A LINEA[illegible]S FOOTBRIDGE

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ABSTRACT

The purpose of this dissertation is to study a linear static analysis of truss footbridge in different shape of truss. The important of this study come out where sometimes an engineer is taking much time or difficult to choose an effectives truss shape to design in real structure. In analysis, three shapes of truss are choosing which are Warren, Pratt, and Howe truss with pinned and roller support at the end of the bridge. The design loads which are pedestrian loads are distributed to the joints on bridge deck. A total of three shapes truss with 6 modelled were investigate and analyse using ANSYS+CivilFEM software. The analysis of all sets of trusses is dividing with two groups. The first group is all load is applied along the bridge deck for three shapes of truss footbridge. For the second group, the load is applied at the mid span of bridge deck. The analysis of all sets of trusses use the same length of the span, same loads and same height of the truss footbridge. The effective of truss shape is determined when the truss footbridge has the lowest displacement and lowest axial stress. The most effectives truss footbridge is depend on number of members and arrangement of member. All the member of the truss footbridge has compression or tension force. The truss footbridge analysis is successfully modelled using ANSYS+CivilFEM software and finite element method.

ABSTRAK

Tujuan projek ini adalah untuk mengkaji statik analisis dalam pelbagai jenis bentuk jambatan kekuda.Kepentingan kajian ini adalah disebabkan oleh kadang kala jurutera mengambil masa yang lama untuk memilih dan menentukan jenis jambatan kekuda yang sesuai untuk dibina.Dalam kajian ini,tiga jenis jejantas kekuda diplilih iaitu Warren,Pratt dan Howe dengan sokongan pin dan roda diletakkan di hujung jambatan.Beban pejalan kaki diletakkan di atas nod lantai jambatan.Sebanyak tiga benduk jambatan pejalan kaki dengan enam model telah di analisis menggunakan perisian komputer.Bagi menganalisis kajian ni,dua kumpulan telah di bahagikan.Kumpulan pertama,bebean diletakkan di sepanjang atas jambatan kekuda.Dan bagi kumpulan kedua pula,beban di letakkan di tengah dek jambatan kekuda.Analisis semua set jmbatn kekuda menggunakan saiz yang sama panjang beban yang sama dan ketinggian yang sama . Kekuatn jambatan kekuda adalah bergantung kepada bilangan anggota dan susunan anggota. Semua ahli jambatan kekuda mempunyai mampatan atau daya ketegangan. Analisis jambatan kekuda berjaya dimodelkan menggunakan perisian komputer dan kaedah unsur terhingga.

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LIST OF SYMBOLS

N_{ED}	The tensile force from the design value
$N_{t,Rd}$	The design tension resistance of the cross section.
$N_{U,Rd}$	Design ultimate resistance of the net cross section
A	Area of the cross section
F_y	Ultimate strength force
$¥_{M2}$	Resistance of cross section in tension to fracture
F_u	Ultimate strength force
$¥_{M0}$	Resistance of cross section whatever the class

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LIST OF ABBREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials.

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

A bridge is basically used to allow crossing over obstacles which are impossible or too dangerous to travel through such as river and road. The lack of bridge or the failure of one can cause serious traffic congestion to the country. Design of bridges are depends on the nature of the terrain where the bridge is constructed, the material used and the function of the bridge. The elements of a bridge can be classified into two primary components which are substructure and the superstructure.

In a bridge system, bridge substructure includes all foundation elements such as wall piers, columns, footing, pile caps, precast, drilled shafts, abutments bearing, pedestals, back wall, wing wall, sheeting and others. The substructure can be generalized as an abutment or pier which can be made of concrete, masonry, stone, steel and timber. The substructure refers to the elements of the bridge that transfer the loads from the bridge deck to the ground. The substructure consists of all elements required to support the superstructure and overpass roadway.

The superstructure comprises all the components of a bridge above the support.The superstructure of the bridge refers to the elements above the substructure which are bridge deck,pylon,wearing surface, primary members, secondary members and cable stays.Bridge deck normally consisits of a combination of various structural elements like longitudinal girders,tranverse girders,deck slabs and others.The deck will be continuous along the bridge span and continuous across the span. To support local patch loads, it will be act as plate. From the bridge deck, the weight is transfer to the

cables. The cable receives the loads and transfer to the pylons.The pylons has a role to receives all loadings from the cables and transfer the weight to the foundation.Finally,the foundation will receives all the loads from the pylons and transfer to the ground.

There are four types were considered of pedestrian bridges which are cable stayed, truss bridge, arch bridge and suspension bridge.The first type is cable stayed pedestrian bridge which are ability for long span and aesthetically pleasing view.The second type is suspension bridge which are ability for long span compare to other bridges, less material may be required even the span is long, leading to reduce for the construction cost, and aesthetically pleasing view . The third type is arch bridge which are aesthetically pleasing view and can support structure due to their ability to reduce bending moment and shear force while carrying the load mainly in compression. The last type is truss bridge which are not to difficult in construction and the use of trusses as a bridge components in large structure is still prevalent.

A footbridge also known as a pedestrian bridge is designed for pedestrians and in some cases cyclist, animal traffic and horse riders, rather than vehicular traffic. For poor rural communities, footbridge is use to access to medical clinics, schools and markets. There are three types of design footbridge include timber, steel, and concrete footbridges. A footbridge can be design as a truss pedestrian bridge.

The truss bridge is design in combination of many triangular to resist tensile and compression force. In trusses, the arrangements of members are indeed multiple steel sections. The truss is more economical and low budget to be constructed compare to beam structural form. The trusses are lighter because of the skeletal nature of construction .For the load the framework distributes the load of each beam and share a portion of the load. The truss bridge is encountered most often in historical engineering projects that require preservation or rehabilitation of an existing structure. Nowadays, the truss is the structure that commonly built because the truss members are typically fracture critical members which is there is no redundancy in the load path. If the one member fails, the whole structure would collapse.

1.2 PROBLEM STATEMENT

Commonly, one of the most serious or dangerous of truss bridge structure is their excessive deflection on bridge deck when subjected to pedestrian loading or walking person. The matter to be considered is the type of bridge truss will affect the bridge structure when the bridge deck receives the loadings and transfers to the ground. Engineers also face a problem to choose a suitable bridge to design in future in term of less failure.

1.3 OBJECTIVES

The main objectives in this research are:

a) To study the different types of truss bridge and its principal components.
b) To analysed different types of truss bridge using linear static analysis.

1.4 SCOPE OF STUDY

These studies focus an analysis of truss footbridge. Three types of truss are choosing which are Warren truss, Pratt truss and Howe truss. This study focused in static analysis on bridge deck which is stress distribution and displacement in horizontal and vertical axis under the load of pedestrian. Plus this study also check the compression and tension force of the truss member.The static analysis will be conducted by considering dead and live load.

The analysis will be carried out using ANSYS software. A simple pedestrian truss bridge will be modelled using ANSYS software. The pedestrian truss bridge is modelled with total length of the span is 20m. The height between bottom and top chord will be fix to 1.5m.Boundary condition for the three types of truss are consider as pin and roller.

1.5 SIGNIFICANT OF RESEARCH

In Malaysia, lack of exposure to computer analysis software is the main problem for a lot of engineering firm. Therefore, study in using ANSYS is the good method to save the time and cost compare to hand calculation.

Study on the different types of truss bridge which are warren truss, Pratt truss and Howe truss. This is a good research for an engineer. The results of the stress distribution and the displacement on truss bridge will allow the engineer to design an adequate shape of truss bridge in the future.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Bridge can be described as an elongated structure that have been constructed above ground connecting between two locations, but with some challenges exist underneath is such as river, traffic and etc. It is develop to get overcome these challenges with no disruption to the existed obstacles, structure or traffic.

According to W.F Chen (1999), a bridge is use to cross over a road, river, railway or other obstacles. There are two elements in bridge truss structure which are superstructure and substructure. The substructure are includes lower part, main trusses or girders, floor system and slab. And the substructure are includes columns, piers, towers, footings, piles and abutments. The superstructure is function to provide horizontal spans for example bridge deck and also girders in addition to carry traffic load specifically. And, the substructure is use to assist a substructure of bridge.

According to J.Kala,V.Salajka and P.Hradil (2009),a lot of bridges were produced in prehistoric periods. The Roman was designed many bridges in their time. These bridges were usually larger than they had to be, but this was done by the Romans to make sure that the component of the bridge were secure and would not confirm risky.

2.2 FOOTBRIDGE

According to Giuseppe Piccardo and Federica Tubino (2012), the modern footbridges can be very delicate to walking-induced the oscillations. The evaluation of footbridge oscillations is due to regular unrestricted pedestrian traffic. It is an external issue in the serviceability research of these structures components.

According to Avery Louise Bang (2007), pedestrian bridge is mainly identified by a population capacity to maintain the facilities over the long term. In non-urban areas, a footbridge is the important facilities to cross the river.

2.2.1 Loading for Footbridge

According to British Standard BD 29/04 states that all footbridge should be satisfy the vibration serviceability requirement in BD 37/01 [3] : Appendix B5.5.The loading also design according to standard Euro code 1: Part 2 which is defines models of traffic loads for the design of road bridges, footbridges and railway bridges.(J.Kala et all;2009).

The load on the cable must be computed to find the tension in the cable. The design approach is according to American Association of State Highway and Transportation Officials (AASHTO) and base on supplemental "Guide Specification for Design of Pedestrian Bridges" document (AASHTO,1997).(Avery Louise Bang;2007).

Generally, the nature of loads can be divided in two which is permanent and transient loading. The permanent loads are including the dead load of structure and superimposed dead loads. Plus, the transient loads is includes of vehicular live loads, pedestrian live loads, impact loads, wind load and earth quake loads. The general trend has been for the permanent loading to decrease and transient loading to increase as bridge design. The design of the bridge will be done according to BS5400 and under Din Standards (Christos Ellinas;2010).

2.3 Dead Load

The dead load or permanent load is the loads which always remain and act on a bridge throughout its life. The dead load is referring to the aggregate weight of all permanent, non-moving superstructure elements resting on the substructure.

There are three sources for the dead load for the pedestrian bridge which are self-weight of the concrete deck, the self-weight of the structure, and the weight of any railing/supports on the side of the walkway (James F Welch et all;2012).

The self-weight of the structure is a permanent loading and the water volume present is considered as a super imposed load (Christos Ellinas;2010).

2.4 Live Load

The live load is referring to the temporary and moving load such as vehicular traffic. There are three types of live load that applied to the bridge which are pedestrian, wind, and moving service vehicle. The specified live load for a pedestrian bridge is 4.3 kPa (90 psf).It is described in the load and resistance factor design LRFD Guides Specification for Pedestrian Bridges. For the live load of 4.0 kPa(85 psf) was applied with a check on the dynamic response(James F Welch et all;2012).

The average weight of a pedestrian loading is 700 N and the load density is set to be 1.5 person/m^2.For the pedestrian load, it is uniformly distributed on the whole bridge deck. The walking activities can be classified into four types according to pacing rate which are slow walk(less than 1.8 Hz),normal walk (1.8-2.2 Hz), brisk walk (2.2-2.7 Hz) and fast walk (greater than 2.7 Hz) .(Ming-Hua Huang et all ;2008).

2.5 Material for Footbridge

The construction cost of steel bridge tends to become lower compare to the concrete bridges. There are two types or steel bridges which are orthotropic steel bridge and steel box girder. For the case of concrete deck of a composite steel bridge, it use to increase the area reinforcement rather than to increase the thickness of the slab. And for the main girder of steel bridges, it will use to increase the design size of critical section rather than to decrease them from the standard point of LCC-effectiveness. Steel bridges also have high quality material, speed of construction, versatility, durability and aesthetics. (Kwang-Min Lee et all;2003).

There are two types of materials usually use in superstructure construction. The materials are steel and concrete. Steels have more advantage compare to concrete. Steels have the lighter weight and more rapid construction. Using steel, it reduces the amount of field labour for operation such as bolting and welding and much more competitive with concrete. Element assembly and welding automation and the use of stay in place forms are just two examples of how steel has improved to meet the challenge of the concrete bridge.(Demetrios et all;2007).

Steel truss has more advantage when using in design of footbridge. Steel has higher ductility, strength and toughness. But to prevent rusting, steel must be painted (W.F. Chen;1999).

2.6 BASIC BRIDGE TYPES

2.6.1 Girder Bridge

The most common and basic bridge is a girder bridge. The length of Girder Bridge is usually between 10 m to 200 m. Two types of Girder Bridge which are I-beam girders and box girders is a common use in girder bridges. The advantages of box girder are able to use for longer span, greater distance and more stable. But the design is more difficult. Compare to I- beam, it is less strong and stable. I-beam is more easy and simple to design (Troitsky, 1994).

2.6.2 Rigid Frame Bridge

Rahmen bridges are also known as rigid frame bridges. For the rigid frame the piers and girder is combine in one solid structure. The design for the rigid frame is more complicated compare to simple-le girder bridges. There are two types of cross sections of the beam in rigid frame which are I shaped and box shaped. But nowadays the styles are almost use (Wenzen,1998).

2.6.3 Suspension Bridges

According to Walter Podolny,Jr.,P.E(1995), suspension bridges are suitable for longest span with cables made of hight strength,zinc-coated and steel wire.Suspension bridges have been one of the preferred bridge types for major bridges because it can construct with long spans,good seismic performance,light and beautiful appearance.

This is support by other researcher which is suspension bridges have been recognized the structure due to the their aesthetic appearance as well as the structural advantages of cables.With the construction technologies and advances in structural analysis techniques,a 2000 m of main span of suspension bridge become reality.Both geometric and material non linearities of structure will be consider for more accurate and precise analysis techniques if the main span length become longer.The non linearities result from the cable sag effect,axial force bending moment interaction in the girder and tower and large displacement is come from non linear stress strain behaviour.(Seung-Eock Kim et all;2010).

2.6.4 Truss Bridge

According to Tihitina Siyoum(2007),truss members are usually presumed to be link with pins at their ends. Every single member of the truss is resisting an axial force both in compression and tension.The dead load of a truss bridge consists of the weight of the floor system, truss, and bracing. The weight of the floor system, which comprises a large percentage of the total weight, can closely be estimated by making a preliminary design of the floor. From the weight of the floor system and bracing the load applied to

the truss can be determined.Before dead load analysis of the truss can be made of the main trusses the weights of thetrusses must be estimated. When using softwares, the self weight of the truss is calculated by the software. When using hand calculation, the weight of the truss can be estimated by increasing the other dead loads by some percentage or by using some approximate formula. The Hudson formula, given as Eq. (2.1), can be used for estimating the weight of the truss.

$W = 17\,S\,L/s$ (2.1)

where:

W is the total weight of the bridge truss including its bracing

S is the maximum total tensile stress in the most stressed chord member

L is the length of the truss in feet

s is the allowable tensile stress

Since S is the maximum total tensile stress due to live load plus impact plus dead load, a value has to be assumed for the truss weight to apply the formula. For this effect, the largest tensile chord member is assumed to extend for the full length of the truss and its weight is assumed to equal 20 percent of the weight of the entire truss and bracing.

The truss is a simple structure with the span length range is between 40 to 500m.All beam in a truss bridge are straight and involves force in tension and compression. The design and fabrication of truss bridge is more simple compare to other bridge. There are three basic truss which are Warren truss, Pratt truss and Howe truss. (Menn and Gauvreau, 1990).

The Warren truss was designed by James Warren in 1848 and become the most popular bridge. To spread out the loads on the bridge, the truss members of the Warren truss was used an equilateral triangle. Other than that, the equilateral triangles is use to reduce the force to only compression and tension (Garrett Boon; 2011).

The design of Warren truss is so famous compare to other types of truss bridges. It is because the Warren truss use equilateral triangle. Each of the trusses has same length. This in effect reduces the force to only that compression and tension. But the

members may switch from been compressive member to one of been tensile when the load is applied to a moving force such as car on a bridge.

The Warren truss will reduces the weight of steel for a smaller span and also will reduces the fabrication costs as it eliminates the need for web members of different length.

Pratt truss was designed by Caleb Pratt as an architect and Thomas as an engineer in 1844.The compression force was occurred at vertical member and the tension force was occurred at diagonal members. The Pratt truss and its derivations had become the most famous metal in the United States by the early twentieth century (John Schroer,1970).

For the Pratt truss, the diagonal members are act to be in tension and the vertical member is act to be in compression. Since these members are in tension, the members tend to be thinner than others as steel is exceptionally strong in tension. This turn can lead to be more economically design of bridge structure.

The actual Howe Truss had been designed by William Howe throughout 1840. This utilised mainly wooden throughout construction and had been well use for extended spans as opposed to Pratt truss. For that reason, the idea became very popular and had been considered the most effective types regarding railroad bridges (Garrett Boon; 2011).

In 1840, the Howe truss is design at that time to limit the stress analysis. The components members of the Howe truss was used a metal for the vertical tension and used a timber for the diagonal compression members. It was called a combination of truss when using of metal and wood materials (Edward; 1976).

This type of bridge is known to be the reverse of the Pratt truss. The diagonal members of all point are away from the centre of the bridge deck. The Howe truss is cause to be in compression rather than tension. So, it requires large steel members in

construction which cause it to be excessively heavy and an uneconomical choice of steel.

2.7 TRUSS COMPONENT

A truss is a structure consisting of member that linked together to form a rigid structure. In most trusses, the members are organized in interconnected of triangles. Because of these arrangements, truss members are mainly in tension and compression when carrying the load.

Each truss is composed of a top chord, bottom chord and several vertical and diagonal members. The deck is the one major component of a truss bridge that usually not created of metal. The material of bridge deck or bridge patio is usually made from concrete, but it also might build from wooden plank or steel grating. Their weight is directly supported by the deck when subjected to pedestrian loading or vehicles.

Then the deck was transferred the load to the floor beam. The floor beam are subjected to dead load reaction from outside and interior stringers.These reactions are applied as concentrated loads to floor beams. The concentrated live loads applied to floor beams from stringers are calculated and placed in the design lane to cause maximum live load moment. Live load bending moment coming from lane load is also computed. Impact moment is then calculated, the total moment summed up, the required section modulus calculated and used for the selection of suitable floor beam.

In truss bridge structure,there are two common types of structural connection used in trusses.There are pinned connection and gusset plate connnection.Pinned connection were used widely in the real structure of truss bridge.For the gusset,the pinned connection uses a single large metal pin to connect two or more members together.