STATIC ANALYSIS OF SOPHISTICATED CABLE ARRANGEMENT ON PEDESTRIAN BRIDGE

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ABSTRACT

The purpose of this research is to study the principal theory of Cable stayed bridge and analyse the behaviour of cable stayed with sophisticated arrangement of cable stays. In this study, static analysis of pedestrian bridge had investigated. Static analysis is to determine the maximum and minimum stress on cable and deck, checking the maximum deflection, resultant moment and strain on the pedestrian bridge at sophisticated cable arrangement to compares with the conventional arrangement. In addition, sensitivity analysis is done to determine the behaviour of the cables when some parameters had changed to determine the analysis of the bridge when some parameters changed (high of pylons) due to static analysis. The important of this study came out when engineers hard to make a choice to build a bridge from design to the actual structure while maintaining aesthetic values. Aesthetic values are very important to maintain the identity of a bridge and thus become a landmark for the country. The design loads which are pedestrian loads are distributed to the joints on bridge deck. A total of each case will analyse three arrangement cables which are conventional arrangement (harp and fan) and a sophisticated arrangement, this study had been analyse using LUSAS software. The result shown, that the fan arrangement is ideal and suitable in construction for short-span structure while harp pattern is not the best from the static or economic point of view; it is attractive because of its undeniable aesthetic advantages. Thus, sophisticated arrangement is also very ideal arrangement because the static analysis results between the conventional arrangements. Furthermore it can maintain the aesthetic value.

ABSTRAK

Tujuan kajian ini ialah untuk mengkaji teori utama jambatan pejalan kaki dan menganalisis kekuatan susunan kabel yang rumit bagi jambatan pejalan kaki ini. Dalam kajian ini juga, analisis statik jambatan pejalan kaki telah dilakukan. Analisis statik adalah untuk menentukan tegasan maksimum dan minimum pada kabel dan dek, maksimum pesongan, daya lenturan dan ketegangan pada jambatan pejalan kaki di susunan kabel yang rumit untuk membandingkan dengan susunan konvensional. Tambahan, analisis sensitive adalah untuk mengkaji perubahan pada jambatan pejalan kaki apabila beberapa parameter telah diubah (tinggi pilon) dan analisis berpandu pada analisis statik. Kajian ini dilakukan adalah untuk membantu jurutera apabila mereka sukar untuk membuat pilihan yang terbaik untuk membina sebuah jambatan dari reka bentuk untuk struktur sebenar di samping mengekalkan nilai-nilai estetika. Nilai-nilai estetika adalah sangat penting untuk mengekalkan identiti jambatan dan dengan itu menjadi mercu tanda untuk negara. Setiap satu kes mengandungi tiga buah jambatan. Beban pejalan kaki diedarkan kepada dek jambatan. Sebanyak tiga jenis susuanan kabel bagi setiap kes adalah susunan konvensional (kecapi dan kipas) dan susunan rumit, kajian ini telah dikaji dan analisis menggunakan perisian LUSAS. Keputusan kajain menunjukkan susunan kipas pada jambatan pejalan kaki adalah lebih baik dari sususnan kecapi kerana susunan kipas sesuai digunakan pada dek jambatan yang pendek. Susunan kecapi tidak bagus dari segi static dan ekonomi tetapi susunan ini lebih menarik dari segi nilai astetik. Bagi susunan rumit, susunan jenis ini jugabagus kerana keputsan berada di tengah antara kecapi dan kipas.

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LIST OF SYMBOLS

kNm	kiloNewton meter
kN/m^2	kiloNewton per meter square
t	ton
s	second
k	kelvin

LIST OF ABBREVIATIONS

CA	Conventional Arrangement
SA	sophisticated Arrangement
LUSAS	LUSAS Bridge software

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

The process of analysis a pedestrian bridge begins by identifying the goals and objectives of the research. These research objectives are translated into the analysis, structural and aesthetic. Structural requirements, including providing adequate strength and durability, complies with the criteria of deflection, and to prevent excessive vibration. Aesthetic goals are more difficult to quantify, however, because they are often expressed in terms of meeting the requirements of the local community or create a landmark structure symbolic.

In building bridges, there are common problems that affect these projects from running smoothly. Project objectives are also sometimes interfere with the smooth running of the bridge. However, the purpose of a pedestrian bridge was built to facilitate and meet the scale of human life. Pedestrian bridge is usually built confines of the city for aesthetic considerations. Bridge designers, such as design professionals in other fields, are faced with the challenge of combining aesthetic goals into a complex set of functional requirements, consideration of structural constraints, and projects while keeping costs within budget.

Long-span pedestrian bridge is rare, because the bridge usually include pedestrian or bicycle access when needed. Most pedestrian bridges are built within the range of short to medium spans, for which numerous structural types and materials are feasible.

This variety of possible bridge types gives the engineer many choices for setting an appropriate structural system that at the same time defines or contributes to achieving the aesthetic goals. Other design professionals can adopt structural expression; however, structural engineers tend to use it with a different sensitivity that stems from their technical training. Engineers are also adapt at integrating bridge alignment, profile, structural details and overall structural form in order to achieve the project aesthetic goals within the discipline of cost and schedule.

Now, the development of bridge construction continues, constantly materials and new technologies were used. While very sophisticated techniques have been developed in order to study the aerodynamics of bridges and stay cables, comparatively few studies have been carried out concerning the static response of cable stayed bridges. This paper is to represent an analysis and modelling of the sophisticated arrangement cable for pedestrian bridge. Cable-stayed bridges are increasingly designed and built due to their aesthetic appearance, and on the other hand because in the scope of rehabilitations of old structures as well as in case of new designs external prestressing is more and more frequently used.

Cable-stay Bridge has three conventional types which are harp-shape, fan shape, and semi fan shape. The differences between those three types are the cable arrangement. The study will show the analysis of conventional arrangement (harp and fan) of cable and sophisticated arrangement on the pedestrian bridge. LUSAS software will use to analysed and modelling the conventional and sophisticated cable arrangement. At least four cases equal to twelve model of cable arrangement will be model by using LUSAS software to determine the local and global analysis. The loading being applied is considering dead load and live load.

1.2 PROBLEM STATEMENT

It was so many courses that effaced the failure of bridge. Most of the bridge collapse was a result of various factors such as weather conditions, accidents, failure of connections, deflection, structural failure and others (Ed Grabianowski, 1999). Bridge linked from one route to another route. For example, due to heavy rains in eastern South Africa, Mpumalanga, 14 people were killed after a bridge collapsed. The analysis shows that the bridge was carrying heavier loads or affects the world's climate affect the stability of the construction. Various construction criteria should be considered. Also, in 1904 in Canada Quebec Bridge collapsed during construction because the bridge cannot sustain the burden of death and the actual weight away from the bridge over the carrying capacity. (MP Bieniek, 1984)

One of the outstanding structural in bridge engineering is Cable Bridge. However, a different arrangement of cables and suitable type of cable for different lengths span bridges. Such as is pedestrian bridge. This type of bridge is short and built for pedestrians with its own aesthetic value and the problem here is to know the load capacity that can be borne by a pedestrian bridge.

Besides, this bridge should give priority to aesthetic value and relevance of the cable arrangement on the bridge. Besides, this bridge should give priority to aesthetic value. The aesthetic value of the bridge is very important. At modelling stage it give more priority for aesthetic value and relevance of cable arrangement on the pedestrian bridge. It gives challenges to engineer to model a complex or sophisticated cable arrangement regarding to the aesthetic value.

1.3 OBJECTIVES

The main objectives of this research are:

1. To study the principal theory of cable pedestrian bridge and analysed the conventional and sophisticated arrangement of cable in cable-stay Bridge.

2. Investigate the Static Analysis - Determine the maximum and minimum stress on cable and deck, checking the maximum deflection, resultant moment and stain on the pedestrian bridge at sophisticated cable arrangement to compares with the conventional arrangement.

3. Investigate Sensitivity Analysis – Determine the behaviour of the bridge when some parameters charged (high of pylons).

1.4 SCOPE OF THE RESEARCH

For this research, analysis and model will be using LUSAS version 14 software. A harp, fan or semi fan arrangement has been discussed at the beginning of the study. In this study four cases of cable arrangement will be model and analysed; two cases will investigated the static analysis and from these two cases, only one ideal and relevant case will be selected to continue the third objective which is investigate for sensitivity analysis. Each case consist a conventional arrangement (harp and fan) and sophisticated arrangement cable on pedestrian bridge.

1.5 SIGNIFICANT OF RESEARCH

This study is to evaluate the principal theory of cable Stay Bridge at pedestrian bridge. Analysis and model the arrangement of cable of the bridge to determine the stress of members. Thus, investigate static analysis and sensitivity behaviour in cable arrangement of the pedestrian bridge.

This study will help engineers determine the type of arrangement that will be used for pedestrian bridge. The results from both analyses will help engineers to design adequate arrangement for cable stay bridge cable in the future. Deflection, the resultant moment, shear resultant and strain analysis will show enough of a bridge suitable for pedestrian bridges. Reviews Bridge in Malaysia is very limited, so most of the references are taken from study abroad.

There has lack of studies by using computer software such as ANSYS, SAP2000, and LUSAS because, the limited experts in computer software that leads to a lack of exposure in the software engineering firm. By conducting this study, the use of LUSAS version 14 in completing the analysis will be exposed. Conducting analysis using computer software can save time for the analysis.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Most pedestrian bridges are built within the range of short to medium spans, for which numerous structural types and materials are feasible. The purpose of this chapter is to review of previous research related to my research in the order of cable-stayed bridge cable which are to determine the principal theory of cable pedestrian bridge and analysed the conventional and sophisticated arrangement of cable in cable-stay Bridge and the maximum and minimum stress on the cable and deck, the maximum deflection, resultant moment and Stain on the pedestrian bridge.

This research is helpful in offering insight into how the research efforts of the past have been included in this study the idea in principle. The research also shows valuable data that has been successfully done. The research is detailed so that the present approach can be properly adjusted to the current body of literature and adds well to allow the scope and limitations of this study.

2.2 CABLE STAYED BRIDGE

The cable stay bridge is an elegant, economical and efficient structure. Virtually unknown 40 years ago, these bridges become increasingly important as their properties have been more fully understood.

They have recently proved to be highly cost-effective for short to medium spans.(Rene Walther, Bernard Houriet, Walmar Isler, Pierre Moia and Jean-Francois Klien – cable stay bridge, 2nd edition ,1999) There are various types of stay cable typically used in bridge and two of the cables are Freyssinet and Anchorage. Stay cables are designed for Freyssinet prestressing system and the type of cable ties; anchored in the transverse girder in the main zone and the transfer of power by an adjustable anchor. Anchors in mast are fixed. Depending on the design of the bridge, the anchor can be constructed of stone or concrete.

Cables are attached to the anchors to keep the tension on the bridge. While still tightly bunched cables for most structures, they are usually separated into pieces before serving to distribute the load on the anchor tension (Ana spasojevic, 2009)

In Malaysia the development of cable-stayed bridges started in 1972 in Sabah, followed by the Penang Bridge in 1985 (currently the longest bridge in Malaysia) and the Motorola Interchange of Lebuh Raya Damansara-Puchong in 1998. The development of cable-stayed bridge in this country is becoming more popular with a few examples such as the Muar Bridge, Putrajaya bridges and Sungai Perai Bridge which is part of the Butterworth Outer Ring Road (BORR) project. Malaysia will continue to develop this system. Projects like the bridge linking Sumatera Island, Indonesia and Singapore are the probable candidates (Wahid and Razali, 2002).

2.2.1 Cable Stay Bridge Provided With A-Frame Pylons

The stiffness and stability of the structure can be even further improve by the use A-frame pylons, with the arms connected to the top. The deck and the two planes of inclined stay then behave like a rigid closed section in bending, which considerably reduces possible rotation of the running surface. Inclined suspension can give rise to certain clearance problems in the transverse direction, calling of the general increase in the transverse cross-section of the deck or the use of corbels in places, out from anchorages.

It is generally necessary to balance the transverse bending of the pylons, introduced by the deviation of the cables, by means of upper bracing; the erection of pylons consisting of vertical arms is simple and economical. (Rene Walther, Bernard Houriet, Walmar Isler, Pierre Moia and Jean-Francois Klien – cable stay bridge, 2nd edition ,1999)

2.3 CABLE

Cable stayed bridges are another common type of cable used in the construction of the bridge. However, in a cable-stayed bridge, less cable is required and the towers holding the cables are proportionately shorter. In a study that was done, the longest cable -stayed bridge is Sutong Bridge on the Yangtze River in China. Cable is one of the main parts of the cable-stayed bridge. They distribute the load off the deck to the pylon. This is a post-tensioned cables usually based on the weight of the deck. Of post-tensioned cables selected and maintained in a manner to reduce both the vertical deflection of the deck and the lateral deflection of the pylons. Cable selection in the construction of bridges depends mainly on the mechanical properties, structural properties and economic criteria. In addition, the type of cable-stayed bridges is discussed based on the order of stay cables including harp, fan, and a semi- fan as described.

2.3.1 Harp Arrangement

Whilst the harp pattern is not the best from the static or economic points of view, it is attractive because of its undeniable aesthetic advantages. The fact that the cables are parallel and cross each other at a constant angle in the eye of the viewer gives the structure a most acceptable appearance. This is why the architect F.Tamms insisted that all the bridge crossing the line Rhine at Dusseldorf should be constructing by that pattern. In spite of the notable differences so far as the static system is concerned and their different methods of construction, the Knie Bridge, Oberkassel Bridge and Theodor Heuss

Bridges are all built with the cables in harp pattern and form a harmonious ensemble, the only one of its kind of the worls. (Rene Walther, Bernard Houriet, Walmar Isler, Pierre Moia and Jean-Francois Klien – cable stay bridge, 2nd edition ,1999)

In order harp, cables made nearly parallel by attaching them to different points on the pole. From an economic point of view, this type of cable stayed bridges is not efficient and less suitable for long span bridges. This is because the long span bridges require more steel for the cables, compression in the deck, and the bending moment in the column. However, in terms of aesthetics it is attractive compared with other types of cable stayed bridges. Parallel cables provide the most pleasing appearance to harp arrangement as described by Bernard et al. (1988). In addition, the need for higher pylons is one of the disadvantages of this type of cable stayed bridges. (Sarhang Zadeh; 2012)

2.3.2 Fan Arrangement

In this type, the function of this cable, all cables stay attached to a point on top of each column. Relatively steep slope accommodation cable cause the cable cross-section is smaller than that of the harp. In particular, horizontal cable forces on the deck in this setting are less than the type of harp (Bernard et al., 1988). However, by adding and increasing the number of stay cables, anchor weights increase and come with cable stays anchored to a hard and difficult.

Therefore, the fan pattern is suitable only for the medium with a limited number of cable stays. (Sarhang Zadeh; 2012).The fan pattern brings all the stay together to the top of the pylons. This solution was use in several recent structures, such as bridge over the Rio Parani and can offer critical advantages.

1. The total weight if the cable needed is substantially below that harp patterns, given the more favourable mean slope of the stays.
2. The horizontal force introduced by the cable in the deck is less.
3. Longitudinal bending of the pylons remains moderate.

4. It is not only possible but also necessary to select side spans which are less than half the central span in length. Where the erection of the structures is by corbelling out, it is possible to take advantages of the stability provide by the piers or the abutments well before the closing of the central span.
5. Movement of the deck due to change in temperature can be absorbs by conventional expansion joint place cross by the abutment, if the horizontal connection between the pylons and the deck is freed. The deck-to-pylons connection provided by the stay is, in fact, flexibility to develop critical force systems.

At first sight, the fan patterns appear less attractive from the aesthetic point of view than the harp pattern because of the optical effect of the crossing of the cables, depending on the angle of observation. However the disadvantage is not apparent in large-span structures as has already been noted. (Rene Walther, Bernard Houriet, Walmar Isler, Pierre Moia and Jean-Francois Klien – cable stay bridge, 2nd edition ,1999)

2.3.3 Semi-Fan Arrangement

In this type, the function of this cable, all cables stay attached to a point on top of each column. Relatively steep slope accommodation cable cause the cable cross-section is smaller than that of the harp. (Sarhang Zadeh; 2012)

An intermediate solution between the extreme of harp and fan patterns, make it possible to combine in the satisfactory manner the advantages of both these systems, whilst avoiding their disadvantages. A semi harp configuration has shown itself to be ideal and the large number of modem cable Stay Bridge has been built using this principle. By spreading of the stays in the upper part of the pylons, good design of the anchorage details is possible, without appreciable the reduction of the deck and hence the efficiency of the stays systems.

Cable situated closed to the pylons is more steeply inclined than those in harp patterns, which make it possible to reduce the stiffness of the horizontal connection between the pylons and the deck. A stiffness which can itself be disadvantageous. With the aim of simplifying the anchoring of the first stays in the pylons, and for aesthetic reasons, the first bay is generally somewhat large than the normal cable spacing throughout the bridge. (Rene Walther, Bernard Houriet, Walmar Isler, Pierre Moia and Jean-Francois Klien – cable stay bridge, 2nd edition ,1999)

In particular, horizontal cable forces on the deck in this setting are less than the type of harp (Bernard et al., 1988). However, by adding and increasing the number of stay cables, anchor weights increase and come with cable stays anchored to a hard and difficult. Therefore, the fan pattern is suitable only for the medium with a limited number of cable stays. (Sarhang Zadeh; 2012)

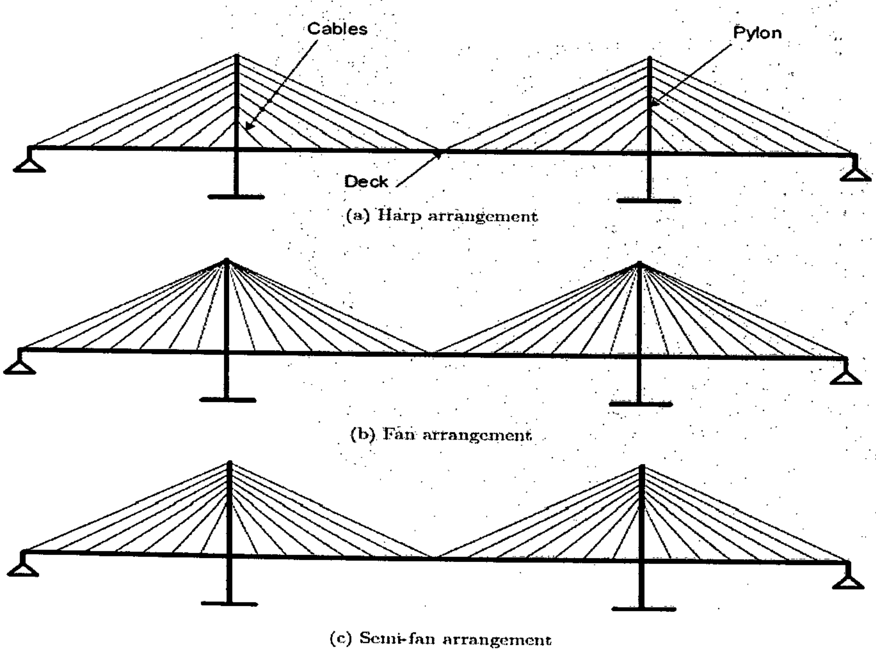

Figure 2.1: Conventional arrangement of cable

Source: Sarhang Zadeh; 2012