

BACHELORS DEGREE ASSIGNMENT SPECIFICATION

Student name:	BERGSON	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I declare that this assignment is all my own work and that I have acknowledged all materials used from the published or unpublished works of other people.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:	Assignments will not be accepted without a signature here	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	15.4
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	16.7
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

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)		53.1 %
	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			

Can FEA replace physical testing?

Emma Bergson P148476

Advanced Stress Analysis & FEA
M6X00420
Kelvin Lake
26 April 2020

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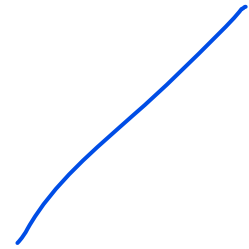
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1 Introduction

This report begins with discussing why companies typically carryout FE analysis alongside physical testing. Using tidal energy as an example, discussions about the fairly new technology and lack of data are looked into.

Secondly, correlation of physical test with an FE model are reviewed. It looks into Experimental Modal Analysis and how it assists FEA. Data Acquisition Systems are investigated and how they help to correlate FE models, providing extra data for datasets. Also, how a physical test on a gear shift lever increased better methods for FEA.

Finally, an examination on whether FE analysis can ever replace physical testing includes research into advanced simulation software and tidal device test centres.



2 Why do companies typically carryout FE analysis alongside physical testing?

FEA is an important part of any engineering project, the ISO 9001 is supplemented with official guidelines when FEA is applied to a design (Anon, 1996). Some of the benefits of FEA includes an array of in-built materials and the ability to do many different types of stress analyses before a physical model is created. One area which sees the benefit of combining experimental testing and the use of powerful software analysis is in tidal power. The combination of Computational Fluid Dynamics (CFD), FEA and physical testing are used to develop innovative ideas for extracting the reliable, predictable energy source (Grosvenor, et al., 2014).

With tidal energy much of the accessible data has been based on wind turbines, however, due to the density of water, a tidal turbine blade can be much smaller to achieve the same rating, thus increasing the load on a smaller structure. This means a tidal turbine blade must have increased strength and stiffness (Arunima, et al., 2018). Hence, with this particular 'new' technology, many scale tests make the use of CFD software such as ANSYS. Every test increases the dataset for companies to access to improve tidal energy production. For example, Liu, et al., (2014), set out to increase the dataset by, 'Model testing a series of bi-directional tidal turbine rotors'. Analysing over 15,000 data runs in the optimisation and simulation process, 7 out of 10 designs were fabricated. A surface mesh was generated, and the blade surface contour used the code to incorporate and create the blade. The physical tests generated datasets available for further experiments by interested companies, which can be repeated to replicate the results in a physical state or numerically (Liu, et al., 2014).

Diagnosing faults and condition monitoring is an essential part in creating new technology. According to Grosvenor, et al., (2019) such new technology, extracting the energy from tidal currents, hasn't achieved long term results of reliability and operational availability. The harsh marine environments will cause difficulties when accessing any device for maintenance and may incur reliability problems (Grosvenor, et al., 2014). Combining the use of CFD and FEA programmes with scale model testing can create any environment before a full scale model is put in to production and as Bahaj (2011) remarked, reducing any ambiguity regarding the operations and maintenance of the tidal devices is essential for increasing investor support to create power extraction which is economically worthwhile (Bahaj, 2011).

3 How can a physical test be correlated to an FE model?

There are a few ways to correlate a physical test to an FE model, all of which will benefit the FE model with the added data gained from the testing.

To better understand vibration characteristics of mechanical structures, modal analysis is an important tool, 'It converts the vibration signals of excitation and responses measured on a complex structure that is difficult to perceive, into a set of modal parameters which can be straightforward to foresee'. After completing a structure, it is good procedure to validate the original FEA model with Experimental Modal Analysis (EMA) results. Through the correlation process using the results from the EMA and FEA, errors can be identified and the FEA model can be updated (Crystal Instruments, 2016).

Data Acquisition Systems (DAQ) are a way to correlate real life performance with theoretical FEA simulations and can be described as, '... the integration of several components within the signal conditioning module, the sensing module, the output/display module, and sometimes the control module that leads to stored, manipulable digital data representations of the sensor measurements.' (Todd, 2014).

There are many companies which offer DAQ. When designing complex models using FEA, an engineer is required, they judge and make appropriate assumptions for the application of loads and boundary conditions, this can be demanding and relies on the experience of the engineer. The ability to provide real life data for load and strain is incredibly useful. The data can be used within the simulations to help develop more precise calculations (Aecentus, n.d.).

Payne, et al., (2017) designed and manufactured, '... a bed supported tidal turbine model for blade and shaft load measurement in turbulent flow and waves.' They concluded that the physical testing in the experimental tank was a vital tool in gathering data on rotor loading and wake development, crucial for the continued progression of turbine design and tidal array layout. The data acquired from their investigation will assist with calibrating numerical models and estimations of rotor loading, and wake developments will be aided when designing full scale machines and array layout (Payne, et al., 2017).

Savadatti, et al., (2018) agree that acquiring physical data to correlate FEA is very beneficial. They wanted to correlate FEA of a gear shift lever with a physical experiment. They discovered the physical test had more realistic values than during the FEA due to assumptions made in the FEA process. However, by creating standard procedures when completing FEA the gap can be reduced,

and confidence can be increased when designing any future projects due to a more reliable procedure (Savadatti, et al., 2018).



4 Thoughts on whether FE analysis can (or should) ever replace physical testing

An experienced engineer can use FEA to complete many types of component analysis which, during the design process will assist with foreseeing strengths and weaknesses. Vast insight when assessing modifications can be gained, identifying small and large scale problems before going into full scale production that would only come to the surface in installation and operation of the equipment. The benefits of, ‘... an integrated fluid and structural analysis...’ will have a positive influence on the running time of a project and save costs (Pretechnologies, 2020).

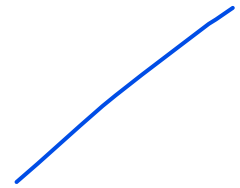
Whilst developing a new tidal turbine, GE Renewable Energy collaborated with MSC Software to create a simulation package that would combine several simulation tools to include, ‘Adams, Adams/ Machinery, Adams/Bearing Advanced Technology and MSC Nastran’. This simulation package was able to predict the dynamic behaviour of the turbine including multiple flexible components, integrate real bearing and gear effect including 3D contacts, simulate various dynamic loads to evaluate complex behaviours and coupling effects and perform modal analysis of the full structure. They aspired for the design to have minimal faults right from the start to lower or remove any chance of repeating the build. This was intended to reduce costs of repeatedly producing a full scale model. After a full simulation, the companies were confident that everything dynamically and kinematically had been ‘de-risked’ before going into the physical testing phase (MSC Software, n.d.). This is evident that even with an extremely advanced simulation package a physical test needs to occur.

FEA always plays a major part in the design of any tidal device. For example, when designing turbine blades, meshing, static analysis and modal analysis is used. Meshing hexagonally is a typical industry standard, static analysis will calculate strength and the critical zone for vibration analysis; modal analysis uses this vibration zone and is referred to as, ‘Dynamic finite element analysis of the blade’. It is commonly used to ensure safety conditions of the blade are met. Arunima et al., (2018) used this FEA method to analyse three types of material; Carbon Fibre Reinforced Polymer, Glass fibre Reinforced Polymer and S2 Glass fibre with the latter having the best performance (Arunima, et al., 2018).

For the foreseeable future, when it comes to tidal energy, physical testing will still be an important part of the process in turbine design. New designs need to demonstrate they can produce efficient renewable energy and where possible, connect to the grid. The European Marine Energy Centre

(EMEC) is based on the Orkneys, this centre of excellence has a scale test site and a grid-connected demonstration zone for full scale devices. Orbital, a tidal device company, started there in 2012 with a 250W scale model and with a world first, exported tidal energy to the grid. Over three months they gathered data to improve their design and in 2016 developed a full scale 2MW version. With the aim of going commercial, this version has again been updated with an array of data being fed into their design software, using FEA to enhance the design to achieve the best possible performance and will be launched later in the year (EMEC, 2019).

Pembrokeshire has recently opened a testing area called META – Marine Energy Testing Area. The areas designated for testing are for scale models, again giving innovative companies an opportunity to test their designs in the harsh marine environment before going commercial (META, n.d.). These tidal designs will always primarily involve FEA but due to the technology being in its infancy, time in demonstration is needed, this gives investors confidence in the ability of a turbine to produce low cost renewable energy.



5 Conclusion

This report set out to investigate whether FEA can replace physical testing and used tidal energy as an example. Although FEA plays a major role in all engineering design, even with continued advances in software technology, physical testing will always be part of the process. From this examination it is clear that they go hand in hand, benefitting from each other. The more physical testing that takes place improves the dataset for the software, which in turn increases the accuracy of FEA, bringing down costs due to reduced time spent on creating a physical prototype and eliminating risks of multiple builds.

GOOD CONTEXTUALISATION, HOWEVER THE REPORT IS FAIRLY SUPERFICIAL & CONTAINS FEW DETAILS.

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