Analysis and Design of Reinforced Concrete Building Using Fiber Reinforced Concrete.

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Contents :

- Introduction
- Methodology
- Production of fibers
- Casting and testing of specimens
- Modeling in ETABS
- Cost comparison

Introduction

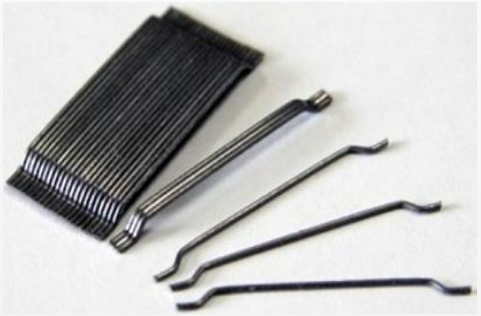
Reinforcement concrete structures are common for many reasons such as: availability of materials, easy in construction, durability, and less thermal conductivity, etc.

Concrete containing cement, water, aggregate and fibers is called as fiber reinforced concrete.

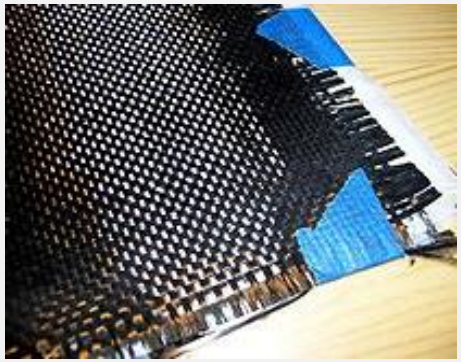
Different type of fibers are used in concrete

Polymer Fibers

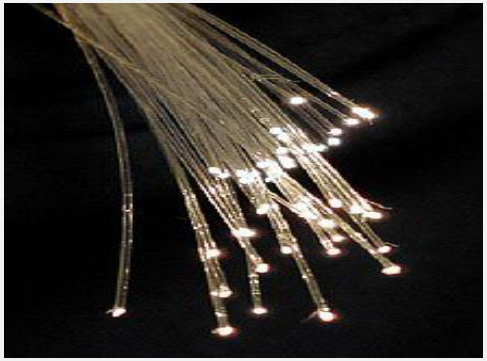
Hooked end fiber



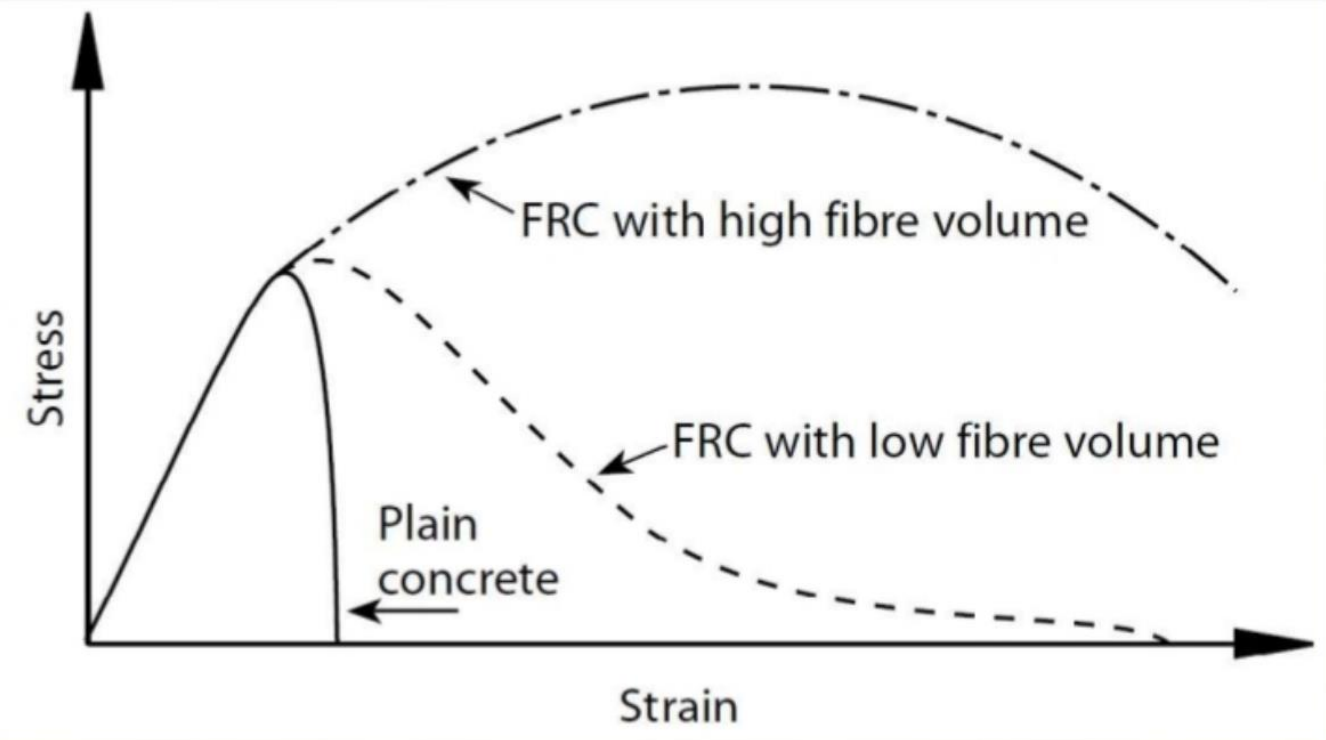
Carbon fiber



Fiberglass Fibers



Introduction(cont.)



Reference: Cement & concrete Institute

http://www.cnci.org.za

Objectives

- To form the economical fibers and study the effect of fibers on concrete properties
- To know the requirements of analysis & design of a multistory RC structures
- To learn and apply ETABS for analysis & design of a RC structures
- Effect of FRC on cost of structure

Methodology

Production of Fibers

- Device to prepare curly fibers
- Produced the fibers from binding wire

Casting & Testing of Specimens

- Arranging materials
- Casting the specimens
- Curing of specimens
- Testing the specimens
- Results & discussions

Modeling of RC Structures in ETABs

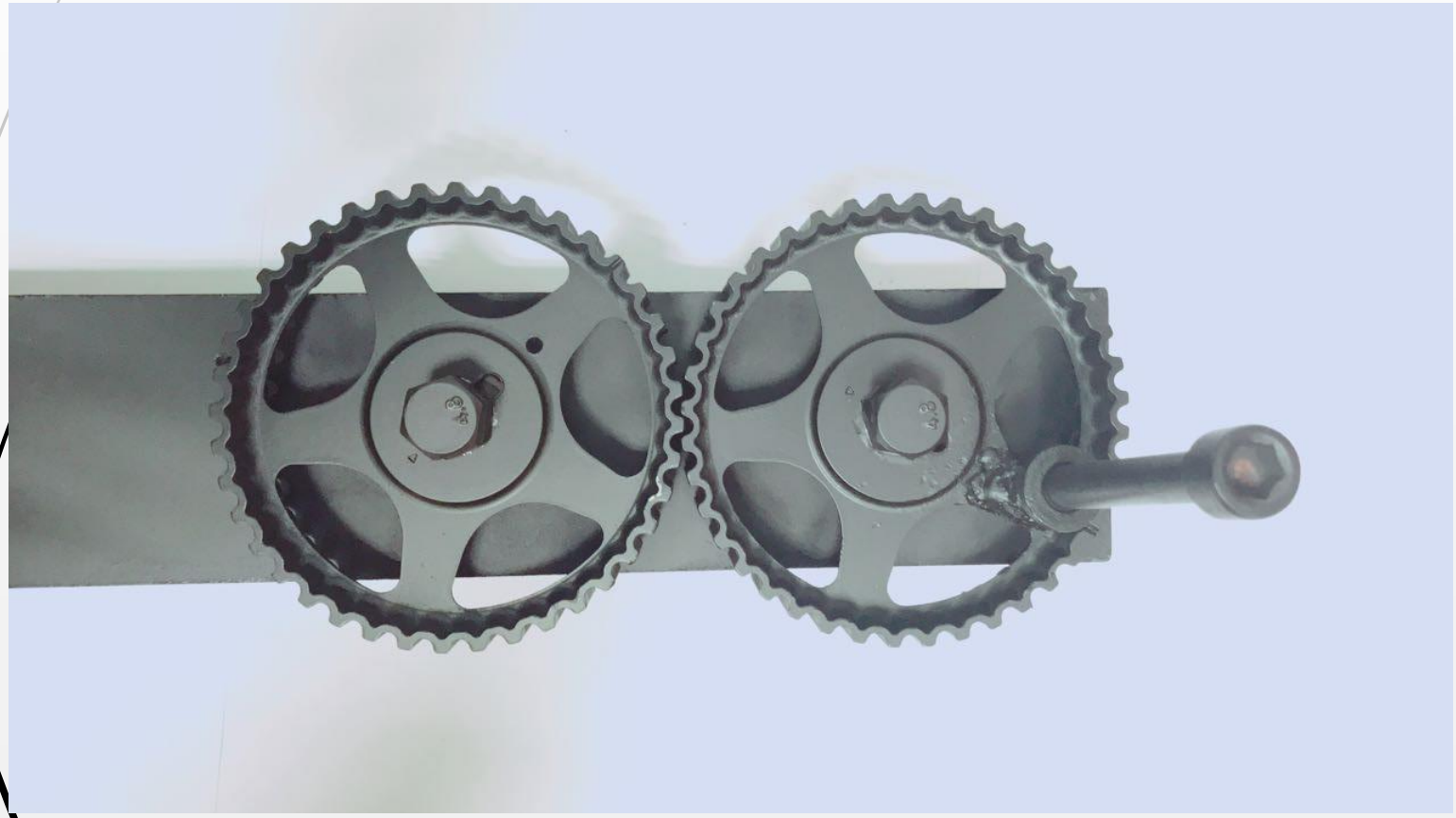
- A Series of 27 Models were prepared
- Different span
- With and without fibers
- Different floors

Estimating & Comparison of Cost

- Quantities of materials for different models
- Check the market price
- Calculate the cost
- Comparison

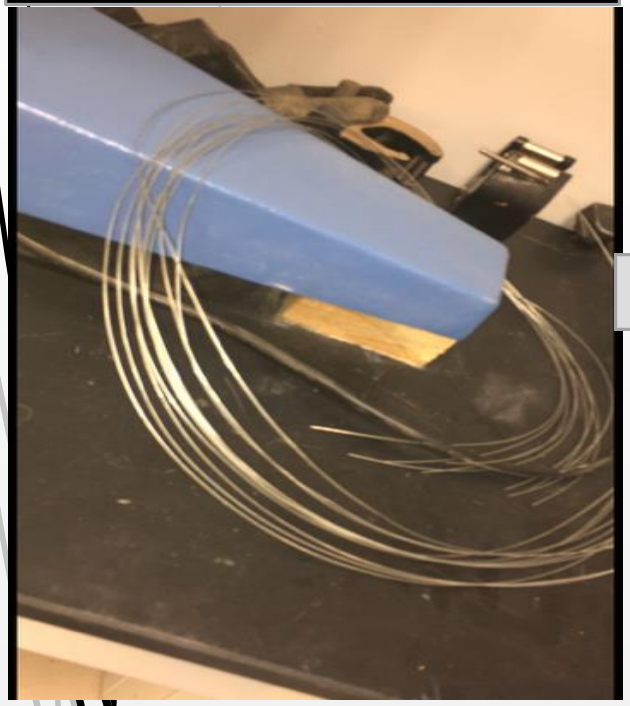
Production of Fibers

We prepare this machine to produce curly fibers



Production of Fibers

Steel wire
[Binding wire]



Steel wire
after passing through machine

Close view of curly steel fibers after cutting

Casting of Specimens

To check the performance of Curly Fibers, we prepare the specimen

- **With ordinary concrete**
- **With ordinary concrete and admixtures**
- **With FRC (admixture is use to increase the workability)**

name of mixing	W/C	Type of Aggregate of mixing		Cement (Kg)	Water (Kg)	Admixture (gram)	Fiber (gram)
		Fine (Kg)	Coarse (Kg)				
Ordinary concrete	0.35	7.07	10.66	7.43	2.82	0	0
Concrete with air content	0.35	7.07	10.66	7.43	1.9	37.15	0
Concrete with Fiber and air content	0.35	7.07	10.66	7.43	1.9	37.15	118

Casting of Specimens (Cont.)

Admixture Brand Name: Masterglenium

Washing of Aggregate

Mixing of concrete

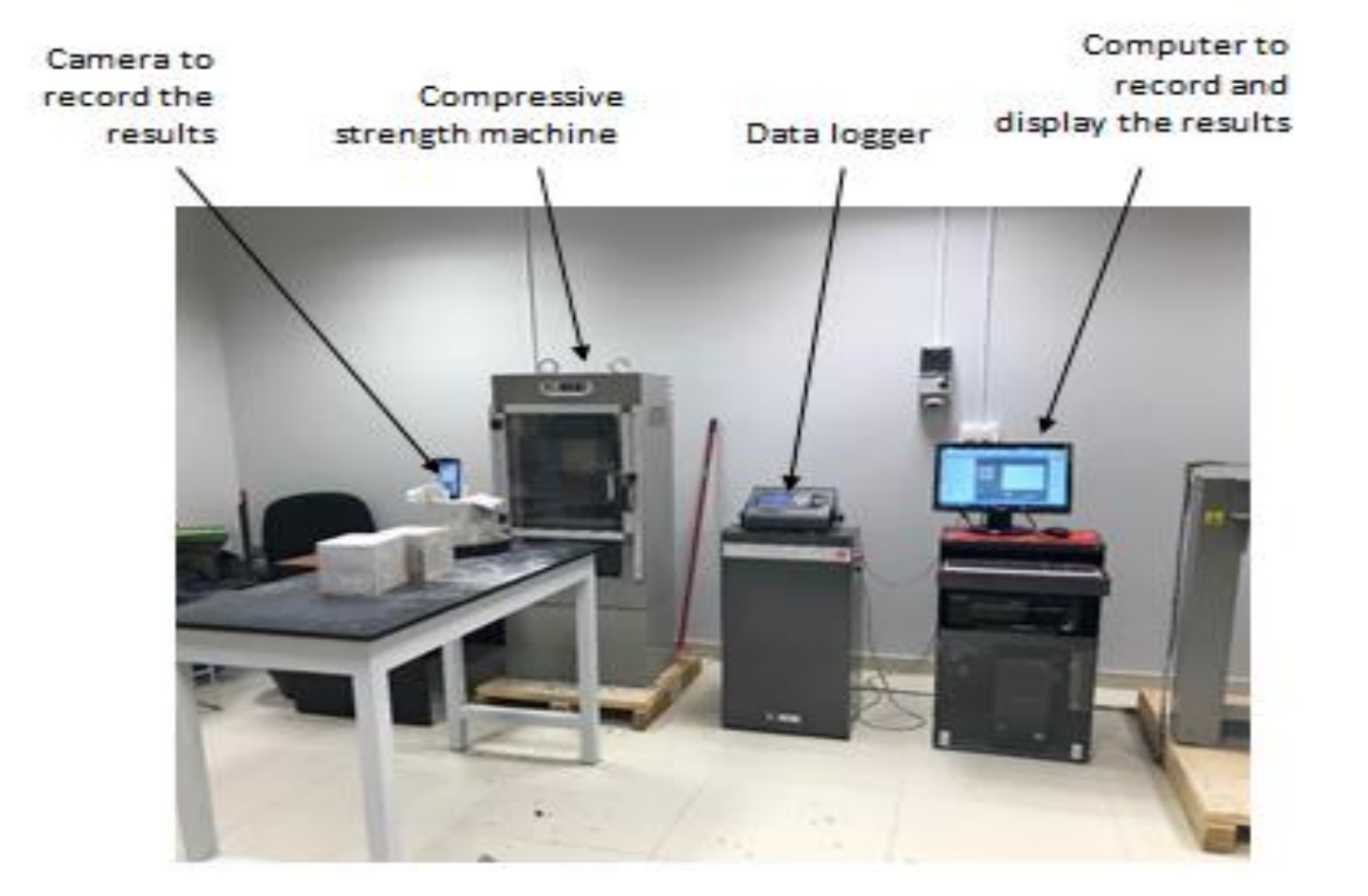
Casting of Specimens (Cont.)

Casting of Specimens (Cont.)

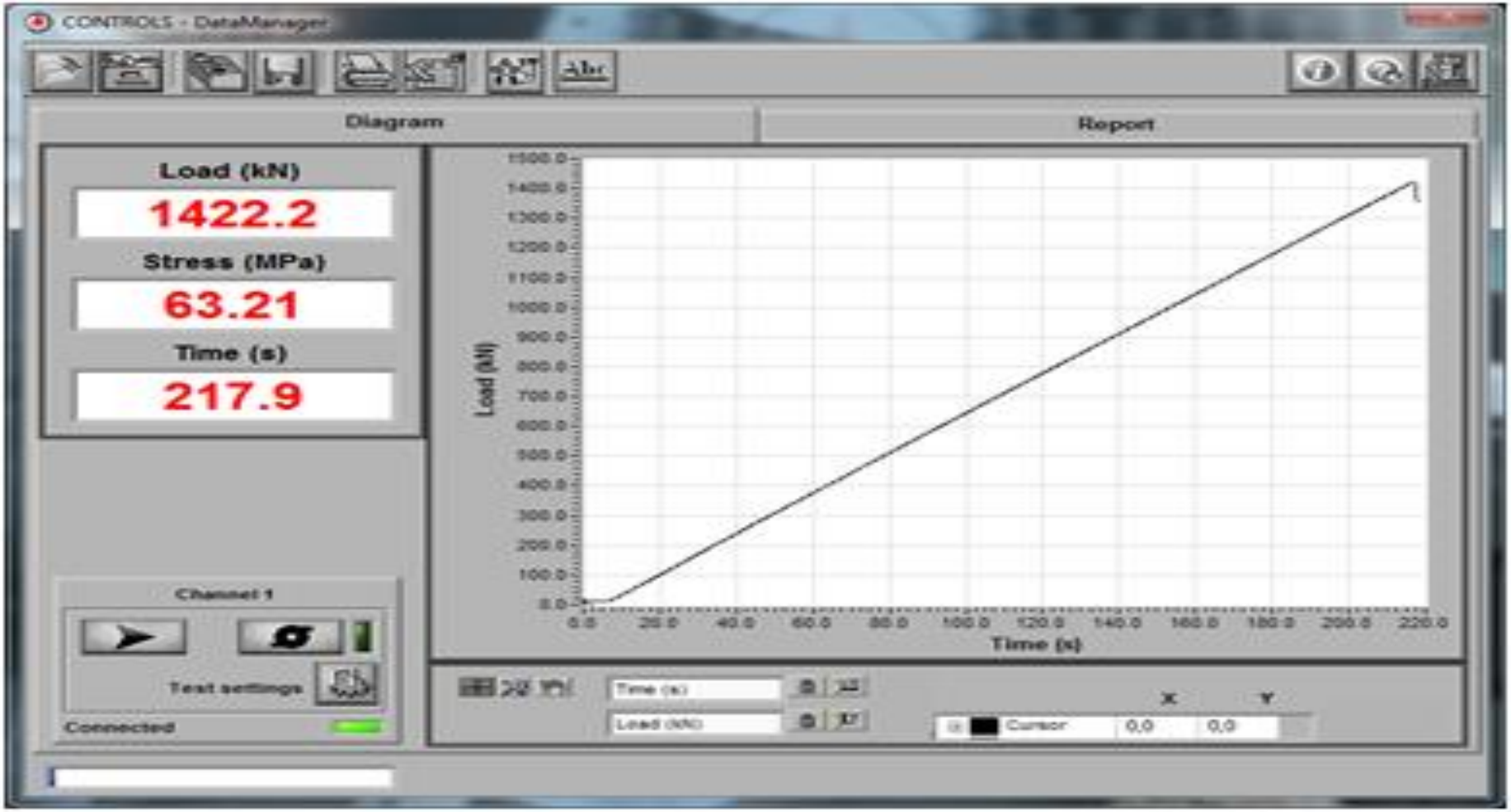
Samples after casting

Testing of Specimens

Testing Arrangement

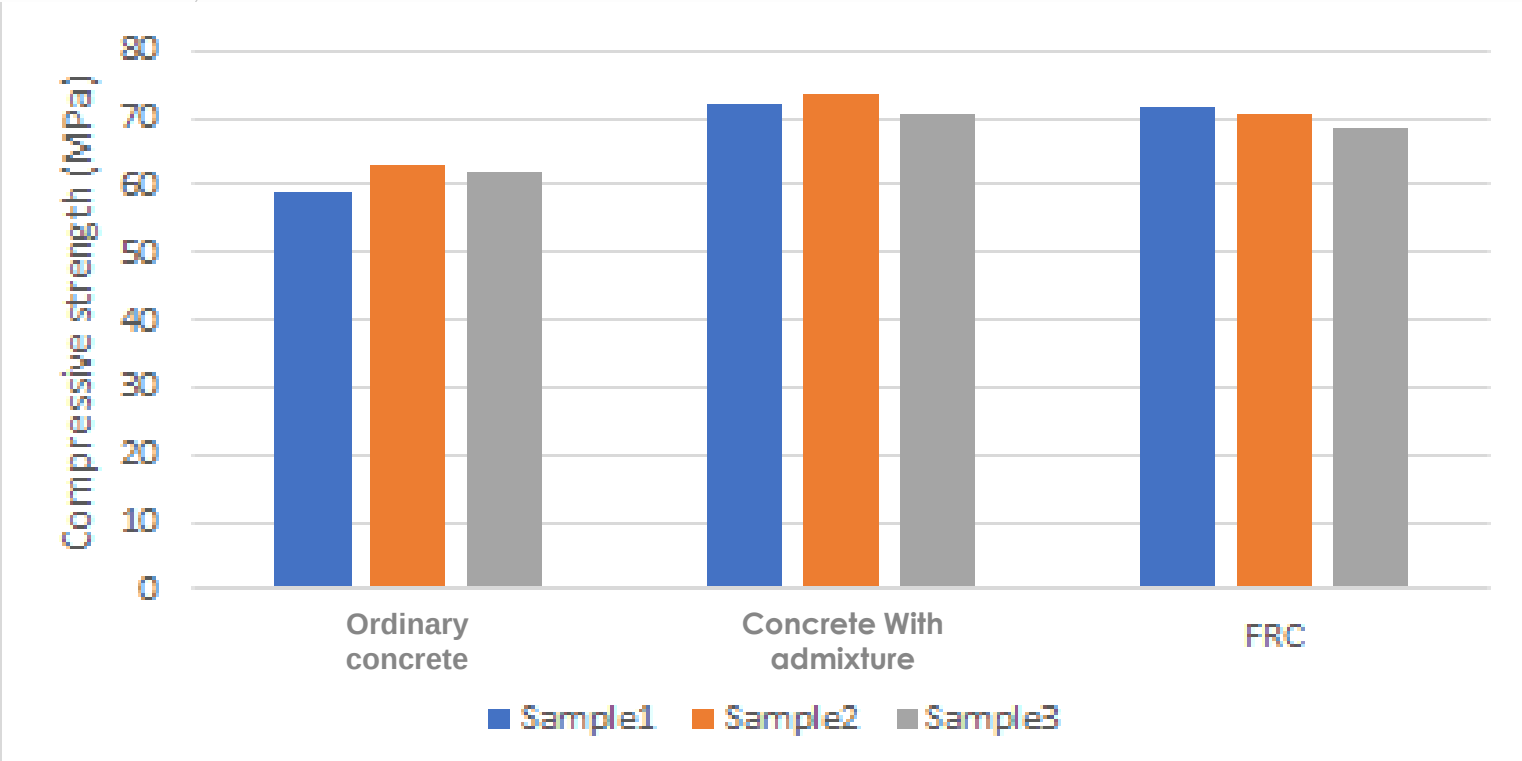


Testing of Specimens (Cont.)



The test results are automatically recoded

Testing of Specimens (Cont.)



- Compressive strength is improved due to addition of fibers
- Compressive strength is improved due to addition of admixtures

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Test on concrete specimen with admixture (Brittle failure)

Test on FRC specimen (Ductile Failure)

Tested Specimen

Production of Fiber

We use the curly fibers, which are produced from binding wires

And curly fiber improve the behavior of concrete from brittle to ductile

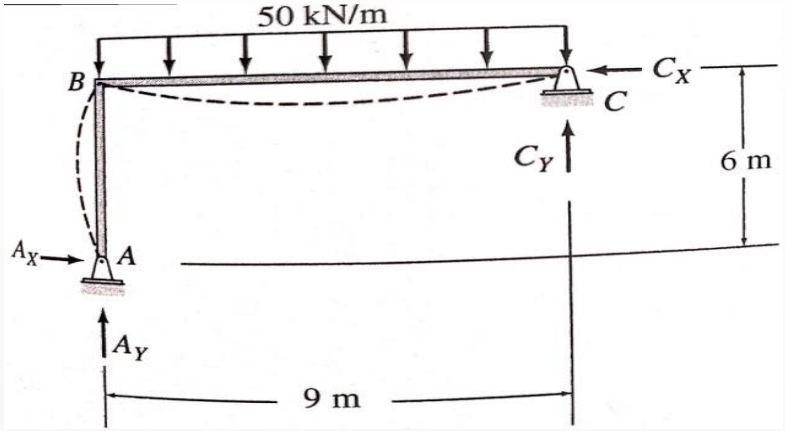
Analysis and Design of RC Structures by using ETAB

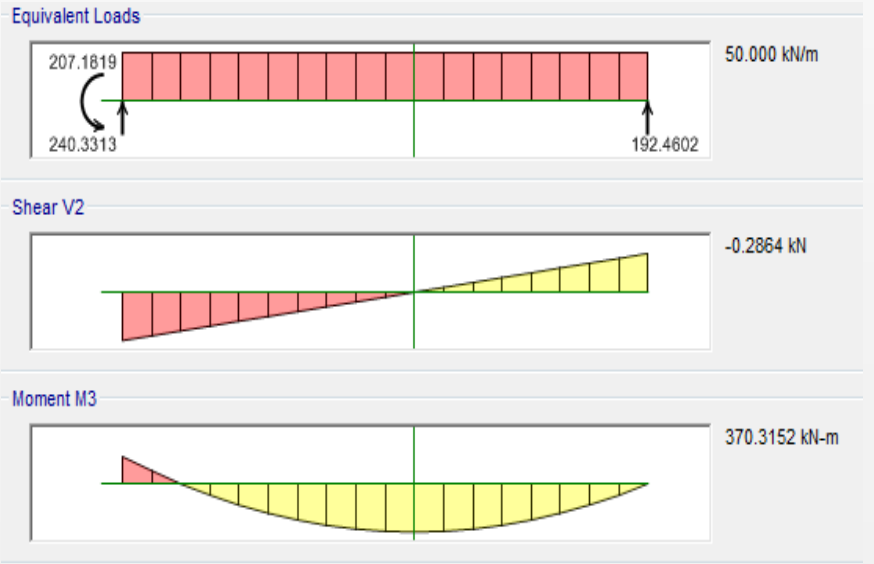
Application of ETABS for Simple Cases

Case-1

- ETABS is use to model simple beam and frame
- The output of ETABS is compared with manual calculation in terms of SF & BM

Joints	Shear force		Binding moment	
	consistent deformations	ETAB	consistent deformations	ETAB
A	-50.63	-48.80	303.75	**297**
B	258.75	240.33	303.75	**297**
C	-191.25	-192.46	365.77	**370.17**





Modeling of RC Structure in ETAB

Case-2 ETAB is use to model RC structures

Basic structural configurations

Dimension

- Number of floors= 4, 6 and 8 floors
- Span = 5, 6 and 7 (m)
- Height of each floor =3.8(m)

Material properties

- Material properties: fc'= 27.5 MPa, steel grade 60 (for ordinary concrete)
- Material properties: fc'= 40 MPa, steel grade 60 (for fiber reinforced concrete concrete)

Loads

- Dead load= marble layer, P.C.C layer +insulation layer, and self-weight
- Expected use of structure: Offices
- Live load on structure = 2.4 KN/m2

Design of Slabs

F27 =0.6*7*F21

Marbal layer	1.3734	kn/m2				
P.C.C	1.4126					
insulation	0.71					
Water proffing	0.44					
R.c.c	3.1	3.7	4.3			
Flooring	3.936					

t_s	125 mm		150mm		175mm	
D.L	7.036	KN	7.636	KN	8.236	KN
L.L	2.5	KN	2.5	KN	2.5	KN

$$t_{min} = h_{min} = \frac{ab}{33.3a + 8.3b}$$

because it is square the distribution of slab loads are two way according to ACI-318-2005 so, we need to find α and β to help us to distribute the load in X axis and Y axis
because the continuity of load distribuation in the slab the value of :

α	0.42					
β	0.27					
t_s	125 mm		150mm		175mm	
W_u	12.44	KN/m²	13.16	KN/m²	13.88	KN/m²
W_a	5.226	KN/m²	5.529	KN/m²	5.831	KN/m²
W_b	3.36	KN/m²	3.554	KN/m²	3.748	KN/m²

m = 1.0 simple span | m = 0.87 exterior span | m = 0.76 interior span

$$V_c = 0.17\sqrt{f_c'}\,bd$$
$$V_u = \max\{0.6\ w\ L\}$$
$$\Phi = 0.75 \qquad \begin{matrix} W_a & a \\ W_b & b \end{matrix}$$

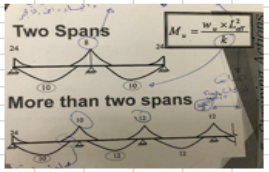
the resiseting of shear

ϕV_c					97.83	KN
V_{cs}					24.49	KN
V_s					15.74	KN
V_u					24.49	KN

for all the $V_u < \phi V_c$

P_{min}	0.002										
P_{max}	0.018										
b	1000	mm									
d_1	150	mm									
d_2	140	mm									

The moment in X,Y direction for L = 7m						the P will be use	As (mm²)	Spacing (mm)	#NO of Bar	Dia(mm)
M_{ca}	28.57	kN.m	p	0.003	k=10	0.00346535	519.802546	125	7	10
M_{cb}	18.37	kN.m	p	0.003	k=10	0.002535884	355.023818	200	5	10
M_{sa}	23.81	kN.m	p	0.003	k=12	0.002872287	430.843115	150	6	10
M_{sb}	15.31	kN.m	p	0.002	k=12	0.002105052	294.707221	250	4	10
M_{ca}	11.9	kN.m	p	0.001	k=24	0.0018	270	250	4	10
M_{cb}	7.653	kN.m	p	0.001	k=24	0.0018	252	250	4	10

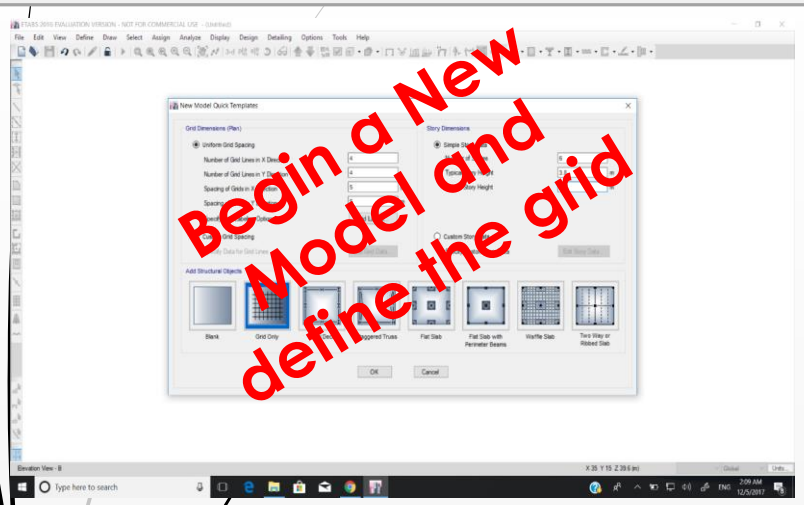


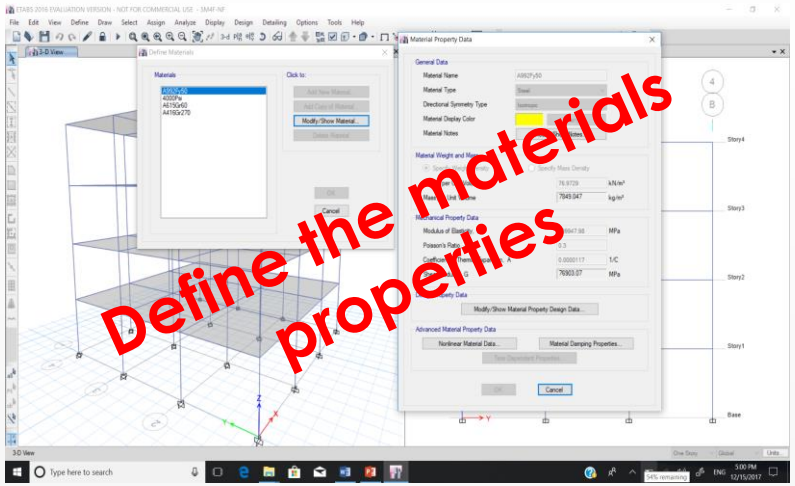
As ≥ Temp. steel
Min. Spacing ≥ ø main steel ≥ 4/3 max agg. ≥ 2.5 cm (1in)
Max. Spacing ≤ 3 t ≤ 45 cm (17in)

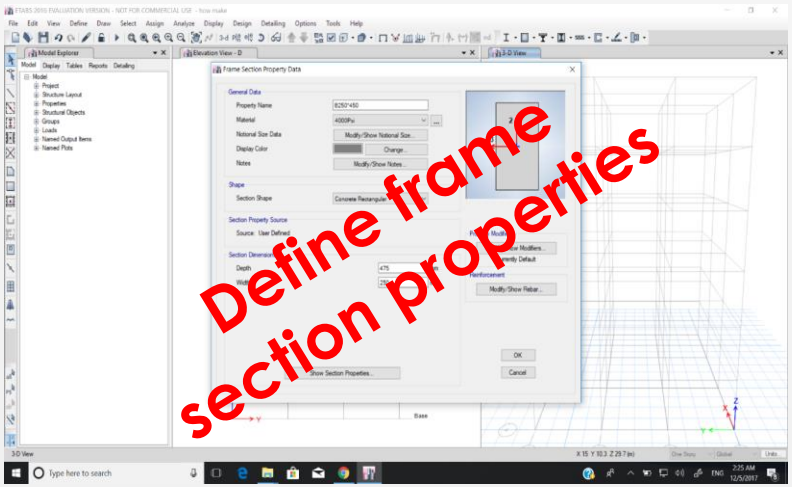
Sheet1

Foundation design is not scope of this study

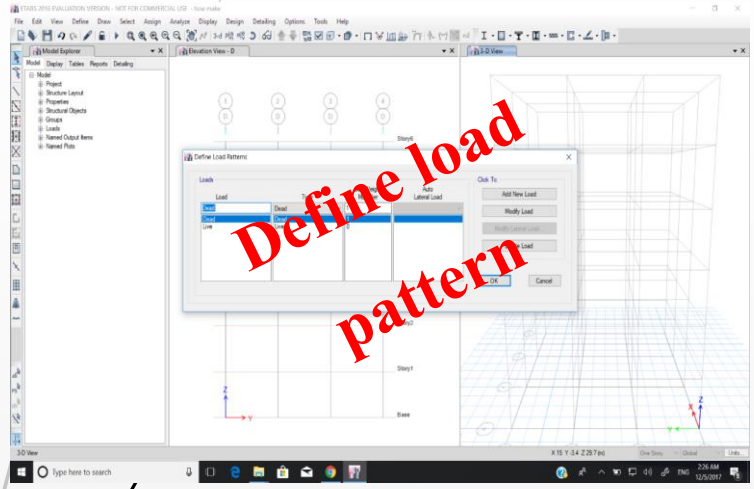
Steps to Model Concrete Structure in ETABS

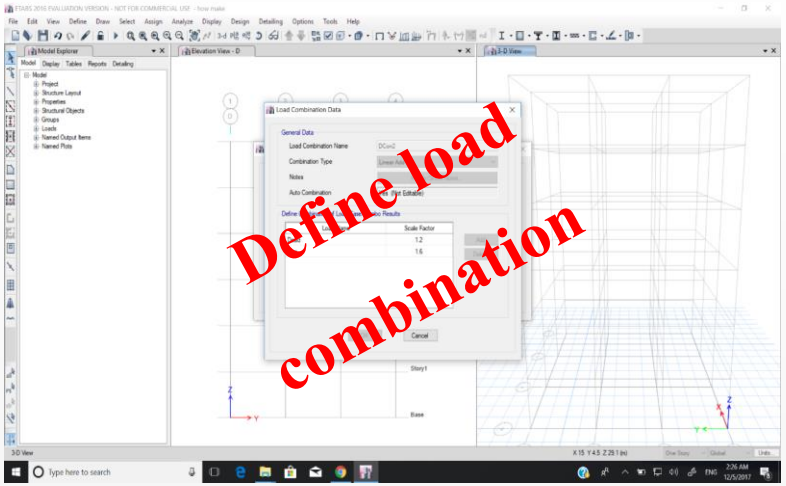


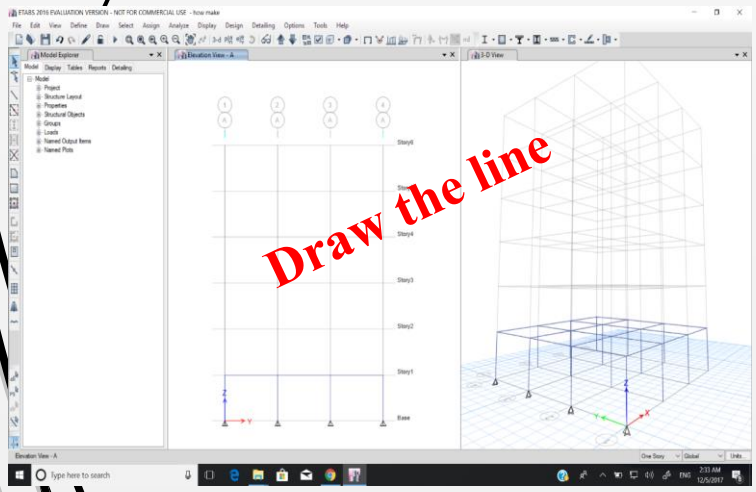


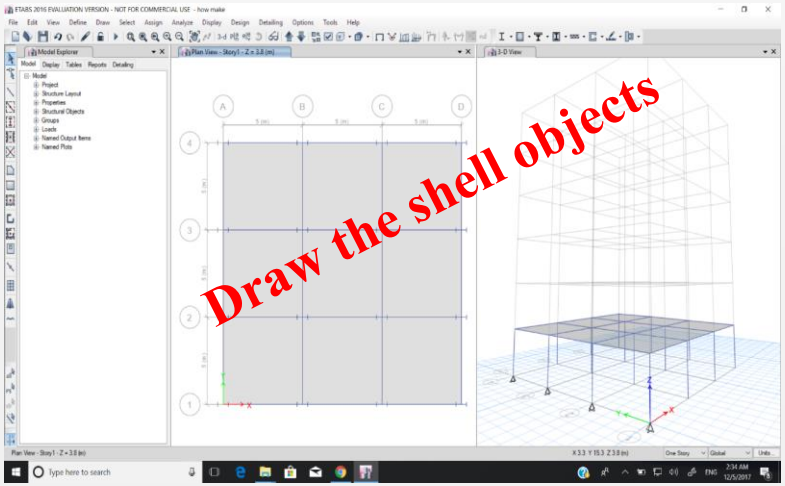


Steps to Model Concrete Structure in ETABS









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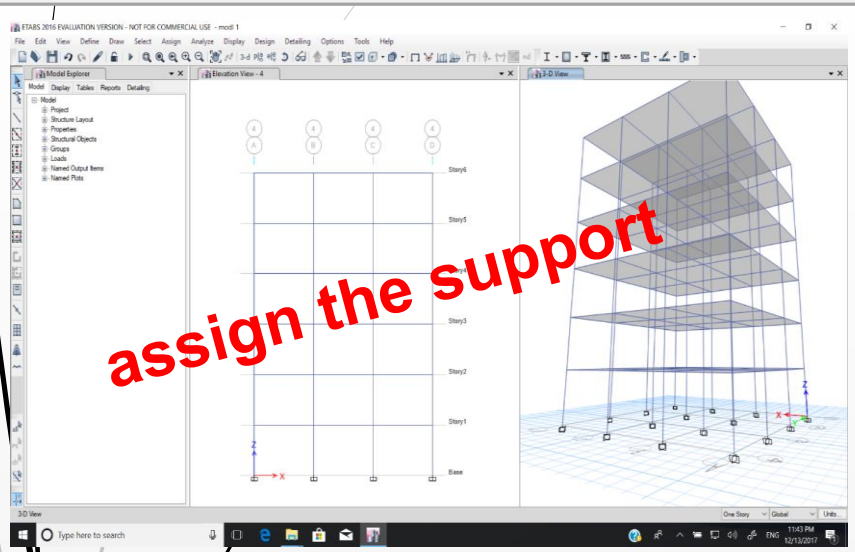
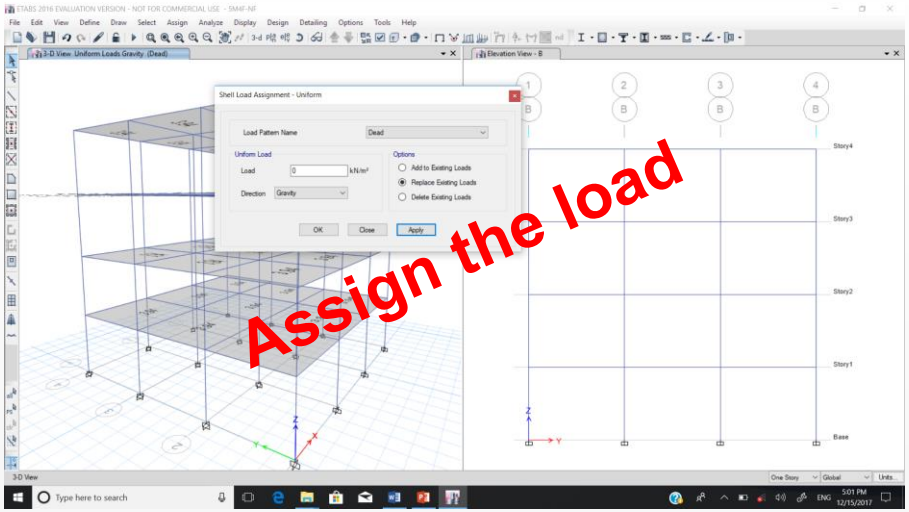
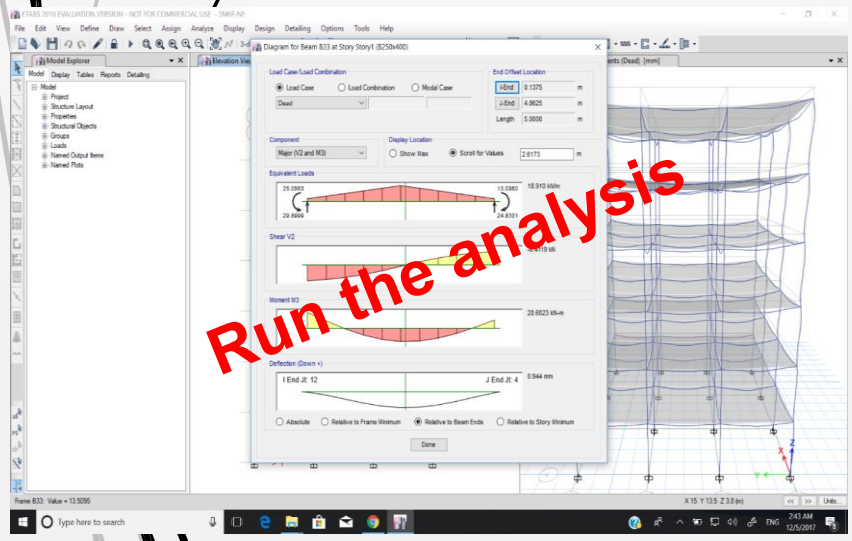
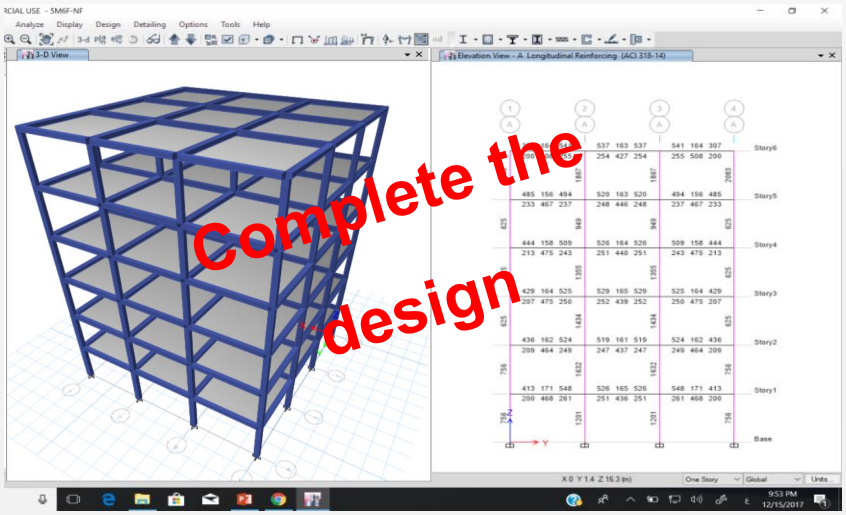
Steps to Model Concrete Structure in ETABS



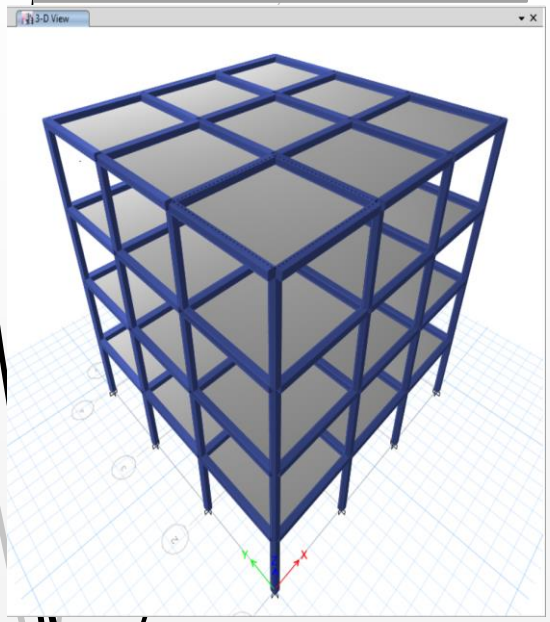






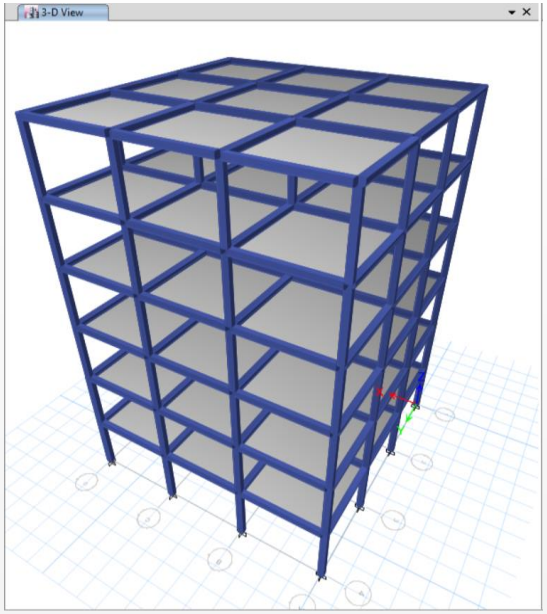
The models after design

Building with 4 floors



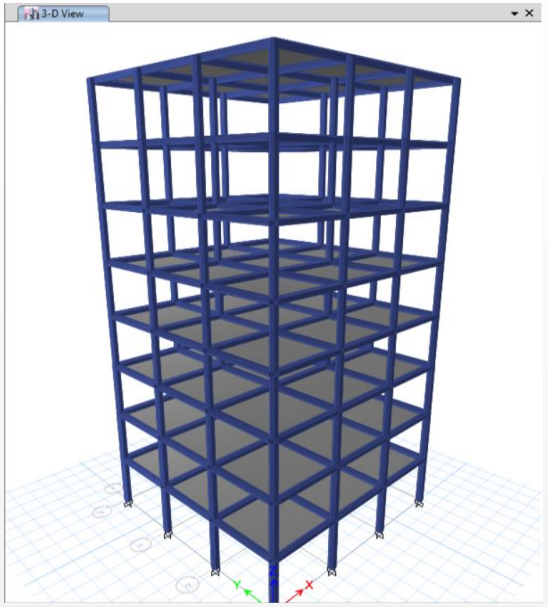
- Design using ordinary concrete
- Design column using fiber
- Design column and beam using fiber concrete

Building with 6 floors



- Design using ordinary concrete
- Design column using fiber
- Design column and beam using fiber concrete

Building with 8 floors



- Design using ordinary concrete
- Design column using fiber
- Design column and beam using fiber concrete

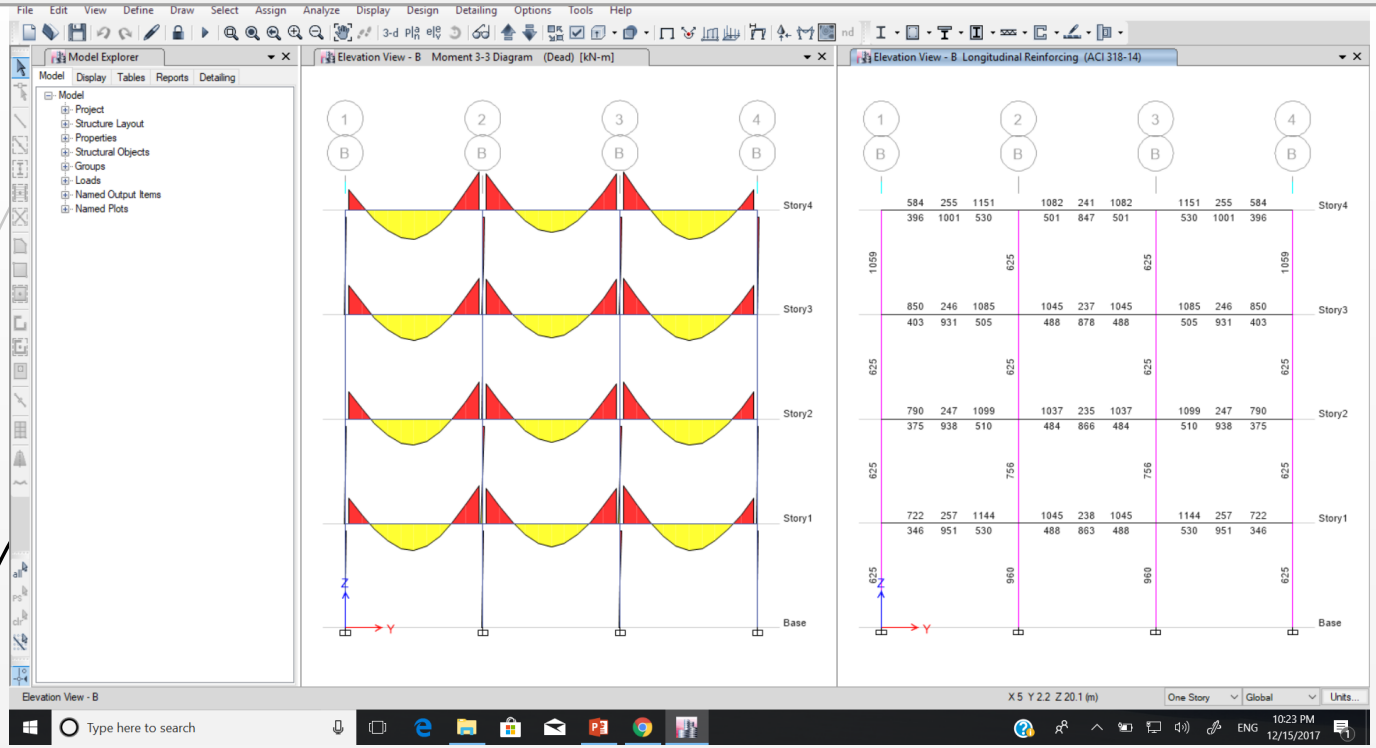
Span length is 5m, 6m and 7m 3x9 = 27 models

Detail of Structure Models

# Samples	Models name	No.of floors	Length of span(m)	Column with fiber	Beam with fiber
1	5M4F-NF-B-NF	4	5	X	X
2	5M6F-NF-B-NF	6	5	X	X
3	5M8F-NF-B-NF	8	5	X	X
4	5M4F-F-B-NF	4	5	√	X
5	5M6F-F-B-NF	6	5	√	X
6	5M8F-F-B-NF	8	5	√	X
7	5M4F-F-B-F	4	5	√	√
8	5M6F-F-B-F	6	5	√	√
9	5M8F-F-B-F	8	5	√	√
10	6M4F-NF-B-NF	4	6	X	X
11	6M6F-NF-B-NF	6	6	X	X
12	6M8F-NF-B-NF	8	6	X	X
13	6M4F-F-B-NF	4	6	√	X
14	6M6F-F-B-NF	6	6	√	X
15	6M8F-F-B-NF	8	6	√	X
16	6M4F-F-B-F	4	6	√	√
17	6M6F-F-B-F	6	6	√	√
18	6M8F-F-B-F	8	6	√	√
19	7M4F-NF-B-NF	4	7	X	X
20	7M6F-NF-B-NF	6	7	X	X
21	7M8F-NF-B-NF	8	7	X	X
22	7M4F-F-B-NF	4	7	√	X
23	7M6F-F-B-NF	6	7	√	X
24	7M8F-F-B-NF	8	7	√	X
25	7M4F-F-B-F	4	7	√	√
26	7M6F-F-B-F	6	7	√	√
27	7M8F-F-B-F	8	7	√	√

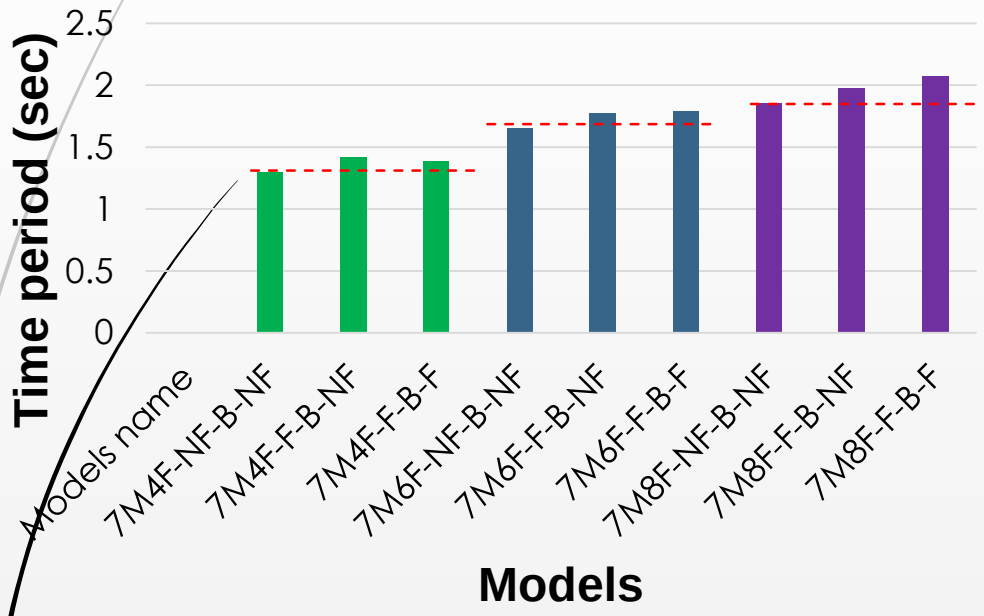
After completing the modeling

Completing the Analysis and Design



After completing the analysis and design of 27 models in ETABS, comparison is made in terms of cost and time period

Variation of time period



Due to addition of fibers the time period is slightly improved

Thus, do to addition of fibers structures becomes soft.

Calculation of cost

For *Comparison* of cost, we calculated the expected cost of beams and columns only.

Because other components are same in all models an

We calculated the total quantity of steel and concrete

Consider the unit cost of steel such that it include the material cost, fabrication and placement cost, labor cost, etc. same for concrete and FRC

Total cost = ∑ (unit price* quantity)

Prices of Materials that used (SR)		
Fiber reinforce concrete (SR / m3)	Ordinary concrete (SR / m3)	steel (SR/ Kg)
492	430	5.1

Calculation of Quantities

Calculationof quantity of single beam									
Inputs									
	B	H	L	Top bars	#of bars	Bot bars	#of bars	Stirrups	spacing (mm)
beam	250	650	7	13	10	10	14	10	150
conc	Wt/m leng(Kg/m)=		0.994	Wt/leng(Kg/m)=		0.56	Wt/m leng(Kg/m)=		0.56
							length(m)=		1.8
Outputs									
			steel Top=	69.58	Kg				
			steel Bot=	54.88	Kg				
			stirups=	47.04	Kg				
Concrete			1.1375	m^3	total steel			171.5	Kg

Calculation the quantity of single beam

Calculationof quantity of single column							
Inputs							
	W1	W2	L	Dia bars	#of bars	Dia of sti	spacing (mm)
	500	500	3.8	29	18	10	150
Wt/m length(Kg/m)=		5.06		Wt/m length(Kg/m)=			0.56
						length	2
Outputs							
	Longitudnal steel		346.104	Kg			
	stirups		28.3733333	Kg			

Calculation the quantity of column

7M4F-WF (beam NF)								
No of story	beam			column				time period (sec)
	250*450	250*500	250*550	250*250	275*275	300*300	350*350	
3		24		12	4			
2		24		12	4			
1		24			12		4	1.418
ground floor		24			12		4	
total		96		24	32		8	
onc/element(m3		0.875		0.2375	0.28738		0.4655	
teel/element(kg		185.416		108.548	121.762		204.815	
otal concrete W								102.6202
Total Conc		84		5.7	9.19616		3.724	84
Total steel		17799.9		2605.152	3896.384		1638.52	25939.99

Calculation of total quantity

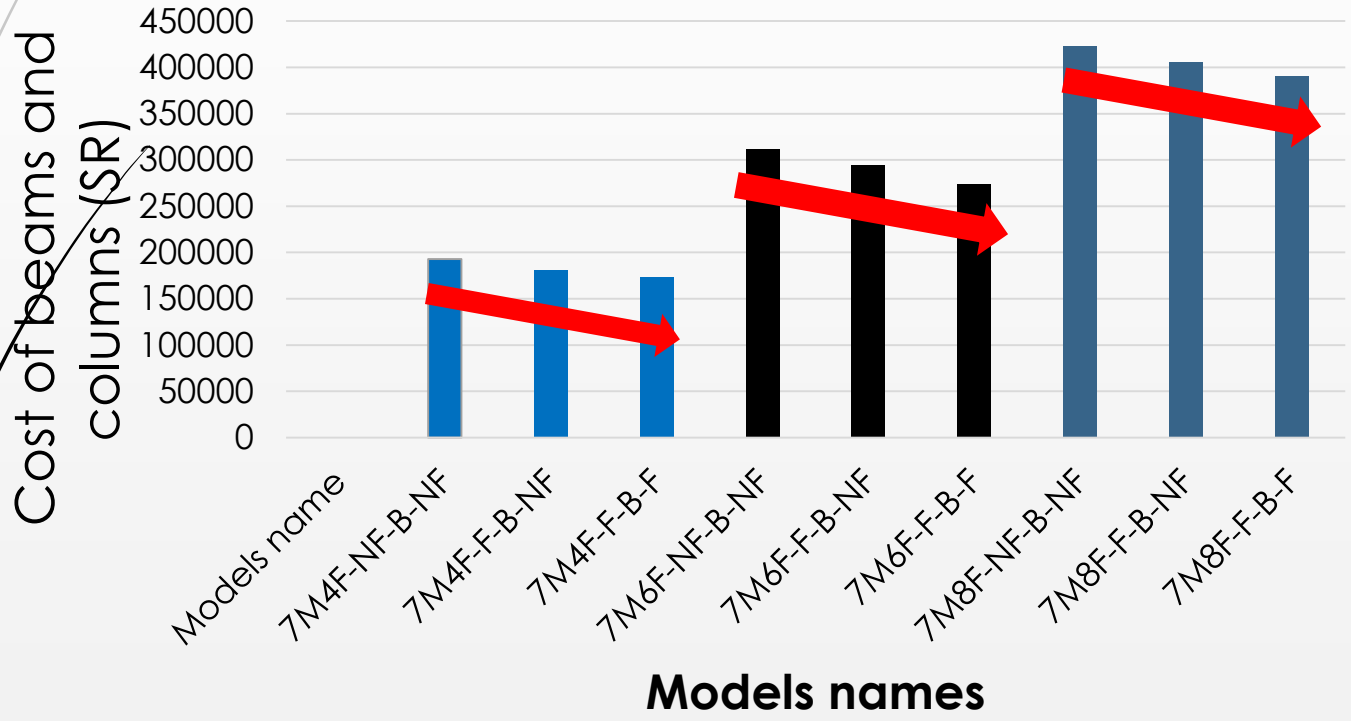
Cost of building

Cost of different models

# Samples	Models name	Ordinary concrete (m^3)	Concrete with fiber (m^3)	steel (Kg)	Cost of beam and column (SR)	Cost of beam and column ($)
1	7M4F-NF-B-NF	106.1162	0	28841.15	192719.8	51391.95
4	7M4F-F-B-NF	18.62	84	25939.99	181628.6	48434.28
7	7M4F-F-B-F	95.41728	0	25967.36	173463	46256.79
2	7M6F-NF-B-NF	177.2083	0	46209.08	311865.9	83164.24
5	7M6F-F-B-NF	33.5163	138.6	41549.73	294506.8	78535.15
8	7M6F-F-B-F	159.5163	0	40216.36	273695.5	72985.45
3	7M8F-NF-B-NF	265.5352	0	60464.66	422549.9	112680
6	7M8F-F-B-NF	52.61152	218.4	54107.43	406023.6	108273
9	7M8F-F-B-F	236.6706	0	56675.37	390812.7	104216.7

Variation in Cost for Different Models

Cost of beams and columns for different models (SR)



Due to addition of fiber, the cost was reduced

Summary

Stage -1:

- An arrangement is made to prepare the curly steel fibers.
- Different cube specimens were produced and tested in compression
- Test results shows that the these fibers are effective to produce the ductile behavior.

Stage-2:

- A series of 27 models are designed by using ETABS (with and without fibers)
- The models are compared in terms of time period and cost
- Results show that due to addition of fibers time period is increased and cost reduces.

“ Thank you “

Any Questions ?