A top down approach to teaching mechanics

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Outline

- Project details
- Module overview
- Student experiences
- Colleague reactions
- Future developments

This study

- Staff Development model
- Action research approach
  - Supported by action learning set
  - As part of PGCert
- Literature perspective
- Qualitative feedback through:
  - Students questionnaires
  - Staff questionnaires

Project outline

- Project details:
  - Design, analyse and test a bridge design
  - To hold 20kg minimum (measured safety factor)
  - Light as possible
  - Minimum 1000mm span
  - Minimum 100mm width
  - Loaded using hydraulic jack
  - Inexpensive to manufacture
- Other project: lift mount system

Module overview

- Introduction to the problem. Mechanics of solids, mechanical design and materials
- Structures, loads, FBD's, stress/strain and the strength of materials
- Material properties - E, ρ, v with lab
- Principal and Von-Mises stresses
- Failure criterion and optimisation

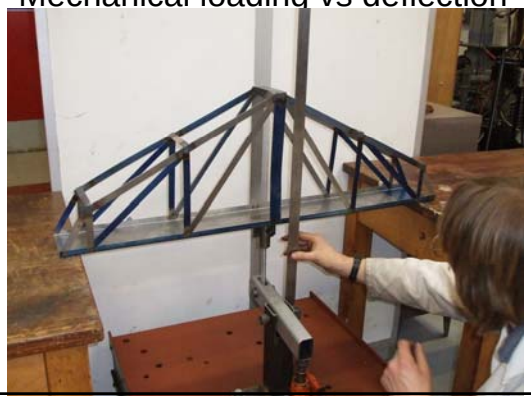
Trip to London – bridge watching

Module overview

- Bridge design & construction in class
- Bridge testing to destruction

Mechanical loading vs deflection

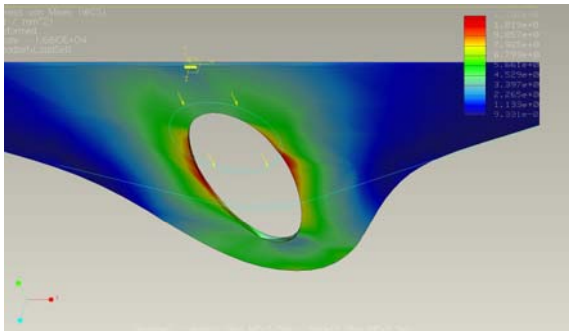
Mechanical loading vs deflection



Module overview

- Stress analysis of bridges - understanding the situation (loads, constraints, materials, issues, stresses, strains)
- FEA context- background theory, simple 1-D example and role in design.
- FEA use- constitutive models, processing steps, convergence and accuracy
- Building a simple FEA model with evaluation
- Pre and post processing (adjusting input and interpreting results)

FEA of lug



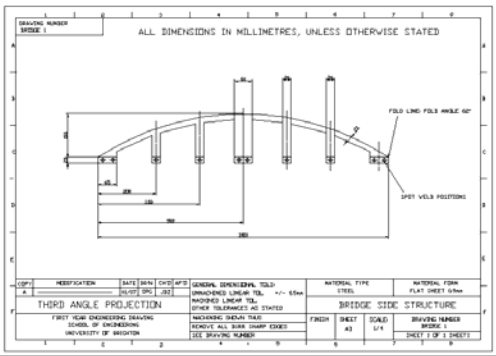
Module overview

- Assumptions and limitations
- Optimisation - what is it ?
- FEA - manual optimisation
- FEA - software optimisation and sensitivity
- 2nd Bridge design, construction and testing
- Assessments

Assessment

- Online test (20%) – midpoint
- Group presentation/demonstration (30%)
- Individual Viva Voce examinations (30%)
- Team report (20%)

Students fabricated and welded bridges



Students risk assessments

Hazard	Possible Outcomes	Potential harm	Solution
MIG and spot welding	Blinding and burns	3/5	Wear mask and cool of metal with water after.
Pillar drill	Clothing and hair getting trapped and cuts	3/5	Secure clothing and loose hair.
Centre punch	Cuts and bruising	1/5	Pay attention to the work and not getting distracted
Hammer	Cuts and bruising	1/5	Pay attention to the work and not getting distracted
Blue die	Irritant, blindness	1/5	Keep away from eyes and wash off skin straight away.
Metal file	cuts	2/5	Pay attention to the work and not getting distracted
Electric hand held metal cutter	cuts	3/5	Keep hands well away from blade
Pillar press	Hit head cuts	1/5	Large red ball on handle for a warning, keep hands away from press
Gelatine	Cuts	1/5	Keep hands away from blade
Metal folder	Bruising	1/5	Pay attention to the work

Student experience

- “I personally like a simple step by step walk through done by the teacher, where I can follow on my computer and make notes”.
- “I found it easier practicing with the program than using worksheets”.
- “a positive aspect of this module was discovering aspects of engineering that I would otherwise struggle to deal with; discovering them in a way I enjoy, i.e. project and computer application”.

Student experience

- “the fact that it is practical is better as we are constantly applying and testing the theory we are learning”.
- “this module is very laid back, which is good in helping me learn!”
- “we used what we had learnt in this module to design a recumbent bicycle and ensure the parts and frame would be strong enough. I feel more confident now”.
- “this module has taught me how to approach engineering problems from a more logical perspective”.

Student experience

- “slightly better conceptual understanding…no clue on maths”.
- “I want to do engineering now, not product design”
- All 10 students surveyed through this questionnaire said that this part of the module was either “quite enjoyable” or “very enjoyable”.
- All of the students surveyed also suggested that this module was “very appropriate”.

Colleague feedback

- “the teaching and learning methods presented in this module support and encourage independent learning strategies and are valuable for a life-long learning model”
- “investigative approaches encourage motivation and participation, especially if there are some informed choices made by the students”
- “students may feel overwhelmed by a lack of underpinning knowledge. Basic requirements should be clearly outlined”

Colleague feedback

- “relevance to the design process can be a positive driver for students”
- “beware lack of perceived structure. This can be reinforced with clear criteria and staged (formative) assessments”
- “try to engage students in evaluation, with you being a moderator type of assessor perhaps?”

Advantages to learning

- Compare model vs experimental
- Can visualise & appreciate limitations of analysis techniques
- Hands on construction:
  - Technical drawings
  - Risk assessments
- Learning in context – the need for learning
- Diverse learning styles / modes
- Emotional involvement - ownership

Limitations and issues

- To teaching methods:
  - Confusion between learning & project outcomes
  - Risk of superficial treatment
  - Application to extended domains may be problematic
  - Limited code development
  - Pro/Mechanica software used not as configurable as others
- To this study:
  - Small sample size leads to lack of quantitative analysis

Future developments

- Use Cosmos FEA software – more configurable and user friendly
- Peer assessment across pairs
- Hide final bridge criteria to start with to broaden design choice
- Scaling for bigger classes
- Your suggestions!