UNIVERSITY OF ASIA PACIFIC

Department of Civil Engineering

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CE 401: Project Planning and Management

PROJECT

Submitted by:

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INTRODUCTION

This project investigates the effectiveness of different retrofitting techniques on improving the flexural strength of beams. Three identical beams will be cast and one designated as the control beam. The remaining two beams will undergo separate retrofitting processes: one using CFRP laminate only, and the other incorporating both embedded bars and CFRP laminate. By comparing the strength of the retrofitted beams to the control beam, we aim to quantify the increase in flexural strength achieved through each retrofitting method. This research will provide valuable insights into the effectiveness of various retrofitting techniques for enhancing the structural performance of beams.

Background of the problem:

This project addresses the imperative to enhance the structural integrity of concrete beams through retrofitting techniques. With a focus on flexural strength improvement, the research evaluates the efficacy of Carbon Fiber Reinforced Polymer (CFRP) laminate and combined CFRP laminate with embedded bars. Understanding failure modes, quantifying strength increases, and analyzing load-deflection behavior are key objectives. This investigation aims to offer insights into effective retrofitting strategies for optimizing beam performance in practical applications.

PROJECT DESCRIPTION

Objectives:

- Evaluate the effectiveness of CFRP laminate in enhancing the flexural strength of beams.
- Investigate the combined effect of embedded bars and CFRP laminate on flexural strength.
- Quantify the increase in flexural strength achieved through each retrofitting technique.
- Analyze and characterize the load-deflection behavior of the strengthened RC beams.

PROJECT PLAN

List of activities:

A. Beam Design (1/2-1-2)
B. Sample material procurement (1/2-1-2)
C. Test the sample materials (2-3-4)
D. Material Procurement (1/2-1-2)
E. Build formwork (1-2-3)
F. Binding of steel case (Rebar) (1-2-3)
G. Material test for mix design (2-3-4)
H. Concrete Mixed design (1/2-1-2)
I. Beam Casting (6-7-8)
J. Curing (28-32-36)
K. Surface Preparation (1/2-1-2)
L. CFRP lamination and Embedded Bar Installation (1-2-3)
M. Curing of Retrofitted Beams (7-8-9)
N. Test Setup (1/2-1-2)
O. Flexural Strength Testing (1/2-1-2)
P. Data Collection and Analysis (6-7-8)
Q. Comparison and Interpretation (25-30-35)
R. Documentation and Reporting (6-7-8)

Cost estimation and budgeting:

Description	Quantity	Unit Price (Tk.)	Total Price (Tk)
Steel	298 kg	102	400
Coarse Aggregate (Stone)	58 cft	125	7250
Fine Aggregate (Sand)	36 cft	70	2520
Cement	19 bags	500	9500
Adhesive materials	3 sets	1500	4500
CFRP	12 sft	150	1800
Embedded Bar	21 ft	100	2100
Transportation	1	4000	4000
Labor	1	5000	5000
Total Amount in Taka=			37070

Required personnel along with their skill & service duration:

Personnel	Quantity	Skills	Service Duration
Skilled Laborer	4	Formwork making, Concrete casting, Curing etc.	2 months 20 days
Technician/ Lab. Assistant	2	Surface preparation techniques (grinding, cleaning), Adhesive making with Epoxy, Test Setup etc.	23 days
Testing Engineer/ Research Assistant	1	Experience with testing procedure of flexural strength, operating testing equipment.	2 months
Project Manager/ Research Supervisor	1	Construction project management experience, budgeting, and scheduling skills	3 months 15 days

List of Equipment, Materials and Technologies Required for the project:

Equipment:

Universal Testing Machine (UTM)
Displacement Transducer
Strain Gauges
Data Acquisition System

Materials:

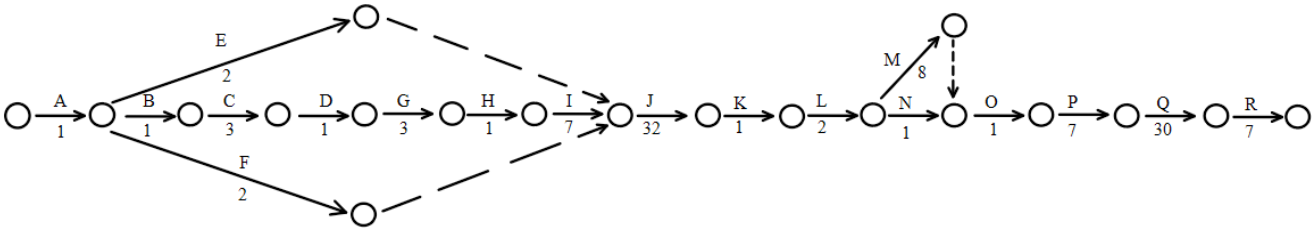
RC Beam Specimens
Carbon Fiber-Reinforced Polymer (CFRP) Wrap
Near-Surface Mounted (NSM) Bar
Grinding Machine Epoxy Resin
Cleaning Tools

Technology:

Design of Experiments (DOE)
Digital Image Correlation (DIC)

NETWORK DIAGRAMS AND ANALYSIS

Activity Oriented Diagram:



Event Oriented Diagram:

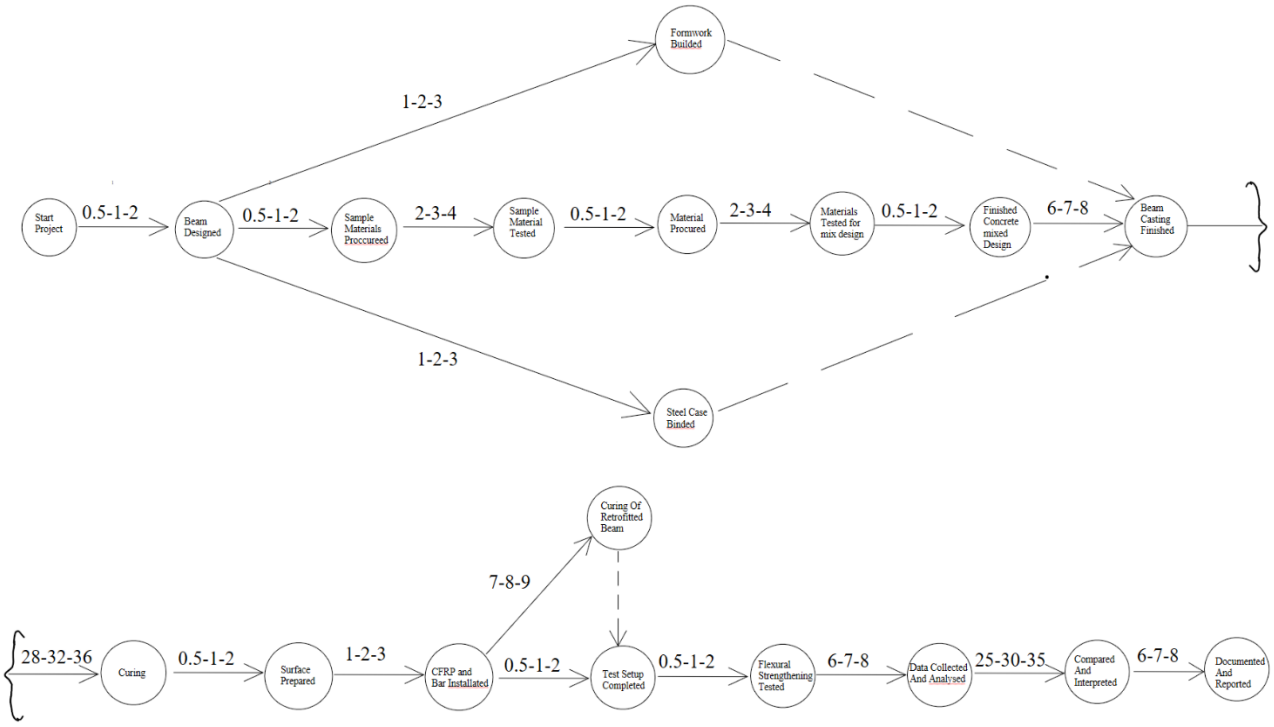


Diagram of Expected Time, t_E (highlighted in blue)

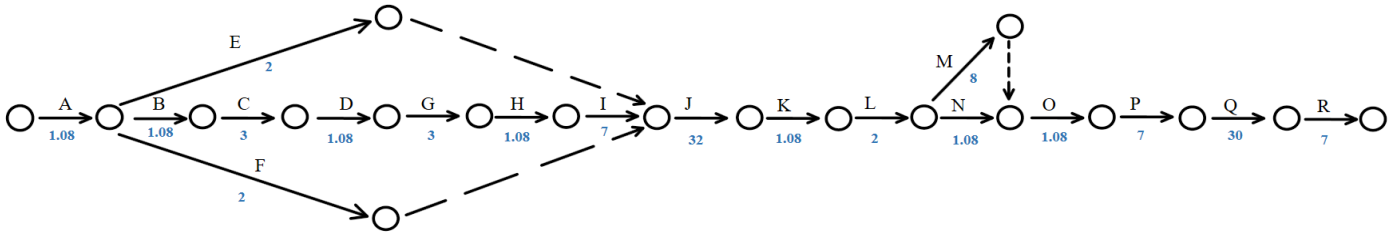


Diagram of Earliest Expected Time, T_E (highlighted in red)

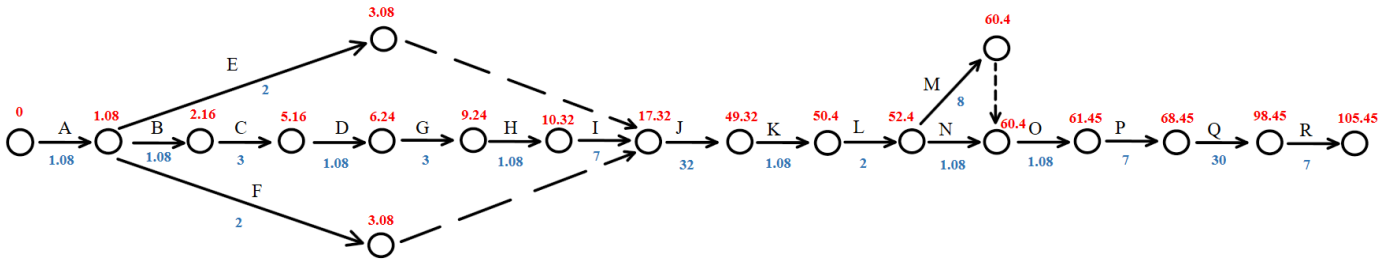


Diagram of Latest Allowable Occurrence Time, T_L (highlighted in red)

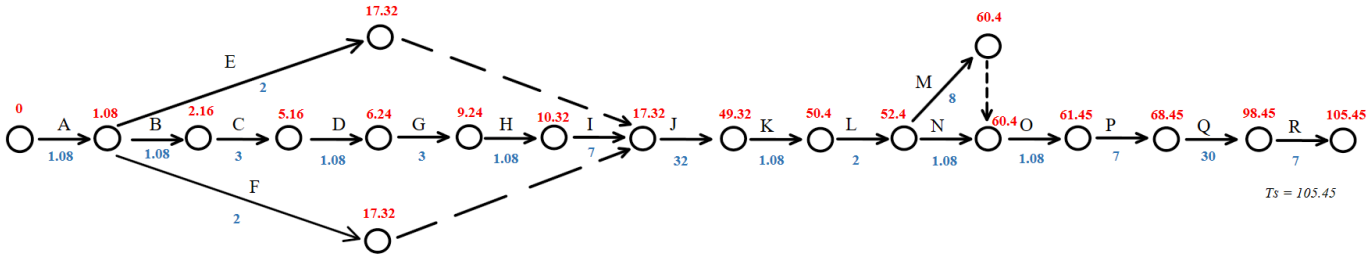
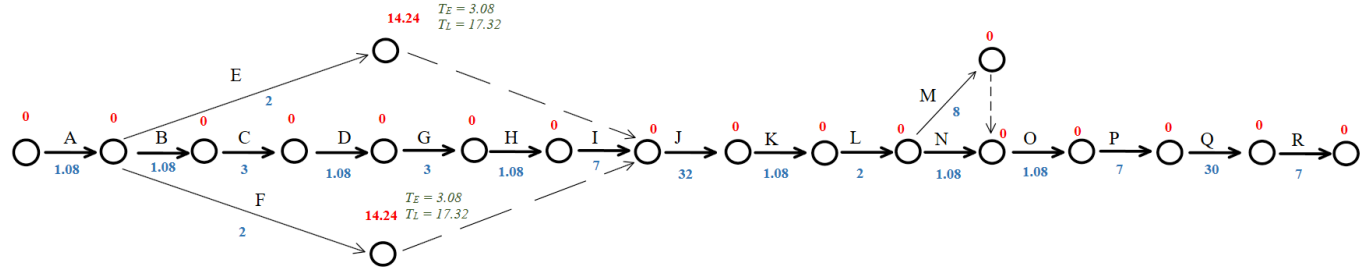
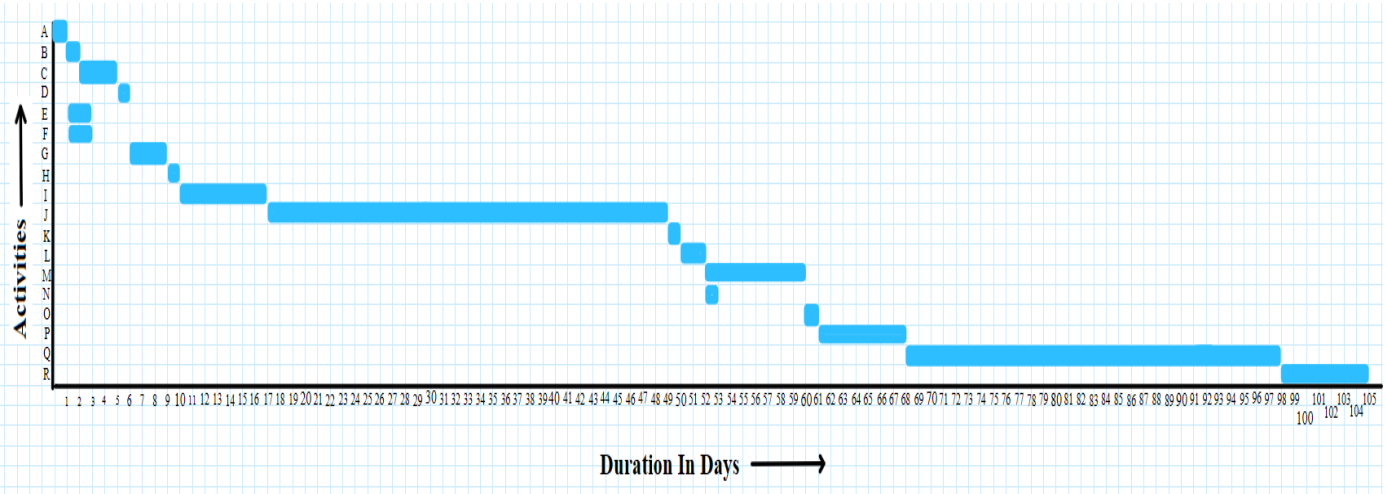


Diagram of Slack, t_E (highlighted in red)

Calculated using the values of previous diagrams.
Slack, $S = T_L - T_E$



Timeline: (Gantt Chart)



Certainties For the Activities:

Activity Oriented and Event Oriented Network Diagram:

ACTIVIES	t_0	t_L	t_P	t_E	VARIENCE
A	0.5	1	2	1.083333	0.0625
B	0.5	1	2	1.083333	0.0625
C	2	3	4	3	0.111111
D	0.5	1	2	1.083333	0.0625
E	1	2	3	2	0.111111
F	1	2	3	2	0.111111
G	2	3	4	3	0.111111
H	0.5	1	2	1.083333	0.0625
I	6	7	8	7	0.111111
J	28	32	36	32	1.777778
K	0.5	1	2	1.083333	0.0625

L	1	2	3	2	0.111111
M	7	8	9	8	0.111111
N	0.5	1	2	1.083333	0.0625
O	0.5	1	2	1.083333	0.0625
P	6	7	8	7	0.111111
Q	25	30	35	30	2.777778
R	6	7	8	7	0.111111

The Expected Time for Each Path:

Path Name	**t_E**
A-B-C-D-G-H-I-J-K-L-N-O-P-Q-R	98.58333
A-E-J-K-L-N-O-P-Q-R	84.33333
A-F-J-K-L-N-O-P-Q-R	84.33333
A-E-J-K-L-M-O-P-Q-R	91.25
A-F-J-K-L-M-O-P-Q-R	91.25
A-B-C-D-G-H-I-J-K-L-M-O-P-Q-R	105.5

The critical path is A-B-C-D-G-H-I-J-K-L-M-O-P-Q-R, where expected time is 105.5 days.

Determination of Time Duration:

The Expected time for the critical path is = 105.5 days.

Standard deviation along the critical path:

$$\sigma = \sqrt{\sum(\sigma_{ij})^2}$$

$$= \sqrt{\begin{matrix} 0.06^2 + 0.06^2 + 0.11^2 + 0.06^2 + 0.11^2 + 0.06^2 + 0.11^2 \\ +1.78^2 + 0.06^2 + 0.11^2 + \\ 0.11^2 + 0.06^2 + 0.11^2 + 2.78^2 + 0.11^2 \end{matrix}}$$

= 3.32

For 95% Probability,

$$\frac{95-94.52}{94.52-95.54} = \frac{z-1.67}{1.6-1.7}$$

Z= 1.65

Ts = $\sigma Z + T_E$

= 3.32*1.65+105.45

= 110.928 days

For 75% Probability,

$$\frac{75-72.57}{72.57-78.80} = \frac{z-0.67}{0.6-0.7}$$

Z= 0.64

Ts = $\sigma Z + T_E$

= 3.32*0.64+105.45

= 107.57 days

For 50% Probability,

Z= 0

$Ts = \sigma Z + T_E$

= 3.32*0+105.45

= 105.45 days

Activity times and floats for each activity:

Activity *(i-j)*	Duration *(t_{ij})*	Slack	Earliest		Latest		Float		
			Start Time (EST)	Finish Time (EFT)	Start Time (LST)	Finish Time (LFT)	Total Float (F_T)	Free Float (F_F)	Independent Float (F_{ID})
A	1.08	0	0	1.08	0	1.08	0	0	0
B	1.08	0	1.08	2.16	1.08	2.16	0	0	0
C	3	0	2.16	5.16	2.16	5.16	0	0	0
D	1.08	0	5.16	6.24	5.16	6.24	0	-5.16	-19.4
E	2	14.24	1.08	3.08	15.32	3.08	0	-2	-16.24
F	2	14.24	1.08	3.08	15.32	3.08	0	3.16	3.16
G	3	0	6.24	9.24	6.24	9.24	0	0	0
H	1.08	0	9.24	10.32	9.24	10.32	0	0	0
I	7	0	10.32	17.32	10.32	17.32	0	0	0
J	32	0	17.32	49.32	17.32	49.32	0	0	0
K	1.08	0	49.32	50.4	49.32	50.4	0	0	0
L	2	0	50.4	52.4	50.4	52.4	0	0	0
M	8	0	52.4	60.4	52.4	60.4	0	-8	-8
N	1.08	0	52.4	60.4	59.32	60.4	0	0	0
O	1.08	0	60.4	61.45	60.4	61.45	0	0	0
P	7	0	61.45	68.45	61.45	68.45	0	0	0
Q	30	0	68.45	98.45	68.45	98.45	0	0	0
R	7	0	98.45	105.45	98.45	105.45	0	-	-

The critical path is along A-B-C-D-G-H-I-J-K-L-N-O-P-Q-R