

FINITE ELEMENT ANALYSIS OF  
SLAB BRIDGE WITH BEAM ELEMENT  
USING ANSYS

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## **STUDENT'S DECLARATION**

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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## ABSTRAK

Dalam kajian ini, model jambatan rasuk telah dianalisis dengan menggunakan ANSYS. Kajian ini adalah untuk mengkaji kecukupan pengukuhan dan juga mengkaji tingkah laku struktur mengikut Eurocode 2. Struktur ini dianalisa menggunakan analisis unsur terhingga menggunakan ANSYS untuk memeriksa kecukupan pengukuhan. Dari hasil simulasi, kita dapat mengetahui tingkah laku struktur di bawah parameter masukan yang digunakan. Di samping itu, dengan menjalankan analisis probabilistik, kami mengumpul hasil fungsi agihan kumulatif, graf histogram, graf kepekaan dan graf sejarah untuk semua parameter. Graf tersebut menunjukkan maklumat seperti nilai min, sisihan piawai, nilai minima, nilai maksimum, kecondongan dan kurtosis parameter. Nilai bagi parameter keluaran dihasilkan dengan simulasi Monte Carlo secara rawak. Parameter keluaran dihasilkan berasaskan parameter masukan yang dihasilkan melalui analisis probabilistik dengan sistem reka bentuk probabilistik ANSYS. Nilai min, sisihan piawai, nilai minimum nilai sampel, nilai maksimum, kecondongan dan kurtosis parameter keluaran ditunjukkan melalui graf sejarah sampel. Sampel 5000 simulasi analisis probabilistik dilakukan, untuk memastikan hasil analisisnya tepat dan seragam. Panjang model ialah 20m. Pada akhirnya, beberapa cadangan diberikan untuk memperbaiki perisian ANSYS untuk memastikan pengalaman pengguna yang terbaik.

## ABSTRACT

In this research, a beam bridge model has been analysed by using ANSYS. This research is to investigate the adequacy of reinforcement and also checking the structural behaviour of the structure according to Eurocode 2. The structure is analysed using finite element analysis using ANSYS to check the adequacy of the reinforcement. From the result of simulation, we can know the behaviour of the structure under the input parameter that applied. Beside these, by carrying out the probabilistic analysis, we collected the result of cumulative distribution function, the histogram plot, sensitivity plot and simple history plot for all parameter. These plots show the information such as mean value, standard deviation, minimum value, maximum value, skewness and kurtosis of the parameters. The values for the output parameter were generated with Monte Carlo simulation randomly. The output parameter is generated based the input parameter generated through probabilistic analysis with ANSYS probabilistic design system. The mean value, standard deviation, sample values minimum value, maximum value, skewness and kurtosis of the output parameter is presented through sample history plot. 5000 loops of probabilistic analysis simulation is done, to ensure that the result of analysis is precise and uniform. The length of the model is 20m. At last, some suggestions is given to improve the ANSYS software to make sure the best user experience.

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## LIST OF SYMBOLS

$\alpha_{cc}$	Coefficient of long term effects on compressive strength
$\beta$	Centroid ratio
$r$	Radius
$h$	Height
$b$	Width
$d$	Effective of section
$\beta$	Centroid ratio
$f_{yk}$	Characteristic yield stress of the reinforcement
$f_{av}$	Average stress
$A_s$	Area of steel reinforcement
$F_s$	Force of steel
$M_{Rd}$	Moment equilibrium
$\gamma_s$	Partial safety factor for steel
$\gamma_c$	Partial safety factor for concrete
$\emptyset$	Diameter
$\pi$	Pi
$x$	Distance
$E_s$	Modulus of Elasticity
$\epsilon_{cu2}$	Ultimate concrete compressive strains
$>$	Greater than
$<$	Lesser than

## LIST OF ABBREVIATIONS

BBH	Distance between holes
BBOT	Bottom width
BCNL	Bridge and Civil Non Linearities
BM	Middle width
BTOP	Top width
BS	British Standard
CDF	Cumulative distribution function
CivilFEM	Civil Finite Element Method
DOF	Degree of freedom
EC2	Eurocode 2
E view	Elevation view
FEM	Finite element method
GAUS	Gaussian
LS	Load step
MP	Mileage point
MZ	Moment from Z direction
NH	Number of holes
Num	Number
PDS	Probabilistic Design System
PDF	Probabilistic Density Function
P View	Plan view
REINFACT	Reinforcement Factor
SS	Substep
TBOT	Bottom thickness
TM	Middle Thickness
TTOP	Top Thickness

## **CHAPTER 1**

### **INTRODUCTION**

#### **1.1 General**

Finite element method is a method of solving a complicated problem by replacing a complicated problems with relatively simpler problems. The study or analysis of phenomenon with finite element method is often called as finite element analysis. This method is to generate approximate values of the unknown at discrete number of points over a body. This is done with a process called discretization which model a body by separating it into an equivalent system of smaller part interconnected at nodes. Instead of solving the body at once, FEM solves it by formulating equation for each part then them to get solution of whole. (Daryl L Logan, 2011).

Bridge are designed in many types such as beam bridge, truss bridge, cantilever bridge, arch bridge etc. Meanwhile, beam bridge is considered the simplest and oldest type bridge as it is just bridge made of a horizontal beam supported by vertical piers.

Despite its simplicity in design, length of beam bridge rarely exceed 76m in a single span as the flexural stresses is proportional to the square of length with deflection is proportional to length to power of 4. In other words, the bridge can be failed on its own weight if it's too long. In this research, we will take voided concrete slab bridge as the example of slab bridge with beam element.

#### **1.2 Problem Statement**

In the case of this, the bridge structure have to be well designed to ensure that it can support the stress and safe for usage over long period of time. In order to carry out the design process easily, ANSYS software is used do the finite element analysis to



study the structural behaviour of the bridge despite there are several methods. This is because by using computer software, more complicated criteria in bridge design such as curve can be easily analysis compared to manual calculation which has higher percentage of mistake and more time-consuming.

### **1.3 Objective**

Every study and project comes with objectives as they are important for the research to be done well. Objective acts as reminder for the researcher of the initial criteria and testing that should be conducted in the research. As for this project, the main objectives are:

1. To make a model of beam bridge with adequate reinforcement.
2. To check on the structural behaviour of the structure in term of force and moment.
3. To carry out probabilistic analysis of the structure.

### **1.4 Scope of Study**

This research focus mainly on the generation of model of bridge through the CivilFEM integrated ANSYS software. Eurocode 2 is use as the guide code on the anlaysis and the parameters are applied to obtain the result. This research will be analysing applying different parameter on the structure. The comparison of the result of will be made to show the mechanism of the design. Do exploration on ANSYS through the tutorial to get familiar with the operation.

### **1.5 Research Outcomes**

Obtain the shear force diagram, bending moment diagram, deformed shape diagram and reinforcement factor diagram from ANSYS. Perform probabilistic analysis on the structure and obtain statistical data of input parameters and output parameter.

### **1.6 Research Question**

1. What is the structural behaviour of voided concrete bridge slab when subjected to loading?

2. What is the critical status of voided concrete bridge slab when subjected to loading? How does it affect the structure when come in real situation?

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