

**ENGINEERING SIMULATION ECOSYSTEM**

Full-Featured Engineering Simulation (FEA / CFD) in Browser and Desktop

WebCAE is a high-performance engineering ecosystem for structural, fluid dynamics, and multiphysics analysis. Built on WebAssembly (WASM SIMD) and WebGPU, it delivers 100% client-side computing ensuring absolute CAD model confidentiality, coupled with autonomous AI agent workflows.

KEY ARCHITECTURAL ADVANTAGES

Zero-Install & Instant Launch

Opens any complex project in a modern web browser in 1 second without massive multi-gigabyte installations or license servers. Lightweight native Tauri desktop app available for Windows, macOS, and Linux.

100% On-Premise Data Privacy

All geometry tessellation, mesh generation, and linear algebra solvers run exclusively in your local computer memory. CAD models and result fields are never transmitted to external cloud servers.

AI Agent Automation (MCP)

Direct integration with autonomous AI coding agents (Claude, ChatGPT, Antigravity) via the Model Context Protocol (MCP). Full programmatic execution of CAD defeaturing, setup, and optimization.

PHYSICS DISCIPLINES & SOLVER CAPABILITIES

Linear & Nonlinear Statics

Direct sparse (Cholesky/LLT) and preconditioned iterative solvers. Full support for large deformations (NLGEOM), geometric stiffness update, and follower pressure loads.

Linear Static

NLGEOM

Follower Loads

Elastoplasticity & Material Nonlinearity

J2 von Mises flow theory, associative plasticity, kinematic and isotropic hardening, and accurate residual stress calculations during load reversal cycles.

J2 Flow Theory

Hardening

Residual Stress

Mortar Contact Mechanics

Segment-based Mortar formulation avoiding nodal point penalty singularities. Frictionless unilateral contact, bonded interface gluing, and multi-body kinematic assemblies.

Mortar Contact

Multibody

Frictionless / Bonded

Computational Fluid Dynamics (CFD)

Incompressible and compressible RANS solver powered by the SU2 engine: Spalart-Allmaras and SST turbulence models, rotating zones (Sliding Mesh), and accurate aerodynamic lift/drag (Cd, Cl).

SU2 CFD

RANS SST

Sliding Mesh

Modal & Buckling Analysis

Krylov-subspace and Lanczos eigensolvers for natural vibration frequencies and mode shapes, including prestressed modal analysis. Linear Euler buckling with critical load factor extraction.

Eigen Modal

Prestressed

Buckling

Transient & Explicit Dynamics

Explicit central difference integration (MFEM) for high-speed dynamic impacts, crash simulations, wave propagation, and element erosion. Implicit Newmark-beta solver for seismic analysis.

Explicit Dynamics

Central Difference

Newmark-Beta



FINITE ELEMENT LIBRARY

CATEGORY	ELEMENT TYPES	MATHEMATICAL FORMULATION	TYPICAL APPLICATIONS
Solid Elements	Tet4, Tet10 (quadratic), Hex8	B-bar integration, volumetric locking free formulation, isoparametric displacement field approximation.	Machined and cast parts, heavy brackets, bearings, tooling fixtures, geomechanical volumes.
Shell Elements	MITC4 (Mixed Interpolation), DKMQ	Mindlin-Reissner plate theory, shear locking free formulation, multi-layer orthotropic composite laminate stackups.	Thin-walled pressure vessels, structural panels, airframe skins, tanks, automotive body sheets.
Beam & Truss Elements	3D Timoshenko Beam (6 DOF), 3D Trusses	Transverse shear deformation inclusion, arbitrary standard cross-sections (I-beam, tube, channel), member end releases.	Space frame structures, communication towers, pipe bridges, building skeletons, truss bridges.
Special Interfaces	RBE2 (Rigid Links), Point Mass, Mortar	Kinematic multi-point constraints with virtual master nodes, point mass inertia distribution, Lagrange multipliers.	Bolt and pin connections, remote load application points, multibody contact interfaces.

B-REP CAD KERNEL & FINITE ELEMENT MESHING

OpenCASCADE Technology (OCCT) Kernel

Integrated industrial B-Rep solid modeler (OCCT 7.9): robust import/export of STEP AP203/214/242 and IGES. Full parametric modeling capabilities including 2D sketches, extrusions, revolves, sweeps, lofts, reliable boolean operations (cut, union, intersect), and automatic geometric defeaturing to suppress small fillets and chamfers before meshing.

Netgen Delaunay Mesh Generation

Embedded Netgen 3D mesher: curvature and feature-adaptive tet generation, spherical and cylindrical local sizing zones, prismatic boundary layer inflation for CFD viscous sublayers, and hybrid hexahedral-tetrahedral zoning.

WEBCAE DSL & AUTOMATION PIPELINE

WebCAE features a clean declarative-imperative scripting language (**WebCAE DSL**) for end-to-end automation from geometry creation and meshing to boundary conditions, solve, and peak stress extraction. The DSL strictly relies on stable topology journal addressing (surface number `N`, edge number `N`). Seamlessly connects with Onshape Cloud CAD, ParaView VTK export, and WebShare 3D links.