CHAPTER 1

INTRODUCTION

1.1. General View

Conventional structures are built to withstand loads by relying on their own strength which comes from the materials that are used. To resist bigger load, the structure will have to be designed with higher ductility and strength. One consequence is to increase the dimension of the structure, which will also impose bigger load on the structure. As such, the structure will have limited performance. Moreover, the material used alone will not be sufficient to provide the desired damping properties to the structure.

The performance of the structure can be increased in many ways. One of the available methods is by applying control systems. In this case, devices will be installed to the structure. These devices will exert forces to the structure as they response to the changes sensed from structural motion and ground motion when needed.

Various control systems are introduced to improve the properties of the structure to overcome this problem. The systems will modify the response of the structure dynamically in a desirable manner. The systems are expected to adjust themselves to the changes in environment, and therefore they are called adaptive systems. A system might consist of sensors and control devices implementing an algorithm to reduce the effects of the environment to the structure. Many of these systems have been considered by researchers and their implementations in field shows that this concept is a promising way to protect structures from wind and seismic excitations.

1.2. Benchmark Problem

A benchmark problem based on the Missouri 74–Illinois 146 cable-stayed bridge spanning the Mississippi River near Cape Girardeau, Missouri, designed by the HNTB Corporation (Hague, 1997) named Bill Emerson Memorial Bridge has been proposed by Dyke et al (2002). The objective of this benchmark problem is to compare the performances of several control systems. A three-dimensional bridge model created based on detailed drawings of the bridge to represent the behavior of the full scale benchmark bridge. Researchers are invited to apply various algorithms, devices, and sensors to the model. Their performances will be assessed based on several criteria that have been identified as critical to the structure.

1.3. Overview of The Bridge of Cape Girardeau

The longitudinal section of the bridge can be seen in Fig. 1.1. The cable-stayed bridge of Cape Girardeau is composed of two towers, 128 cables, and 12 additional piers in the approach bridge from the Illinois side. It has a total length of 1205.8 m (3956 ft). The main span is 350.6 m (1150 ft) in length, the side spans are 142.7 m (468 ft) in length, and the approach on the Illinois side is 570 m (1870 ft). (Dyke et al, 2002)

A cross section of the deck is shown in Fig. 1.2. The bridge has four lanes plus two narrower bicycle lanes, for a total width of 29.3 m (96 ft). Additionally, a concrete barrier is located in the center of the bridge, and a railing is located along the edges of the deck.

The deck is composed of steel beams and prestressed concrete slabs. The reinforcement steel ASTM A709 grade 50W is used, with an f_y of 344 MPa (50 ksi). The concrete slabs are made of prestressed concrete with an f_c' of 41.36 MPa (6000 psi). The 128 cables are made of high–strength, low–relaxation steel (ASTM A882 grade 270). The smallest cable area is 28.5 cm^2 (4.41 in^2) and the largest cable area is 76.3 cm^2 (11.83 in^2). The cables are covered with a polyethylene piping to resist corrosion. The H-shaped towers have a height of 102.4 m (336 ft) at pier 2 and 108.5 m (356 ft) at pier 3. Each tower supports a total 64 cables. The towers are constructed of reinforced concrete with f_c' of 37.92 MPa (5.5 ksi).

The cross section of each tower varies five times over the height of the tower, as shown in Fig. 1.3. Section A is used in the top of the legs, section B in the middle of the legs, and section E in the bottom of the towers. Some of these elements have variable sections. Section D shows the cross section in the bottom strut, and section C shows the cross section of the strut located in the middle of the tower. The approach bridge from the Illinois side is supported by 11 piers and bent 15 which are made of concrete. The deck consists of a rigid diaphragm made of steel with a slab of concrete at the top. The densities of the materials as specified in the drawings are summarized in Table 1.1.

The bridge in located in the proximity of the New Madrid seismic zone. This fact makes the protection of the bridge against seismic activities a big challenge for engineers.

Table 1.1: Density of Materials (Dyke et al, 2002)

Material	Density (Kg/m^3)	Density (PCF)
Reinforced concrete	2402.77	150
Prestressed concrete	2482.86	155
Seal Concrete	2306.66	144
Stay cable grout	2322.68	145
Structural Steel	7849.08	490

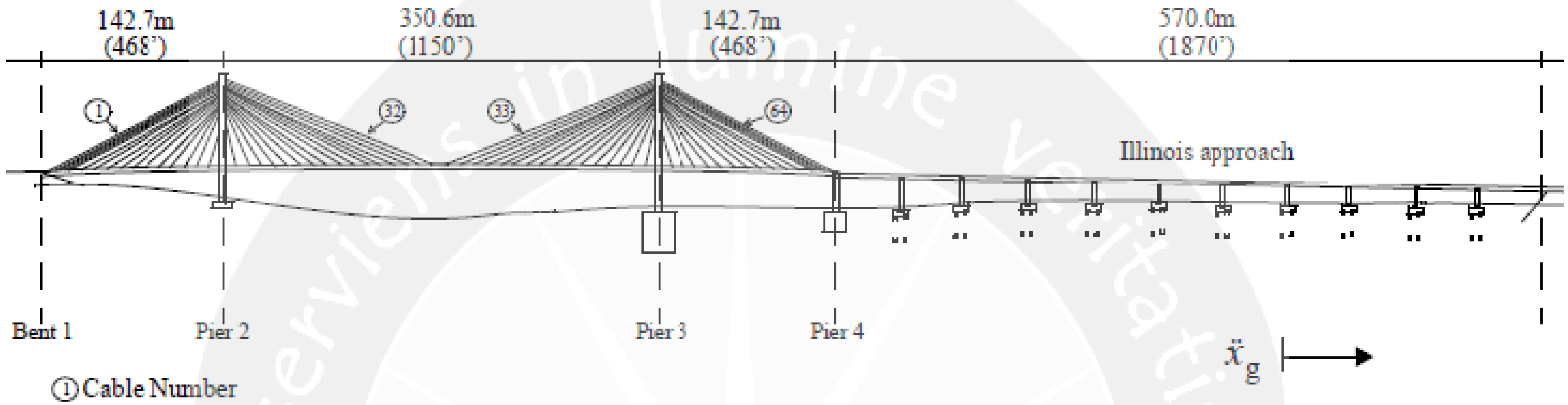

Fig 1.1. Drawing of Cape Girardeau Bridge (Dyke et al, 2002)

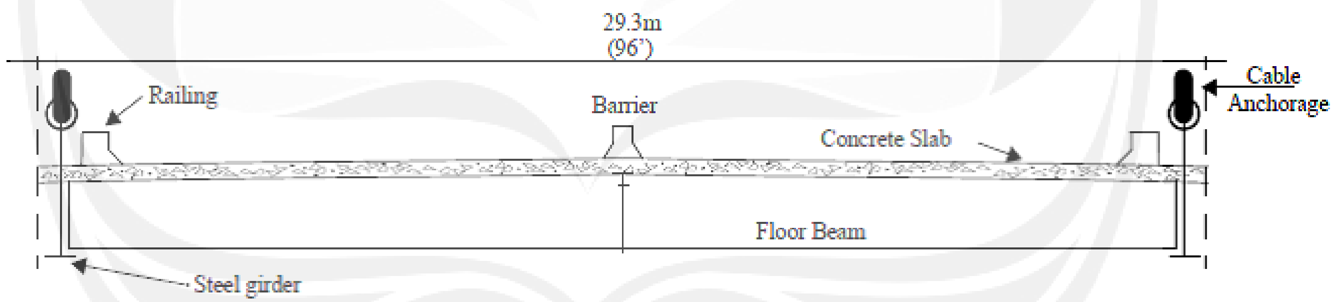

Fig 1.2. Cross-Section of Bridge Deck (Dyke et al, 2002)

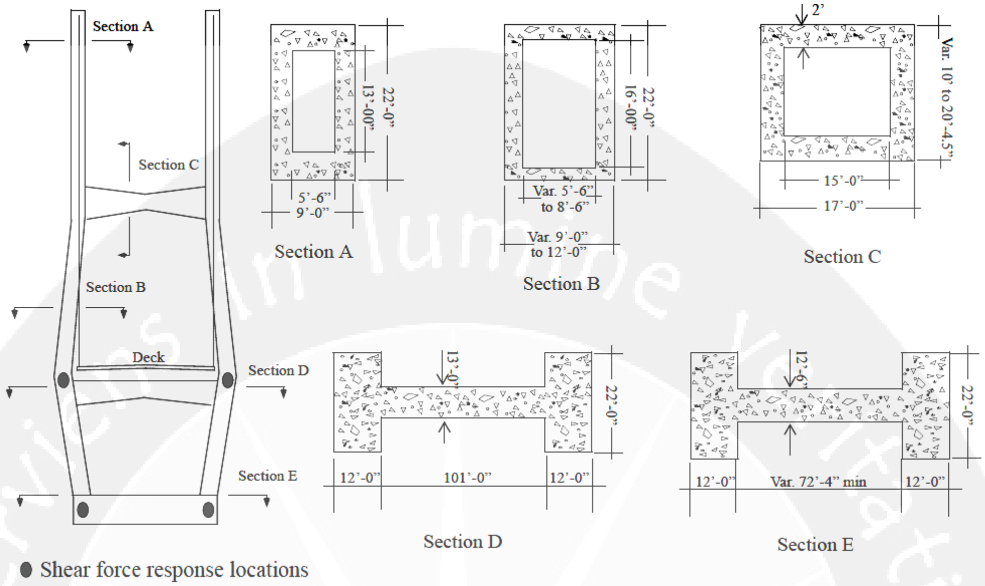

Fig 1.3. Tower Cross-section (Dyke et al, 2002)

1.4. Problem Limitations

The foundation of the bridge is attached to bedrock, so the effects of soil–structure interaction can be neglected. One-dimensional ground acceleration is applied in the longitudinal direction. This direction is considered to be the most destructive in cable-stayed bridges. (Dyke et al, 2002)