FX+ Modeler

General Pre & Post-processor for Finite Element Analysis
Overview

Overview
Geometry Modeling
Mesh Generation
LBC & Analysis

02
14
28
45
“FX+ Modeler is a general purpose, FEA (Finite Element Analysis) pre-processor with state-of-the-art Windows based graphic user interface providing a complete FEA environment for linking geometry modeling and meshing...”
Developed based-on **Task-oriented Design Paradigm**
FXP’s **Works Tree** displays geometry, mesh, analysis data and result data in a tree structure as Windows Explorer.

Works Tree provides its own context menu and supports the convenient model management. Works Tree changes its form depending on the working mode.
- FXP’s **Property Window** provides the various information of the selected item and allows the change of the basic properties such as name, color, etc.
- In post-processing mode, Property Windows is used as a control panel of the post-processing options.
Task-oriented User Interface

Drawing Type Selection

Dynamic Instruction for Current Input

Location Entry Field
- Mouse Snap:
- Keyboard Input: Mathematical expressions can be used. <Ex> 100/2*\sin(40)
Overview

Graphic Display - Geometry

Advanced Nonlinear and Detail Analysis Program

Shading

Shading with Edge

Shading + Transparency

Wireframe

Mouse-out

Mouse-in

Bounding Box
Overview

Graphic Display - Mesh

Advanced Nonlinear and Detail Analysis Program

Shading

Wireframe

Shading + Shrink

Feature Edge

Feature Edge (Geotechnical Model)
Virtual Mesh Transformation

Virtual Transformation
(Translation, Rotation, Scaling)
by Mouse Dragging

Shaver
(Component Assy.)
Overview

Selection Method

Advanced Nonlinear and Detail Analysis Program

Select
Unselect
Unselect All

Selection Filter

ID
Displayed
Query Pick
Polyline
Polygon
Circle
Pick / Window
Include Intersected

Polygon Selection
Circle Selection
Polyline Selection
Overview

Selection Method

Advanced Nonlinear and Detail Analysis Program

ID Selection (Node/Element)

Query Pick Selection

Detected Entity List

Displayed Selection

1000 to 1024 by 2

Add | Replace | Clear | Close
### Overview

#### Data Exchange

- **Import (Geometry/Mesh)**
  - STEP, IGES, Parasolid
  - AutoCAD DXF (2D)
  - STL (Mesh)
- **Export (Geometry/Mesh)**
  - STEP, IGES
  - STL (Mesh)
- **Import/Export (Analysis Data)**
  - MIDAS/Civil, MIDAS/Gen
  - Nastran, Ansys, ABAQUS, etc
  - Neutral File (Pre: ASCII, Post: Binary)

### Standards for Data Exchange

- **STEP (STandard for the Exchange of Product Model Data)**
- **IGES (Initial Graphics Exchange Specification)**
- **STL (STereo Lithography)** – De facto standard for RP
Geometry Modeling

Overview

Geometry Modeling

Mesh Generation

LBC & Analysis
Advanced modeling functions can be used in surface & solid modeling.
Geometry Modeling

Curve Modeling

**Generation**
- Line
- Arc
- Circle
- Ellipse
- Parabola
- Hyperbola
- B-Spline
- Polyline
- Rectangle
- Polygon
- Profile
- Helix
- On-surface Curve
- Shortest Path Line
- Surface Intersection
- Offset Curve
- Extrude Vertex
- Tangent Line

**Modification**
- Fillet / Chamfer
- Trim / Extend
- Merge / Break
- Intersect
- Coincide Ends
- Make Wire

![Diagram of curve modeling generation and modification processes](image)
Solid Modeling

Trim

Blend

Fuse

Cut

Divide

Common

A

B

(A ∪ B)

(A - B)

(A ∩ B)

Symmetric Model

Advanced Nonlinear and Detail Analysis Program
Trim 2 Surfaces

Chamfer

Fillet

Offset

Profiles (2 Circle)

Cut: Through-all

Fuse: Defined Height

Local Prism

Shell
Geometry Healer

Specialized Module for Geometry Healing

Topological Validity Analysis
### Geometry Modeling

**Geometry Repairing**

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### Analyze / Heal (Fix Corrupted Geometry)
- Topological Validity, Free Boundaries
- Fix Missing Seam-edge
- Fix Orientation: Edge, Wire, Face
- Fill: Gaps, Holes
- Sew, Split
- Upgrade: Continuity, Converting

### Repair (Modify for Meshing)
- Divide: Edges, Faces
- Merge: Faces, Edges, Face-Edges, Edges
- Fix Small Edges/Faces, Split Revolved Faces
- Remove: Floating Objects, Faces, Internal Wires, Sub-shapes
- Convert to NURBS Geometry to Canonical Geometry (Analytical Form)
- Convert: Wire to Face, Shell to Solid, Solid to Shell
Geometry Modeling

Geometry Repairing

Advanced Nonlinear and Detail Analysis Program

Merge Surfaces
Geometry Modeling

Geometry Repairing

Invalid Topology (Unshadable Face)

Check & Fix Topology

Split Surface by Continuity
Check Geometry

Check Shape
- Free Edge
- Manifold Edge
- Non-manifold Edge
- Short Edge
- Sliver Face

Check/Remove Duplicate
- Vertex
- Edge
- Face
Advantage of Geometry-based Modeling Approach

1. Flexible
   - Using the advanced geometric modeling functions, especially surface and solid modeling functions, modeling various real and complex terrain and/or stratum geometries can be accomplished very easily!

2. Convenient
   - Compared to manual operations, geometric modeling functions require fewer inputs. It does not require tedious information input like nodal coord’s, element connectivity, etc. It just needs the least real geometric information!

3. Accurate
   - Using the geometric modeling functions, the complex geometric operations like intersecting and dividing the free-form surfaces can be performed in a matter of seconds. Exact solutions are obtained with no hassle!
Geometry Modeling

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Mesh Generation

Auto

- Solid
- Surface
- Edge
- Planar Area
- 4-Curve Area
- 2D → 3D

Type
- Quadrilateral
- Combined
- Triangle

Map

- Solid
- Surface
- k-Curve Area
- k-Face Volume
- 4-Node Area
- ...

Type

Object
- Geometry
- Element
- Node

Protrude

- Extrude
- Revolve
- Project
- Fill
- Sweep

Manipulation

- Create
- Extract
- Connection
- Change Para.
- Smooth
- Divide
- Check
- Quality
- Merge
- Transform
- ...

Advanced Nonlinear and Detail Analysis Program
- **Loop Mesher**
  - Direct Surface Mesher based on **Looping Algorithm**

- **Delaunay Mesher**
  - Indirect **Surface** Mesher based on **Delaunay Triangulation**

- **Grid Mesher**
  - Hybrid **Surface** Mesher based on **Modified Grid-based Approach**

- **Tetra Mesher**
  - **Solid** Mesher based on Delaunay **Tetrahedralization & Advancing Front**

- **Map Mesher**
  - Structured **Surface/Solid** Mesher based on **Transfinite Interpolation**
## Automatic Surface Meshing

<table>
<thead>
<tr>
<th></th>
<th>Regularity Uniformity</th>
<th>Boundary Sensitive</th>
<th>OrientationInsensitive</th>
<th>Sizing Control (&lt; 1/2)</th>
<th>Internal Curve/Point</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loop Mesher</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>△</td>
</tr>
<tr>
<td>Delaunay Mesher</td>
<td>△</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Grid Mesher</td>
<td>○</td>
<td>○</td>
<td>△</td>
<td>×</td>
<td>○</td>
</tr>
</tbody>
</table>

### Mesh Generation

**Loop Mesher**

- Regularity Uniformity: ○
- Boundary Sensitive: ○
- Orientation Insensitive: ○
- Sizing Control (< 1/2): ○
- Internal Curve/Point: △

**Delaunay Mesher**

- Regularity Uniformity: △
- Boundary Sensitive: ○
- Orientation Insensitive: ○
- Sizing Control (< 1/2): ○
- Internal Curve/Point: ○

**Grid Mesher**

- Regularity Uniformity: ○
- Boundary Sensitive: ○
- Orientation Insensitive: △
- Sizing Control (< 1/2): ×
- Internal Curve/Point: ○
- FXP’s surface meshers generate **offset elements** near boundary for best quality.

- FXP provides a number of controls to manipulate **mesh pattern & density**, and generates **optimum meshes** required in practice.
- **FXP’s Tetra Mesher** auto-generates tetrahedral solid mesh with variable sizes in smooth transition. *(200,000 Tetra’s/min)*

- **FXP’s Tetra Mesher** is capable of including holes, curves and points that are present in/on solids.
- FXP’s Map Mesher generates structured (regular & orthogonal) mesh both in surfaces and solids.
- **FXP’s Solid Map Mesher** generates hexa and/or penta mesh in simple solids by **full mapping** or combination (auto+map).
- FXP provides various size control methods, **uniform size, division, linear grading (size & ratio and symmetry option)** and **refinement option**.
- FXP provides adaptive seeding function based on user-specified mesh size and geometric characteristics (curvature and feature).
Mesh Generation
Element-based Meshing

Advanced Nonlinear and Detail Analysis Program

2D Mesh Imported from STL Data

STL (Stereo Lithography)

Regenerated Mesh
Mesh Generation

Element-based Meshing

Advanced Nonlinear and Detail Analysis Program

3D Scanned Data
Tria: 130000

Decimated Mesh
(Reduction Factor: 0.2)

Final Mesh
Tria: 8,938

STL

FEA Mesh

3D Scanned Data
Tria: 49,998
(RapidForm Sample)

Decimated Mesh
Tria: 7,498
(Reduction Factor: 0.2)

Final Mesh
Tria: 8,938

STL

FEA Mesh
Mesh Generation

Element-based Meshing

- Sliver Faces
- Invalid NURBS (Uneven knot vectors)
- Singular Vertex
- Poor Mesh

Element-based Meshing Process:
1. Invalid NURBS (Uneven knot vectors) → Generated Mesh (Parametric Meshing) → Resolved Mesh
2. Singular Vertex → Poor Mesh → Resolved Mesh
Mesh Protrusion

**Extrude** (2D→3D)

- 2D Base Mesh
  - Linear Extrusion

**Non-uniform Offset**

- (2@25, 2@50)

**Fill**

- (Curve→2D)

**Extrude** thru Node Sequence (Curve→2D)

**Simulate**

**Revolve** (2D→3D)

**Section**
Mesh Generation

Mesh Manipulation

Advanced Nonlinear and Detail Analysis Program

Extract Element
- Extract 2D Mesh from 3D Mesh

Smoothing
- Smoothing (Laplacian/Winslow/Angle)

Mesh Connection
- Disconnect
- Link (Elastic, Rigid)
- Insert Interface Element
- Closest Link
- Coincident Link

Divide Element
- (2, 3-Refinement)
**Mesh Generation**

**Check & Quality Assurance**

- **Check & Verify**
  - Free Edges/Faces
  - Check & Align ECS

- **Quality Assurance**
  - Aspect Ratio
  - Skew Angle
  - Taper (2D)
  - Warpage (2D)
  - Jacobian Ratio
  - Twist
  - Collapse (Tetra)

- **Mesh Quality Plot**

- **Twisted Penta**
- **Collapsed Tetra (Near Zero Volume)**
- **Free Face**
- **No Free Face**
- **Reference Csys**: Rectangular, Cylindrical, Spherical
- **Function-based Definition**: Variable Condition (Load, Property, etc.)
- **Graphic Display**: Symbol / Text, Contour Plot (Nodal, Elemental)
- **Table**: Real Value
Function-based Definition

- **Spatial Function**
  - Rectangular, Cylindrical, Spherical
- **Non-spatial Function**
  - Time, Velocity, Temperature, etc.

Variable Plate Thickness

$T \times \text{Base Function}$
Why FX⁺ Modeler?

- Fast
- Easy
- User-friendly
- Powerful
- Accurate

FX⁺ Modeler

The Most Productive Solution!
Thank You!

General Pre & Post-processor for Finite Element Analysis

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