

QUESTION 1

a) FEA CAN BE USED TO REDUCE PHYSICAL PROTO TYPES AS WHEN USING CAE AND CAD WE CAN EXTENSIVELY TEST DIFFERENT PROTOTYPES IN THE VIRTUAL WORLD BY TESTING VARIOUS MATERIALS, BOUNDARY CONDITIONS AND SUBJECTED LOADS. FROM ~~WHICH~~ WE CAN ~~PO~~ OPTIMIZE TOPOLOGY TO ENSURE COMPONENTS FIT AND ~~ARE~~ ARE MANUFACTURABLE AND LIGHT AS POSSIBLE I.E FOR AUTOMOTIVE TO REDUCE FUEL CONSUMPTION BUT STAY STRONG. FROM THIS WE CAN ALSO PRODUCE CASTING MOLDS TO ENSURE THE DESIGN IS ~~MANUFACTURABLE~~ MANUFACTURABLE.

CARRY OUT SHAPE OPTIMISATION TO REDUCE POSSIBLE FAILURE POINT DUE TO FATIGUE.

PERFORMANCE ASSESSMENT TO SHOW HOW IT ACTS DURING OPERATION AND REDUCE ANY PEAK LOADS.

WE CAN THEN USE OPTIMISED CAD DESIGN TO DESIGN A ROUGH ~~OF~~ PROTOTYPE ~~BEFORE~~ FOR PHYSICAL TEST BEFORE MANUFACTURE.

b) PHYSICAL PROTOTYPES ARE ALWAYS REQUIRED FOR TESTING AND PERFORMANCE CHECKS AS WELL AS ~~APPEAR~~ APPEARANCE DEPENDING ON IF COMPONENT NEEDS TO BE AESTHETICALLY APPEALING. TESTING IS ALWAYS REQUIRED TO ALLOW CROSS CHECKS WITH DESIGN MAKE SURE MISTAKES HAVEN'T BEEN MADE TO GIVE CUSTOMER AND CONSUMER CONFIDENCE.

c) CORRELATION IS ALWAYS NEEDED TO CHECK

- STRESS AND STRAIN RESULTS COMPARE
- CAN THE SPECIMAN LAST THE NUMBER OF USE CYCLES THE MODEL HAS SAID THEORETICALLY
- HOW DOES TEMPERATURE AFFECT SPECIMENS BEHAVIOUR

FROM THESE CORRELATION RESULTS BETWEEN FEA ACTUAL WE ARE LOOKING FOR GOOD CORRELATION NO. MORE THAN 15%.

AND IF OUTSIDE 15% THE PROBLE CAUSE ARE THINGS SUCH AS BOUNDARY CONDITIONS MATERIAL PROPERTIES, RESIDUAL STRESSES I.E WELDING, BOLTING ~~ARE~~ ALSO EXPERIMENTAL ERROR

Question 2

a) PRE PROCESSING IS UNDERSTANDING THE PROBLEM, SPECIFICATION AND WHAT THE OUTCOME NEEDS TO BE AND THE ACCURACY WE USE TO THINK OF PREPROCESSING PART OF FEA IS

S. I. M. P. L. E

SPLITTING INTO ELEMENTS - INTERPRET GEOMETRY MATERIAL INFORMATION PHYSICAL PROPERTIES LOADING EVALUATION OF RESULTS = POST PROCESSING

SO THE SIMPL CAN BE THOUGHT A PRE PROCESSING

SPLITTING THE COMPLEX PROBLEM INTO SMALL UNDERSTANDABLE ELEMENTS. THIS MEANS THAT MATHEMATICAL ASSUMPTIONS CAN BE MADE ON MORE SIMPLISTIC GEOMETRIC ELEMENTS. THE GEOMETRY OF THESE ELEMENTS ARE DETERMINED BY THE TYPE OF COMPONENT

INTERPRET GEOMETRY. UNDERSTANDING THE GEOMETRY TO SMALL DETAILS WHICH AT RUN TIME TO ANALYSIS BUT MAKE LITTLE STRUCTURAL DIFFERENCE. E.g IF MODELING STRESS ON AN ENGINE THE FINS ARE FOR HEAT DISSIPATION NOT STRUCTURAL THEREFORE DO NOT THE COMPLEXITY TO THE MODEL FOR STRESS.

~~Leading~~ MATERIAL. UNDERSTANDING MATERIAL PROPERTIES ARE IMPORTANT TO UNDERSTAND THE MODEL AND WHAT ANALYSIS CAN BE CARRIED OUT FOR EXAMPLES IF A BRITTLE METAL USED IS VON MISES THE BEST USE. AND ALSO MODELLING IN CORRECT MATERIAL WILL GIVE BETTER CORRELATION OF PROTOTYPE.

PHYSICAL PROPERTIES ARE KEY WHEN ~~FE~~ USING DIFFERENT ELEMENT TYPES. Eg 1D WILL REQUIRE SECOND MOMENT OF AREA AND POOR SECOND MOMENT OF AREA. 2D ELEMENTS RELY ON THICKNESS OF MATERIAL IS A. SIMPLE BEAM FOR EXAMPLE. IF WRONG PROPERTIES OR ELEMENTS ARE USED AGAIN POOR CORRELATION WITH PROTOTYPE 3D ELEMENT US ~~SHARP~~ ~~PROP.~~ GEOMETRY PROPERTIES WITH MATERIAL PROPERTIES

LOADING: ONCE THE ABOVE INFORMATION HAS BEEN ADDED TO THE FE MODEL THE SOLVER WILL BE ABLE TO CALCULATE THE STIFFNESS MATRIX FOR THE STRUCTURE. FROM THIS, A SET OF SIMULTANEOUS EQUATIONS CAN BE OBTAINED. IN ORDER TO SOLVE THESE, THEN THE LOADING AND BOUNDARY CONDITIONS NEEDS TO BE KNOWN. THAT IS TO SAY, HOW IS THE PART LOADED. IN WHAT DIRECTION, HOW IS IT CONSTRAINED? THIS CAN ALSO BE A SOURCE OF POOR CORRELATION (PROBABLY THE MAIN CAUSE OF POOR CORRELATION.) FOR EXAMPLE OVER WHAT AREA IS THE FORCE BEING APPLIED (IF THE PART IS BEING LOADED AT A SINGLE NODE, THEN IN THEORY THE STRESS IN THIS LOCATION WOULD BE INFINITE ($\text{STRESS} = F/A$)). IN WHAT DIRECTION? IT IS VERY EASY TO SAY FACE IS FIXED IN 6 DEGREES OF FREEDOM. (IE IT CAN NOT MOVE AT ALL) BUT THIS SUGGESTS THAT THE PART THE COMPONENT IS ATTACHED TO IS OF INFINITE ~~STRESS~~ STIFFNESS WHICH WILL NOT BE THE CASE

~~QUESTION 2b)~~

QUESTION 2b)

~~POST~~ PROCESSING IS WHERE THE FINITE ELEMENT METHOD IS USED TO SOLVE THE FE MODEL. ~~THIS IS DO.~~

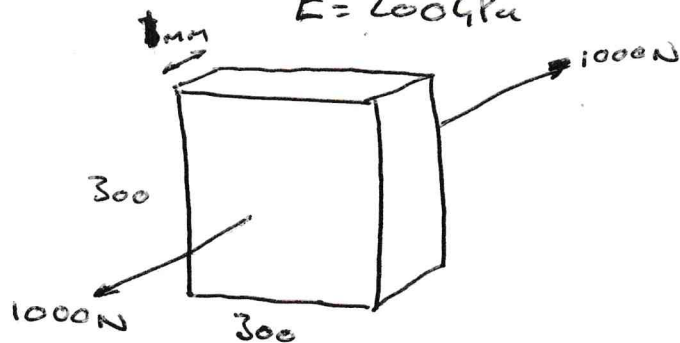
- c) POST PROCESSING IS THE E PART OF S.I.M.P.L.E AND IS EVALUATING THE RESULTS
- BY COMPARING TO THE PROTOTYPE AND CORRECTION BETWEEN THEM.
 - HAVE OUR ASSUMPTIONS THAT WE HAVE MADE CHANGED THE RESULTS AND ARE THEY THEORETICAL.

QUESTION 3

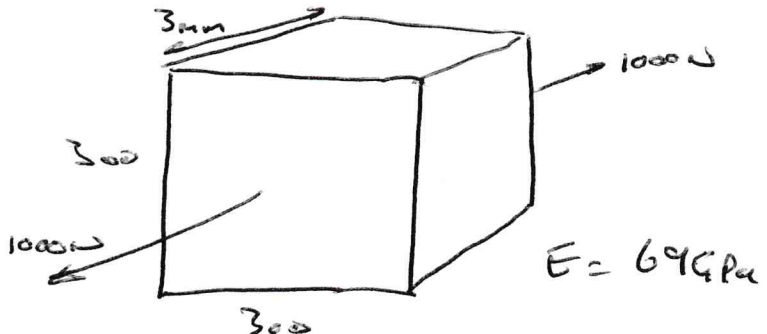
a)

STEEL

$E = 200 \text{ GPa}$



ALUMINIUM



$E = 69 \text{ GPa}$

$$E = \frac{\text{FORCE}}{\text{AREA}} \times \frac{\Delta L}{L}$$

$$\Delta L = \frac{FL}{AE}$$

$$\Delta L = \frac{1000 \times 0.001}{(0.03 \times 0.03) \times 200 \times 10^9}$$

$$= \frac{1}{18 \times 10^7}$$

$$\Delta L = 5.56 \times 10^{-9} \text{ m}$$

$$\Delta L = \frac{FL}{AE}$$

$$= \frac{1000 \times 0.003}{(0.03 \times 0.03) \times 69 \times 10^9}$$

$$= \frac{3}{62100000}$$

$$\Delta L = 4.8 \times 10^{-8} \text{ m}$$

$$\text{RESILANCE} = \frac{\sigma^2}{2E}$$

$$= \frac{\left(\frac{1000}{(0.03 \times 0.03)} \right)^2}{2 \times 200 \times 10^9}$$

$$= \frac{10000000}{4 \times 10^{11}}$$

$$= 2.5 \times 10^{-6}$$

$$= \frac{\sigma^2}{2E}$$

$$= \frac{\left(\frac{1000}{(0.03 \times 0.03)} \right)^2}{2 \times 69 \times 10^9}$$

$$= \frac{10000000}{1.38 \times 10^{11}}$$

$$= 7.2 \times 10^{-6}$$

ALUMINIUM HAS HIGHER STIFFNESS

QUESTION 3

b) STEEL

$$I = \frac{0.03 \times (0.03)^3}{12}$$

$$= 6.75 \times 10^{-8}$$

$$Flexural = E \times I$$

$$= 200 \times 10^9 \times 6.75 \times 10^{-8}$$

$$= 13500 \text{ N}^4$$

Aluminium

$$I = \frac{0.03 \times (0.003)^3}{12}$$

$$= 6.75 \times 10^{-8}$$

$$= E \times I$$

$$= 69 \times 10^9 \times 6.75 \times 10^{-8}$$

$$= 4657.5 \text{ N}^4$$

ALUMINIUM HAS A HIGHER FLEXURAL RIGIDITY

c) STEEL $\rho = 7900 \text{ kgm}^3$
 ALUMIN $\rho = 2700 \text{ kgm}^3$

$$\text{STIFFNESS TO WEIGHT RATIO STEEL} = \frac{E}{\rho}$$

$$= \frac{200 \times 10^9}{7900}$$

$$= 25316455.7$$

$$= 25.3 \times 10^6 \text{ Pa m}^3/\text{kg}$$

$$\text{OF ALUMIN} = \frac{E}{\rho}$$

$$= \frac{69 \times 10^9}{2700}$$

$$= 25.6 \times 10^6 \text{ Pa m}^3/\text{kg}$$

3d) Aluminium HAS ITS ADVANTAGES OVER STEEL DUE TO THE LOWER DEFLECTION SHOWN IN PART (a) WHICH MEANS THE MACHINE COULD WITH STAND HIGHER TORSION FORCES. WE CAN ALSO SEE IT HAS A MUCH HIGHER STIFFNESS WHICH IS DEPENDANT ON THE CROSS SECTION RATHER THAN THE THICKNESS OF THE PANELS. SO IF THEY WERE BOTH SAME THICKNESS ALUMINIUM WOULD BE ALMOST 3 TIMES STIFFER WHICH IS GREAT FOR A PANEL. FROM PART (b)

AND IN PART (c) WE CAN SEE THAT THE STIFFNESS TO WEIGHT RATIO IS SIMILAR. ~~SO FOR LESS MATERIAL WE GET WEIGHT~~ WE CAN HAVE SLIGHTLY HIGHER PERFORMANCE FROM ALUMINIUM TO STEEL IN WEIGHT