ANALYSIS OF CABLE-STAYED BRIDGE UNDER THE EFFECT OF SETTLEMENT OF THE PIERS

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1. INTRODUCTION

Cable-stayed bridge is a bridge structure that consists of one or more columns (normally referred to as towers or pylons), with cables supporting the bridge deck. In the construction and service stage, the pylons or supporting piers might experience displacements due to the settlement and seismic activity. In fact, these effects cause significant damage for the bridge constructions.

In this paper, the cable, essential part of long span cable-stayed bridge, was put under the analysis and evaluate the reaction with simulated displacement to figure out how the construction work under this kind of impact.

2. MODELING EXAMPLE CABLE-STAYED BRIDGE

2.1. Description of the Bridge

The example long span cable-stayed bridge considered here is the Can Tho Bridge (2010), crosses the Hau River, and connects Can Tho City and Vinh Long province (South of Vietnam). The bridge is currently the longest main span cable-stayed bridge in Southeast Asia. The cable-stayed span arrangement is 40 + 40 + 270 + 550 + 270 + 400 + 40 m **(Fig.1)**.

Typically, the main girder is the Pre-stressed Concrete Box Girder, 26 m wide and 2.7m high, with four traffic lanes. In order to make good moment balance and cost saving, the girder was designed to have the steel box girder at 210m in the middle of the 550m span. The pylons are inversed-Y shaped steel reinforced concrete pylons, 171m high, as shown in **Fig.2**. The cables are arranged into two-vertical-plane system.

Bored piles were used in the foundations for all the pylons and cables, with the properties shown as **Table.1.**

Table 1. Properties of Bored Pile

	Pylon	Pier
Number of Piles	30	12
Diameter (m)	2.5	1.2
Length(m)	92	75

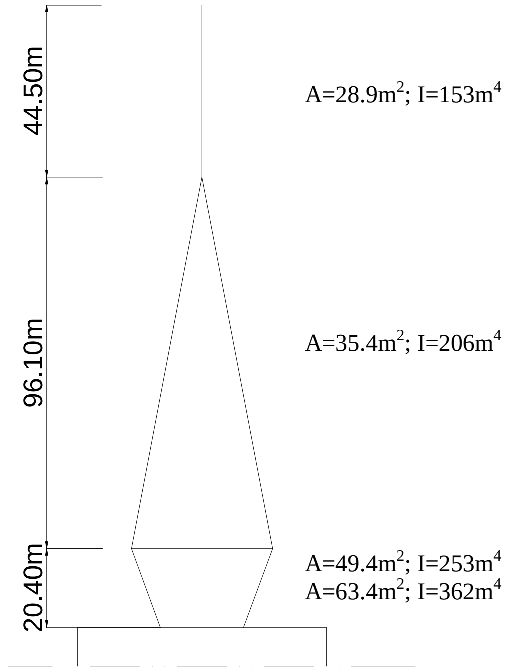

Figure 2. Reinforced Concrete Pylon

2.2. Cable Consideration

In this study, cable is treated as a plain truss element which has the tensile axial force only and nonlinear material property.

During the construction and service stage, the cable stress changes from σ_1 to σ_2, the equivalent elastic modulus of each cable could be obtained as follows:

$$E_{eq} = \frac{E}{1 + \frac{(L_0\gamma)^2(\sigma_1 + \sigma_2)}{24\sigma_1{}^2\sigma_2{}^2}E} \tag{1}$$

The material data of cable is shown as **Table.2**.

Table 2. Properties of Cable

Tensile Strength	1770 N/mm^2
Yield Strength	0.9 Tensile Strength
0.8% proof stress	1370 N/mm^2
Young Modulus	195,000 MPa

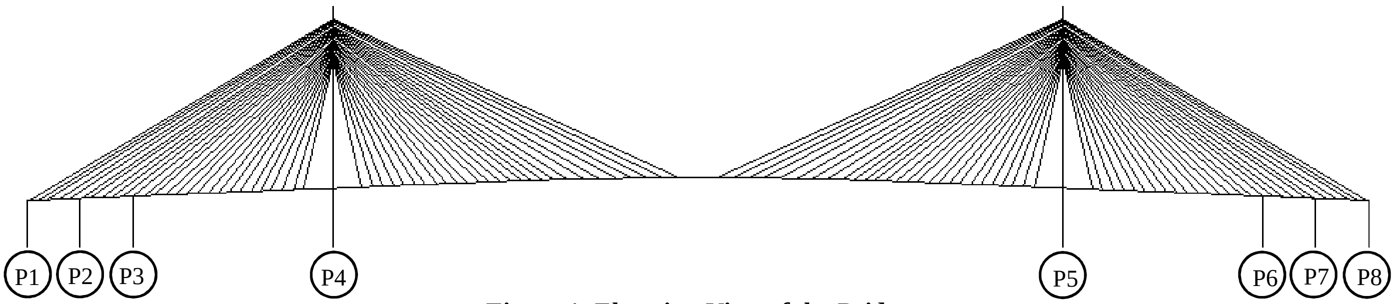

Figure 1. Elevation View of the Bridge

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2.3. Structure Modeling

The example bridge was modeled using the TDAP III software, based on the Finite Element Method. The main girder is divided into 252 two-dimensional elements. The bridge's dead loads and live loads are applied after geometry modeling. All nodes are fixed into a two-dimensional coordinate system.

Forced displacements are applied increasingly on the pylons and supporting piers until the structure damaged. In each case, several combinations of piers and pylons' settlement were evaluated to find out the most dangerous sample. In fact, the combination displacement of P4, P6, P7 and P8 is applied for almost situation.

3. RESULTS AND EVALUATIONS

The below figure shows the maximum stress appeared in the cable under the effect of the pylons and supporting piers' displacement (the structure was analyzed under the Strength I Limit State – AASHTO)

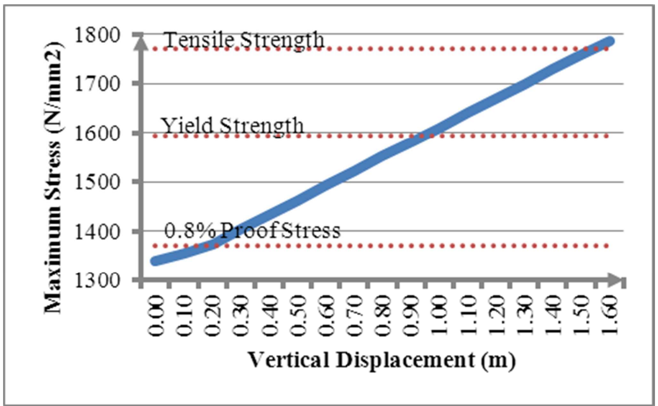

Figure 3. Maximum Cable Stress

Due to the increasing vertical settlement, the stresses inside the most tensioned cable grow up quite linearly. At the point where the displacement meets 30cm, the stress surpass the 0.8% proof stress limit, the overall stresses of all cables at this stage shown below (**Fig.4**):

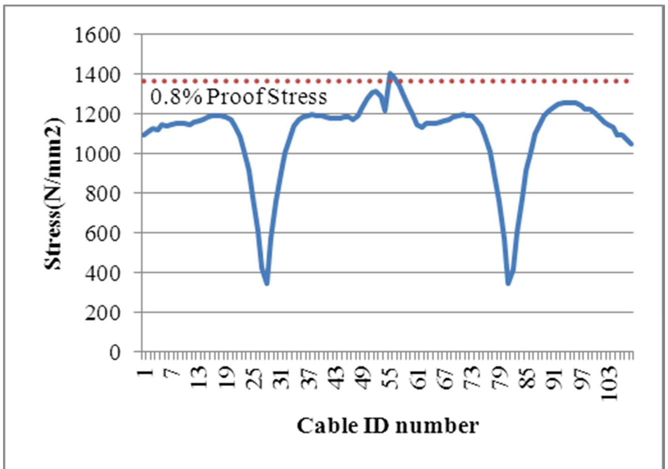

Figure 4. Cables' Stresses at Δ=30cm

Only 2 cables at the middle span reach the 0.8 proof stress limit and no cable have the stress that reach the yield strength limit, the bridge retains working ability.

When the vertical displacement grow up to 100cm (**Fig.5**), almost cable's stress was below the 0.8% proof stress limit, the cable at the middle span is still working. The bridge construction needs to be reviewed seriously.

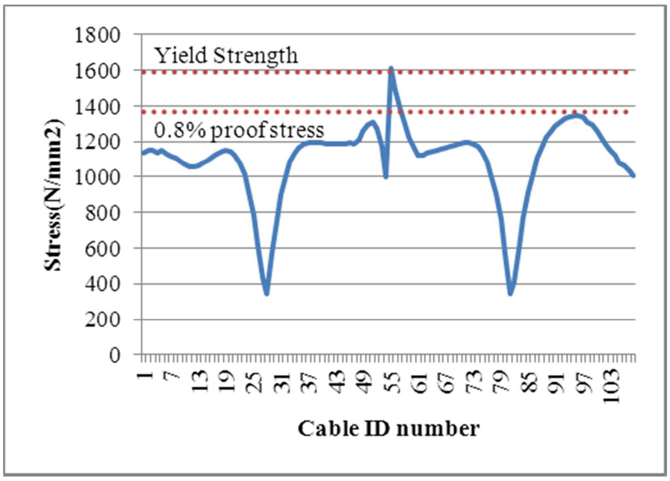

Figure 5. Cables' Stresses at Δ=100cm

The final figure (**Fig.6**) show the stresses in the cable when the vertical displacements reach 160cm. The mid-span cable surpasses the stress of 1770N/mm2, tensile stress, and not working anymore, the structure changes the working condition because of the damage. The bridge is in the dangerous condition and should not be exploited.

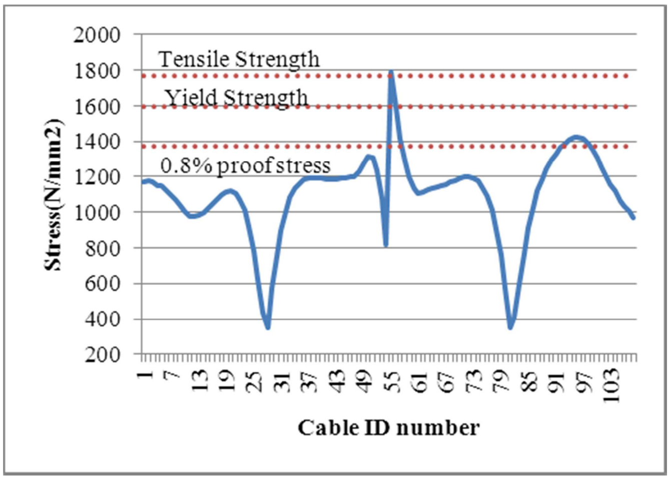

Figure 6. Cables' Stresses at Δ=160cm

4. CONCLUSIONS

The effects of pylons and piers' displacement to the cable-stayed bridge are significant and need to be considered seriously.

The limitation of settlement for construction working normally (8-30cm), specified by the AASHTO RLFD is completely suitable with the result of this study.

REFERENCE

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