FEMtools™ Correlation

A Complete Solution for Modal Pretest Analysis, FE Model Verification and Validation using Test-Analysis Correlation

Overview

FEMtools Correlation contains modules for

- **Pretest Analysis** — Planning, simulation and optimization of modal tests.
- **Correlation Analysis** — Visual and numerical comparison between 2 sets of data (FEA-Test, FEA-FEA, Test-Test).

Pretest Analysis

If a baseline finite element model is available, then this model can be used to simulate tests. This provides test engineers with optimal locations and directions to excite the structure, and to position measurement transducers. The FE model can be reduced and converted into a test model. Questions that can be answered with pretest analysis include:

- How many modes can be expected in a given frequency range.
- What are the optimal locations and directions for sensors, exciters and suspensions from a set of candidate locations.
- Create a test model from a reduced finite element model and export in a format readable by modal test packages.
- Determine the directions normal to surface of curved surfaces from the finite element model and use this information for decomposing modal test displacements in global Cartesian coordinates.
- Asses the influence of the accelerometer mass on the modal parameters.

Using the pretest analysis tools in FEMtools Correlation it is possible to plan an optimal modal test strategy early in the project and increase quality of modal data for validation and updating of FE models.

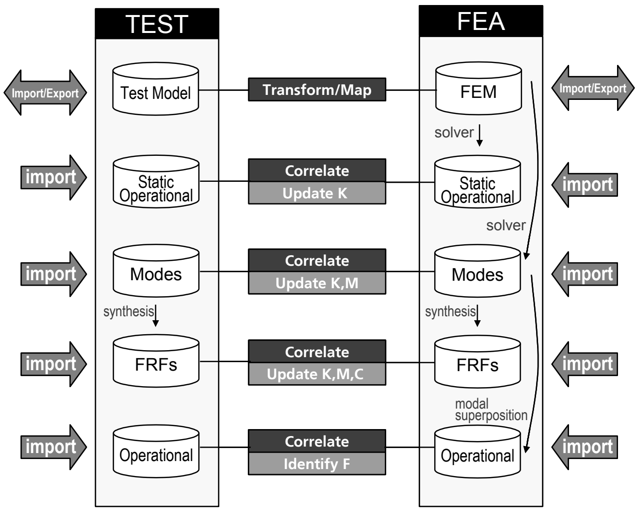
Key Features

- **Baseline finite element analysis** — Analyze mode shapes in the frequency range of interest. FEA data (model, modes, FRFs) can be imported or computed using FEMtools Framework or external solvers.
- **Target Mode Selection** — Select modes in the frequency band of interest based on energy considerations. Methods include: Modal Effective Mass, Kinetic Energy Fraction.
- **Selection of Candidate Sensor Locations** — Use criteria like accessibility, cost, geometry (surface, edge or corner nodes) or any other user-defined criteria to select candidate locations.
- **Sensor Placement Metrics** — These are semi-automatic methods to find optimal exciter, suspension and measurement locations and directions. They are based on the observability of target modes using information on modal displacement or energy (kinetic or strain). Methods include: Normalized Modal Displacements, Nodal Kinetic Energy.
- **Sensor Elimination Methods** — These methods iteratively eliminate sensors from the set of candidates in a way to optimally maintain linear independence or orthogonality between mode shapes. Methods include: Effective Independence Method, Elimination by MAC, Iterative Guyan reduction.
- **Mass Loading Evaluation** — This tool evaluates the effect of accelerometer mass on the modal parameters.
- **Creation and Export of Test Model** — Truncation of the FE model, conversion to test model and export to a modal test software. Automatic generation of tracelines between retained sensor locations. Directions normal to the surface can be obtained from the FE model.

Correlation Analysis

The following tools for quantitative and qualitative correlation analysis are included:

- **Spatial correlation** – Compares location in space between response locations resulting in a table with mapped degrees-of-freedom. This may require changing orientation and scaling of the models, which can be done in a manual way or using automatic tools.
- **Visual shape correlation** – Visually compare shapes (static displacement shapes, mode shapes and operational shapes) using side-by-side, overlay and animated displays.
- **Global shape correlation** – Globally compares shapes using various criteria. The result is used for shape pairing.



FEMtools
simulate › validate › update › optimize

- **Local shape correlation** – Analyzes local spatial correlation between shapes. Results can be interpreted to localize modeling deficiencies and serve as guideline for selecting model updating parameters.
- **Shape pairing** - Creates a table of shape pairs (static, modal or operational).
- **FRF pairing** - Creates a table of FRF pairs.
- **FRF correlation** - Analyzes correlation between FRF functions, either globally between 2 functions or shape and amplitude correlation functions for a set of FRF pairs as function of frequency.
- **Correlation coefficients** - Calculates values of error functions from a selection of reference responses. These functions are used in model updating to monitor the 'distance' between the updated model and a reference.

Applications

- Link experimentally obtained modal damping to the corresponding analytical mode shape.
- Scaling of test mode shapes obtained by output-only modal analysis.
- Evaluate different modeling strategies.
- Identification of modeling deficiencies or structural damage.
- Finite element model validation.
- Define targets and parameters for FE model updating.

Key Features

- FEA-Test, FEA-FEA, Test-Test Correlation.
- Automated or manual model mapping.
- DOF pair table definition, ranking and filtering.
- Static, modal and operational shape correlation analysis using Modal Assurance Criterion (MAC).
- Mode shape auto- and cross-orthogonality check using full or reduced system matrices.
- Automated support for double modes (axisymmetric structures).
- Automatic mode shape pairing.
- MAC contribution analysis.
- Spatial shape correlation using Coordinate MAC (CoMAC), Coordinate Orthogonality Check (CORTHOG), Correlated Shape Difference and Modal Force Residue analysis.
- FRF correlation (SAC, CSAC, CSF).
- Correlation using local coordinate systems.

User Interface

- All definition, editing and analysis accessible via intuitive menus and dialog boxes or using free format commands for batch processing and process automation.
- Complete electronic documentation.
- Dedicated graphics viewers for model inspection and results evaluation.
- Point-and-click interactive selection.
- Direct access to FEA and test data.

Benefits

- All pretest analysis and correlation tools are programmed in FEMtools Script language and can be easily customized or extended.
- Customizable user interface.
- Solver-neutral integration with virtually every FEA and test data.
- Computing and OS platform-independent solutions.

Prerequisites

- FEMtools Framework with basic FEA Solvers (included).
- FEMtools Dynamics (included).

Options

- Upgrade to FEMtools Model Updating or FEMtools Full Version.
- NASTRAN interface and driver.
- ANSYS interface and driver.
- ABAQUS interface and driver.
- UNIVERSAL FILE interface and driver.
- Rigid Body Properties Extractor (Add-on).

Services

- Regular software maintenance.
- Installation, training and customization.
- Support by e-mail, fax and phone.
- Internet support site.
- Custom software development.
- Project research.
- Engineering services.

Supported Platforms

- Window XP, XP Pro, Vista/7/2003/2008 32-/64-bit
- Unix (HP-UX, IBM AIX, SUN Solaris)
- Linux (32-bit and 64-bit)

Flexible node-locked or floating licensing of annual or paid-up licenses.

For more information, contact us at

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