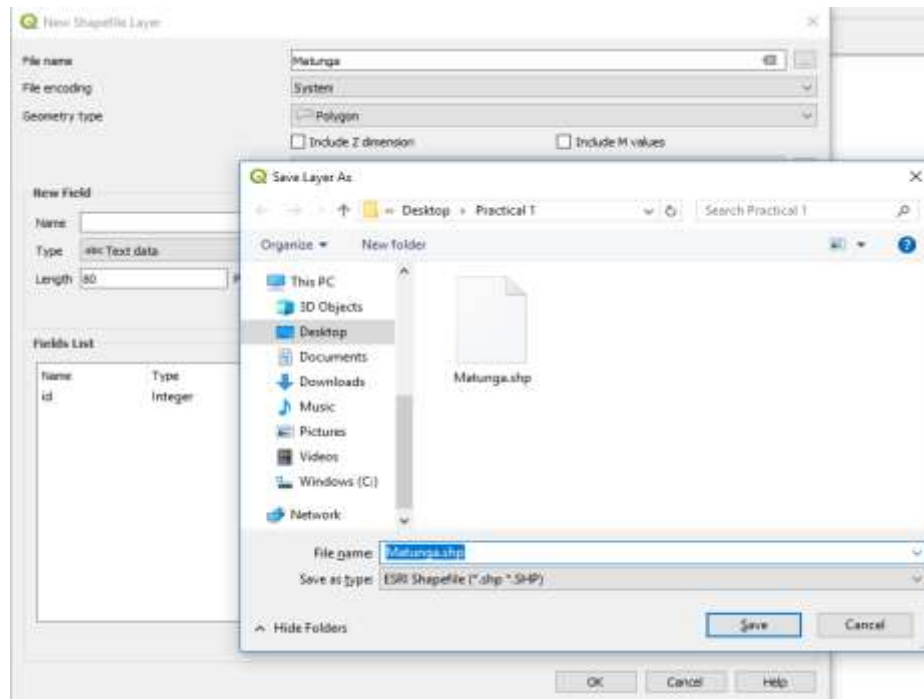


- Following dialog box will appear on the screen. Select Polygon option from Geometry type.



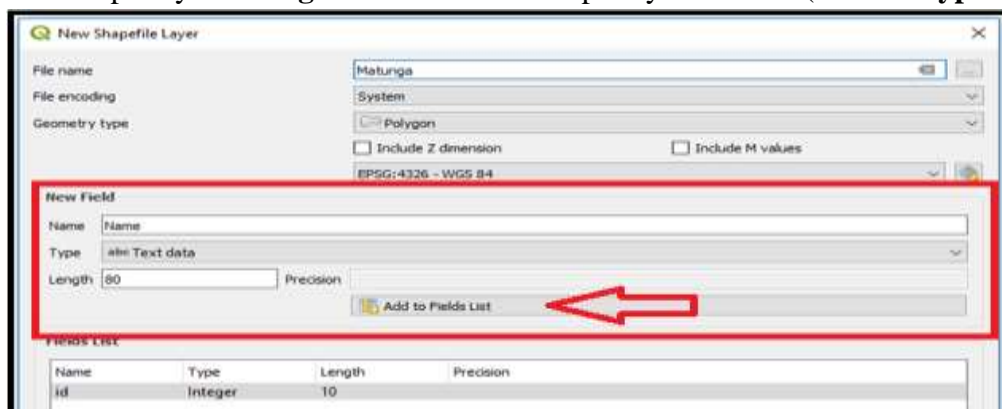
- Fill the appropriate information in each text box.
 - File name :
 - By default the file will be saved in bin folder.
 - To avoid it click on following button to change the location of file.



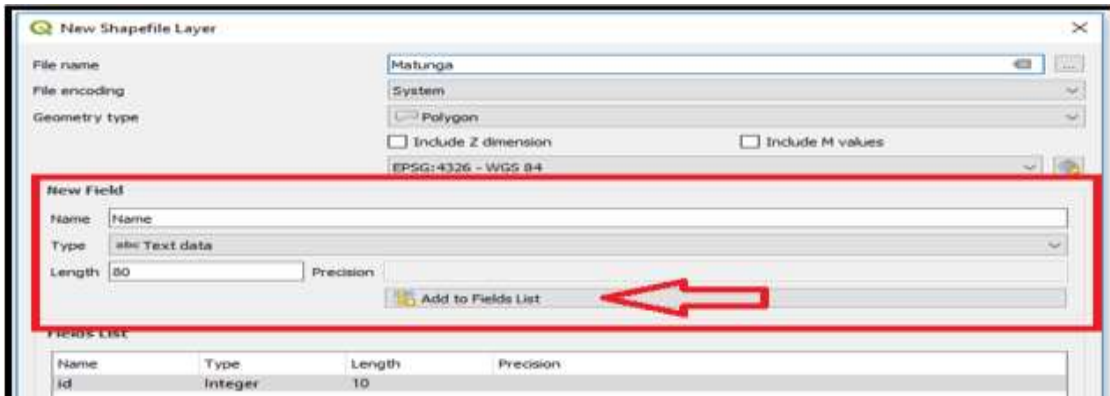


➤ Field Panel

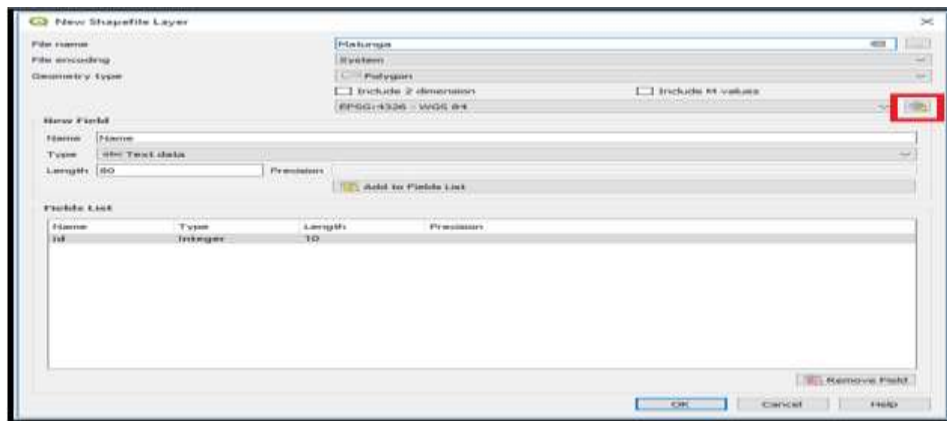
- Add the **Attribute** you want to show. (**Column Name** for Table)
- b. Specify **Type (Data Type: Text Data/Decimal Data/Whole Number/Date)** of Attribute
- c. Specify the **Length** of the Attribute. Specify **Precision** (If **Data Type** is **Decimal**)



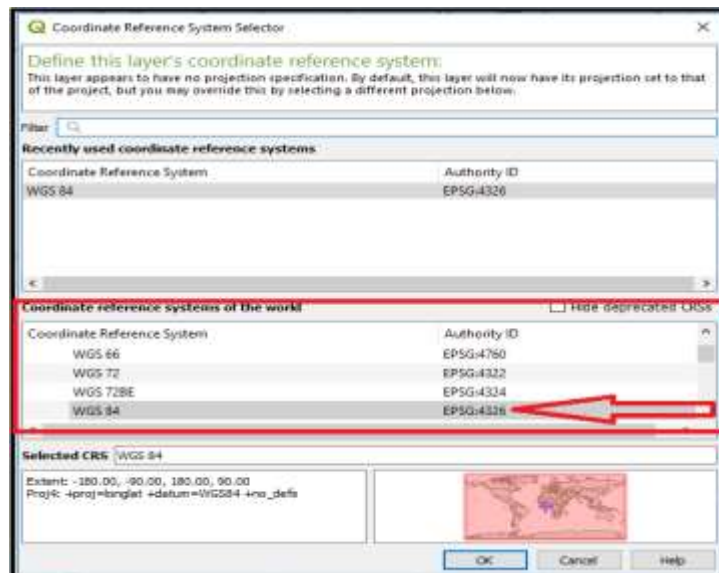
- Click on **Add to Field List** Button.
- You can add as many **fields (Column Name)** as you want for the layer.



Click on the following button

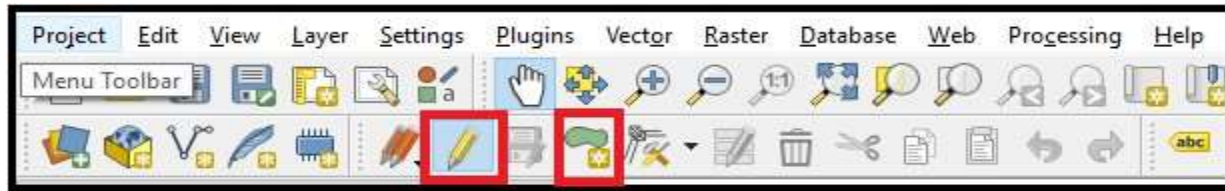


- The CRS dialog box will appear on screen. Click on the WGS84 option and it will be selected as follows. click on **OK**

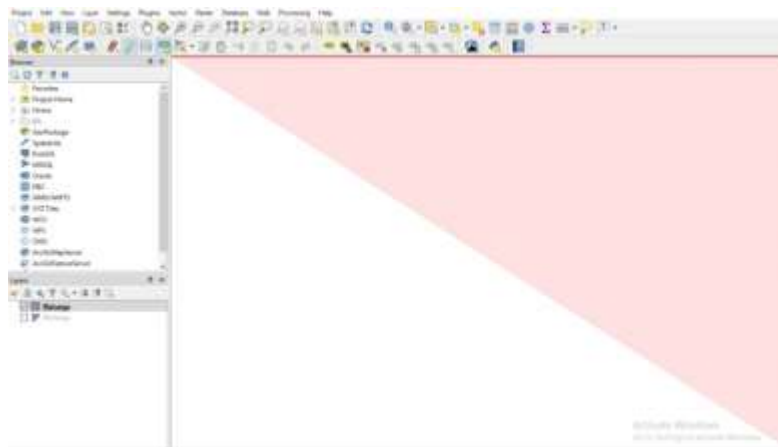


a) Follow the steps to plot **Polygon features**.

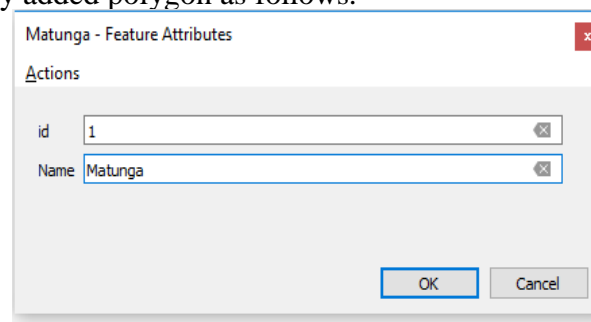
➤ Select the **Polygon Feature**(In our case it is **Matunga** for **background**) from layer panel



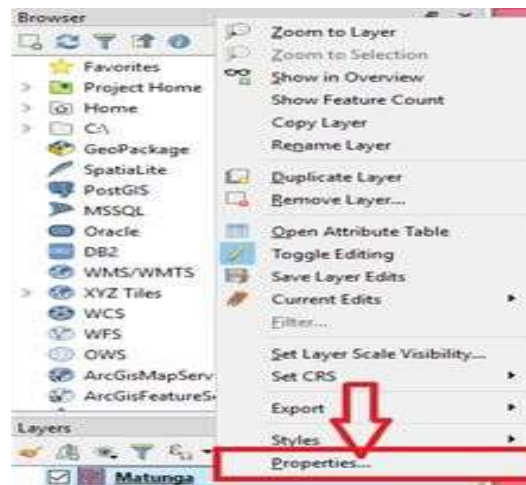
➤ Click **Toggle Editing Button** → Click on **Add Polygon** → Now place the cursor at the location where you want to place the polygon. for **polygon layer minimum 3 points** should be selected



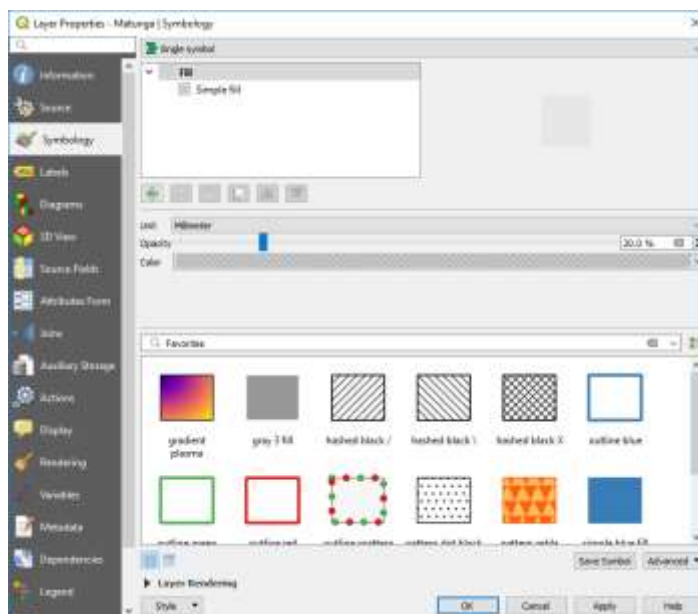
➤ Save the newly added polygon as follows.



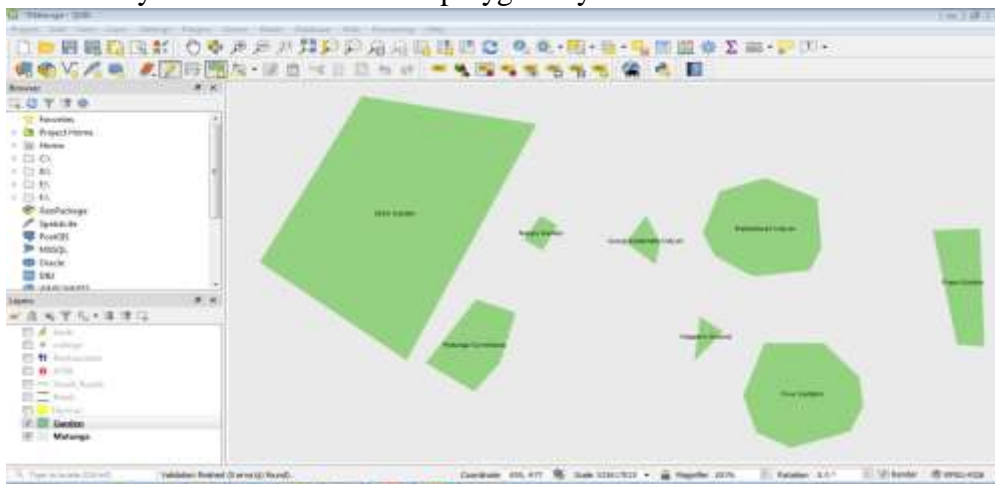
➤ Set **style** for polygon by using property window(**Right click** on Matunga Layer)



➤ Following screen will appear on the screen. Select **pattern** as you want and **click on OK**.

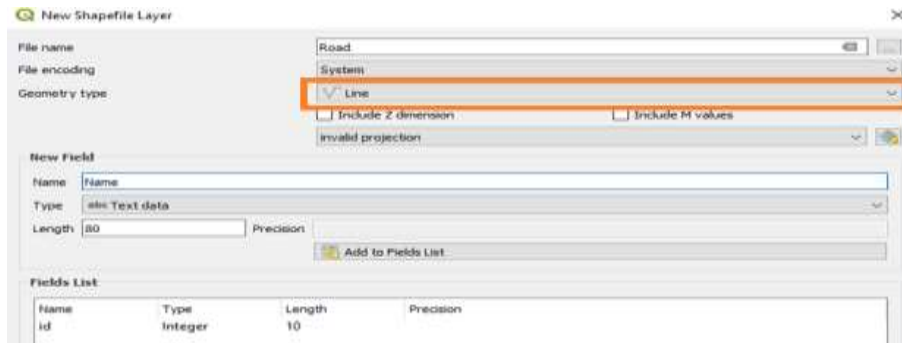


➤ Same way we can add one more polygon layer for Gardens.



a) Creating Line vector layer

- Repeat the same steps as we have done for polygon layer.
- Select geometry type Line.

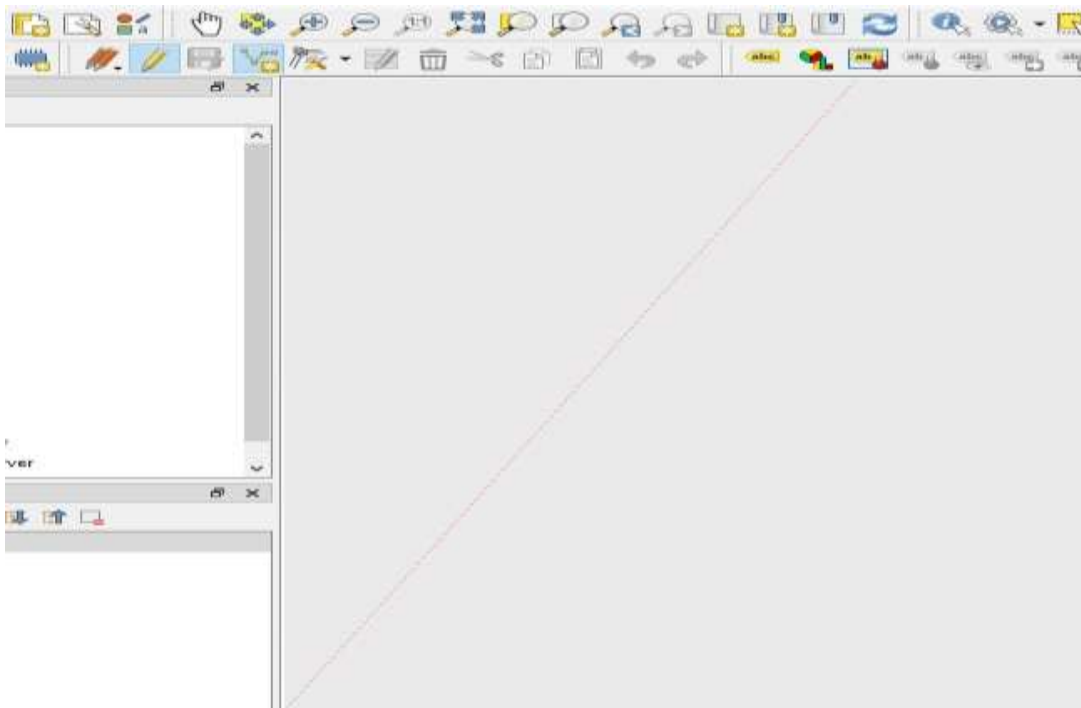


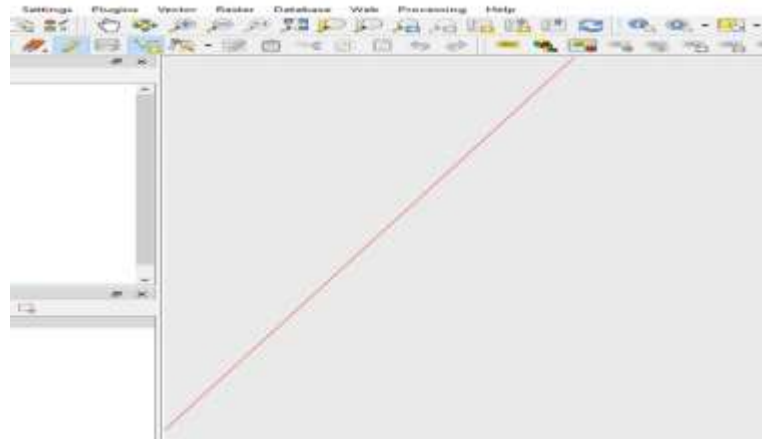
➤ Road layer :

- To plot road **click on Add Line Feature.**

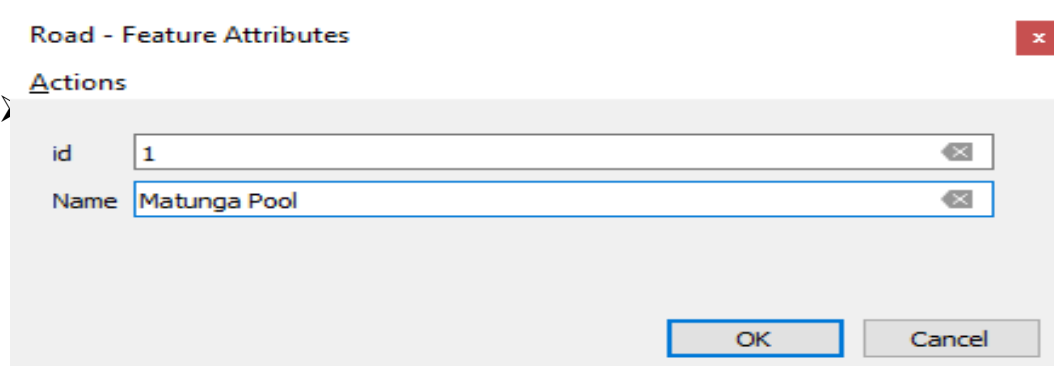


- Click on the map where you want to draw line.

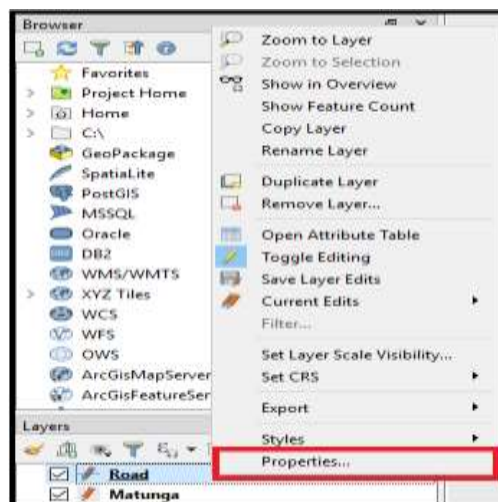


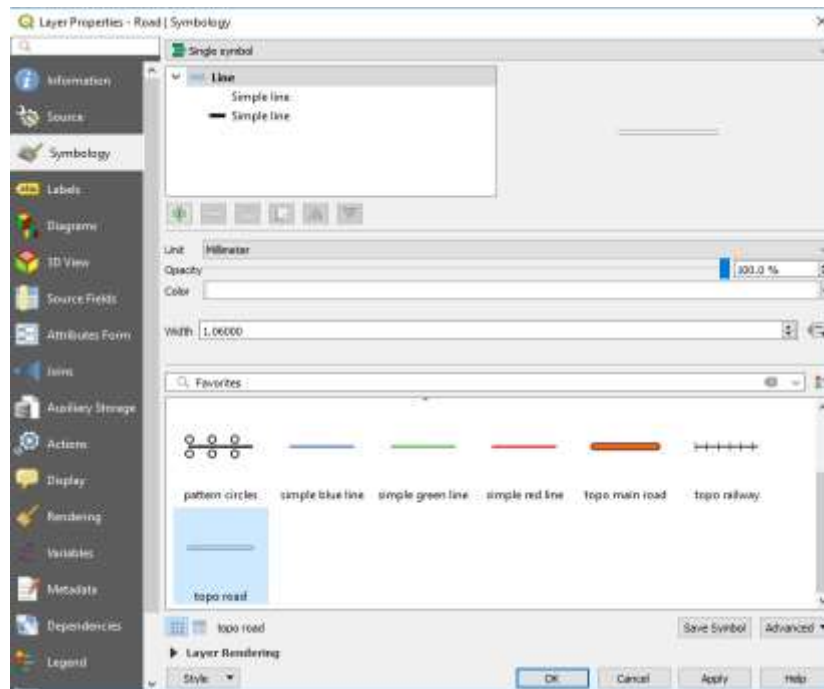


- **save** your data

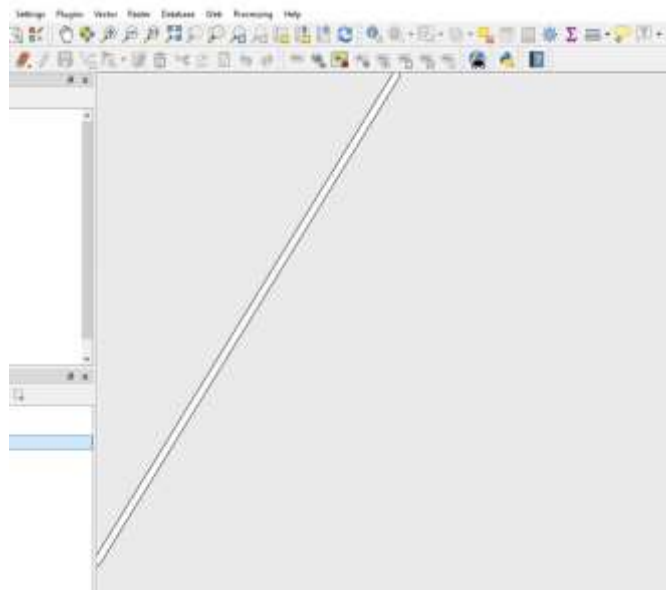


- **set style** for Roads in the same way as we have done for polygon

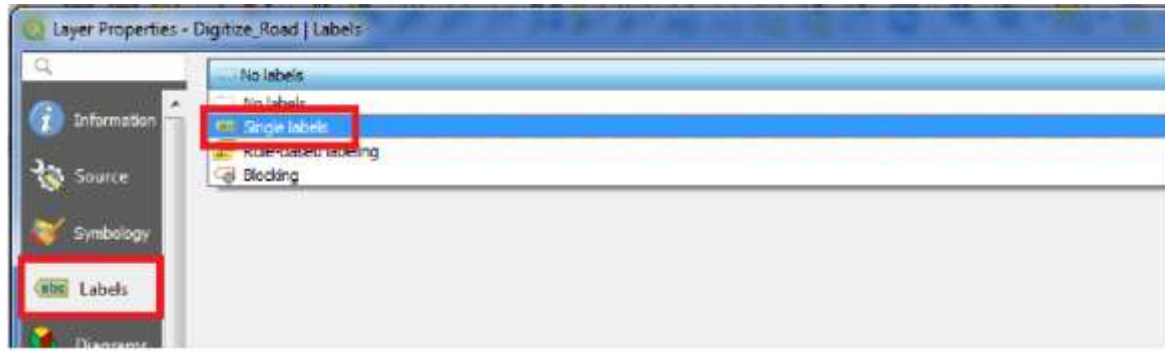




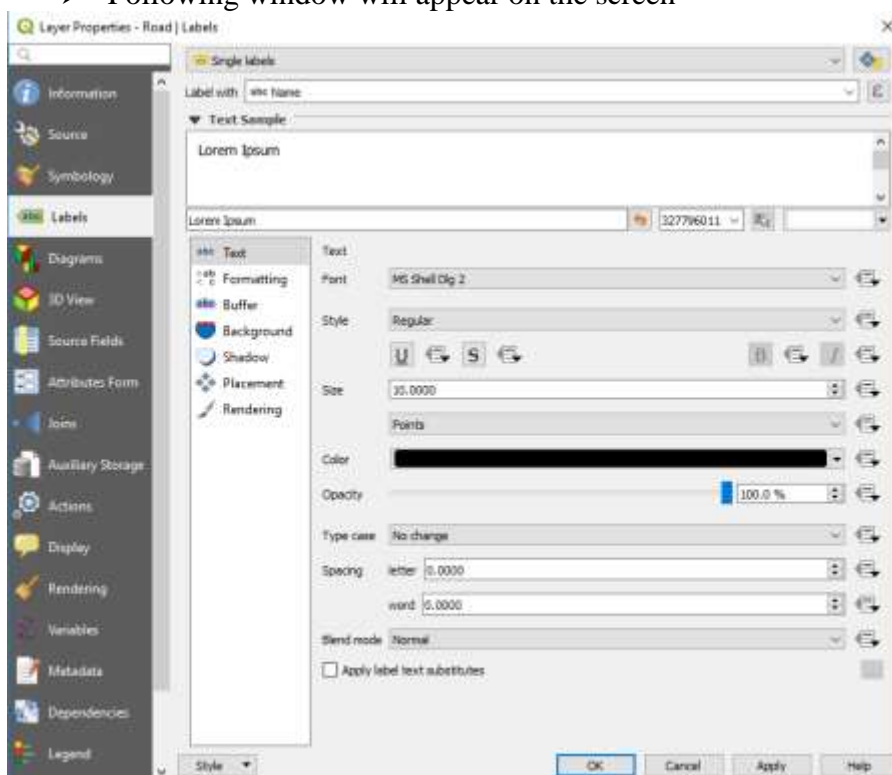
Road will look as below



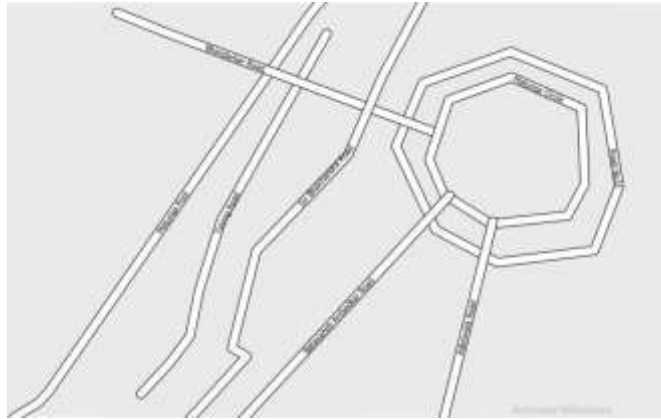
To label your roads **Right click** on **Road layer** .Go to **properties** window then select label and set single **label property**



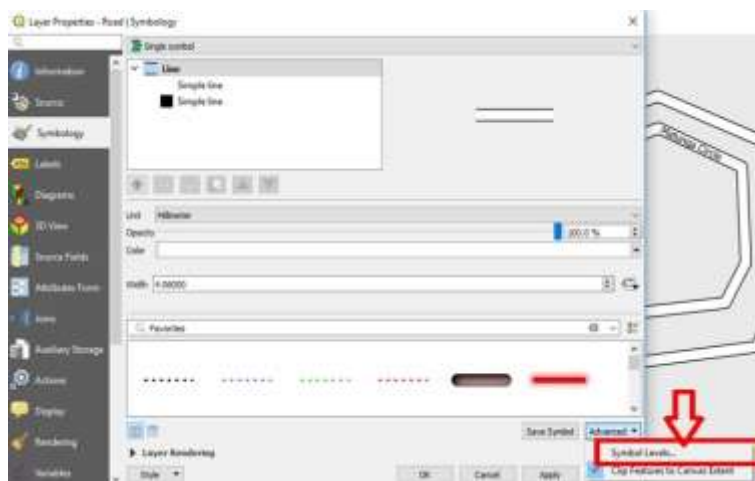
➤ Following window will appear on the screen



➤ Roads will look like these



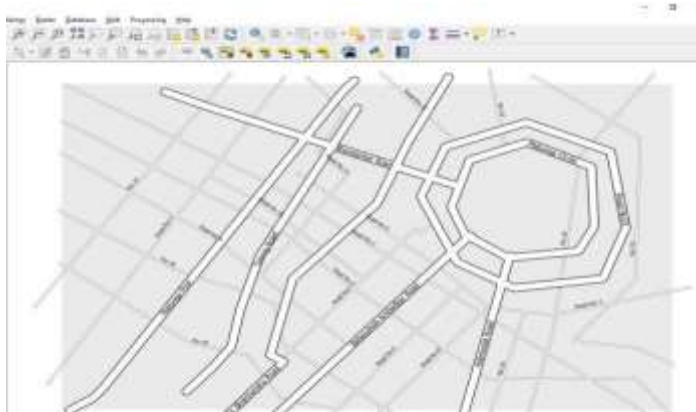
- To merge roads
 - Go to **properties** of road then select **symbology**. Click on **Advanced button** select Symbol levels.



- Check **Enable symbol levels** option

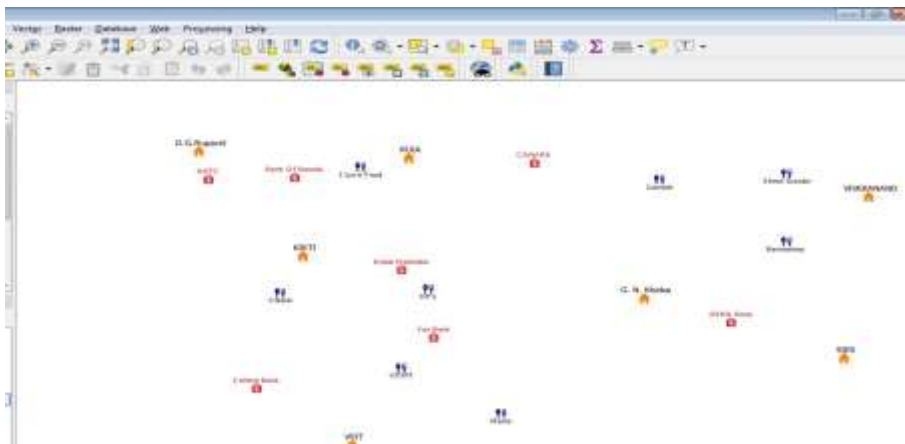


- Click ok & Road will appear as follows



C. Create Point vector layer

- Repeat same steps to add point layers as we have done in previous layers.(For ATM, Restaurants, Banks, Bus Stops etc)

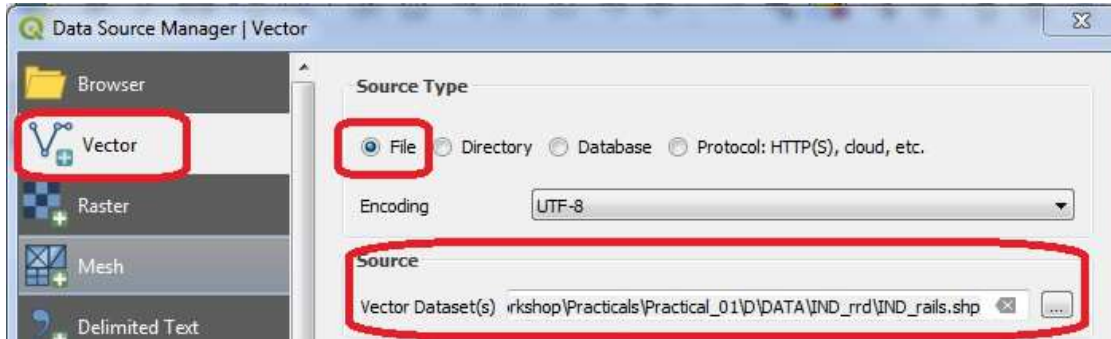


Final output:



d) Calculating line lengths and statistics

- Go to Layer → Add Layer → Add Vector Layer
- Add the following file to project



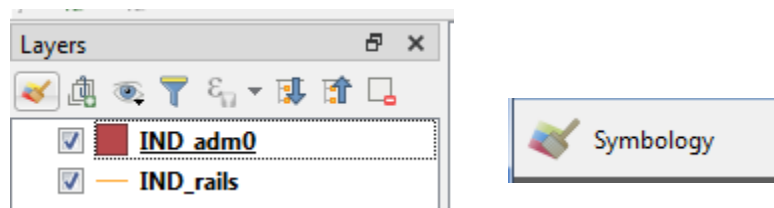
"\GIS_Workshop\Practicals\Practical_01\D\DATA\IND_rrd\IND_rails.shp"

Press "ADD"

- Also add India Administrative Map

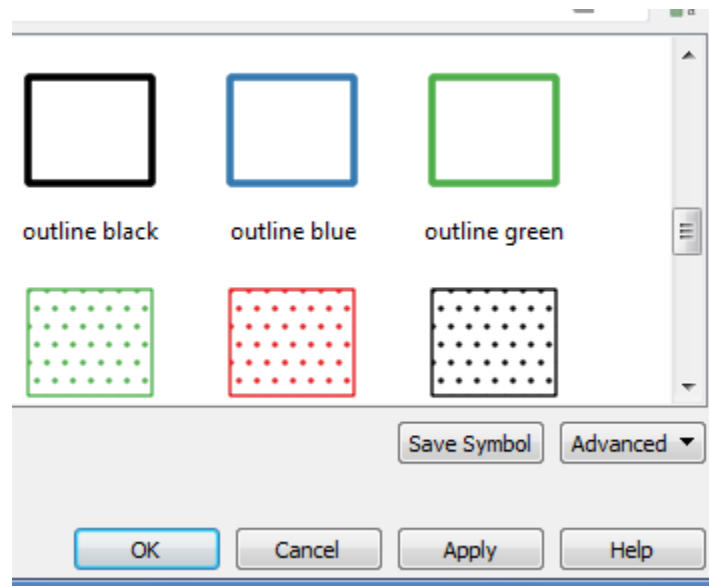
"\GIS_Workshop\Practicals\Practical_01\D\DATA\IND_adm\IND_adm0.shp"

- Double Click on IND_adm0



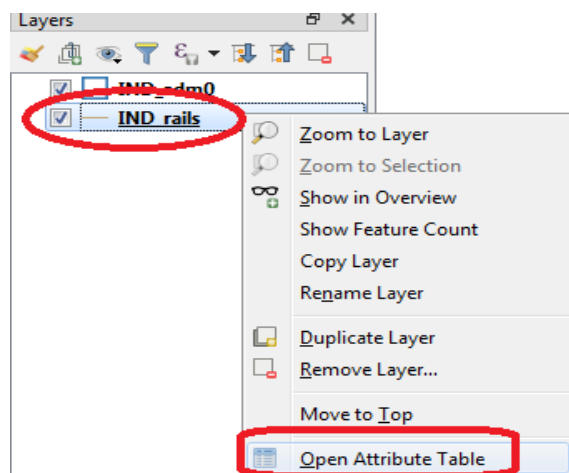
Select



→ Select any outline style from below given options.

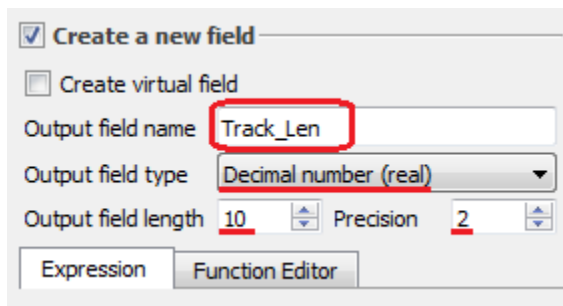


Press OK

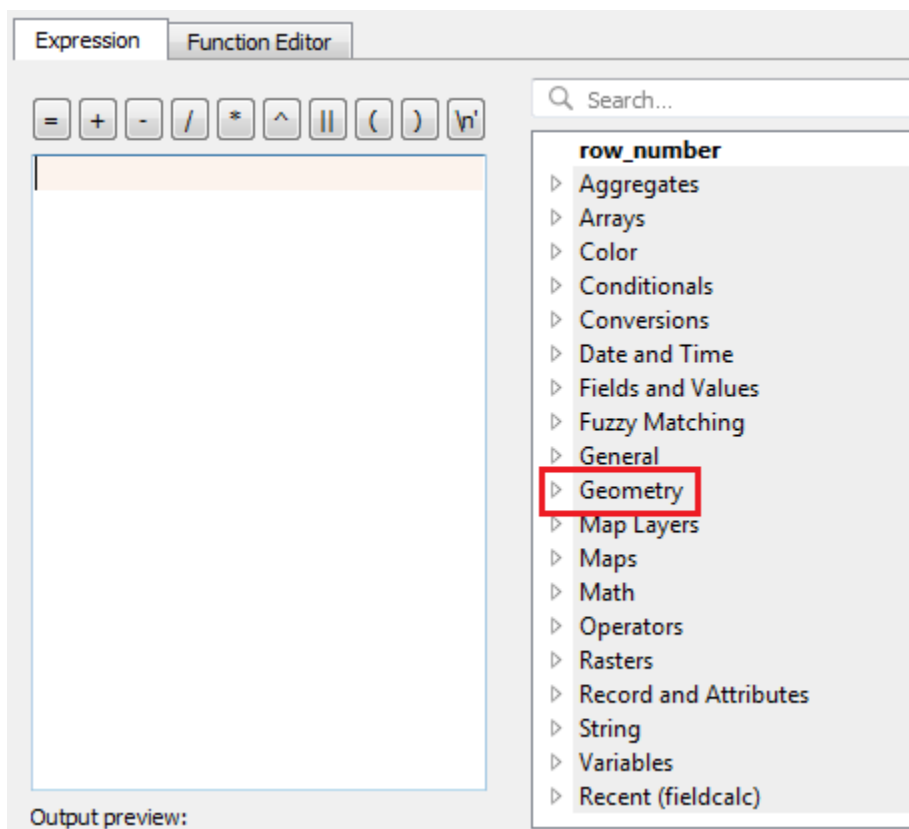
- The display window will appear like



- Press Toggle Editing button using  button, on Attribute table window toolbar.
- Press Open Field Calculator using  button.
- Set the output field as “Track_Len”, field type to “Decimal Number”.



- From Function List search \$length or go to Geometry → Select \$length



- Set expression as



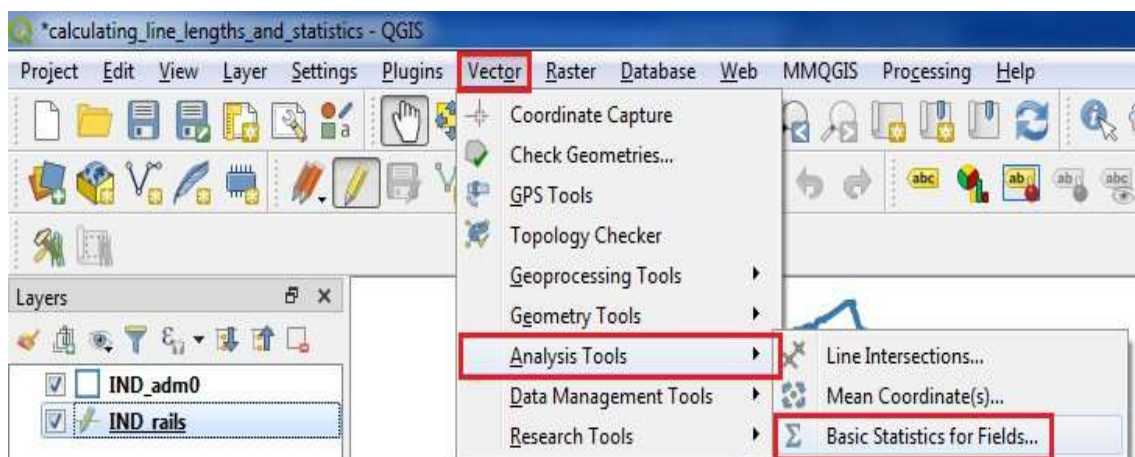
Press “OK”

- A new column is added to the attribute table with value representing the length of track in KM.

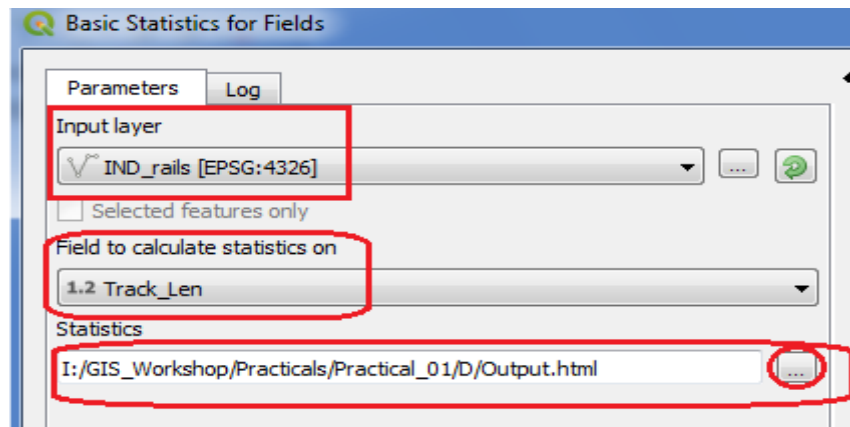
	FID_rail_d	F_CODE_DES	EXS_DESCRI	FCO_DESCRI	FID_countr	ISO	ISOCOUNTRY	Track_Len
1	144645	Railroad	Operational	Single	102	IND	INDIA	29.01
2	145991	Railroad	Operational	Single	102	IND	INDIA	66.13
3	146001	Railroad	Operational	Single	102	IND	INDIA	2.33
4	146008	Railroad	Operational	Single	102	IND	INDIA	63.81
5	146096	Railroad	Operational	Single	102	IND	INDIA	92.71
6	146394	Railroad	Operational	Single	102	IND	INDIA	22.24



- Press CTRL+S or click on Save Edits option on tool bar
- Close the attribute table window.
- For calculating the total length of Railway tracks in India.
- Select Vector → Analysis Tools → Basic Statics for Fields

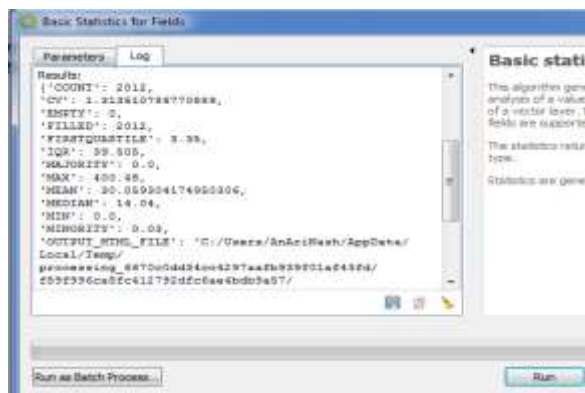


- Select IND_rails layer from input layer. And select Track_Len in “Field to Calculate statistics on”



➤ Press RUN

➤ The Result is



- Open the “**output.html**” file to get the field statistics.

Analyzed field: Track_Len

Count: 2012

Unique values: 1608

NULL (missing) values: 0

Minimum value: 0.0

Maximum value: 400.48

Range: 400.48

Sum: 60479.320000000014

Mean value: 30.059304174950306

Median value: 14.04

Standard deviation: 39.483220276624444

Coefficient of Variation: 1.313510786770889

Minority (rarest occurring value): 0.03

Majority (most frequently occurring value): 0.0

First quartile: 3.35

Third quartile: 42.855000000000004

Interquartile Range (IQR): 39.505

- The above statistics show that the total length of Railway track in India is **60,479.32 KM**.

Experiment 8

MS Excel

a. Computation of earthwork

A railway embankment is to be formed with a width of 12.5 m at the formation level and a side slope of 2:1. The ground levels at every 50m along the central line are as under

Distance	0	50	100	150	200	250	300	350	400
RL	154.8	155.5	156.2	156.8	157.5	157.3	157.2	157.9	158.3

The formation level at zero chainage is 157.0 and the embankment has a rising gradient of 1 in 100m. The ground is level across the central line. Calculate the volume of earthwork using both trapezoidal and prismoidal rules.

Aim: To tabulate the earthwork of a stretch having a level section by using a spread sheet application.

Principle: The areas of cross sections may be calculated using the formula $A = (b + nh) h$

Where, b = width of base and h = height of formation.

Trapezoidal Rule.

$$V = d [(A_1 + A_n)/2 + A_2 + A_3 + \dots + A_{n-1}]$$

Prismoidal Rule.

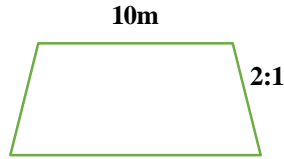
$$V = d/3[(A_1 + 4(A_2 + A_4 + \dots) + 2(A_3 + A_5 + \dots) + A_n)]$$

No	distances	R. L	Rising gradient	Filling	Cutting	Area	
1	0	154.8	157	-2.2		A1	37.18
2.	50	155.5	157.5	-2		A2	33
.						.	
.						.	
.						.	
9						A9	

Result: Volume of earthwork using trapezoidal rule =

Volume of earthwork using prismoidal rule =

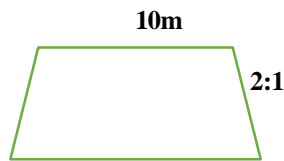
Find the Quantity of earth work for an embankment 180m long and 10m wide at the Top. Side slope is 2:1 and depth at each 30m interval are 0.8, 1.1, 1.2, 1.4, 1.5, 1.6 and 1.3.



Mean area Method:

Station	Depth	Center Area=B*d	Area of Sides=Sd ²	Total Area =B.D+Sd ²	Mean area= $\frac{A1+A2}{2}$	Interval	Quantity		
							Cut	fill	
0	0.8	8	1.28	10.24					
30	1.1	11	2.42	26.62	18.43	30	552.9		
60	1.2	12	2.88	34.56	30.59	30	917.7		
90	1.4	14	3.92	54.88	44.72	30	1341.6		
120	1.5	15	4.5	67.5	61.19	30	1835.7		
150	1.6	16	5.12	81.92	74.71	30	2241.3		
180	1.3	13	3.38	43.94	62.93	30	1887.9		
Total amount of cut/fill								8777.1m ³	

Find the Quantity of earth work for an embankment 150m long and 12.5m wide at the Top. Side slope is 2:1 and depth at each 30m interval are 0.4, 1, 1.2, 1.3, 1.2, and 1.5.



Mean area Method:

Station	Depth	Center Area=B*d	Area of Sides=Sd ²	Total Area =B.D+Sd ²	Mean area= $\frac{A1+A2}{2}$	Interval	Quantity	
							Cut	fill

b. Design of Horizontal Curve by offset method.

Calculate necessary data using ordinate method at 10m intervals to set out a horizontal curve of radius 200. Given that the length of long chord is 80m.

Aim: To calculate the ordinates at 10 m interval from the long chord for the given horizontal curve.

Principle: The versing can be calculated which will give the mid ordinate using

$$O_0 = R - \sqrt{R^2 - L/2^2}$$

Remaining ordinates are calculated for one half of the curve only since the curve will be symmetric about its mid ordinate using.

$$O_x = \sqrt{R^2 - x^2} - (R - O_0).$$

Solution:

x distance	Ordinate
$O_0 =$	$O = R - \sqrt{R^2 - L/2^2}$
$O_{10} =$	$O_x = \sqrt{R^2 - x^2} - (R - O_0)$
$O_{40} =$	

Result: Necessary ordinates were calculated and an approximate plot is made using excel chart.

c. Design of Super Elevation

Design the rate of super elevation for a horizontal highway curve of radius 220 m and speed 100 km/h.

Aim: To prepare a programmed spread sheet to design the super elevation at a horizontal curve.

Solution: The scheme of formula writing is written below.

Design of Super Elevation

Allowable Super Elevation	0.07
Allowable Coefficient of Friction (f)	0.15
Design Speed (v)	100
75% of Design Speed	= 75 % of Design Speed
Radius of Circular Curve(R)	220
Super Elevation Calculated	= $V^2/225*R$
Super Elevation to be provided	SE Cal (or) 0.07 whichever is less
f = Friction Developed	$F = V^2/ (127 * R - \text{Allowable})$
Sufficiency of Friction Coefficient	F Developer should be less than allowable friction
Allowable Speed	If f is not sufficient limit the speed at curve by $V = \sqrt{(27.94 * R)}$

Result:

Super Elevation Provided=

Speed limit proposed =

Demonstration Experiments

Experiment 9

Creating structural model and analysis of high rise structures

Structural Design

The principle elements of an R.C.C building frame consist of:

- Slabs to cover a large area.
- Beams to support slabs and walls.
- Columns to support beams.
- Footings to distribute concentrated column loads over a large of the supporting soil such that soil bearing capacity is not exceeded.
- In a framed structure, the load is transferred from slab to beam, from beam to column, and then to the foundation and soil below it.

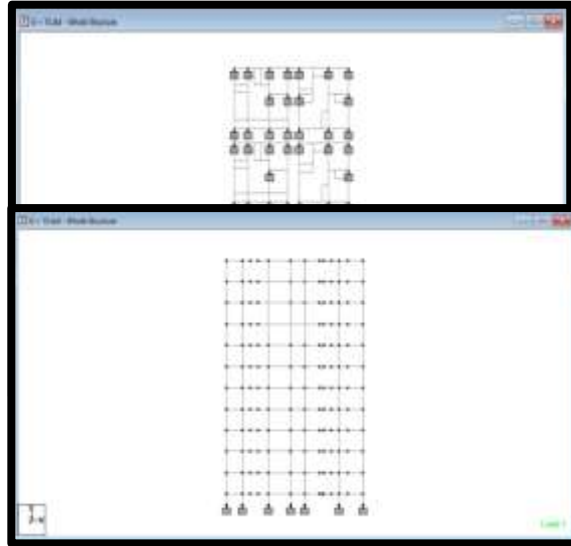
1. Maximum Span of Slabs

<i>Support Condition</i>	<i>Cantilevers</i>	<i>Supported</i>	<i>Fixed/Continuous</i>
<i>One-way Two-way</i>	<i>One-way Two-way</i>	<i>One-way Two-way</i>	<i>One-way Two-way</i>
<i>Maximum Recommended span of slabs</i>	<i>1.5m 2.0m</i>	<i>3.5m 4.5m</i>	<i>4.5 6.0m</i>

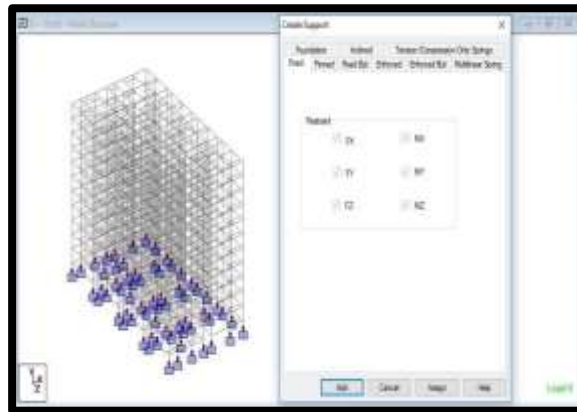
2. Maximum Spans of Beam Carrying Live Load

<i>Beam type</i>	<i>Cantilevers</i>	<i>Supported</i>	<i>Fixed/Continuous</i>
<i>Rectangular</i>	<i>3meters</i>	<i>6meters</i>	<i>8meters</i>
<i>Flanged</i>	<i>5meters</i>	<i>10meters</i>	<i>15meters</i>

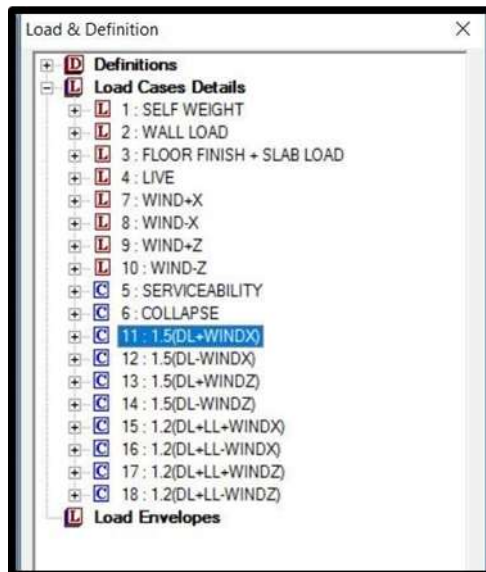
Area of Plot	131'.6" x 72'.6"
Number of Floors	G + 10
Number of Units	80 (Ground floor parking)
Type Apartment	2BHK
Area of Each Apartment	Flat 1: 1104 S.ft Flat 2-4: 1094 S.ft Flat 5-7: 1163 S.ft Flat 8: 1173 S.ft



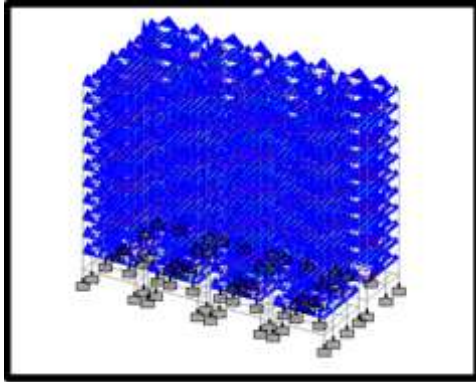
Elevation



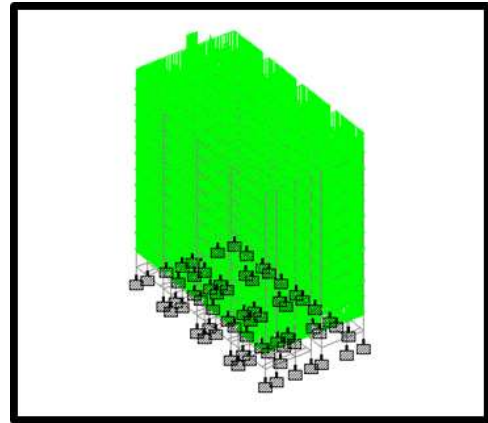
Support Generation



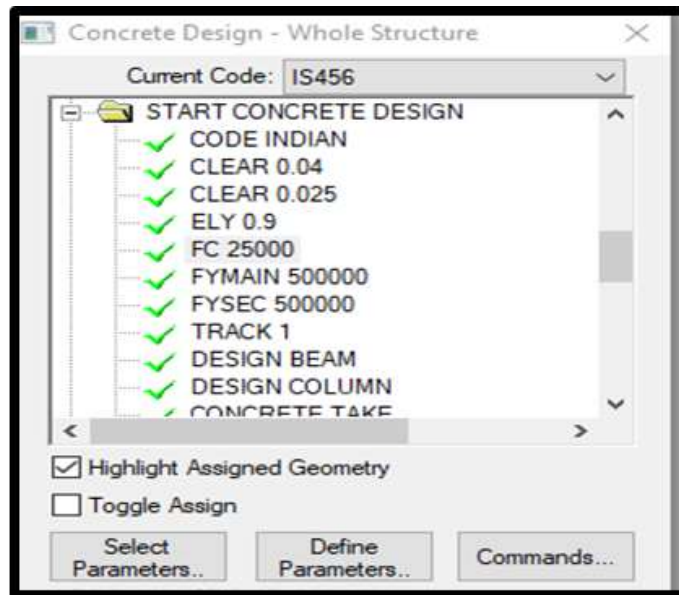
Load Combination



Dead Load and Live load



Load combination on structure



Assigning Design parameters