



Department of Mechanical Engineering

MUH 104 - An Introduction to Mechanical Engineering

What is Finite Element Analysis (FEA)

by

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I confirm that I have followed the Academic Integrity Rules.

A handwritten signature in blue ink, appearing to be 'Gökay', on a light gray background.

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Table of Contents

Abstract	3
1.Introduction	4
2.1 What is Finite Element Method?	4
2.1.1 Finite Element Method: Node and Element Modelling	4
2.2 What is Finite Element Analysis?	6
2.2.1 Benefits of Finite Element Analysis	6
2.2.2 Types of Finite Element Analysis	7
2.2.3 Finite Element Analysis Usage Areas	7
2.2.4 Software Used in Finite Element Analysis	8
3. Conclusion and Recommendations	8
4.Appendices	9
References	10

List of Figures

Figure 2.1 Finite Element modelling example	4
Figure2.2 Basic element examples	5
Figure 2.3 Basic element nodes example	5
Figure 2.4 Vehicle Accident Test	6
Gif 2.1 Bridge FEA Simulation	7
Figure 4.1 Beam element usage	9
Figure 4.2 Shell element usage	9
Figure 4.1 Solid element usage	9

Abstract

This report examines what Finite Element Analysis is and what problems it solves in mechanical engineering. In the old times, the products were produced as a prototype before mass production as the classical method and the problems were noticed. The most important feature that distinguishes this method from the classical method is that an imaginary model is optimized by performing various performance tests in a completely computer environment. This method has time and economic advantages. This analysis method has become one of the basic engineering methods. Since it contains many types of analysis, specialization areas have been formed. It is one of the most useful and profitable methods of computer aided systems. It has also been examined in detail in this report.

1.Introduction

In the last century, computer-aided systems have entered many engineering fields in the world. One of the most prominent and functional features of this is Finite Element Analysis. Before the product is produced, prototype production should be made and analyzed with the necessary performance tests, but with the development of technology, the analysis of the products begins at the design stage with the finite element analysis. In this report, necessary information is given about the historical process of Finite Element analysis, its differences from the classical system, its usage areas and analysis types. As a result, the positive benefits of this system in engineering are shown.

2.1 What is Finite Element Method?

In order to learn Finite Element Analysis comprehensively, we must learn the Finite Element Method. Finite Elements Method first divides the object to be analyzed into smaller structures (elements). Then, an equation is created for each element and the elements are connected to each other through points (nodes) and a global (main) equation is created. Engineers who make the equation add the necessary conditions to the equation such as hardness, temperature, strain, strength, pressure.

The more accurate and comprehensive the modelling made in the Finite Element Method, the more accurate the analysis and solution of the problems will be. It requires caution and expertise.

2.1.1 Finite Element Method: Node and Element Modelling

In order to perform mathematical modelling in the analysis process, we first transform objects consisting of infinite points into finite node and element structures as shown in Figure 2.1.

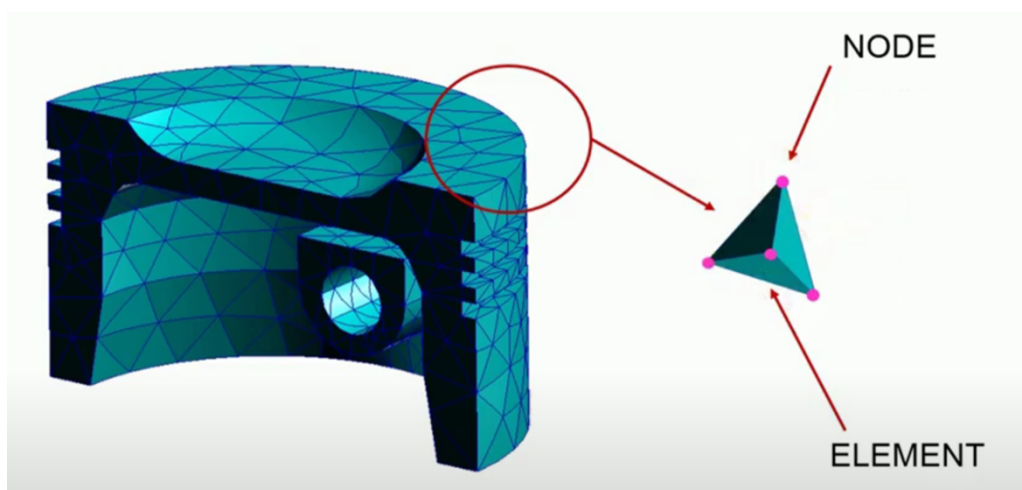


Figure 2.1 Finite Element modelling example

In the Finite Element Method, there are 3 basic elements as shown in Figure 2.2.

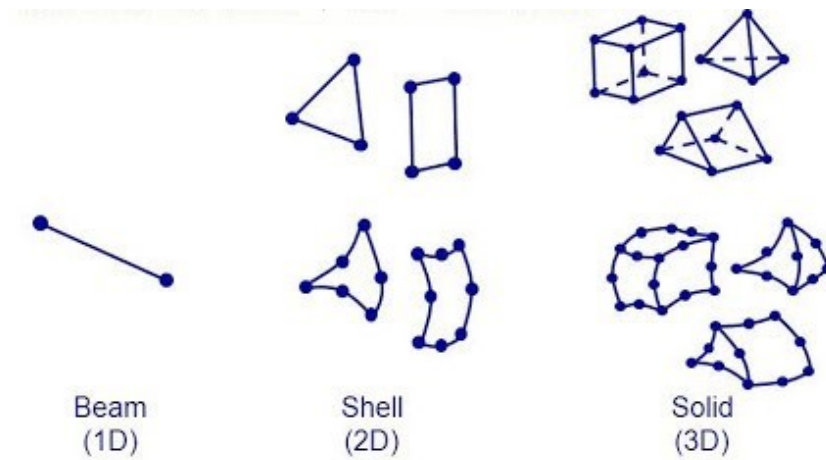


Figure 2.2 Basic element examples

In the Finite Element Method, we specify the nodes as shown in Figure 2.3.

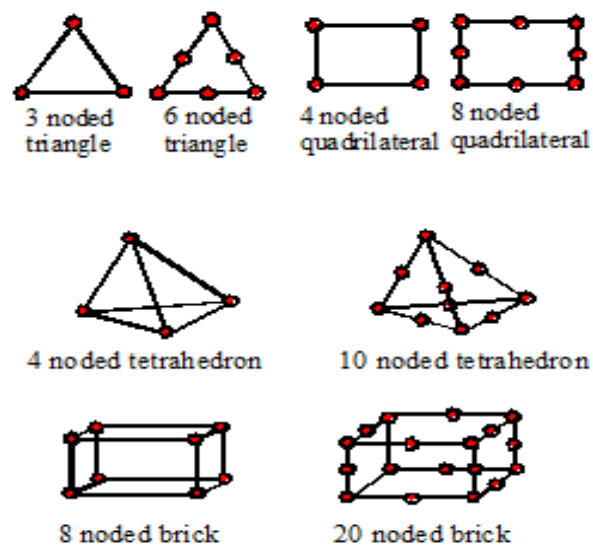


Figure 2.3 Basic element nodes examples

Examples of finite element modeling as shown in Figures 4.1, 4.2 and 4.3 are given in the Appendices.

2.2 What is Finite Element Analysis?

When an engineer enters the testing phase after the design phase in the project he has developed, the Finite Element Analysis part begins. In this process, does the main purpose meet the required needs of the model as expected? and what are the model's limits to various factors? is to find answers to your questions.

Finite Element Analysis tests the design drawn in 3D using the Finite Element Method into simulations and tests it repeatedly under desired conditions.

"The method was first proposed in the 1940s and was used in aircraft wing designs for Boeing in the 1950s." [1] Later, this method became an indispensable field with the development of computer programming and software. Today, it has become a standard requirement in many disciplines.

2.2.1 Benefits of Finite Element Analysis

Before the production of a model, a prototype must be produced and passed through various types of analysis, but the more the number of trials to be made on a product, the more the cost required to supply the product. In this process, we can test many times with a single virtual model with the Finite Element Analysis method.

Nowadays, analysis of a model with software support has begun in the design phase and potential problems are solved early. This process makes a difference in terms of time and economy. It also brings us to the most ideal (optimized) design.

As can be seen in Figure 2.4, tests can be performed very close to real tests in a vehicle accident test process.



Figure 2.4 Vehicle Accident Test

2.2.2 Types of Finite Element Analysis

Many types of analysis can be done with this method according to the needs of the model.

This list is;

- Optimization Analysis
- Dynamic and Static Analysis
- Thermal Analysis
- Deformation (Durability) Analysis
- Vibration and Sound Analysis
- Structure and Stress Analysis
- Security Analysis

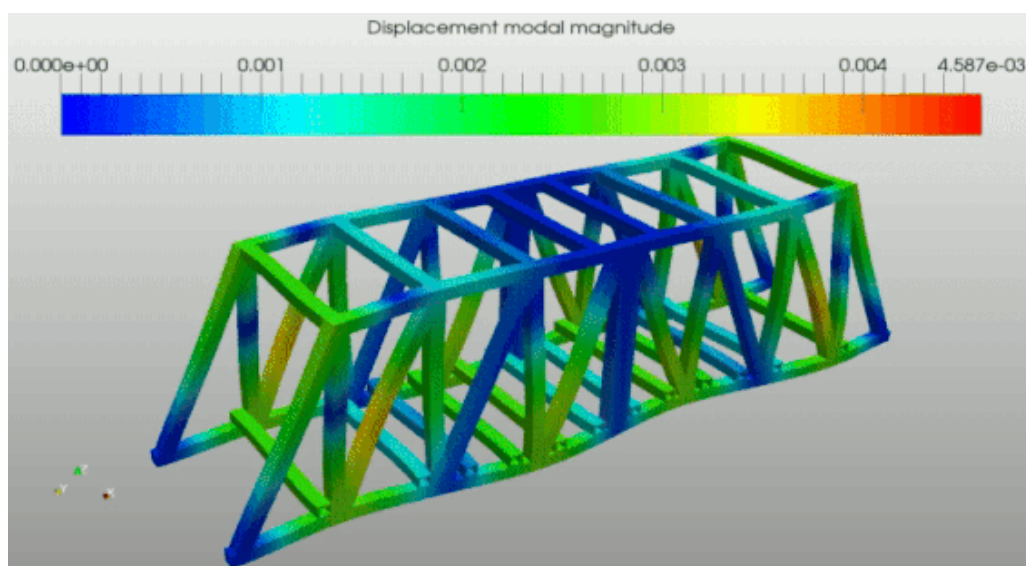
2.2.3 Finite Element Analysis Usage Areas

It is a type of analysis used in many areas where basic engineering is used.

This list is;

- Automotive
- Space / Aviation
- Biomedical
- Mechanical Engineering
- Acoustic
- Electromagnetic Fields

It is a Finite Element Analysis simulation of a bridge as seen in Gif 2.1. [1]



Gif 2.1 Bridge FEA Simulation

2.2.4 Software Used in Finite Element Analysis

There are many programs that measure this analysis, but the most accurate and most comprehensive program is "ANSYS".

Other software are;

- MSC SOFTWARE
- ALTAIR HYPERWORKS
- ALGOR
- SIMULIA ABAQUS
- DYNAFORM
- SIMUFACT

In addition, there are analysis modules in CAD software such as Catia and SolidWorks.

3. Conclusion and Recommendations

Considering all that has been explained, computer aided methods have become indispensable for advanced engineering analysis. In this way, analyzes become cheaper, more precise, more efficient and closer to the desired targets. Of course, a correct method should be done for this and advanced mathematical equations should be established and solved. The diversity in the finite element method process enables the product to be tested under many non-standard conditions. In order for these analyzes to show the truth, there are fully equipped computer software, and it can be said that an ecosystem has been created with CAD programs.

This type of computer-aided virtual experiments need to be used more in space and aviation technology. Billions of dollars are not lost in the trial and error process of aviation systems. I think that in the future, many simulations will be developed beyond the engineering systems of these systems.

At the end of all that has been said, the development of technology is able to solve the imaginary problems of an imaginary product in an imaginary world and eliminate the problem.

4. Appendices

2.1.1 Finite Element Method: Node and Element Modelling

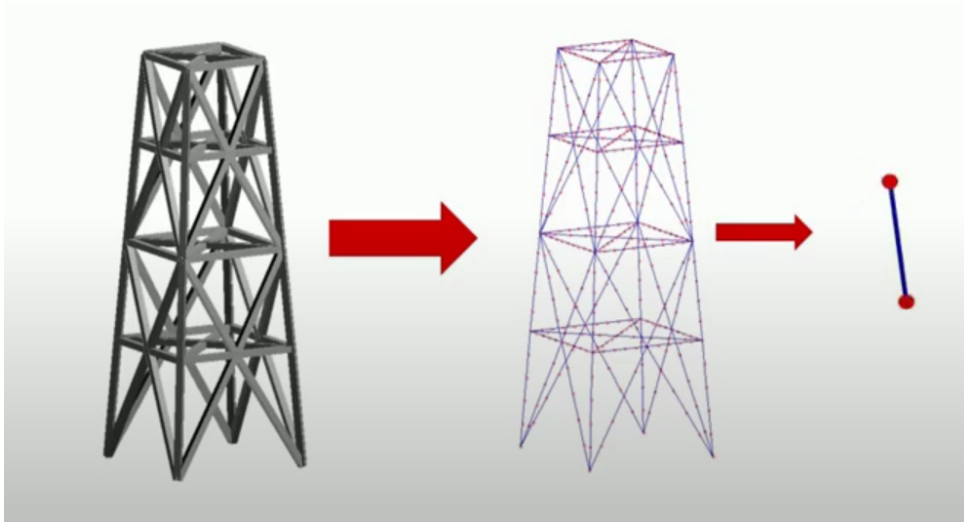


Figure 4.1 Beam element usage

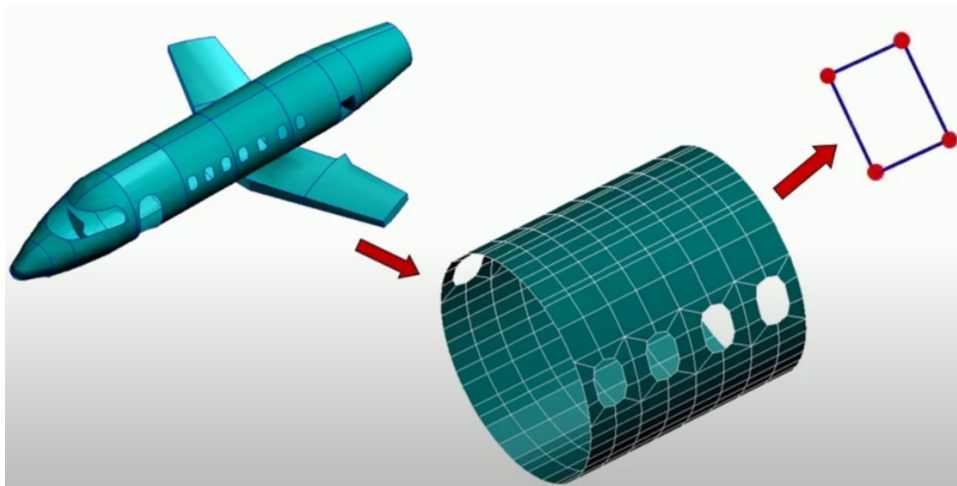


Figure 4.2 Shell element usage

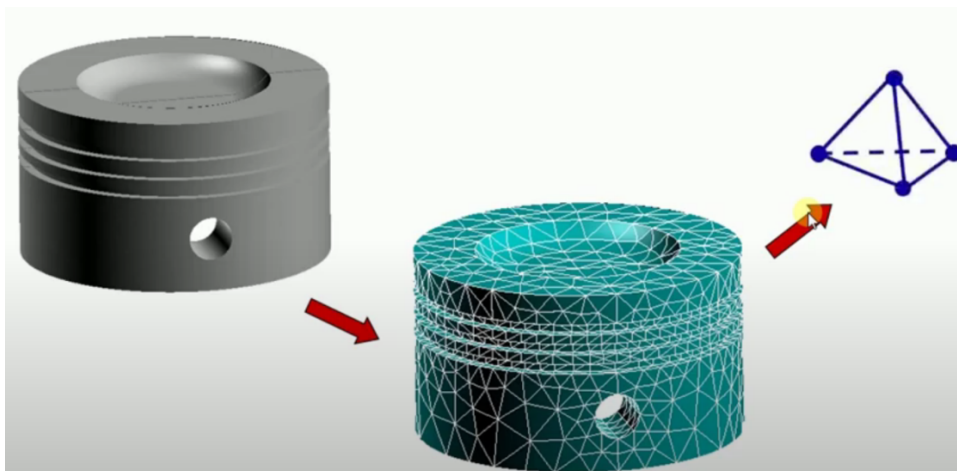


Figure 4.1 Solid element usage

References

Web Site

[1] "Finite element method", retrieved from https://tr.wikipedia.org/wiki/Sonlu_elemanlar_y%C3%B6ntemi#Galeri, on March 19th,2021.