

FINITE ELEMENT ANALYSIS

What is it and how can it help your company?

Finite Element Analysis (FEA) is a computer based method of simulating/analysing the behaviour of engineering structures and components under a variety of conditions. It is an advanced engineering tool that is used in design and to augment/replace experimental testing.

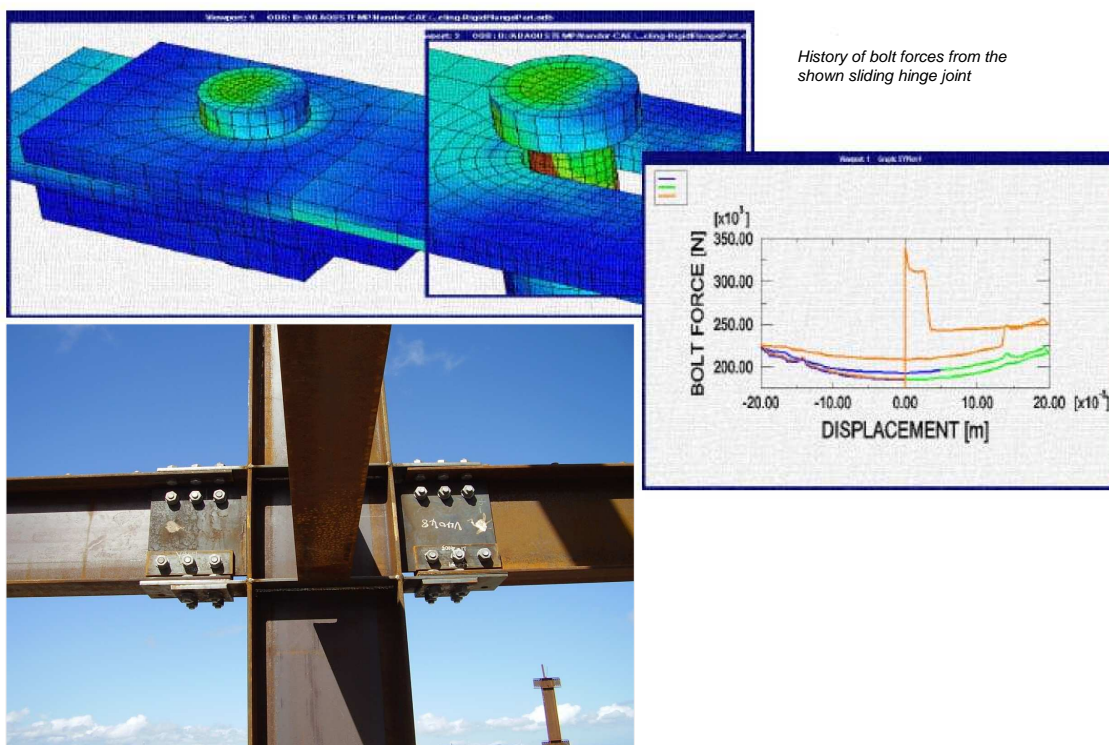
Introduction

FEA is widely accepted in almost all engineering disciplines. The method is often used as an alternative to the experimental test method set out in many standards. The technique is based on the premise that an approximate solution to any complex engineering problem can be reached by subdividing the structure/component into smaller more manageable (finite) elements. The **Finite Element Model (FEM)** is analysed with an inherently **greater precision** than would otherwise be possible using conventional hand analyses, since the actual shape, load and constraints, as well as material property combinations can be specified with much greater accuracy than that used in classical hand calculations.

The method is comprised of three stages

- (A) **Pre-processing**, in which the analyst develops a finite element mesh of the geometry and applies material properties, boundary conditions and loads
- (B) **Solution**, during which the program derives the governing matrix equations (stiffness x displacement = load) from the model and solves for the displacements, strains and stresses. This is the case in implicit code applications. Alternatively explicit codes can be used, mostly for high strain rate engineering problems.
- (C) **Post-processing**, in which the analyst obtains results usually in the form of deformed shapes, contour plots etc. which help to check the validity of the solution.

A variety of reporting tools can be used to illustrate the behaviour of the analysis model including colour contour and vector plots, section cuts, isosurfaces, animations, graphs and text output. The results are interpreted and areas of concerns are discussed.



The Benefits and Application of FEA

FEA is particularly suitable for:

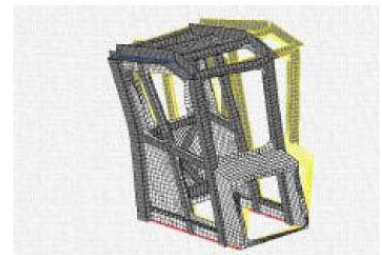
- Structural/mechanical engineering design
- Product development
- Manufacturing processes
- Improving the efficiency of existing designs
- Failure analysis investigations.

FEA provides engineering information (Stress/strain, deformation, natural frequencies, etc) about a structure/component which cannot be obtained by using traditional analysis methods.

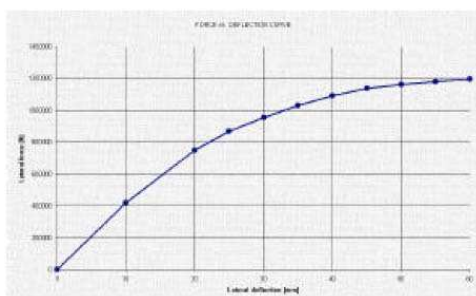
It is possible to generate a **simulation of any design concept** and to determine its real world behaviour under almost any imaginable environments, therefore allowing the concept to be refined prior to the creation of drawings, when few dollars have been committed and changes are inexpensive. Once a model has been developed the analysis helps in evaluating the feasibility of the new design as well as trouble shooting failed designs already in the market and finding solutions without the need to prototype and waste time and money.

The following is a more specific list (but by no means comprehensive) of possible analysis types and applications:

- Linear and non-linear (e.g. elastic-plastic) static stress/displacement analysis (buckling, thermal loading, quasi-static analysis)
- Dynamic stress/displacement analysis (modal and transient modal dynamic analysis, non-linear transient analysis e.g. impact)
- Non-linear stress analysis for the simulation of manufacturing processes, e.g. metal forming
- Contact analyses to simulate contact between parts and assemblies
- Analyses of a welded and/or bolted connections
- Fatigue and fracture analysis
- Sub-modelling to study a local part of a larger model
- Roll-over and falling-object protective structures
- Steel & reinforced concrete buildings/frames.
- Analyses of structures due to fire.



Crash simulation of cab structure



Force Versus Deflection curve of the cab structure

The Bottom Line

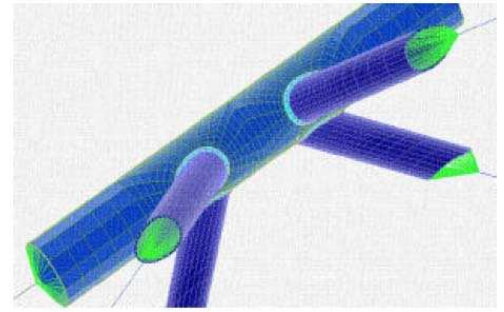
- The availability of FEA enables engineers to achieve objectives which they otherwise could not, for instance making design modifications of highly stressed areas.
- In almost any type of engineering endeavour, FEA saves time and money.
- FEA aids understanding of the structural behaviour which helps to remove uncertainty and unnecessary pessimism.

Limitations

As explained in the introduction, like any other approximate numerical method, the solution produced by finite element analysis contains a certain amount of error. The magnitude of the error is highly dependent on the type, size, and accuracy of the model used for the analysis. That's why **not all finite element models are created equal**. Indeed, the educational and industrial experience of the analyst and the sophistication of the software are the two most critical factors in obtaining reliable results. Validation of a FE model is carried out by comparison of the results with measured test data and/or by values obtained by other independent means (hand calculations or other FE program).

Finite Element Analysis - Consultancy

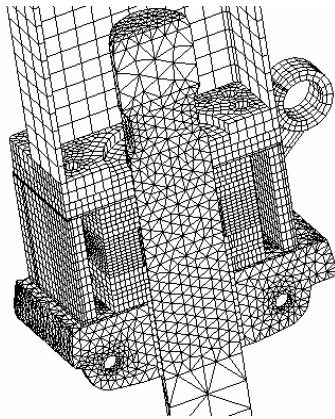
HERA takes full advantage of today's leading finite element analysis packages mostly using ABAQUS/Standard/Explicit solvers with CAE pre-processor to set up and analyse complex engineering problems in our applied research and in industry service. Post-processing is performed in ABAQUS/Viewer.



Welded K Joint built for a hot spot stress fatigue analysis

We can help you answer questions like:

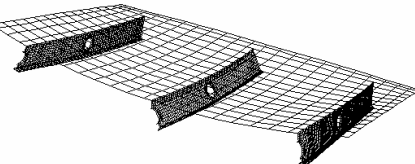
- Will your structure/product withstand all working loads or how does it behave in fire?
- Will permanent deformation occur under given conditions?
- Will it vibrate uncontrollably under certain conditions?
- Can it withstand accidents safely?
- Can you reduce material contents or use less expensive material?



Example from a consulting application for "Rocktec Limited".



```
Max X +2.286e-02
at node JOIST-2.552
Min X -2.108e-04
at node JOIST-1.62
Max Y +1.780e-02
at node JOIST-2.247
Min Y -1.928e-01
at node JOIST-2.63
Max Z +4.830e-04
at node JOIST-1.366
Min Z -4.896e-02
at node JOIST-2.248
```



The actual deformed shape of half of the Speedfloor slab at 180min of Standard Fire loading.



Deformed shape after the fire test shows joists glowing and the buckled shape of the mid joist as it was lifted up some 10 minutes after the furnace was shut down.

CONTACTS FOR AN OBLIGATION FREE DISCUSSION ON FEA IN CONSULTANCY

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