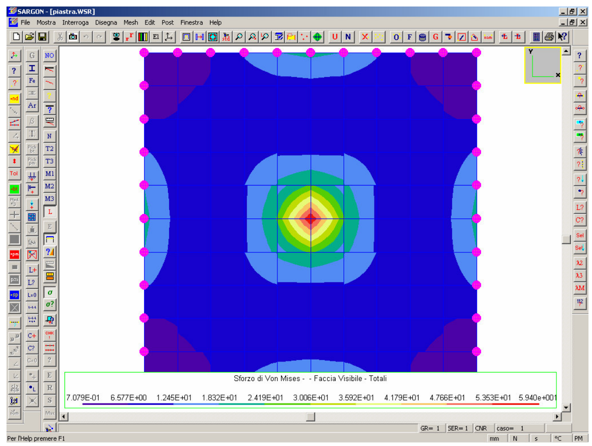
WHO DOES WHAT



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1. Foreword

This document is intended as a guide for thirdy party analyzing Sargon models and Sargon results, so as to check the work done by Sargon users. Sargon users should be completely aware of all the important concepts remembered in this document, because they are fully reported into Sargon documentation.

This document is kept willingly short: much more informations could be got into Sargon documentation, which could be furnished together with “sargon reader” by the user himself.

2. What the program does

2.1. Design lines

Sargon is a finite element program using displacement-method, and is conceived to expose finite element concepts, not to hide them. This means that willingly there is no automatic algorithm to generate a model fit for any design purpose. It is up to the user to build the finite element model in such a way that the mesh, loads, constraints and more are fit for the design purpose at hand.

Sargon producer does not believe that automatic generation of models is a possible way of working when dealing with general purpose software. On the other hand, Sargon can be used, if properly managed, to study a very wide class of structures, ranging into industrial, civil, naval, mechanical and more.

Actually, during the years since 1991, it has been used in each of these field.

Given a fem model, prepared into it, Sargon mainly computes stresses, displacements and exploitation indices according to different standards. Sargon is able to present results in very many possible ways and is a powerful analysis tool which can highly speed up computations and checks, performing very complex tasks in a reasonable computational time.

Nothing in the program is intended to mean that the program could anyhow

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substitute designer's skill and experience, no matter the program is the result of years of caruful highly specialized programming (since 1991), by experts in the field of structural analysis.

2.2. General info

Sargon is a software package made up of mainly four groups of programs: GUI (graphic user interface), solvers, checkers, and helpers.

The model is necessarily built up using the GUI. Some command allows to import meshes prepared elsewhere (not drawings: drawings automatically leading to fem models is considered an unsafe practice by producer), or to export finite element models already done.

The solvers are: CLEVER (linear static analysis); LEDA (modal analysis); SPECTRUM (response spectrum analysis); FREQUENCY (frequency response analysis via modal analysis); SOCLEVER (non linear static analysis in small displacements, geometric effects, not material nonlinearities).

The checkers are: CNR (allowable stress and limit states); AISC-ASD; BS 5950 (1985); EN 1993-1-1 (2005).

Helpers external modules are: checksolvers (validation purposes); mergedbase (load cases overwriting); samba (cross sections management); several programs to export and import the model into various formats.

2.3. Short reference main program (GUI)

The program manages the following finite elements:

1. truss (two noded)
2. beam (hermitian two nodes, *id est* cubic shape functions)
3. membrane (in plane stiffeness only, 3 and 4 noded elements, several formulations: CST, bilinear quad, SRI, Wilson Ibrahimbegovic);
4. thin plate (Kirchhoff plate theory, 3 and 4 noded elements, DKT, 4DKT);
5. thick plate (Mindlin-Reissner plate theory, 3 and 4 four noded elements, Hughes)

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6. solid (4, 6, 8 noded elements, several formulations)
7. spring

The program manages the following loads:

1. Nodal loads (forces and moments);
2. Temperature loads (applied to elements);
3. Distributed loads applied to beam elements (constant, concentrated, linear to partial length, forces and moments)
4. Constraints settling

Distributed loads over surface and solid elements are added into GUI and are always immediately conversed into nodal loads (by lumping). This means that the mesh should be sufficiently fine to allow such modelling. No graphic illusion about the real nature of load modelling is thus possible (coarse meshes with finely positioned internal loads are meaningless no matter their appearance).

Constraints are applied to nodes.

2.4. Short reference: solvers

CLEVER:
Linear static solver using two possible solution algorithms: skyline solver and sparse matrix solver. Both use Choleskij linear system solution method. The program is very strict in not allowing not positive definite stiffeness matrices.
LEDA:
Modal analysis solver using subspace iteration method. Matrix triangularization is done using skyline techniques. An ortogonality check is done at each run.
SPECTRUM:
Response spectrum combination also including an “error factor” feature. Key points regard mode combination rules (SRSS, CQC, correction methods, modal amplification method).
FREQUENCY:
Linear frequency response. The user inputs forces, frequencies, damping, and chooses

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the modes to include into computation.

SOCLEVER

Nonlinear static solver (Newton Raphson) able to perform second order analysis over models made up of beams and trusses. If the loads applied are higher than buckling loads, the program stops and predicts the load level at which the matrix is no more positive definite.

2.5. Short reference: checkers

All the checkers checks resistance and stability of members. Global stability checks should be done using SOCLEVER or by displacement checks. Connection checking is not within the program applicability range (use CSE instead). As well, local checks like web buckling under concentrated loads are out of the range of the checkers.

Checks are performed for every load combination. No envelope concept is used in checking because it is not possible or convenient in steel structures.

When a member is made up of several finite elements stability checks are performed using "superelements" which must have been added to the model by the user.

The internal forces used by the checkers are those stored into SDB file. This file could be managed by the solvers directly, or by mergedbase, if the user has chosen to use it.

3. What the user should do

GUI

The user must conceive the finite element model in such a way that the model is properly fit for the design purpose at hand. Mesh size, finite element kind and formulation choice, setting up several possible models and studying solution sensitivity is all up to the user and is strongly recommended.

The user must apply loads properly and using internal commands must check global and partial resultants against expected values. Load spatial distribution must be

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carefully checked. Load combinations are absolutely of the greatest importance in view of the checks. The user could use automatic rules and/or add combinations by hand, and must be sure of the proper definition of the combinations. When combinations are hundreds or thousands, it is suggested as a normal safety procedure that sample combinations should be checked undependently in a separate model.

When using surface and solid elements the user must assure a proper mesh size.

Mesh should be checked for double nodes, unreferenced nodes, unconnected elements by carefully using internal commands and by carefully checking displacement field and stress fields.

Constraints must reflect real design situation.

Solvers

CLEVER

The user must be aware that singularities in the stiffness matrix could be due to unproper design and must fully understand the reasons why a model does not run, avoiding the ad hoc addition of constraints to bypass the stop. LEDA with shift can be used to outline rigid or almost rigid body motions, if any.

LEDA

The user must choose properly the number of modes, the tolerance and the target total mass percentage.

SPECTRUM

The user must fully understand all the mode combinations rules and understand that some of them loose signs while others use “numerical” sign permutations to get results. Mode amplification method, when possible, should be used together with SRSS and CQC.

FREQUENCY

Mode choice and damping tuning are key points in using this solver. They must be fully explained and documented.

SOCLEVER

Here the number of steps and the tolerance play an important role. If final displacements are not within the range of small displacement theory the analysis loses its meaning.

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Checkers

The user must carefully set the three slenderness coefficients of all elements and superelements to properly tune the stability checks. The program cannot set these coefficients automatically because there are no affordable ways to do that.

The user must have completely understood the way superelements work in Sargon and should have added as many superelements as needed in the model to assure that the checks are properly done. Changing superelements may dramatically change model results.

The user must have added the correct number of combinations.

4. Validation

Here is summed up what the user should do to better assess model affordability. Sargon producer validation policy is explained into another document (sargon: validation, also downloadable from the web site).

4.1. Solvers

The user should use the module “checksolvers.exe” and carefully look at the output file of this program, which is (optionally) run at each solving. This program controls the output undependently from the solver, and so is able to point out solving phase possible problems. “Checksolvers.exe” output file should be integral part of the output documentation available to thirdy party.

Besides, the user should manually check some key features of the stress and displacement fields:

1. global simplified equilibrium checks to once more control load resultants and constraint reactions
2. order of magnitude of stresses and displacements;
3. displacement fields, deformed views must be compliant with the exected behaviour.

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4. internal action diagrams should be sampled in a proper number of points and diagrams should match the theorically expected ones.
5. constraints and end releases should be compliant with the initial settings (e.g. free displacement vs possible obstacles)
6. displacement amplitude must be compliant with small displacement theory.

4.2. Checkers

The user must carefully review resistance and stability checks and check them undependently in a sample made up of a number of checks which must increase with the load combinations number and the finite element model size.

This undependent checks must be done in a simplified way, possibly completely undependent from the model results. Possible tests regard axial force estimate, simplified buckling checks, maximum bending moment evaluation and simplified checks against stress limits. Key members should be checked in an undependent way and results must be discussed and explained in view of the program results.

If available, checking the model with more than one Sargon checker (using allowable stress and/or partial factors method) is highly recommended.

Automatic checks cannot completely free designers from the burden of their work which is of the greatest importance. Automatic checks are a design instrument, *not the design itself*.

4.3. Thirdy party managing

In order to simplify the checks made up by thirdy party, the user should follow these possible paths:

1. Prepare an input file for other solvers by using sargon internal commands and give it to the thirdy party in charge of undependent checks;
2. Inform thirdy party of the existence of a Sargon Reader version, completely free, which could be downloaded from Castalia web site www.castaliaweb.com . Thirdy party could watch the model and check it by using the same program. Program

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version and model version should be aligned for obvious reasons.

3. An higher level of safety is got if the model is run in a different solver or, possibly, remade undependently using a different program (see Italian norms, NTS, chapt. 10).

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