

Automotive FEA Analysis

FEA basics, automotive solvers, modeling workflow and a cross-member mesh study

Key Concepts

FEA / FEM	Finite element analysis uses the finite element method to solve the PDEs behind structural, thermal and fluid behavior numerically.
Why use it	Test load cases virtually (e.g. FMVSS 214 side impact) before prototypes; iterate faster and cheaper.
Garbage in, garbage out	Results are only as good as the operator's assumptions.
1D element	Line with assigned section properties: fast, but no direct stress result here.
2D element	Meshed shell geometry: accurate displacement and stress; keep elements near-square.
RBE3	Spreads a point load over an area so one node doesn't over-deform.

Common Automotive Solvers

Software	Typical use
Altair HyperWorks (HyperMesh, OptiStruct, HyperView)	Pre-processing, optimization, post-processing
Abaqus	Nonlinear structural, crash and impact
ANSYS	Multiphysics: structural, thermal, fluid
LS-DYNA	Explicit crash and high-speed impact
Nastran	Linear structural and NVH
SolidWorks Simulation	CAD-integrated early design work

Hand-Check Formulas (standard, fixed-fixed beam, center load)

Max deflection	$\delta_{\max} = P L^3 / (192 E I)$	Use to sanity-check FEA displacement.
Max moment	$M_{\max} = P L / 8$	At the ends and at mid-span.
Bending stress	$\sigma = M c / I$	Compare with yield.
Square section	$I = b^4 / 12$	Solid b × b section.

Case Study: Hood-Latch Cross Member

Item	Value
Model	30 × 30 mm square steel beam, fixed both ends, 1,000 N center point load (aero load)
Steel	E = 210 GPa, ν = 0.3, ρ = 7,850 kg/m³, yield 210 MPa
Workflow	HyperMesh (CBEAM for 1D, extruded 2D shell) → OptiStruct → HyperView
Mesh study (2D)	1, 3 and 5 mm meshes: displacement –1.73 to –2.08 mm; stress 235 to 1,967 MPa
Best trial	3 mm mesh most realistic

Lessons

- Displacement is insensitive to mesh size; stress near concentrated loads is very sensitive.
- Constrain all 6 DOF on every end node to model a clamped support.
- Model aero load as distributed, or enlarge the RBE3 area, to avoid false stress peaks.
- 1D gave lower displacement than 2D (fewest nodes, least accurate).