COST OPTIMIZATION OF BEAM

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Approval

This is to certify that the thesis entitled "**Cost optimization of the beam**" submitted by **Md. Riadul Islam** (163-47-212), Session Fall 2016**, Al Rifat Akash** (163-47-266), Session Fall 2016, **Atikur Rahaman** (163-47-268), Session Fall 2016, has been accepted as satisfactory in partial fulfillment of the requirement for the degree of **Bachelor of Science in Civil Engineering** on January 2021.

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Acknowledgement

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Dedication

This research paper dedication to our honorable **Supervisor,** He is our biggest inspiration.

A project and thesis submitted to the Department of the Civil Engineering Daffodil International University, Bangladesh in partial fulfilment of the requirements for the degree of Bachelor of Science (B.Sc.) in Civil Engineering.

Declaration

This is hereby to certify that the research work reported in this thesis has been performed by us under the Supervision and guidance of **Rayhan Md. Faysal**, Lecturer (Senior Scale), Department of Civil Engineering, Daffodil International University, Dhaka. And this work has not been submitted elsewhere for any purpose (except for publication).

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Abstract

The objective of these our work is to optimize the cost of the RCC structure use the Bangladesh. For optimizing the structure dimension materials properties of the concrete can be varied. So we have variant these parameters in our work steel strength, concrete strength, depth, and width in beam. And we have some finding use in singly fixed beam then cost of the structure will significantly reduce. If we use in beam high strength concrete and steel beam cost will optimize. This paper is on cost optimization of RCC beam. The formula for this optimization has been designed in accordance with ACI and BNBC. This optimization system is based on the strength of f'c, fy, and the dimension of the beam. Here singly beam, singly fixed beam and doubly beam have been worked on our thesis. Here singly beam optimize 20% less than doubly beam, and the cost of a singly fixed beam is 57% and 17% less than doubly and singly beam. Beam's own manufacturing cost has been added to the cost optimization method and it has been designed as cost as per moment.

Table of Contents

Chapter- 5

Conclusion and Recommendation

List of Figures

List of Tables

Chapter- 1

Introduction

1.1 General

Beams are commonly horizontal and straight members to carry to vertical load, these types of members are designed and built to resist bending moment. According to BNBC 2006, the minimum and maximum reinforcement percentage of the beam depends on the strength of the materials concrete strength and steel strength value. Most of the designers analyzed singly and doubly reinforcement beam. However, for a particular loading condition, there is only one section that can be found economical, which means for high strength of reinforcement in the optimized. The high strength reinforcement in the optimized section is found to vary with the price ratio of steel to concrete. The cost optimization of the beam should satisfy the strength and serviceability conditions as per the design code ACI 318-08, which will act as constraints for the optimization issue.

1.2 Background cost optimization of concrete beam

Many structures cannot be constructed in time because of financial problems. Using the optimizing sections can reduce overall construction costs. Optimization of the concrete column has been reported by Abdullah Al Mamun (2014) but we do not see similar studies dealing with the beam concrete beam section in the literature. This study focuses on the optimization of the concrete beam.

1.3 The objective function

The main objective of this work is to optimize the cost of the reinforced cement concrete beam. To accomplish this objective, the following objectives need to be focused on.

1. To see the effect of the material strength on the cost of reinforced cement concrete beam.
2. To see the effect of dimensions on the cost of reinforced cement concrete beam.
3. To see the effect of material strength and dimensions, together, on the cost of reinforced cement concrete beam.
4. To see the effect of types of a beam on the cost of reinforced cement concrete beam.

Chapter – 2

Literature Review

2.1 Introduction

A literature review is a record of what has been published on a topic by authorizing researchers and specialists. Infrequently it is asked to write one as a different task, however more frequently it is important for an article, research report, or thesis. In writing the literature review, the writer's motivation is to pass on to his/her reader what information and thoughts have been set up on a topic and what their strengths and weaknesses are.

Literature reviews provide a helpful manual for a particular topic. If someone has limited time to conduct research, literature reviews can give you an outline or go about as a venturing stone. For professionals, they are valuable reports that stay up with the latest with what is current in the field. For scholars, the profundity and broadness of the literature survey underscore the believability of the essayist in his/her field. Literature reviews additionally give a strong foundation to a research paper's examination. Exhaustive information on the literature of the field is basic to most research papers.

2.2 Organizing the literature review

Literature reviews should comprise the following elements:

1. An overview of the subject, issue or theory under consideration, along with the objectives of the literature review.
2. Division of works under review into categories (e.g. those in support of a particular position, those against, and those offering alternatives entirely)
3. Explanation of how each work is similar to and how it varies from the others
4. Conclusions as to which pieces are best considered in their argument, are most convincing of their opinions and make the greatest contribution to the understanding and development of their area of research.

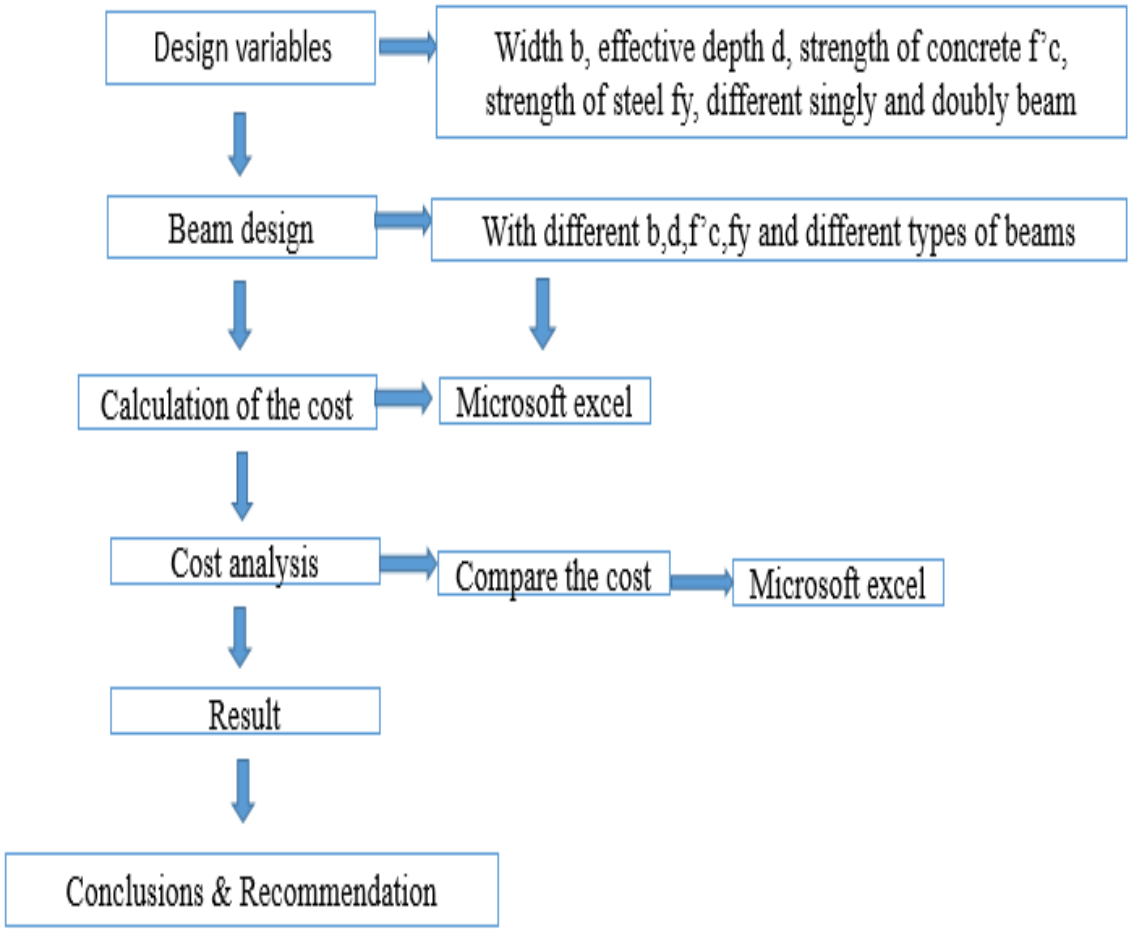
2.3 overview

The author has to discuss what he/she has learned from reviewing literature so far and what he/she has learned. After reading this chapter the reader should be convinced that the author's proposed research will play a necessary the role in furthering role in that field.

Chapter- 3

Methodology

3.1 Introduction



3.2 Cross-section of RCC beam

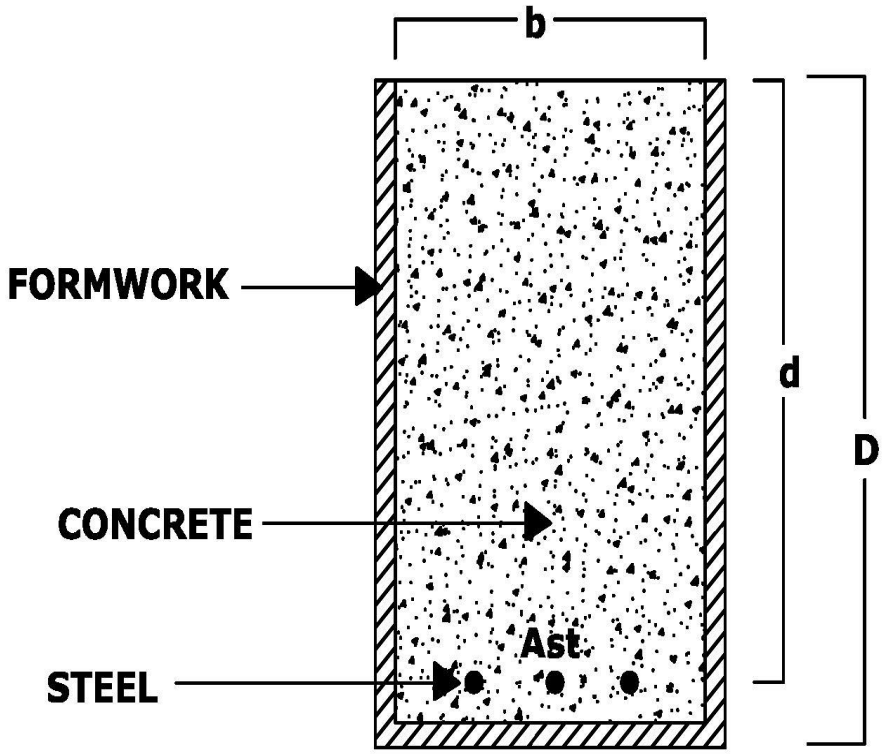


Fig. 3.1: Cross-section of RCC beam

3.3 Diagram of beam details

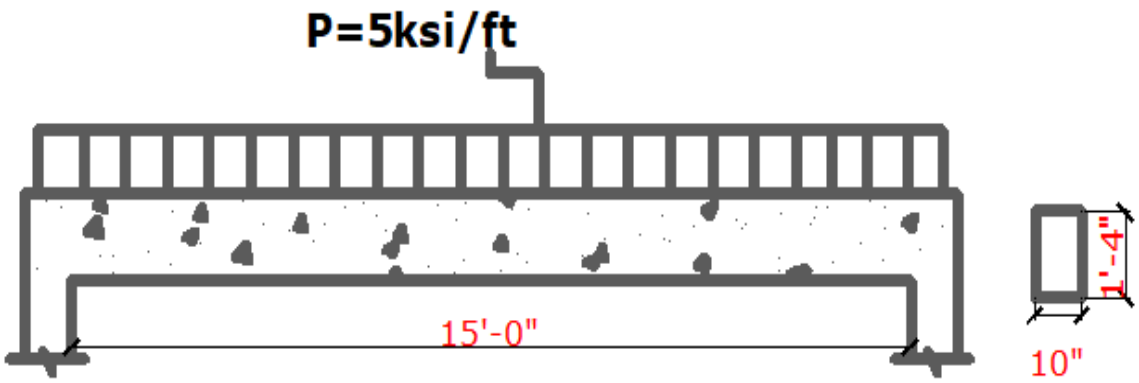


Fig. 3.2: Details of the beam.

- Cost per moment = (Cost per unit length / maximum moment)

3.4 The design variables and constants

There are 4 design variables chosen for the optimization problem. Four of them are continuous variables which are the width of the beam b, effective depth d, area of tension steel A_{st}, and strength of concrete f'c. The grades under consideration are 3ksi, 4ksi, 5ksi, and 6ksi. The constant parameters used in the problem include effective depth d, cost of concrete Cc, cost of reinforcement Cs, cost of formwork Cf... The value of effective cover for our beam is 1.5 inches for all the cases.

3.5 Cost of materials

The cost of materials was taken from the Dhaka schedule of Rates 2020.

Cost of formwork including centering shuttering and removal,

Cf = 420 TK/ ft^2

Materials	Grade (ksi)	Quantities	Cost (tk)*
Steel Bars	72	1 ton	61000
	60	1 ton	59000
	40	1 ton	55000
Ready-mix concrete	3	1 cft	230
	4	1 cft	250
	5	1 cft	280
	6	1 cft	300

Table 3.1: Cost of materials details

*Ref: https://thefinancialexpress.com.bd

Chapter- 4

Result

4.1 Singly reinforcement beam result graph

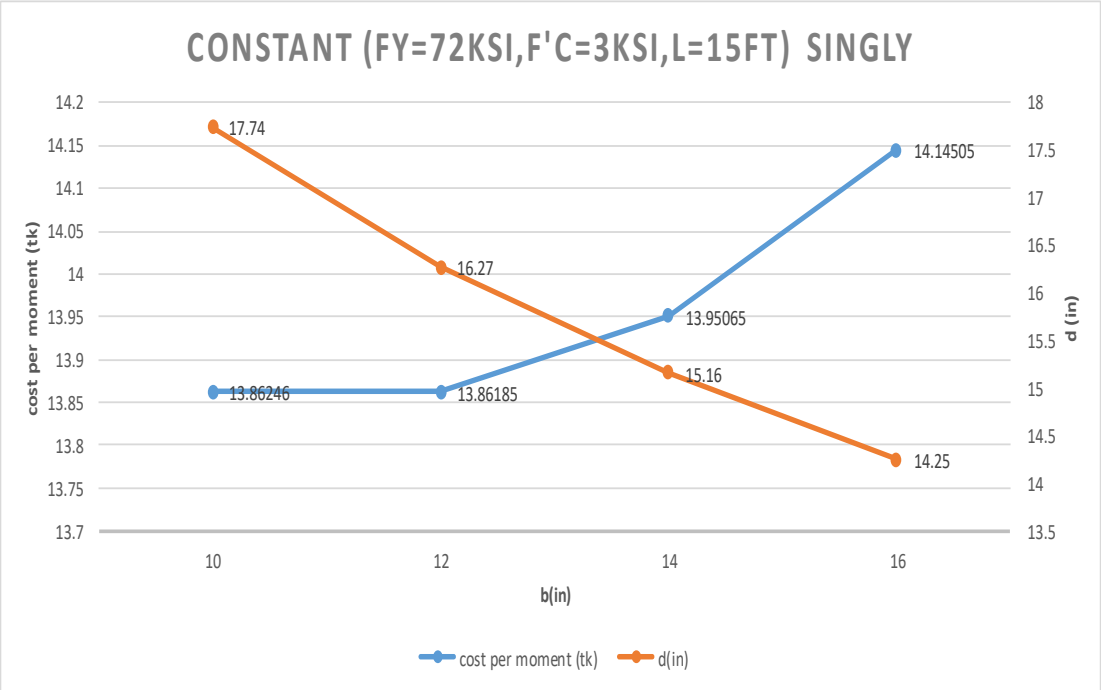


Fig. 4.1: Consider of "b (inch)"

Here, the singly RCC graph result shown materials and length constant and width "b" increasing then the depth "d" reduce. And this graph step by step increase width 10", 12", 14", 16" and depth cost is decreases 17.74tk, 16.27tk, 15.16tk and 14.25tk. But cost per moment cost will increase with increasing width.

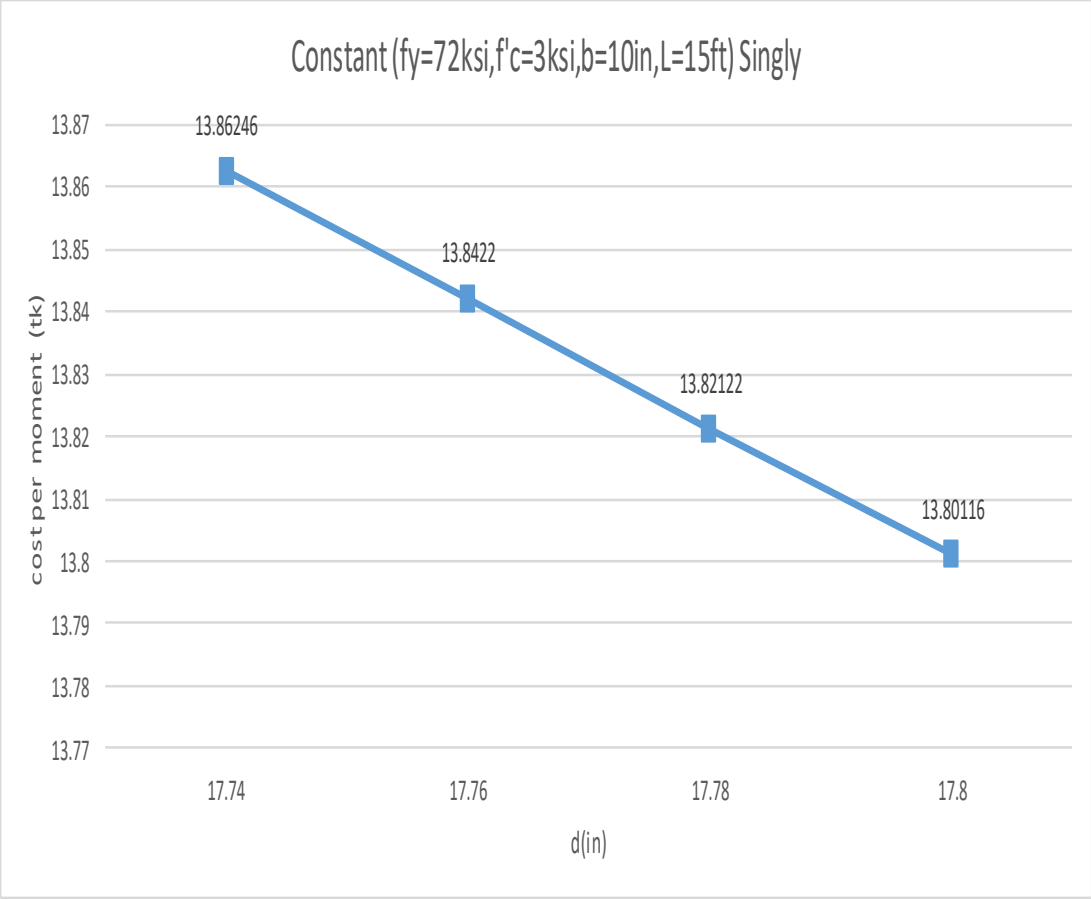


Fig. 4.2: Consider of "d (inch)"

In this graph materials strength constant, width and length constant. And depth "d" is varying such as 17.74 inch, 17.76 inch, 17.78 inch and 17.8 inch. Here cost per moment and depth cost is very low amount save 13.80tk.

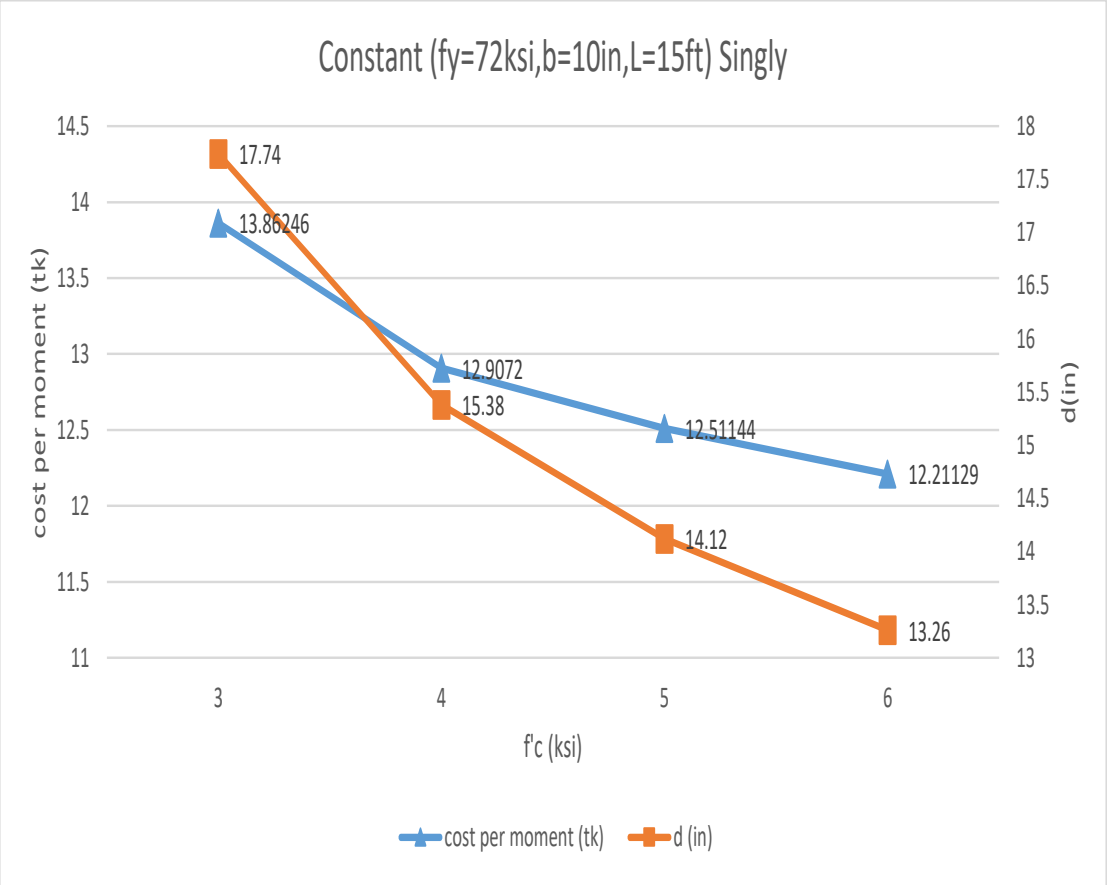


Fig. 4.3: Consider of "f'c (ksi)"

Here, this graph steel strength, width and length keep constant. And concrete strength varying 3ksi, 4ksi, 5ksi and 6ksi taking step by step then depth is decreased. And cost per moment and depth together cost is reducing. Here low cost of depth of 13.26tk and a low cost of per moment 12.21tk.

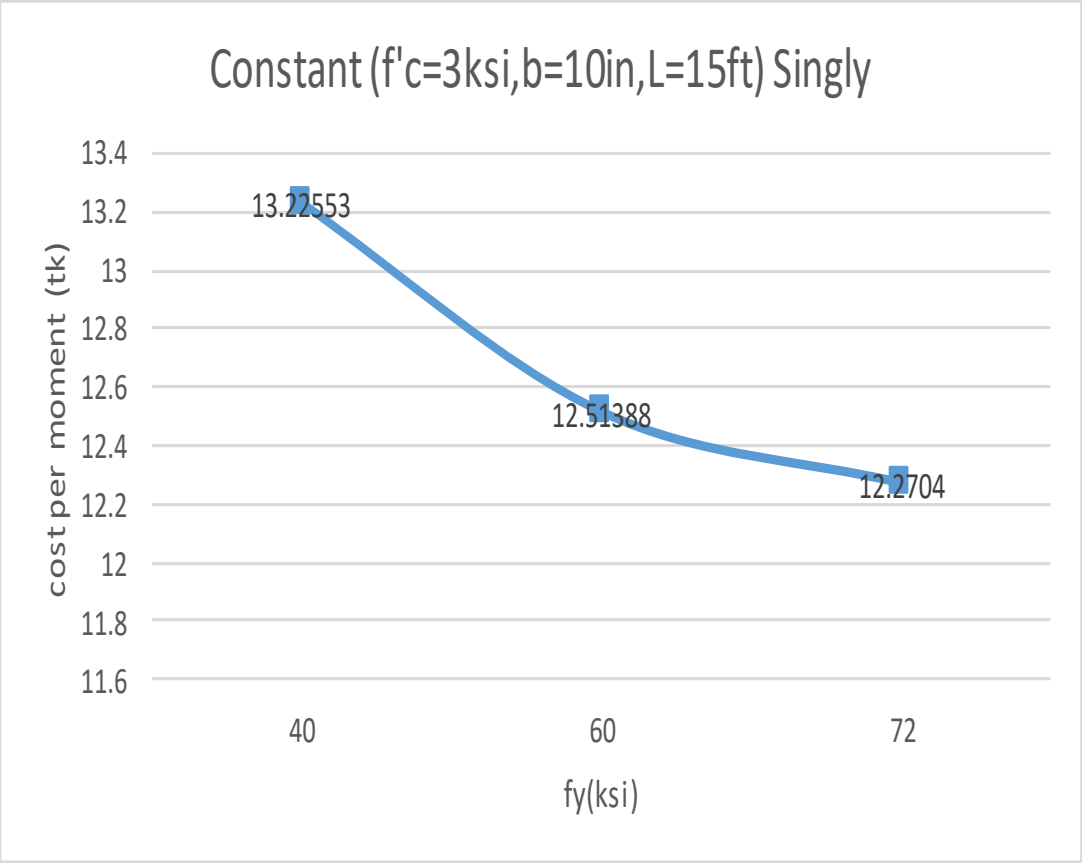


Fig. 4.4: Consider of "fy (ksi)"

This graph shown concrete materials and width constant. And steel strength increasing step by step 40ksi, 60ksi and 72ksi steel strength taken. And it's per strength cost 13.22tk, 12.51tk, 12.27tk. Here high strength steel cost will optimize. Also cost per moment decreasing very low amount 11.6tk.

4.2 Singly fixed (d) reinforcement beam result graph

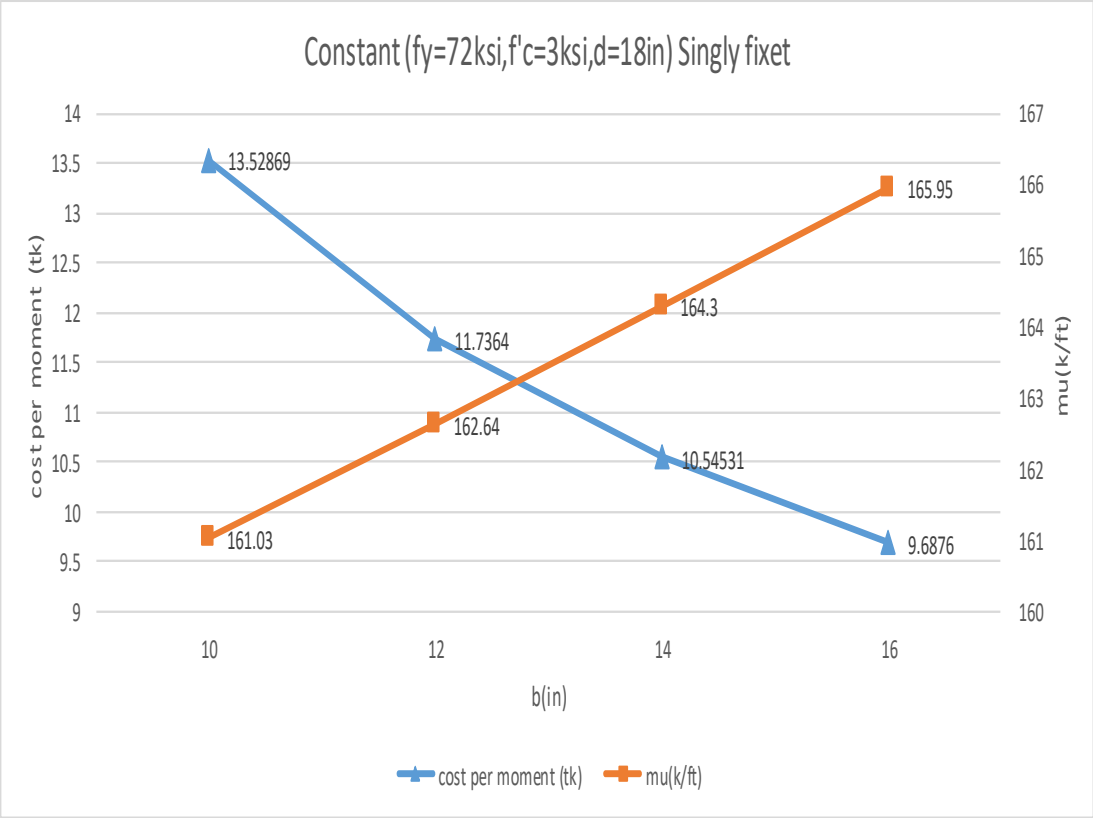


Fig. 4.5: Consider of "b (inch)"

In this graph shown singly fixed RCC beam, singly fixed means depth "d" measure keep fixed every singly fixed formula. Here, steel strength, concrete strength, and depth constant. Width "b" measure varying 10" to 16" and per moment cost decrease when width increasing 13.52tk to 9.68tk. But ultimate moment high for width increasing.

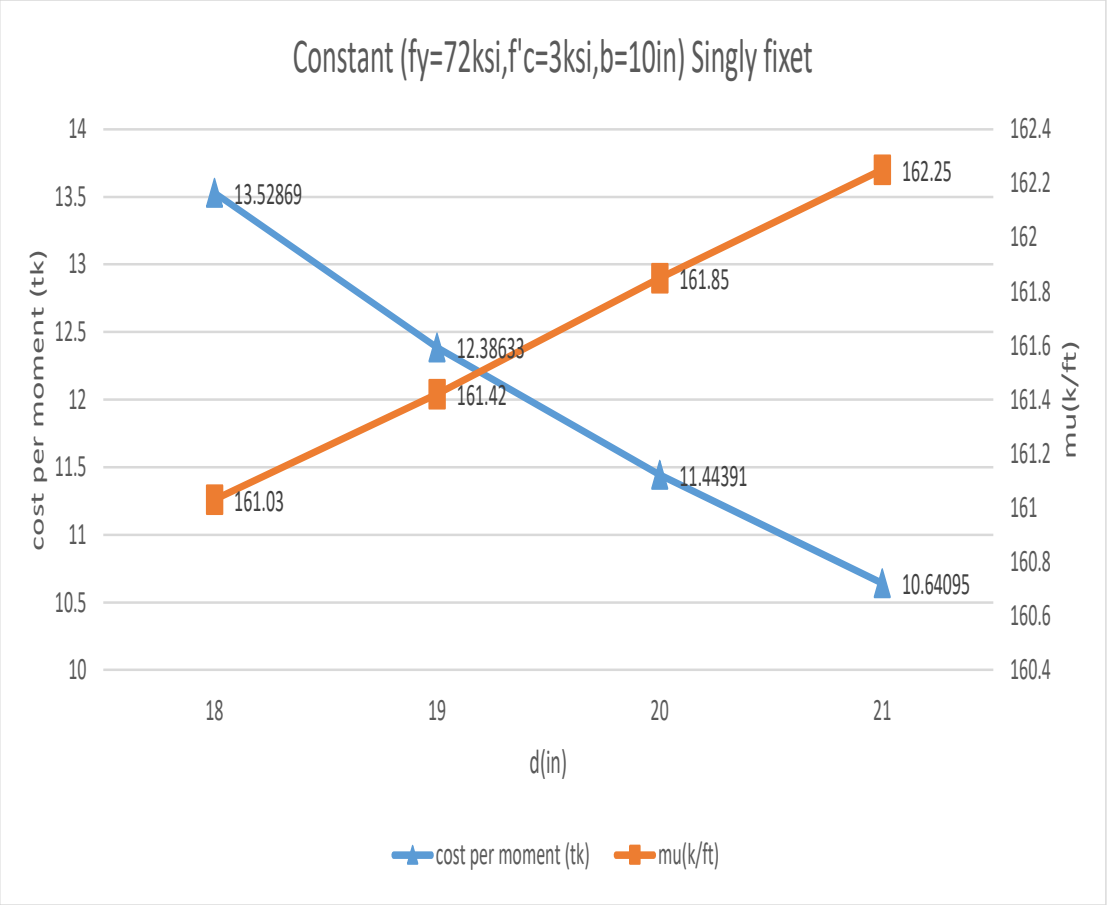


Fig. 4.6: Consider of "d (inch)"

Here, consider of depth "d" materials strength and width constant. This graph increasing the depth then ultimate moment high but the cost per moment decrease.

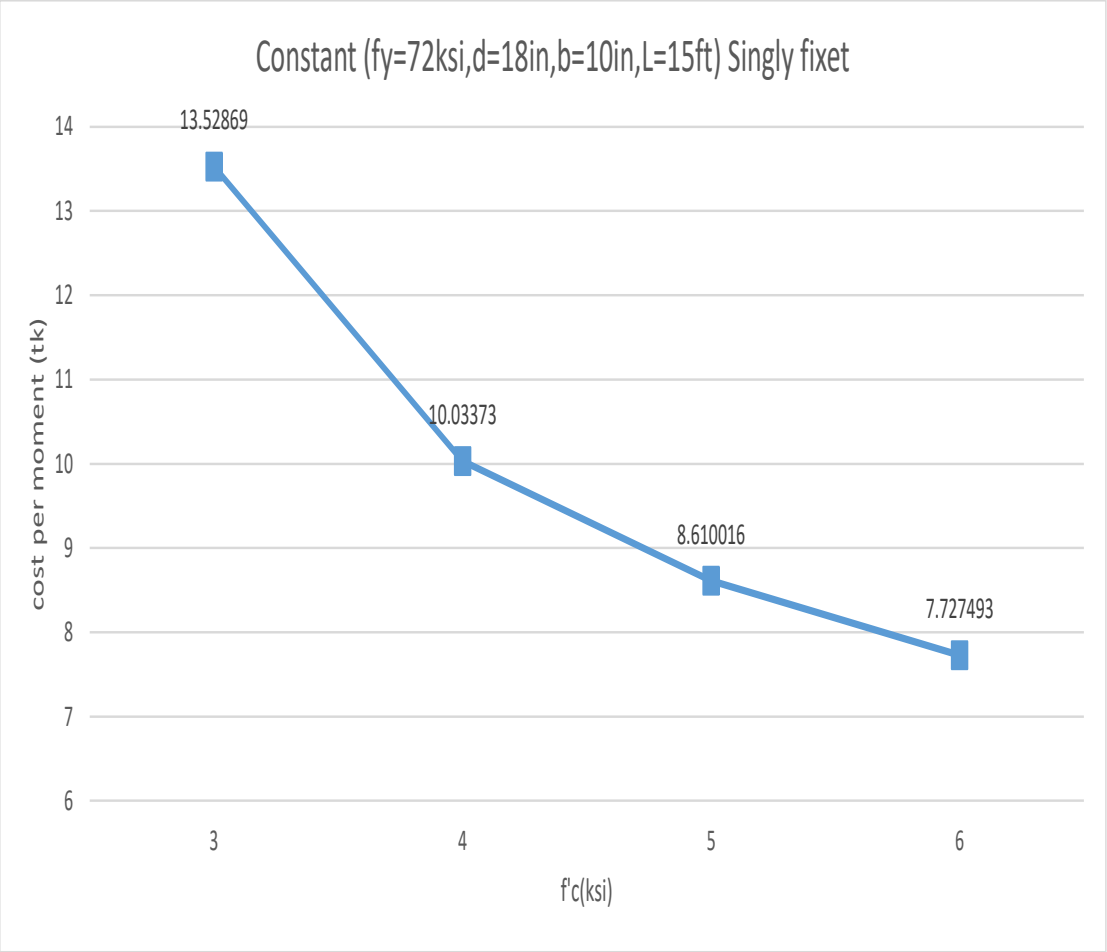


Fig. 4.7: Consider of "f'c (ksi)"

In this graph concrete strength varying and steel strength, depth, and width constant. Here concrete strength 3ksi to 6ksi and cost per moment decrease 13.52tk to 7.72tk. High strength concrete use cost will decrease very low cost.

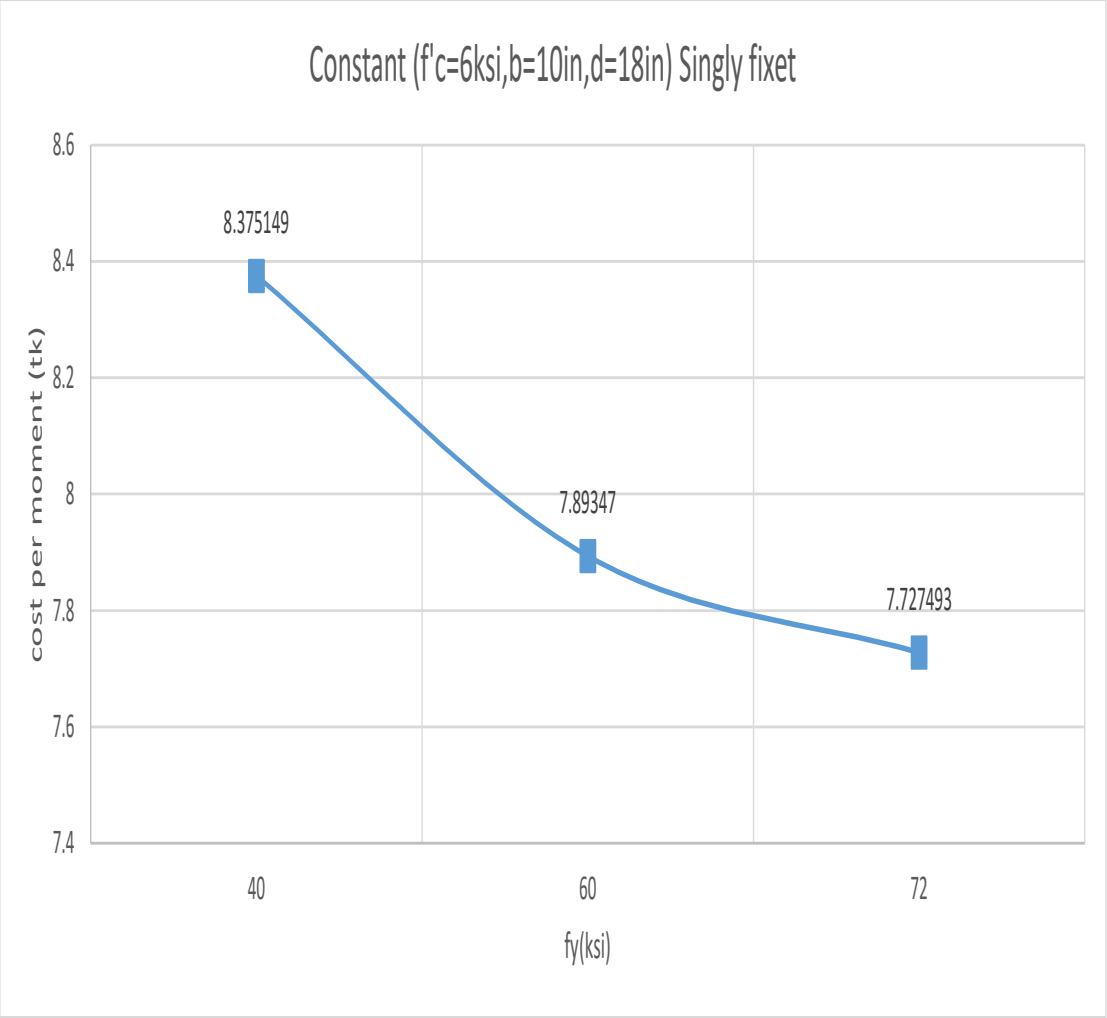


Fig. 4.8: Consider of "fy (ksi)"

Here, in this graph shown concrete strength, depth, and width constant and consider of steel strength 40ksi to 72ksi. This formula's high strength steel use cost per moment will optimize 8.35tk – 7.72tk.

4.3 Doubly reinforcement beam result graph

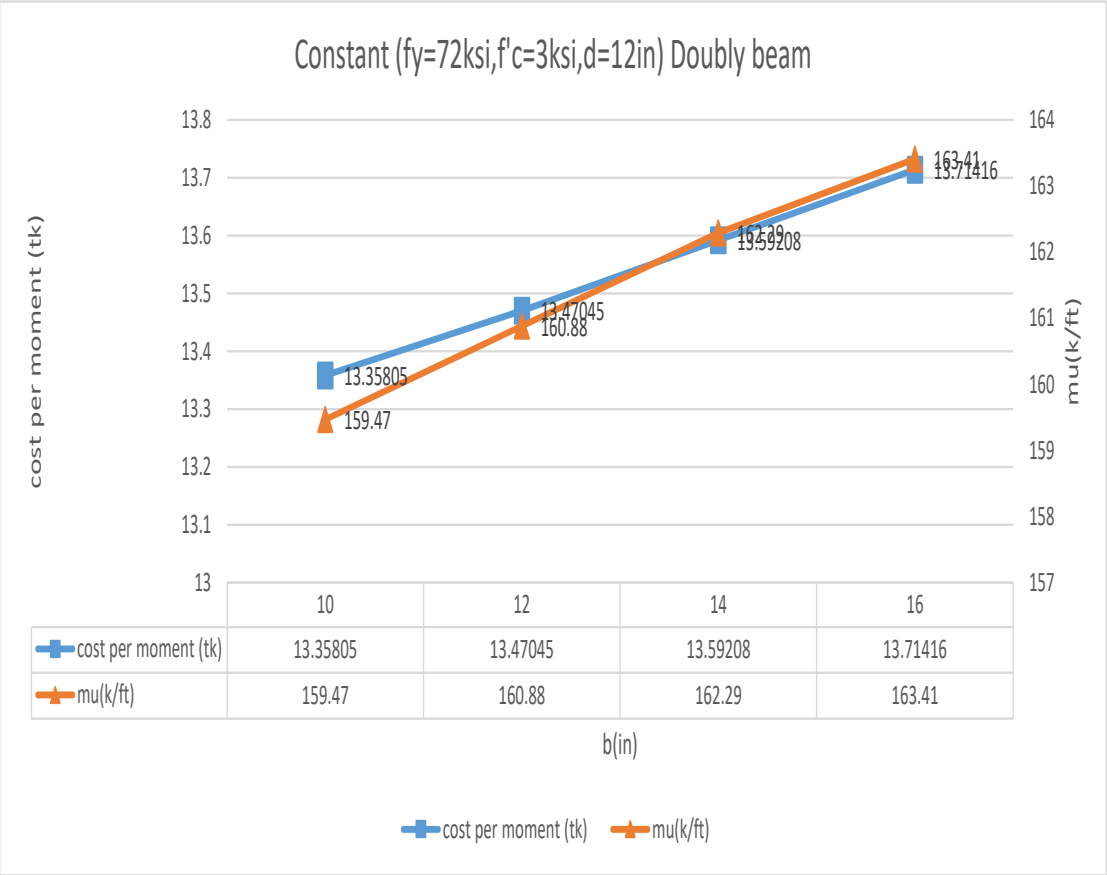


Fig. 4.9: Consider of "b (inch)"

In this graph Doubly RCC beam result shown width is varying and steel strength, concrete strength, and depth constant. Here, width 10", 12", 14", 16" increasing per moment cost will be increasing. Also ultimate moment will be high.

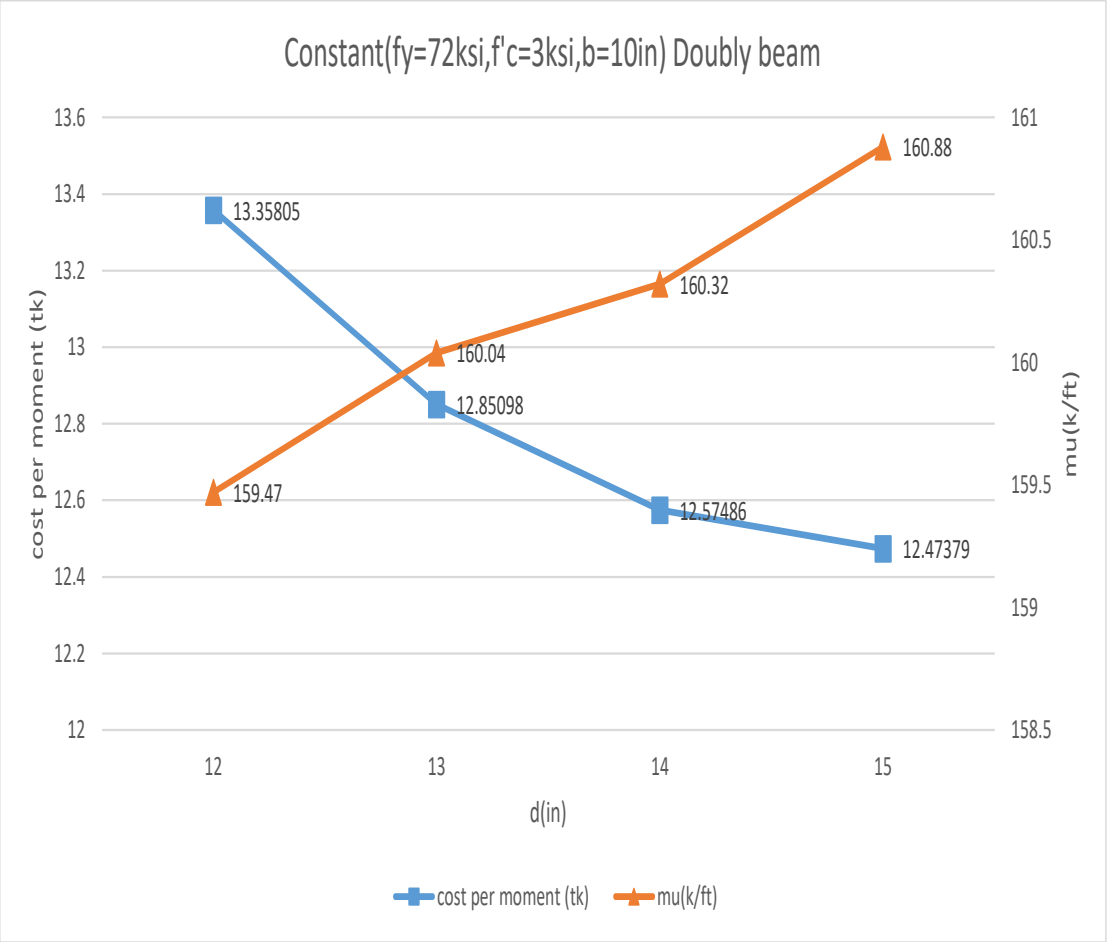


Fig. 4.10: Consider of "d (inch)"

In this graph, depth is consider and other materials is constant. Here, depth measures 12"-15" and cost per moment 13.35tk-12.47tk. Depth will be increase then cost per moment decrease.

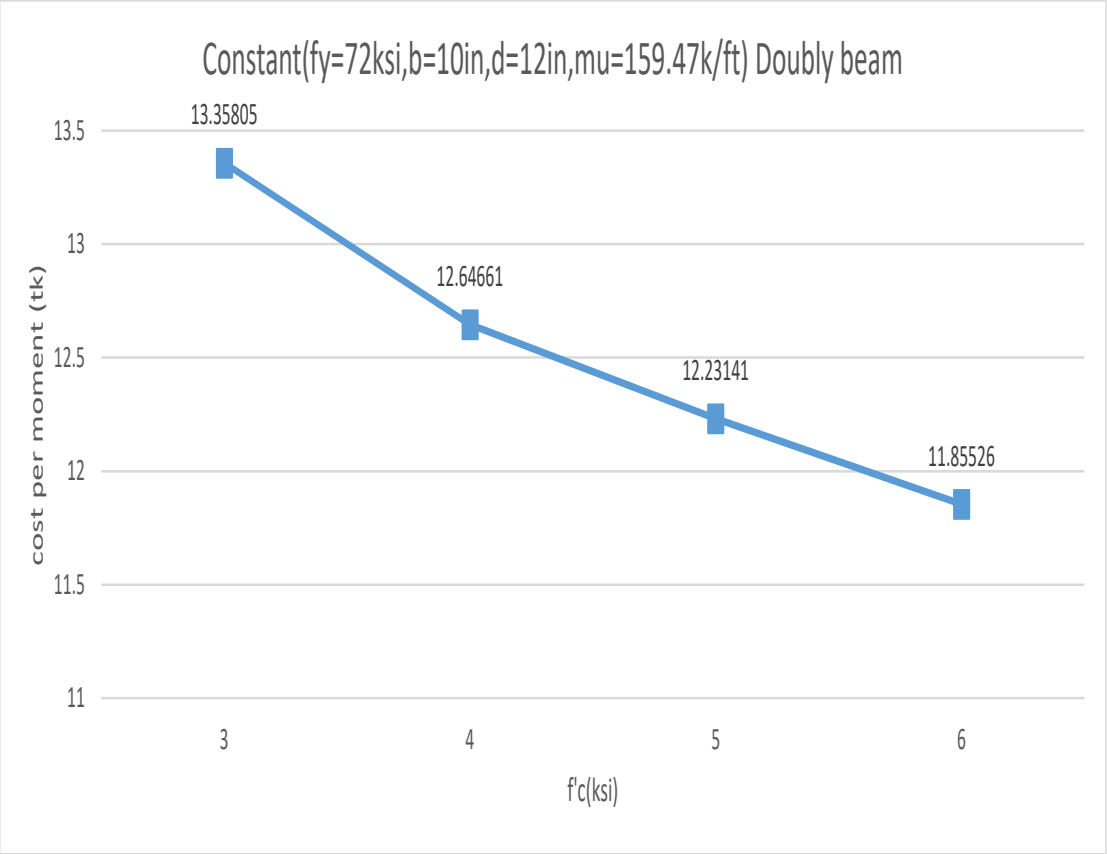


Fig. 4.11: Consider of "f'c (inch)"

Similarly Fig.10 consider of concrete strength and other materials is constant. Concrete strength "f'c" value 3ksi - 6ksi. Here high strength concrete use cost will reduce.

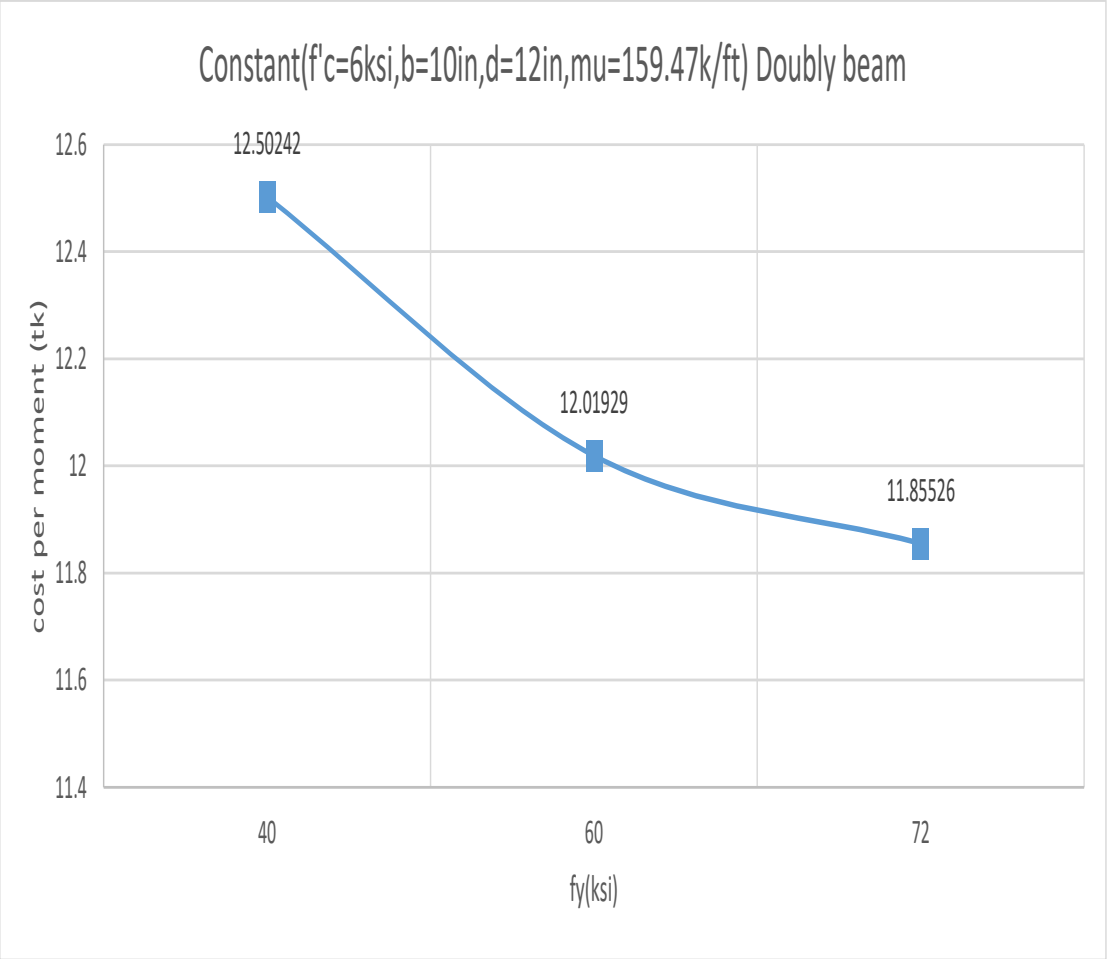


Fig. 4.12: Consider of "fy (inch)"

Here, the doubly RCC beam graph considers steel "fy" strength and other materials is constant. Steel strength value 40ksi to 72ksi and cost per moment 12.50tk – 11.85tk. Here high strength steel use then per moment cost will decrease.

4.4 Compare between singly, singly fixed and doubly beam

Cost vs Fy Constant (f'c=6ksi,b=10in,L=15ft)							
Fy(ksi)	**Singly Beam, cost per moment (tk)**	**Per: %**	**Singly Fixed Beam, cost per moment(tk), (d=18in)**	**Per: %**	**Doubly Beam, cost per moment(tk), (d=12in)**	**Per: %**	**Remark**
72	**13.22**	**-**	**8.37**	**-**	**7.76**	**-**	**Singly fixed beam is better than Doubly and Singly beam**
60	**12.51**	**5.37**	**7.89**	**5.73**	**12.01**	**3.92**	
40	**12.27**	**7.18**	**7.72**	**7.76**	**11.85**	**5.20**	

Table 4.1: Consider of "fy (ksi)"

Cost vs f'c Constant (fy=72ksi,b=10in,L=15ft)							
f'c(ksi)	**Singly Beam, cost per moment (tk)**	**Per: %**	**Singly Fixed Beam, cost per moment(tk), (d=18in)**	**Per: %**	**Doubly Beam, cost per moment(tk), (d=12in)**	**Per: %**	**Remark**
3	**13.86**	**-**	**13.52**	**-**	**13.35**	**-**	**Singly fixed beam is better than Doubly and Singly beam**
4	**12.90**	**6.92**	**10.03**	**27.6**	**12.64**	**5.31**	
5	**12.51**	**9.74**	**8.61**	**36.3**	**12.23**	**8.38**	
6	**12.21**	**11.90**	**7.72**	**42.9**	**11.85**	**11.2**	

Table 4.2: Consider of "f'c (ksi)"

Cost vs b Constant (fy=72ksi,f'c=3ksi,L=15ft)							
b(in)	**Singly Beam, cost per moment (tk)**	**Per: %**	**Singly Fixed Beam, cost per moment(tk), (d=18in)**	**Per: %**	**Doubly Beam, cost per moment(tk), (d=12in)**	**Per: %**	**Remark**
10	**13.86**	**1.98**	**13.52**	**-**	**13.35**	**2.62**	**Singly fixed beam is better than Doubly and Singly beam**
12	**13.86**	**1.98**	**11.73**	**13.2**	**13.47**	**1.75**	
14	**13.95**	**1.34**	**10.54**	**22**	**13.59**	**0.87**	
16	**14.14**	**-**	**9.68**	**28.4**	**13.71**	**-**	

Table 4.3: Consider of "b (inch)"

Cost vs d Constant (b=10in,fy=72ksi,f'c=3ksi,L=15ft)								
d(in)	**Singly Beam, cost per moment (tk)**	**Per: %**	**Singly Fixed Beam, cost per moment(tk), (d=18in)**	**Per: %**	**Doubly b(in)**	**Doubly Beam, cost per moment(tk), (d=12in)**	**Per: %**	**Remark**
18	**13.86**	**-**	**13.52**	**-**	**12**	**13.35**	**-**	**Singly fixed beam is better than Doubly and Singly beam**
19	**13.84**	**0.14**	**12.38**	**8.43**	**13**	**12.85**	**3.74**	
20	**13.82**	**0.28**	**11.44**	**15.4**	**14**	**12.57**	**5.84**	
21	**13.80**	**0.43**	**10.64**	**21.3**	**15**	**12.47**	**6.59**	

Table 4.4: Consider of "d (inch)"

Chapter- 5

Conclusion and Recommendation

5.1 Conclusion

- If we are using 3 ksi concrete instead of 6 ksi concrete saves 27%-43% of the cost, this method applying to a singly fixed reinforcement beam. For doubly save 5%-11% cost. And singly save 7%-12% cost.

- High strength is steel used to reduce the section and at the same time it is economical to range from 8% for singly fixed, 5% reduce doubly and 7% singly beam. We see here singly fixed reinforcement beam is economical.

- If we are increasing depth then reduce beam cost 8%-21% for a singly fixed beam. And doubly reduce from 3%-6% cost.

- Here we are increasing “b” singly and doubly beam cost is rising. But singly fixed reinforced beam cost optimize is decreasing 13%-28%.

- If we use high strength steel and concrete and increasing depth cost optimize step by step. But if we are increasing the width beam cost not optimize.

- Here we are practice 3 types of beam on singly, singly fixed, and doubly reinforcement beams. After our practice, we get optimize cost only singly fixed.

5.2 Recommendation

- From our study, we found increasing the depth and increasing the strength of the materials that's mean by f'c, fy optimize the beam cost. And we get singly fixed reinforcement beam will optimize the concrete structural cost. We can recommend high strength-materials and singly fixed beam.

- If we use high strength steel and high strength concrete use for singly fixed reinforcement beams our beam section is optimized.

- At last, we can say here that we will be used the design procedure for the singly and doubly reinforcement beam economy. But singly fixed beam more than cost to optimize between singly and doubly beam.

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