Virginia Commonwealth University
Engineering Concepts 102

Project #1

Kurt Wainwright
Chip Combs
Kevin Sears
Brian Haug

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Summary

To be able to make decisions on design, one must analyze a particular structure in many different forms in order to choose the form which best fits the description of the customers' needs. In this project, that is exactly what we have done. The structure being analyzed (See Figure 1) was originally a crane device which lowered heavy objects down a hill, but it has been modified into a bridge that will support a walkway. The specified length of the structure is to be 32 ft. long and is to support 1000 lbs. of downward force every 8 ft. The decision to attach cables to the structure was made because this was believed to be the best way to improve the support of the walkway. Different cable positions were then chosen to optimize this design. After analyzing all three design options, Design #1 clearly showed a minimum of forces in each member.

Introduction

The structure being analyzed was originally a crane device which lowered heavy objects down a hill, but it has been modified into a bridge that will support a walkway. The specified length of the structure is to be 32 ft. long and is to support 1000 lbs. of downward force every 8 ft. The axial forces of the members and cables needed to be determined before any decision can be made on which is the better design. Three different designs were analyzed, each with an altered cable arrangement. After analyzing each structure, Design #1 proved to be the most efficient in terms of internal forces and weight distribution among each of the members. Below is a sketch of the original structure before modifications.

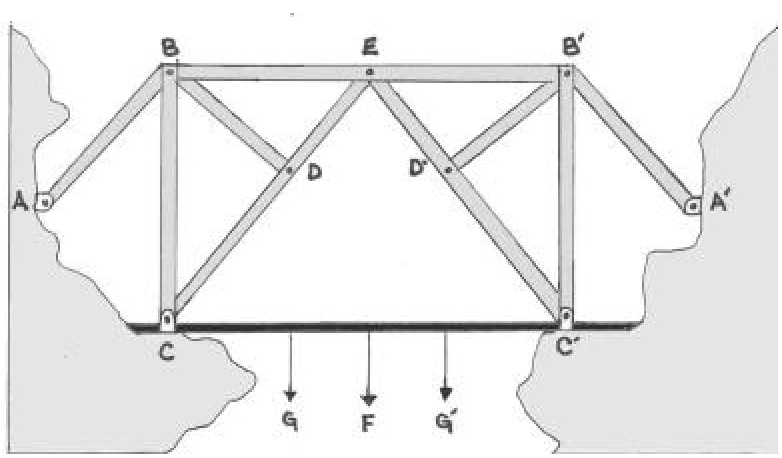


Fig 1. Original Structure

Strategy and Development

The preliminary analysis was approached with working knowledge of how each member would react overall since half of this structure was part of a previous assignment. This particular structure showed that all of the external forces were dependent on the magnitude and distribution of the downward force, such as G or F in Figure 1. The following example demonstrates this dependency:

- A_y= -0.5(Weight)
- A_x= -1.2(Weight)

With this in mind, it was decided that cables should be used to hang the walkway. The cables could be attached to the structure from various points along the truss and the modifications to the original structure could then be analyzed. The cable arrangements were chosen in such a way that the load could be distributed evenly throughout the internal structure of the truss. Three designs were analyzed, each with a different cable position. The design which best supports the load will be the design of choice. It should be noted that no Excel spreadsheet was developed to analyze these designs.

Fig 2. Design #1

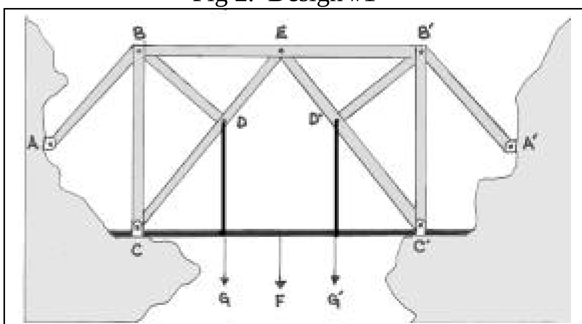
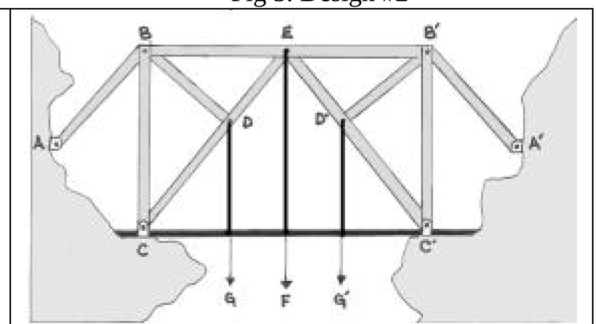


Fig 3. Design #2



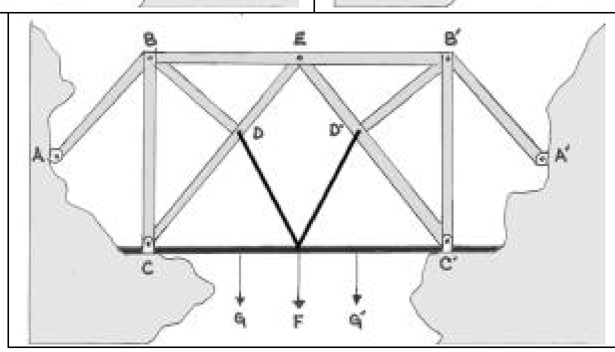


Fig 4. Design #3

Results and Analysis

The decision to suspend the walkway by cables, as shown in Figures 2-4, was made because the original structure had proven to be a very good way to support a load. Therefore, changing the configuration of the truss did not seem logical. As one can see in Table 1, all of the external forces in all three designs have the same values; this is because even though cables were added as part of each design, the cables and the span of the walkway are considered internal to the structure as a whole.

Before the three designs were analyzed, it was thought that Design #2 would be the best design. It seemed logical that three cables would support the load better than two. The attempt to analyze Design #3 failed because there was no way to calculate the internal forces without accounting for deflections, which is beyond the scope of this course. This particular structure when "cut" resulted in four unknowns and three equations, which is unsolvable. The method of joints was also attempted with the same result. Therefore, Design #3 can be disregarded as a viable design for this project.

Design #2 indicated rather high tensile and compression forces comparable to the load. Force F_{CB} was –5,496lbs., which seemed very high compared to the overall 3,000lbs of downward force on the walkway. Design #1 proved to be the best design because the internal forces were low compared to the overall load. The internal forces in Design #1were smaller because the two vertical cables distribute the downward force more evenly than in Design #2.

Table 1: Project Results

Project Results						
	Design 1		Design 2		Design 3	
External Reactions						
A	-1,920 lbs.		-1,920 lbs.		-1,920 lbs.	
Ax	-1,200 lbs.		-1,200 lbs.		-1,200 lbs.	
Ay	-1,498 lbs.		-1,498 lbs.		-1,498 lbs.	
Cx	1,200 lbs.		1,200 lbs.		1,200 lbs.	
Cy	3,498 lbs.		3,498 lbs.		3,498 lbs.	
F	N/A		1,000 lbs.		1,000 lbs.	
G	1,500 lbs.		1,000 lbs.		1,000 lbs.	
G'	1,500 lbs.		1,000 lbs.		1,000 lbs.	
Internal Reactions						
T_{DG}	1,000 lbs.	<-	1,000 lbs.	<-	N/A	<-
$T_{DG'}$	1,000 lbs.	<-	1,000 lbs.	<-	N/A	<-
T_{EF}	N/A		1,000 lbs.	<-	N/A	<-
T_{DF}	N/A		N/A		3,000 lbs.	
F_{AB}	2,698 lbs.		2,698 lbs.		N/A	
F_{CB}	-2,586 lbs.		-5,496 lbs.		N/A	
F_{BD}	938 lbs.		640 lbs.		N/A	
F_{BE}	799 lbs.		798 lbs.		N/A	
F_{DE}	1.4 lbs.		3,202 lbs.		N/A	
F_{DC}	2,561 lbs.		2,561 lbs.		N/A	
F_{CG}	-469 lbs.		-2,801 lbs.		N/A	
F_{GF}	-400 lbs.		-2,800 lbs.		N/A	

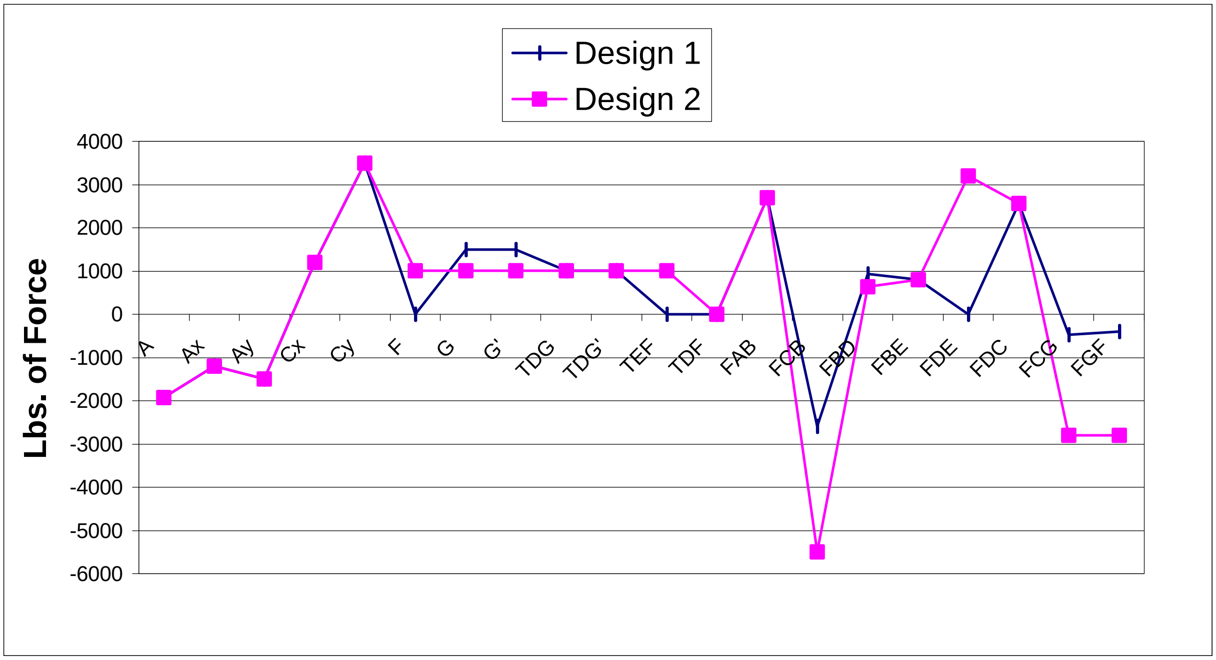


Chart 1: Loading at individual members and supports

Conclusion

As Chart 1 indicates, Design #1 is well within the parameters of Design #2 which leads one to conclude that Design #1 has the best cable configuration. Notice that forces F_{BD}, F_{DC}, and F_{GF} are all considerably lower in Design #1 than in Design #2. This is because these forces are dependent on force F_{DE}, which has a very low value of 1.4lbs. It is the opinion of this group that Design #1 should be used to construct this proposed bridge.