

BACHELORS DEGREE ASSIGNMENT SPECIFICATION

Student name:	D1 CROSTA	Student P number:	
Programme:	BEng Automotive and Manufacturing streams		
Module:	Advanced Stress Analysis & FEA	Module Level (4, 5, 6):	6
Module code:	M6X00420	Contribution to Overall Module Assessment (%):	50 %
Lecturer:	Kelvin Lake	Internal Verifier:	Rob Goodson
Assignment Title:	Can FEA replace physical testing?	Assignment No (x of x):	1 OF 1
Hand Out Date:	25/02/2020	Submission deadline:	29/03/2020

Referencing:	In the main body of your submission you must give credit to authors on whose research your work is based. Append to your submission a reference list that indicates the books, articles, etc. that you have read or quoted in order to complete this assignment (e.g. for books: surname of author and initials, year of publication, <u>title of book</u> , edition, publisher: place of publication).			
Disclosure:	I declare that this assignment is all my own work and that I have acknowledged all materials used from the published or unpublished works of other people. All references have been duly cited.			
Student's Signature:	<i>Assignments will not be accepted without a signature here</i>	Date:		
Turnitin: Lecturer to tick to indicate if an electronic version of the assignment must be submitted to Turnitin. Note: the Turnitin version is the primary submission and acts as a receipt for the student. Penalties for late submission: Up to four weeks late, maximum mark of 40%. Over four weeks late, Refer. Only Year Tutors and the Programme Director may grant an extension.			YES	✓
			NO	

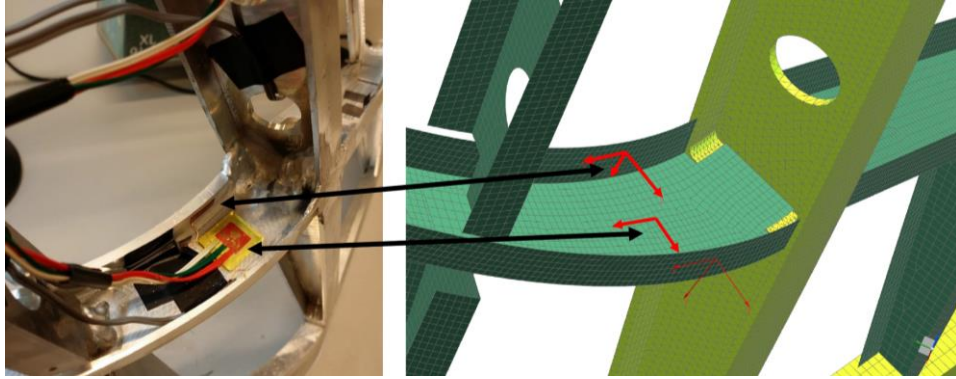
Learning Outcomes tested (from module syllabus)	Assessment Criteria To achieve each outcome a student must demonstrate the ability to:
Demonstrate an ability to analyse a range of engineering problems using advanced stress analysis principles.	

- DO NOT put this form into Turnitin or it will match many similarities with other students' submissions.

TASK DESCRIPTION

This assignment explores FEA and the role that it plays in product development. It is expected that the student will research this topic (referencing any sources used, using Harvard or Vancouver).

GUIDANCE FOR STUDENTS IN THE COMPLETION OF TASKS



The above image shows a component undergoing physical testing and the corresponding FE model. Your task for this assignment is to discuss the following;

1. Why companies typically carryout FE analysis alongside physical testing.
2. How a physical test may be correlated to an FE model.
3. If you think that FE analysis can (or should) ever replace physical testing.

In order to do this, you should consider a case study and use this to discuss the above tasks.

This report should be 3000 words long and should be submitted via moodle

STRUCTURAL SECTION MARKING CRITERIA AND STUDENT FEEDBACK

This section details the assessment criteria. The *extent* to which these are demonstrated by you determines your mark. The marks available for each criterion are shown. Lecturers will use the space provided to comment on the achievement of the task(s), including those areas in which you have performed well and areas that would benefit from development/improvement.

Common Assessment Criteria Applied	Marks available	Marks awarded
1. Research-informed Literature Extent of research and/or own reading, selection of credible sources, application of appropriate referencing conventions.		
(Assessed in point 1)	30	16.5
2. Knowledge and Understanding of Subject Extent of knowledge and understanding of concepts and underlying principles associated with the discipline.		
(Assessed in point 2)	30	15
3. Analysis Analysis, evaluation and synthesis; logic, argument and judgement; analytical reflection; organisation of ideas and evidence		
(N/A)	0	
4. Practical Application and Deployment Deployment of methods, materials, tools and techniques; application of concepts; formulation of innovative and creative solutions to solve problems.		
(Assessed in point 3)	30	16.5
5. Skills for Professional Practice Attributes in professional practice: individual and collaborative working; deployment of appropriate media; presentation and organisation.		
(Assessed in report presentation and structure)	10	6.7

Assignment Mark Overall (Assessment marks are subject to ratification at the Exam Board. These comments and marks are to give feedback on module work and are for guidance only until they are confirmed.)	Late Submission Penalties (tick if appropriate)		54.7 %
	Up to one-week late		
	Over one week late		

COMMON ASSESSMENT AND MARKING CRITERIA

	OUTRIGHT FAIL	UNSATISFACTORY	SATISFACTORY	GOOD	VERY GOOD	EXCELLENT	EXCEPTIONAL
Assessment Criteria	0-29%	30-39%*	40-49%	50-59%	60-69%	70-79%	80-100%
1. Research-informed Literature Extent of research and/or own reading, selection of credible sources, application of appropriate referencing conventions	Little or no evidence of reading. Views and findings unsupported and non-authoritative. Referencing conventions largely ignored.	Poor evidence of reading and/or of reliance on inappropriate sources, and/or indiscriminate use of sources. Referencing conventions used inconsistently.	References to a limited range of mostly relevant sources. Some omissions and minor errors. Referencing conventions evident though not always applied consistently.	Inclusion of a range of research-informed literature, including sources retrieved independently. Referencing conventions mostly consistently applied.	Inclusion of a wide range of research-informed literature, including sources retrieved independently. Selection of relevant and credible sources. Very good use of referencing conventions, consistently applied.	A comprehensive range of research informed literature embedded in the work. Excellent selection of relevant and credible sources. High-level referencing skills, consistently applied.	Outstanding knowledge of research-informed literature embedded in the work. Outstanding selection of relevant and credible sources. High-level referencing skills consistently and professionally applied.
2. Knowledge and Understanding of Subject Extent of knowledge and understanding of concepts and underlying principles associated with the discipline.	Major gaps in knowledge and understanding of material at this level. Substantial inaccuracies.	Gaps in knowledge, with only superficial understanding. Some significant inaccuracies.	Evidence of basic knowledge and understanding of the relevant concepts and underlying principles.	Knowledge is accurate with a good understanding of the field of study.	Knowledge is extensive. Exhibits understanding of the breadth and depth of established views.	Excellent knowledge and understanding of the main concepts and key theories. Clear awareness of challenges to established views and the limitations of the knowledge base.	Highly detailed knowledge and understanding of the main theories/concepts, and a critical awareness of the ambiguities and limitations of knowledge.
3. Analysis Analysis, evaluation and synthesis; logic, argument and judgement; analytical reflection; organisation of ideas and evidence	Unsubstantiated generalisations, made without use of any credible evidence. Lack of logic, leading to unsupportable/missing conclusions. Lack of any attempt to analyse, synthesise or evaluate.	Some evidence of analytical intellectual skills, but for the most part descriptive. Ideas/findings sometimes illogical and contradictory. Generalised statements made with scant evidence. Conclusions lack relevance.	Evidence of some logical, analytical thinking and some attempts to synthesise, albeit with some weaknesses. Some evidence to support findings/ views, but evidence not consistently interpreted. Some relevant conclusions and recommendations, where relevant	Evidence of some logical, analytical thinking and synthesis. Can analyse new and/or abstract data and situations without guidance. An emerging awareness of different stances and ability to use evidence to support the argument. Valid conclusions and recommendations, where relevant	Sound, logical, analytical thinking; synthesis and evaluation. Ability to devise and sustain persuasive arguments, and to review the reliability, validity & significance of evidence. Ability to communicate ideas and evidence accurately and convincingly. Sound, convincing conclusions / recommendations.	Thoroughly logical work, supported by evaluated evidence. High quality analysis, developed independently or through effective collaboration. Ability to investigate contradictory information and identify reasons for contradictions. Strong, persuasive, conclusions, justifiable recommendations.	Exceptional work; judiciously selected and evaluated evidence. Very high quality analysis, developed independently or through effective collaboration. Ability to investigate contradictory information and identify reasons for contradictions. Highly persuasive conclusions
4. Practical Application and Deployment Effective deployment of appropriate methods, materials, tools and techniques; extent of skill demonstrated in the application of concepts to a variety of processes and/or contexts; formulation of innovative and creative solutions to solve problems.	Limited or no use of methods, materials, tools and/or techniques. Little or no appreciation of the context of the application.	Rudimentary application of methods, materials, tools and/or techniques but without consideration and competence. Flawed appreciation of the context of the application.	An adequate awareness and mostly appropriate application of well established methods, materials, tools and/or techniques. Basic appreciation of the context of the application.	A good and appropriate application of standard methods, materials, tools and/or techniques. Good appreciation of the context of the application, with some use of examples, where relevant.	A very good application of a range of methods, materials, tools and/or techniques. Very good consideration of the context of the application, with perceptive use of examples, where relevant. Evidence of some innovation and creativity.	An advanced application of a range of methods, materials, tools and/or techniques. The context of the application is well considered, with extensive use of relevant examples. Application and deployment extend beyond established conventions. Innovation and creativity evident throughout.	Outstanding levels of application and deployment skills. Assimilation and development of cutting edge processes and techniques.
5. Skills for Professional Practice Demonstrates attributes expected in professional practice including: individual initiative and collaborative working; deployment of appropriate media to communicate (including written and oral); clarity and effectiveness in presentation and organisation.	Communication media is inappropriate or misapplied. Little or no evidence of autonomy in the completion of tasks. Work is poorly structured and/or largely incoherent.	Media is poorly designed and/or not suitable for the audience. Poor independent or collaborative initiative. Work lacks structure, organisation, and/or coherence	Can communicate in a suitable format but with some room for improvement. Can work as part of a team, but with limited involvement in group activities. Work lacks coherence in places and could be better structured.	Can communicate effectively in a suitable format, but may have minor errors. Can work effectively as part of a team, with clear contribution to group activities. Mostly coherent work and is in a suitable structure.	Can communicate well, confidently and consistently in a suitable format. Can work very well as part of a team, with very good contribution to group activities. Work is coherent and fluent and is well structured and organised.	Can communicate professionally and, confidently in a suitable format. Can work professionally within a team, showing leadership skills as appropriate, managing conflict and meeting obligations. Work is coherent, very fluent and is presented professionally.	Can communicate with an exceptionally high level of professionalism. Can work exceptionally well and professionally within a team, showing advanced leadership skills. Work is exceptionally coherent, very fluent and is presented professionally.

Student Self Evaluation Form

Student name:		Student P number:	
Programme:		Year of programme	
Assignment Title:			

This section repeats in brief the common assessment criteria detailed on previous pages. The *extent* to which these are demonstrated by you determines your mark. Using these criteria, tick the box that best indicates the level of achievement you feel you have achieved with regard to each of them.

Common Assessment Criteria Applied	Level of Achievement						
	REFER		3 rd	2:2	2:1	1 st	1 st
	OUTRIGHT FAIL	UNSATISFACTORY	SATISFACTORY	GOOD	VERY GOOD	EXCELLENT	EXCEPTIONAL
1. Research-informed Literature	0-29% ☐	30-39% ☐	40-49% ☐	50-59% ☐	60-69% ☐	70-79% ☐	80-100% ☐
2. Knowledge and Understanding of Subject	0-29% ☐	30-39% ☐	40-49% ☐	50-59% ☐	60-69% ☐	70-79% ☐	80-100% ☐
3. Analysis	0-29% ☐	30-39% ☐	40-49% ☐	50-59% ☐	60-69% ☐	70-79% ☐	80-100% ☐
4. Practical Application and Deployment	0-29% ☐	30-39% ☐	40-49% ☐	50-59% ☐	60-69% ☐	70-79% ☐	80-100% ☐
5. Skills for Professional Practice	0-29% ☐	30-39% ☐	40-49% ☐	50-59% ☐	60-69% ☐	70-79% ☐	80-100% ☐

PLEASE COMMENT ON AREAS IN WHICH YOU FEEL THAT YOU HAVE PERFORMED WELL	PLEASE COMMENT ON AREAS YOU FEEL THAT YOU NEED TO DEVELOP

Student's Name		Date	
Student's Signature			



Prifysgol Cymru
Y Drindod Dewi Sant
University of Wales
Trinity Saint David

CAN FEA REPLACE PHYSICAL TESTING?

Emanuele Di Crosta

P151088

DATE

28/03/2020

COURSE

BEng Motorcycle Engineering Course

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1 Introduction

Performance, durability and robustness are some of the key features of a better product and therefore their analysis under certain conditions is fundamental. Physical prototyping requires time and therefore has a cost, that is when the engineering field had introduced finite element analysis, FEA.

USE PAST TENSE

The following report will present explanation on why the industry uses FE along side physical testing, presenting some of the mathematical principles and the computational cycles used by the software behind a structural analysis.

It will be discussed furthermore, how FEA packages work~~s~~, which are the steps to perform a simulation to best understand why a physical test is still very important to the validation of the results.

Finally, throughout the simulation of a simple physical experiment it will be highlighted how, even though FEA provides accurate results, the software is very sensible to certain set-ups affecting accuracy.

2 Task 1: FEA along physical testing, why?

What it is FEA?

The finite element method, FEM, is used by the industry to break down and solve the time-consuming mathematical operations, pillars of structural analysis computation. FE is used to analyse and predict structures' behavior under static and dynamic loading or to investigate material's reaction (Simscale, 2010).

FEA is a numerical-based process to model and analyze complex systems, the analysis occurs in a virtual environment which results are validated in a cross-referencing way.

In the engineering fields, it is used to calculate strength, behavior and characteristics of a component under various scenarios: stress, deflection and vibration.

Prior 1990, FE analysis was exploited and restricted to the aeronautical, defense and nuclear industries (Manor, 2016) due to the high cost of the software and computational power required. Nowadays, FEA is reaching a major audience of users thanks to more accessible costs than before as well as the high computational power commonly available.

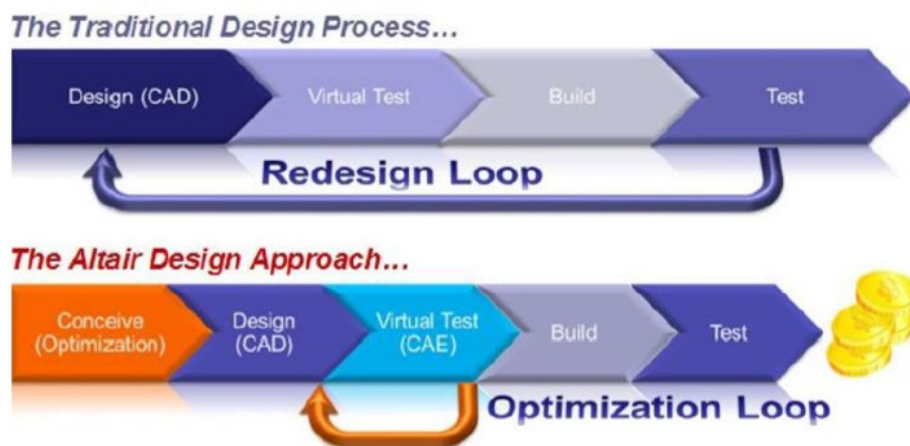


Figure 1 Project cycle scheme *REF?*

The main reason FEA is largely used by the industry is highlighted in *Figure 1* and explained further on.

An analysed component is identified in space with a global coordinate system, and is broken down into smaller sections, which will be identified by a local coordinate system that can be aligned or not with the overall one. This subdivision allows the software to understand how the overall structure will behave under an external influence.

The resulting structure has the shape of a fishing net and is the so-called mesh, where each sub-region which is constituted by is defined by boundaries, making every element a finite one (Hearn, 1997).

Each finite element is in relation one to the other by discrete points, at their corners or at the midpoints, called nodes. A node is a single point either is in a 2-dimensional or 3-dimensional element and holds information of its location and of the material properties.

Each node-to-node connection is what defines an element to be the finite.

The mesh embraces the entire element/component analysed and could be denser according to the level of precision of the results wanted: intuitively a denser mesh comprehends a larger number of elements, therefore nodes, resulting in a more complex computation (Manor , 2016).

Each finite element is defined by multiple set of equations, holding information regarding its displacements, acceleration, inertia, stress, material properties etc and each function is in relation to the finite elements nearby; all the equations are solved simultaneously to determine how each node responds to an external input. To solve such equation's web the governing equations are organized in matrix form.

Each element, therefore, under applied loads, adjusts its equations which will create or relieve stresses, modifying its borders and the neighbour ones. The computation is used to solve each finite element equation considering its relation to the near elements and combining them all to achieve the overall solution

The industry therefore exploits the computational capability of repeating calculations to solve simultaneously the governing equations organized in matrices form, more of these later.

It will not be discussed and presented the calculations behind the research of the element's stiffness; however, it must be remembered that each node holds information of various nature. During structural analysis, to put into relation each node's information the system is simplified to multiple spring models each one connected to the neighbour one.

Each node can be free to move (rotate or translate) and this possibility is represented by the degree of freedom (DOF): in a 2-dimensional system, each node has three degrees of freedom, two translational, one perpendicular to the other, and a rotational one (Erochko,

2016), in a 3-dimensional system instead there are six DoF per each node, translational motion along x,y,z axis and a rotational one around x,y and z.

Hook's law and Young's modulus definition are applied per each node and then combined to identify the overall element stiffness:

$$F_{elastic} = k * \delta Length \quad ; \quad E = \frac{stress}{strain} = \frac{\frac{Force}{Area}}{\frac{\delta Length}{Length}}$$

$$k = \frac{Area * E}{Length}$$

To find k value, each node is evaluated as a single spring and combined to next one in a matrix form as:

$$\begin{Bmatrix} F_1 \\ F_2 \end{Bmatrix} = \begin{pmatrix} k_1 & -k_1 \\ -k_1 & k_1 \end{pmatrix} \begin{pmatrix} x_1 \\ x_2 \end{pmatrix} \quad (1)$$

Where $\begin{pmatrix} k_1 & -k_1 \\ -k_1 & k_1 \end{pmatrix}$ is the stiffness matrix; the above matrix (1) is the one generated by a single element with two nodes; however, a mesh is constituted by numerous elements which have many nodes and the equivalent stiffness matrix for the entire structure is the sum of all matrixes depending on each node, as below. The equivalent matrix 's dimension dictates the number of degrees of freedom.

$$\begin{Bmatrix} F_1 \\ F_2 \\ F_3 \end{Bmatrix} = \begin{pmatrix} k_1 & -k_1 & 0 \\ -k_1 & k_1 + k_2 & -k_2 \\ 0 & -k_2 & k_2 \end{pmatrix} \begin{pmatrix} x_1 \\ x_2 \\ x_3 \end{pmatrix}$$

$$\{F\} = k(x)$$

Another reason why FEA is carried out by the industries is for the computational work done to align each element to a single coordinate system, transforming local ones into global, throughout matrix manipulation and trigonometry.

It is therefore, highlighted one of the main reasons why industry relies on FEA: the time saving and higher precision that computational power has over hand-calculations.

FEA's smaller time constrains allows benefits within the entire development process of a component: the virtual prototyping allows a higher number of new model's attempts, i.e. different characteristics can be tried, and so higher quality and more efficient products are generated in less design cycles i.e. time (Manor , 2016).

Directly related to time is cost, therefore the development process will be cheaper also due to a new development cycle that allows prototyping to be left only at the final stages, close to the

defined end-product. Multiple simulations for different designs, materials and shapes can be run in hours instead of days or more, therefore discovering or confirming suspect results at early stages, avoiding expensive physical tests.

To do so, FEA packages permit the user to assume or define, prior the simulation, regions of interest where stresses concentration might be and improve the analysis by the usage of a more refined mesh. The power and time required to compute therefore, can be manipulated and influenced preventing to overlook parameters since the early design stages, resulting in an increased material accuracy. In fact, it is possible to evaluate the entire structure either inside and outside and determine where failure might occur.

- DETAILS OF THE FEM WERE NOT NEEDED
- INSTEAD, YOU COULD HAVE EXPANDED THE SECTION WHERE YOU DISCUSSED THE IMPACT ON THE DESIGN PROCESS.

THE BRIEF ASKED YOU
THIS

3 Task 2: How Physical tests are correlated to FEA?

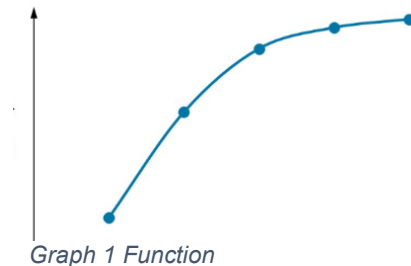
How FEA works? ← NOT
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Throughout the production process of a component, physical tests still plays a fundamental role for the development of it; the reason of their importance lays in the process and rules which FEA packages runs on: the finite element method has been invented by engineers to solve structural equations (e.g. calculate the stresses raised by a truck passing on a bridge or the effect of wind on a building). It is used to solve differential equations, which represents nature and its continuous problems, and transform them into discrete ones, which computers are capable to solve (Science, 2013).

For clarity purpose, it is identified with the word *discrete*, a finite number of unknowns in a system whilst *continuous* describes an infinite number of unknowns (Manor , 2016).

The results are achieved throughout approximations, based on what can be called a S.I.M.P.L.E. process. These assumptions affect the results therefore engineering judgement is used as well to take decisions.

To run a structural simulation a mesh is a fundamental requirement to replicate the structure; calculations per each element are carried out and then combined, generating a map like *graph 1*.



Polynomials approximations are used to interpolate each element's information. The slope of a function is calculated as the difference between two points, however the accuracy lays in the degree of the polynomial used to "curve fit" the connecting line between the two points. (Simscale, 2010)

Values are known at specific points within the element, nodal points, but not elsewhere, for instance it is known the deflection at two specific points but not how the deformation under a load interpolates the flection between these two. The accuracy of the slope therefore is dependent on the polynomial approximations which can be linear, quadratic, cubic etc. Furthermore, FE method can be identified by three steps: pre-processing, solution and post-processing.

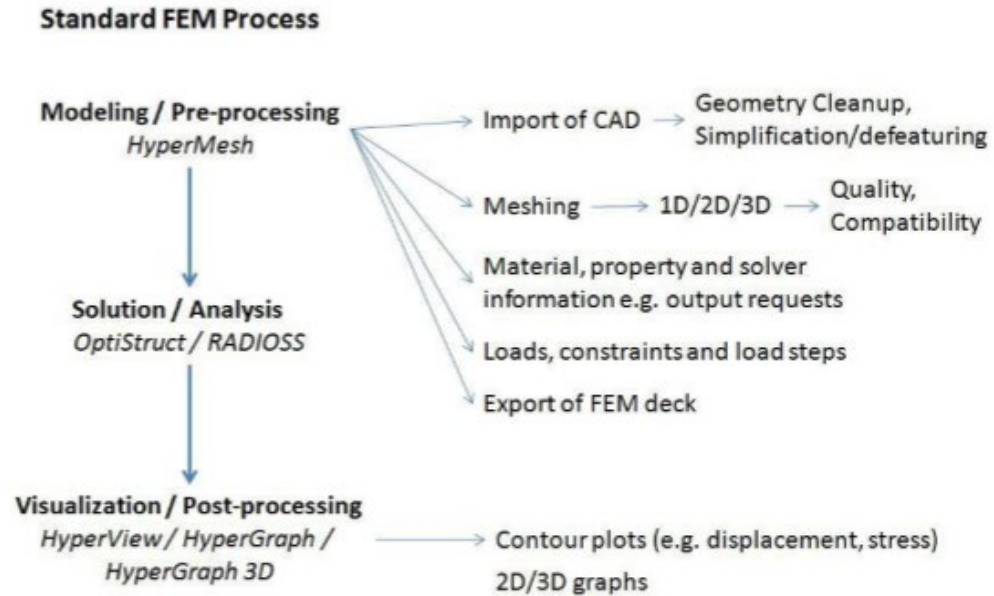


Figure 2 FEM steps

It can be said that FEA's key step around which the entire analysis is dependent is pre-processing. Each set-up, assumption or feature used during the pre-processing is vital for the simulation and its correctness.

The model's geometry is the first control: open surfaces or detached ones would result in not valuable simulations.

The mesh is then created, to approximate the geometry and, because is the first step for numerically solve the partial differential equations, a fundamental role is played by its quality.

The quality of the mesh identifies a group of factors that affect the performance of the simulation.

For clarity of the argument it must be known that there are two kind of meshes: a structured and an unstructured. The first one is also called a grid mesh due to the regular shapes that the elements have, making easy to identify neighbour cells and points.

The second kind is a more arbitrary mesh, it could have any geometry shape and is used for complex geometries.

These cells types can be 2-dimensional or 3-dimensional

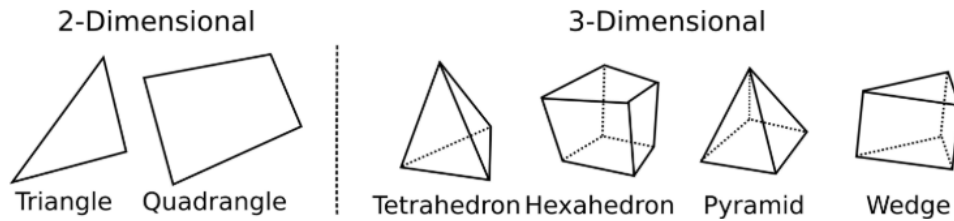


Figure 7: Common 2-Dimensional and 3-Dimensional cell types

Figure 3 2D and 3D mesh shapes

Mesh quality therefore controls different characteristics of the mesh it-self:

- Node's coincidence: if elements shear nodes.
- Free edges: if each element is connected to the neighbor one, only boundary elements should have free edges.
- Mid-sides nodes position: if the mid-side node is not at the medium point along the element's side will generate distortions and degrade the element performance.
- Internal angles: too small or too large can affect other parameters and therefore cause distortion. For quadrilateral elements the idea internal angle is 90° , for triangular 60° .
- Warping: is the deviation of the element shape from a planar reference. It is appreciable the solidity and advantage of a triangular shape over a quadrilateral one, no-matter the unevenness of the supporting surface.
- Distortion: the deviation of the shape from the original one, identified with the aspect ratio.

(Hearn, 1997)

Once the mesh is completed are then defined material properties and finally the loads and constraints.

The validity of the simulation is therefore dependent on the set-ups parameters used and on engineering judgment: for instance, critical thinking and decision are made for the loads and constraints step. Very important is to identify all the possible load situations that occur on the structure and determine which one/ones to use for the simulation. (Altair University, 2019)

THERE IS NO DISCUSSION AS
TO HOW YOU COULD ACTUALLY
CORRELATE A F.E. MODEL.
E.G. STRAIN GAUGES,
ACCELEROMETERS ETC.

4 Task 3: FEA can/should replace physical testing?

To understand the influence that certain parameters or engineering assumptions have over the simulation, a simple experiment was conducted and then replicated into FEA.

An aluminum bar (6061-T6 SS) of 260x28 millimeters, with a 7.6 mm width, was loaded at one extreme with 50 grams at the time, up to 600 grams total, and through a dial gauge it was read its displacement at the extreme where the load was applied.

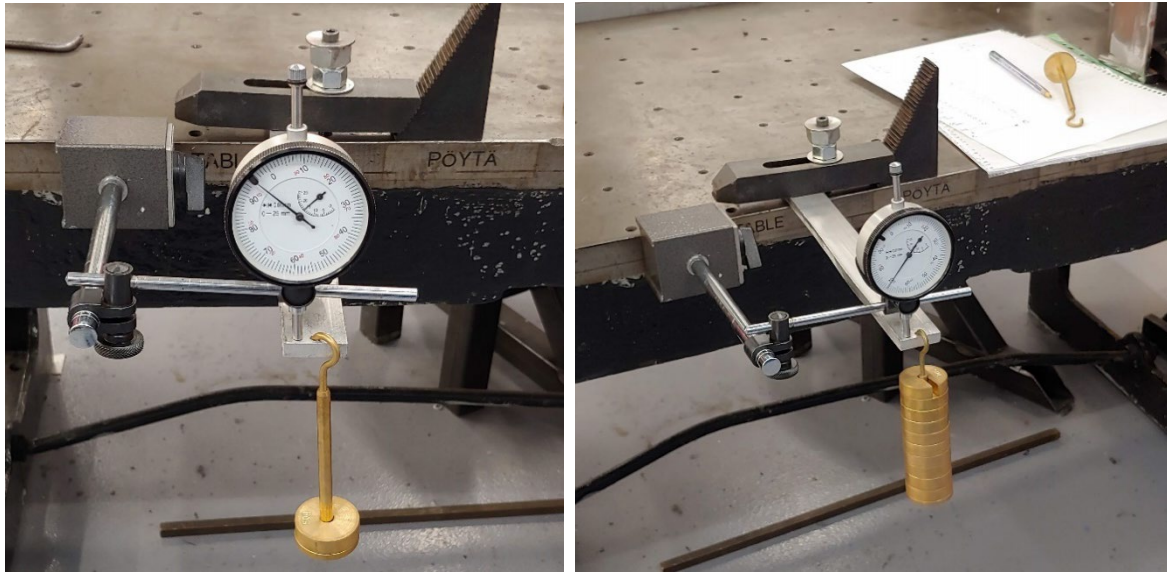


Figure 4 Experiment layout

The experiment was then replicated into Solidworks:

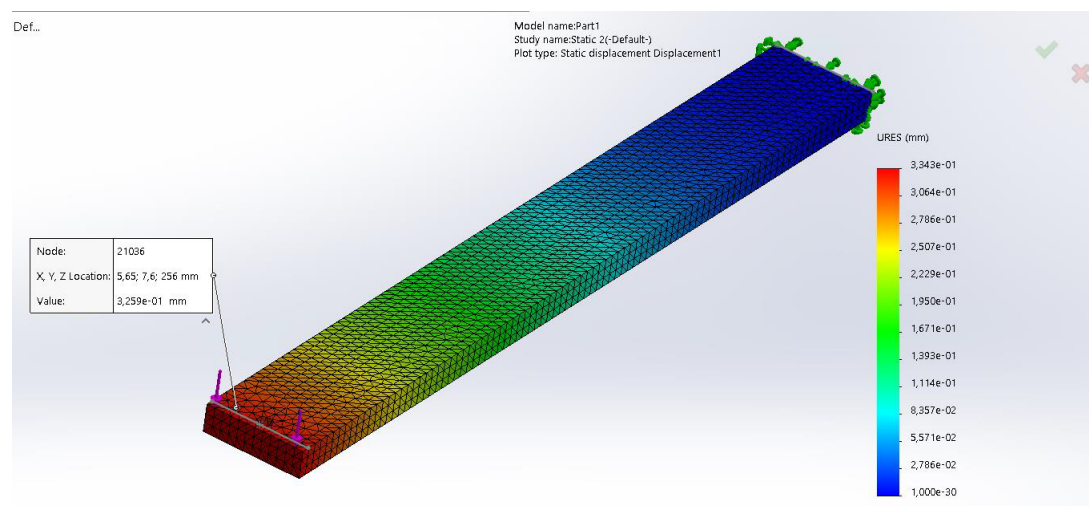


Figure 5 FEA

The simulations have been conducted to understand the influence of mesh, material, load application and constraints: a first set of simulations was run by varying the mesh' size, starting

with a 5 mm, then a 2.5 mm and, due to computational power and time constraints, stopped at a 1 mm mesh. The same mesh's variations have been used with a different material. Finally, a set of simulations have been conducted by varying the location of the load.

PROPERTIES	6061-T6 SS	6063-T6	UNITS
Elastic Modulus	6900.00067	69000	N/mm ²
Poisson's Ratio	0.33	0.33	N/A
Shear Modulus		25800	N/mm ²
Mass Density	2700	2700	Kg/m ³
Tensile Strength	310	240	N/mm ²
Yield Strength	275	215	N/mm ²
Thermal Expansion Coefficient	2.4e05	2.34e-05	/K
Thermal Conductivity		209	W/(m*K)
Specific Heat		900	J/kg*K
Hardening Factor	0.85		N/A

Table 1 Material Properties

Furthermore, some engineering assumptions have been used for the pre-processing stage as well and secondly changed to prove their influence: even though the length of the bar was 260 mm, for the simulation the bar was reduced to 230 mm instead due to the clamping solution used in the experiment. Therefore, it was assumed no influence of the remaining bar's section under the clamping device. As well, the clamping element was replicated into the simulation as a fixed constraint along the width of the bar.

EXPERIMENT		SIMULATION						
weight	displacement	material:	6061_T6 SS			6063_T6		
		mesh:	5	2,5	1	5	2,5	1
		load location:	top edge			top edge		
		load	displacement			displacement		
50	0,01	0,4905						
100	0,05	0,981	0,05	0,05	0,05	0,03	0,03	0,03
150	0,07	1,4715						
200	0,1	1,962	0,1	0,1	0,1	0,09	0,09	0,09
250	0,13	2,4525						
300	0,15	2,943	0,16	0,16	0,16	0,14	0,14	0,14
350	0,18	3,4335						
400	0,21	3,924	0,21	0,21	0,21	0,19	0,19	0,19
450	0,23	4,4145						

500	0,26	4,905	0,27	0,27	0,27	0,25	0,25	0,25
550	0,29	5,3955						
600	0,31	5,886	0,32	0,32	0,32	0,3	0,3	0,3

Table 2 Experiment and FEA data

As the table highlights, the simulation was not repeated per each weight increment; furthermore, it is highlighted the influence that material has over the simulations. On the contrary, mesh's dimension does not affect the displacement results however its influence is over the accuracy of other parameters, as strain and stresses. The below picture highlights how, along the same edge, stress is only visible with the smaller mesh and its magnitude is at the same time, influenced, as the legend on the side suggests.

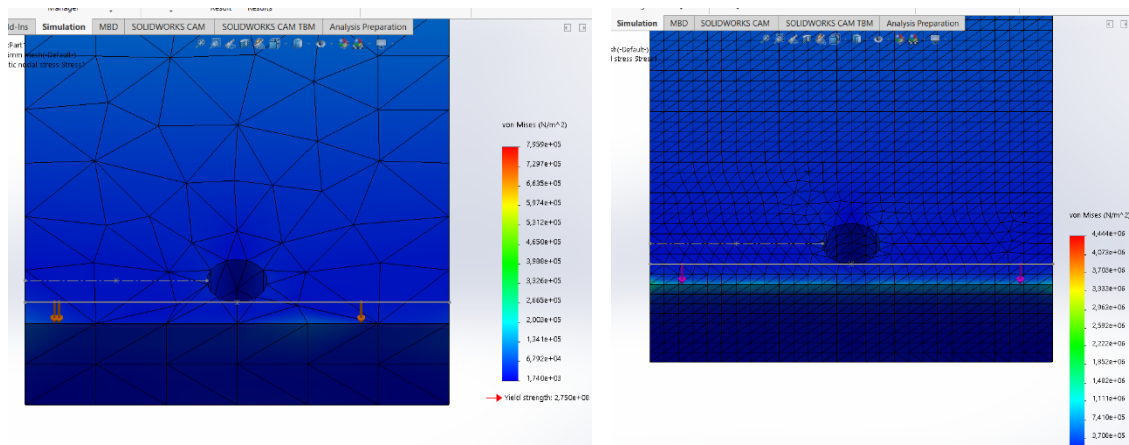


Figure 6 Mesh differences (5 mm vs 1 mm)

The load application was simplified to a single force acting along the top edge (figure), instead of the used hook hanged to the center hole. However, it was tried to apply the load to the entire side face of the bar, but no differences were found.

However, once all the parameters and assumption used are considered to be correct, there is still a very important variable that can affect the results when is the post-processing step: as the below figure highlights, displacement's readings were heavily affected by where the probe tool was placed.

Within a range of less than one millimeter, the readings were giving a 0.52 mm maximum difference between the points.

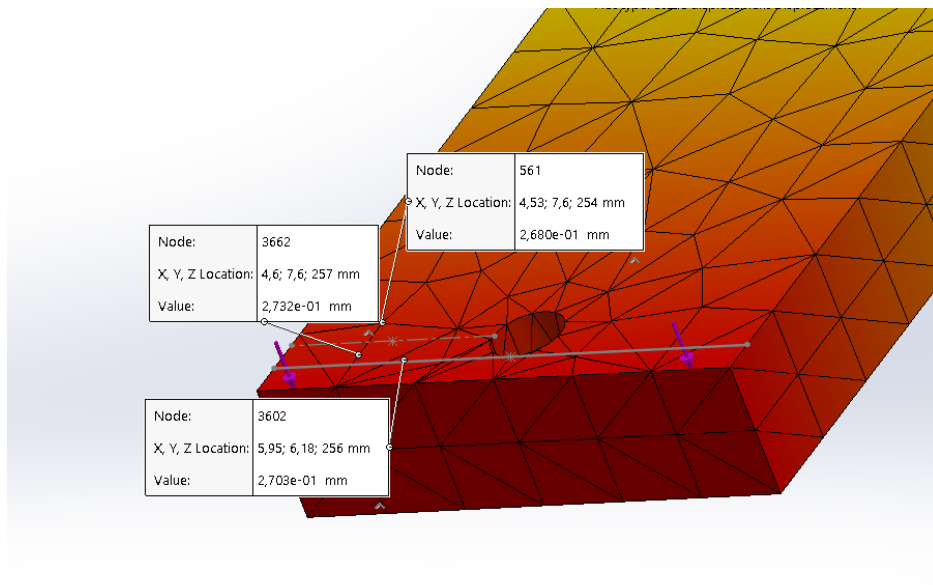


Figure 7 Measurement point

Therefore, the number of variables that can affect the correctness and validity of the results are many:

- Material definition
- Component Constrains: the real ones and the ones replicated into the software
- Load application location on the component
- Displacement's result readings (global o local)

FEA can therefore, be used as a verification tool to the physical experiments or vice versa highlighting how physical test are correlated to FE models, can be used to improve, optimize the existing model

INTERESTING CASE STUDY
BASED ON PRIMARY RESEARCH

5 Conclusion

In conclusion, it was understood that FEA takes complex problems and subdivide them into smaller simpler ones that can be solved.

Companies carry out FEA alongside physical testing due to the repeatability of simulations in a fixed environment, exploiting the computational power, capable to closely resolve the mathematical equations behind structure analysis.

However, it was understood that the principles behind the compute of the solutions are based around specific approximations therefore, it is highlighted the importance of physical testing alongside FEA, to validate either results.

However, using FEA allows the company to produce better quality products, in a shorter design cycle and with less waste of material i.e. more nature friendly.

In conclusion, the author does not believe that FEA will ever replace the physical testing, at least not soon, due to the principles used by it to solve structural problems. Furthermore, FEA software packages can provide very accurate results that hand calculations will not, however, it was highlighted how easily affected the results can be according to which set-ups, parameters and engineering assumptions are made in the pre-processing stages.

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