

FINITE ELEMENT ANALYSIS OF STEEL ARCH FRAME USING ANSYS

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ABSTRACT

In this study, A arches are a continuous-curve, plane, structural elements usually lie in a vertical plane designed to carry load, especially vertically. The main characteristic is the ability to move the arch of the external load through the power mainly, with the support of the compression. The 3D arch frame analysed by manual calculation and ANSYS program with the probability method. This analysis is to determine the stress, strain, deflection and deformation. In addition, the structure is examined according to Eurocode 3 as well. It is very stable in terms of everything and low cost. Materials and space truss geometry satisfied for this study because it passed all design criteria in the design of tension, compression and buckling. Numerical results show very good agreement with the results of manual calculations. From the simulation results, we recognize the actual behaviour of the structure under the applied load. In the analysis of probability, we get the results of the cumulative distribution function, histogram plot, and history plot sensitivity easily by 10,000 times simulation for any input and output.

ABSTRAK

Dalam kajian ini, A gerbang adalah berterusan-keluk, kapal terbang, elemen struktur biasanya terletak pada satah mencancang yang direka untuk membawa beban, terutama menegak. Ciri utama ialah keupayaan untuk menggerakkan gerbang beban luaran melalui kuasa terutamanya, dengan sokongan mampatan. Rangka gerbang 3D dianalisis dengan pengiraan manual dan program ANSYS dengan kaedah kebarangkalian. Analisis ini adalah untuk menentukan tekanan, terikan, pesongan dan ubah bentuk. Di samping itu, struktur diperiksa menurut Eurocode 3 juga. Ia adalah sangat stabil dari segi segala-galanya dan kos rendah. Bahan dan kekuda ruang geometri berpuas hati untuk kajian ini kerana ia lulus semua kriteria reka bentuk dalam reka bentuk ketegangan, mampatan dan lengkokan. Keputusan berangka menunjukkan perjanjian yang sangat baik dengan hasil pengiraan manual. Dari hasil simulasi, kami menyedari tingkah laku sebenar struktur di bawah beban yang dikenakan. Dalam analisis kebarangkalian, kita akan mendapat hasil fungsi kumulatif pengedaran, histogram plot, dan sejarah sensitiviti plot dengan mudah dengan 10,000 kali simulasi bagi apa-apa input dan output.

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LIST OF SYMBOLS

tw	Web thickness
tf	Flange thickness
hw	Height of web

i	Height
b	Width
d	Depth
A	Area of section
I	Moment of inertia
W_{pl}	Plastic modulus
i	Radius of gyration
N	Axial load
V	Shear force
M	Moment
α	Imperfection factor
γ_{M0}	Partial factor for resistance of cross-sections whatever the class is
γ_{M1}	Partial factor for resistance of members to instability assessed by member checks
λ	Slenderness value
\emptyset	Value to determine the reduction factor
X	Reduction factor
L_{cr}	Buckling Length
K_{zy}	Interaction factor
[K]	Global-coordinate structure stiffness matrix

LIST OF ABBREVIATIONS

2D	Two Dimensional
3D	Three Dimensional
CIVIFEM	Civil Finite Element Method

LatBuck	Lateral Buckling
ChckAxis	Check Axis
BMSHPRO	Beam and Shell Properties
CS	Coordinate System
LS	Load Step
DOF	Degree of Freedom
PRES	Pressure
GAUS	Gaussian
DENS	Density
ELASTIC	Elastic modulus
POISON	Poison ratio
LOAD	Point load
WINDLOAD	Wind load
TEMP	Temperature
PDF	Probabilistic density function
CDF	Cumulative distribution function
MAXIMUMDEFLECTION /MAX_DEFLECTION	Maximum Deflection

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Arch shape is more impressive to transfer loading against the beam line, due to its ability to withstand general loading by combination of compression and reduced major axis bending different action along its length (Pi Y-L, Trahair NS, 1998). Steel arches that are widely used in the global environment, development, especially in length along the span elements such as terminal roof, bridges and airports . Steel as the material known for having a rather extensive durability, versatility, ductility and strength to weight ratio as compared with the usual material used in construction. This useful properties, coupled with the advances in technology that allow efficient production of steel structure design standard and complex, which popular use of the steel arches.

Civil engineers design and build structures and facilities that are essential in our daily life's primary. Civil engineering maybe be in the area of engineering, because it is associated with the creation, enhancement and protection of the environment, providing facilities for living, industry and transport, including large buildings, road, bridges, canal and other engineering construction. Throughout history, civil engineering has made significant contributions and advances towards the environment and the world we

live in today. In the recent year, there are advances in computer technology and there is a trend toward the use of computer for modeling in the design structure analysis. Engineers are often dealing with the problem of choosing the proper dimension structure consistent with safety, cost effective, aesthetically appealing design.

Currently available a lot of software which already used to design and structural analysis. The main function of this software is to make the work becomes easier to get a more precise result. Software has performed some equations that govern the behavior of similar elements and solve problem. STADD III, AXIS VM, ANSYS and ETABS are several software that can be used to analyze the steel structure.

1.2 PROBLEM STATEMENT

In Malaysia, a major problem in the construction of buildings and civil engineering is preferred concrete structure design comparable to steel structure design. Lack of use of lead exposure steel structure design software application that helps engineering firms to analysis steel structure regarding the increasingly widespread use in other countries. The introduction of ANSYS CivilFEM software has resulted in considerable advances in the analysis and design of the steel arch structure. Therefore, it is great encouragement to study and understand the use or software in solving the practical problem.

1.3 RESEARCH OBJECTIVE

Every thesis has its own objectives. The objective depends on what we want to achieve. The objective is target for everything that we want to do. This thesis has a few objectives that related to the arch frame analysis. So many things we need to find to realize these objectives are:

1. To analyze the steel arch frame using ANSYS software.
2. To determine the deflection on the arch frame when the load is applied.
3. To study probabilistic response analysis of arch frame.

1.4 SCOPE STUDY

To achieve the objectives of this research, the scope of which has been identified in this project. The scope is to analyze the design steel arch frame using ANSYS. Before analyzing, I need to study and become familiar with software ANSYS. In order to start, getting and learning tutorial from the CivilFEM. There are many tutorials to try and explore before I start my steel arch frame analysis. The study shows how the load will affect general structure and more specifically, how load affect the moment, stress and strain of arch structure.

For this project, the design height must minimum height of four storey building and all member structure is passed without having any member failed during model is the analysis. The material for this analysis will chose from the Ansys CivilFEM material library. By using the Eurocode 3, steel grade is used is Fe510 and shape is pipes.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION OF ARCH

Curved structure, characteristic that promote their well-know, the best economics of engineering construction. It is typically used in construction of entertainment hall and exhibit pavilions. Due to the high level of compressive forces that occur in the arch, one of the main design problem is the issue of buckling arch. For example, the critical loads for circular and parabolic arches, including the boundary conditions are different, give (John Wiley & Sons; 1976) and the Langer girders stability has also been considered (Wiesbaden: Vieweg; 1982). Most ordinary practically apply using the parabolic arches normally two hinged arch because the arch as it is known parabolic line represents the pressure in case a uniform load. The adverse arch frequently carried by tension ties which connects both arch support. In order to remove negative slack that series, frequently backed acquire vertical hangers.

2.2 TYPE OF ARCH

Arches are a continuous-curve, plane, structural elements usually lie in a vertical plane designed to carry load, especially vertically. The main characteristic is the ability to move the arch of the external load through the power mainly, with the support of the compression. Because this issue accommodate horizontal and vertical reactions at both ends, suitability depends on the ability of the support structure to hold the transverse component of force without excessive movement. If one end of the transverse arch does not withstand changes in behavior with a curved beam, laden dominant in bending with an extended range of issues which will vary depending on the applications where space fence arches in a situation where the fundamentals are not able to resist horizontal loads. Arches are usually classified according their support condition of which there are three principal types.

2.2.1 FIXED ARCH

Fixed arch is the most efficient type of arch due to their rigidity, but depend on a strong buffer to react vertical, horizontal and rotational required. Because there are three reactions in any capacity to make a total of six unknown, only three equilibrium equations can be generated can not be determined to make the arch of the third degree. A solution of rotation relative or advocate can introduce significant additional pressure. In a system of fixed arch is usually used in on-site concrete arch structure due to the nature of the construction method, but this rarely used as a solution in the use of lightweight structure, especially transformable structure.

2.2.2 TWO-PIN ARCH

Two-pin arches are the usual form as a supporting structure allows the rotation of the pin at the end of the arches under load, temperature changes and accommodate horizontal support settlement, making them quite flexible and less likely to develop high bending stress. Together the four forces of reaction and three structural balance equation is indeterminate to the first degree.

2.2.3 THREE-PIN ARCH

Three-pin arch contains one additional pin is usually located in crown structure. Additional pin allows supporters to move freely without bending stress developing in both parts of the arches. This structure is static. For this reason it is not sensitive to changes in temperature solution or vertically and horizontally. Uses series system between the arches support structure change two pin and three pin arches to a closed system. This feature is useful where support is unable to provide the required transverse reaction. Arches in this case acts as an independent unit, because the tie that brings the horizontal reaction. This type of arches is stable system itself does not require power horizontal structural support and is somewhat influenced by the vertical settlement of the sport. Form arches structure is common solutions for lightweight structure and can be used together with two pin and three pin configuration arches.

2.3 FINITE ELEMENT AND ANSYS CIVILFEM

Finite element analysis consists of the computer model of a material or design that is stressed and analyzed for a specific result. It is used in new product design and existing

product refinement. A company is able to verify a proposed design will be able to perform to the client's specification prior to manufacturing or construction. Modifying an existing product or structure is utilized for quality the structure for a new service condition. In case of structural failure, FEA may be used to help determine the design modification to meet the new condition. ANSYS+CivilFEM allows to solve with only one software a wide range of reinforced concrete structure, steel structure, prestress concrete and etc. CivilFEM is suitable for modeling steel structure and other type structure. Special beam elements are used to model the bending moment in frames, tunnel linings and other slender structure.

It can be visualized in enhanced graphical features, the ANSYS CivilFEM software incorporates a steel database with a wide range of tools used for analyses and calculations. The database contains the following characteristic includes steel properties not considered by ANSYS, allows the user to make correlations between variables with different origins or different definitions, a very common practice in steel and includes libraries of characteristic properties of steel and type cross section as well as a vast number of correlations obtained from related literature and experience.

2.3.1 THE ANSYS PROBABILISTIC DESIGN SYSTEM

With its name, the ANSYS probabilistic design system (APDS) was created to address the problem of probability. Therefore, it can be used to analyze the uncertainty or reliability analysis. It is tightly integrated in the ANSYS, using the same graphical user interface, and it has the same look and feel as a form of self ANSYS. The engineers are comfortable with performing advanced finite element analysis using ANSYS regular basis. The APDS by ANSYS Parametric Design Language (PDL), which allows users to parametrically construct a finite element model, finish, obtained results and the results of its output parameters including maximum tension for example.

In addition, PDL provides the possibility to use input variables and parameters results in arithmetic expressions, do-loop and construct if-then-else. With the APDS is completely free of physics arrested in finite element analysis, and for example, includes a range of typical linear elastic stress calculations for multi-physics analysis plus the with more advanced.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

Methodology is a guiding system for solving a problem, with specific components such as phases, tasks, methods, techniques and tools. By using this approach, the project can run in a smooth way. This research consists of four phases. First, a study produced by the objective and purpose. Second, the data obtained from previous studies, carried out the source book and journal. Third, the study conducted. Finally, the result will be compared and conclusions are made.

3.1.1 INFORMATION GATHERING

This process starts in the beginning of the research. The purpose of this process is to find the useful information about the topics and start collecting the information to give more understanding for what's supposed to do in this topic generally. All the information about the steel arch frame structure and the Ansys CivilFEM are being searched. The methods that being used information gathering are from reading the articles, journal, past thesis, books and from the internet.

3.1.2 LITERATURE REVIEW

A literature review knows as substantive findings as well as theoretical and methodological contributions to a particular topic. It can be secondary sources, it also can be interpreted as a review of an abstract accomplishment. Most often associated with academic-oriented literature, such as a thesis, literature review usually proceeds a research proposal and result section. Its main goals are to situate the current study within the body of literature and to provide context for the particular reader.

The purpose of this process is to give the knowledge more detail about research topics. Review of the literature has used the steel structure of journal articles, conference papers, theses and books relevant prior test associated with the topic. Numerous studies describe the versatility of ANSYS CivilFEM and also success in solving the problem of steel structures is discussed.

3.1.3 ANSYS SOFTWARE

As start for this project, the basic step of Ansys CivilFEM software had to be learned. By using the tutorial form CivilFEM, makes the learning process much easier. The other resource, such as the internet and past thesis are being used to make better understanding about this software. ANSYS is general purpose finite element modeling package for the numerical solution of various problems of mechanical problems. These problems include the study of static and dynamic structure, heat transfer and fluid problems and also problems of acoustic and electro-magnet. In general, finite element solution can be divided into several stages. This is a general guideline that can be used to provide any finite element study.