Understanding Structural Concept of Cable-Stayed Bridge

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Background

There are many long-span cable-suspended and cable-stayed bridges in the world. (Ji, 2003) A cable-stayed bridge is a bridge that consists of one or more columns (normally referred to as towers or pylons), with cables supporting the bridge deck.

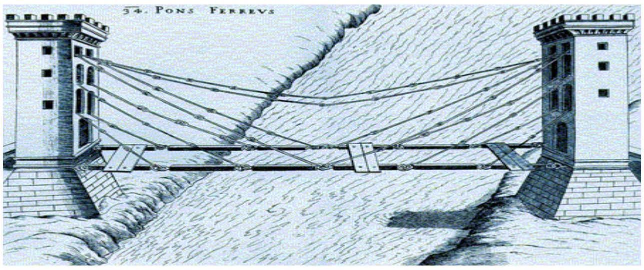

Figure 1 (Wikipedia, 2012)

Cable-stayed bridges can be dated back to 1595, where designs were found in a book by the Venetian inventor Fausto Veranzio, called *Machinae Novae* which showing in Figure 1. (Wikipedia, 2012)

Introduction

There are two major classes of cable-stayed bridges shown in Figure 2: In a *harp* design, the cables are made nearly parallel by attaching them to various points on the tower(s) so that the height of attachment of each cable on the tower is similar to the distance from the tower along the roadway to its lower attachment. In a *fan* design, the cables all connect to or pass over the top of the tower(s). (Wikipedia, 2012)

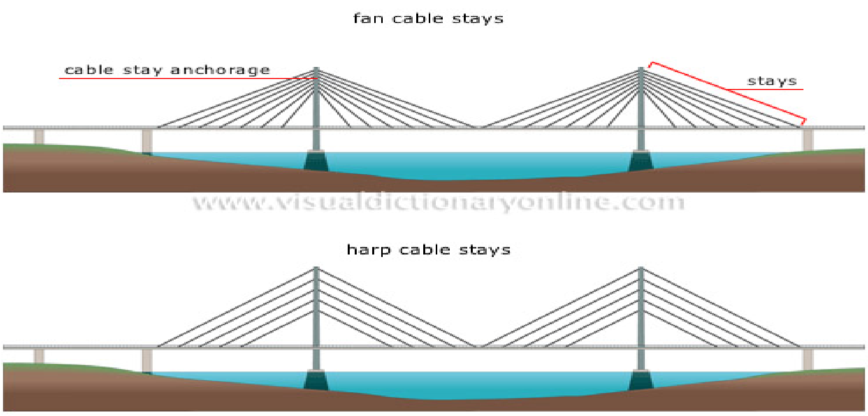

Figure 2 (Merriam-webster,2012)

The research cause of this structural concept of cable-stayed bridge, which was starting from an interesting 'iphone' game called *Bridge Constructor* from App Store. The monitoring test of the completed bridge is to confirm which any bridge is safe or not that process following as shown in Figure 3 & 4:

Sign related colour to load

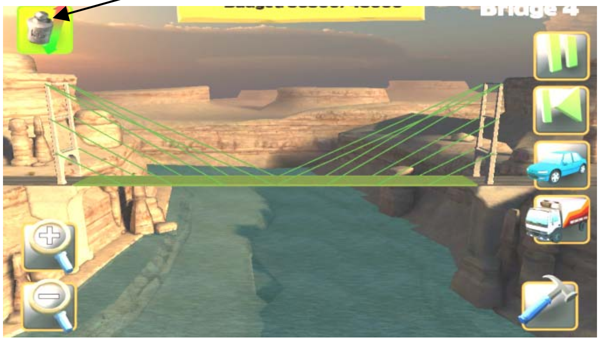

Figure 3

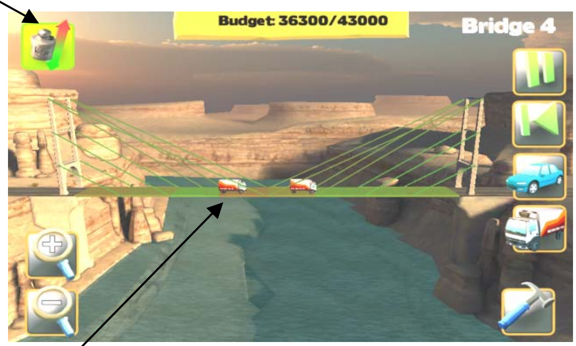

Figure 4

Span colour turns to red due to truck load

This is shown that the test programme of the completed cable-stayed bridge, which indicates how changed distributed load when trucks went across this cable-stayed bridge by the changing colour (load level defined by colour from green (low) to red (high)).

Analysis for Model Design

To understand the monitoring test of the cable-stayed bridge for this 'iphone' game, what is more; analysing the load distribution, I made a modelling structure of the cable-stayed bridge as a half of combining *harp* and *fan* cable stays design to test using some plastic toys and cords shown in Figure 5:

Data:

Span Length: 710 mm;
Span Width: 50 mm;
Span Depth: 10 mm;
Deck High: 100mm;
Deck Area: 600 mm^2
Tower High: 280mm;
Cables Length: 110 mm;
240 mm;
370 mm;
430 mm;

Figure 5

Figure 6

This figure 6 is shown that the effective impact of the load distribution for the cable-stayed bridge model when a truck toy model went across the middle point of this bridge. It states that each cable stayed had tensile effect, having press deformation and maximum deflection on the mid-span and load force transmitted to tower support when the truck load produced downward force. There had one upward reaction on each deck. With increasing the load which the number of vehicles on the span of the cable bridge, it could happen easily breaking on the span connection and cracking on the deck if vehicles load is larger over than the factor of safety for this cable-stayed bridge. Therefore, it is more important for cable-stayed bridge design to estimate connection between cable stayed and tower with deck.

Tower produced bend clearly

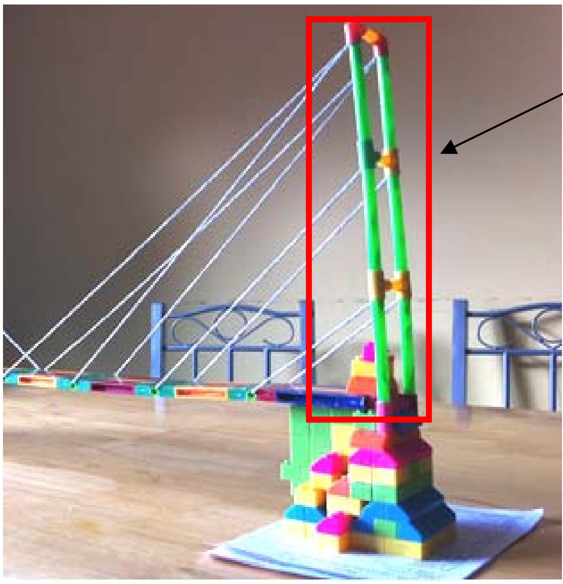

Figure 7

Figure 8

On the other hand, it is shown that the tower of this modelling structure had bended lightly without load function, and even had already bended markedly with a truck load effect in Figure

7 & 8. So, this modelling structure design which the half of combining *harp* and *fan* cable stays is not strange.

Further Analysis

The half of combining *harp* and *fan* cable stays design produced which is based on one structural design of the game programme which having an effective function in that case. Otherwise, the material of the tower is made of reinforcement concrete in game case, but plastic material of tower is designed in my real modelling structure. Therefore, it is quite significant for design of tower of the cable-stayed bridge. For further analysis of the cable-stayed bridge test, I want to inspect and verify the whole combining *harp* and *fan* cable stays structure based on Figure 2 shown for a new cable-stayed bridge as shown in Figure 9.

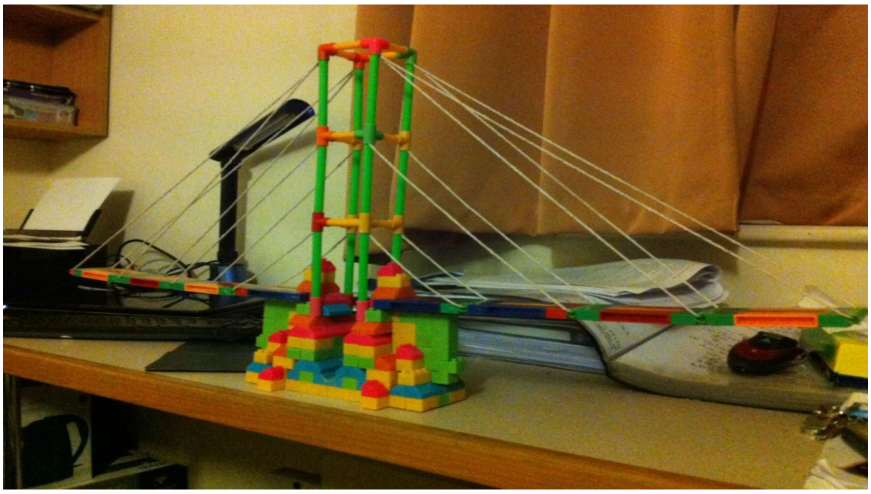

Figure 9

Data:
Span Length: 710 mm;
Span Width: 50 mm;
Span Depth: 10 mm;
Deck High: 100mm;
Deck Area: 1200 mm^2;
Tower High: 280mm;
Tower Width: 50 mm;
Tower Area: 2500 mm^2;
Cables Length: 110 mm;
240 mm;
370 mm;
430 mm;

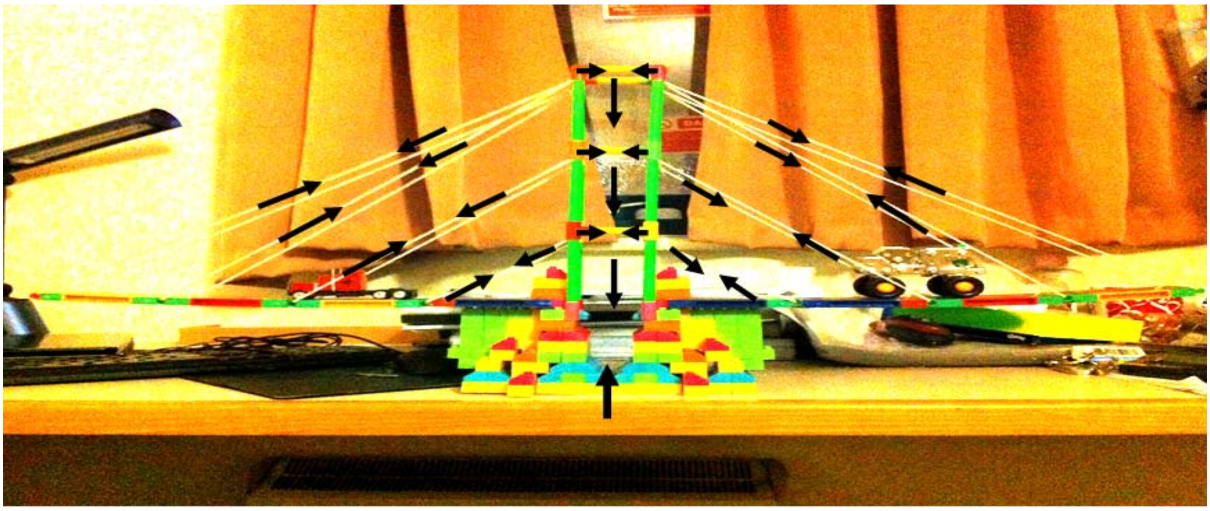

Figure 10

This figure 10 is shown that the small impact of the load distribution for the cable-stayed bridge model when two truck toy model went across two the middle point of the span of this cable-stayed bridge. It indicates that each cable stayed had imperceptible tensile effect, having press deformation and maximum deflection on the mid-span and load force transmitted to tower support when the vehicles load produced downward force. With increasing the load which the number of vehicles on the span of the cable bridge, it could happen hardly breaking on the span connection and cracking on the deck.

Conclusion

Through these two different modelling structure designs which the half of combining *harp* and *fan* cable stays design and the whole combining *harp* and *fan* cable stays design, I found some important structural concepts for cable-stayed bridge structure design as described below:

1. Tower material of cable-stayed bridge design is one important factor to keep a high level stability for the structural body.

2. It is quite significant for cable-stayed bridge design to estimate connection between cable stayed and tower with deck.

3. The towers are bent significantly as they are subjected to large bending in the bridge structure. It needs additional cable acting the force on the opposite directions to balance the forces generated by the existing cables on the tower.

4. There has an effective function for cable-stayed bridge to analysis load distribution flow, especially, understanding and research cable design on the bridge or other cantilever structures.

Reference

Ji, T, (2003), Concepts for designing stiffer structures, The Structural Engineer, Vol.81,No.21,pp.36-42

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