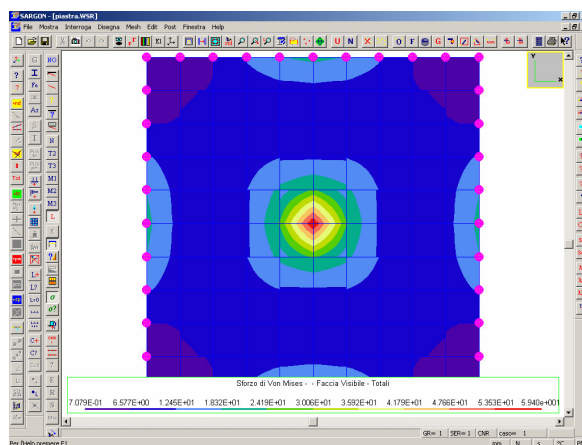




VALIDATION CRITERIA



<http://www.castaliaweb.com>

Via Pinturicchio, 24

20133 Milano

staff@castaliaweb.com

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Sargon is a wide finite element program mainly oriented to steel structures. It was born in 1990 and has been continuously developed since that time.

Validation is a key point in software developing, and this is particularly true for design-oriented softwares which are used to perform complex structural analyses.

Sargon has a powerful set of validation tools, and has been extensively tested by the producer and by several hundreds of customers, in tens of thousands of different computer runs. No matter this relevant set of designs and of realized structures, all around the world, Sargon validation is continuously – i.e. at each version of the program -, improved.

Main validation sources and strategies can be summarized as follows, not in order of importance:

1. The work done in the last 17 years (since 1990) to continuously improve the program, always by experienced structural engineers.
2. Internal tests executed by producer before releasing each new functionality of the program.
3. Theoretical tests published in books where the performances of the program are compared to existing results and/or results obtained using other programs or procedures.
4. Test benchmarks added to program documentation, or published in the company web site.
5. Systematic use of a procedure to test each program version by running a set of reference tests in a standardized way.
6. Systematic independent control of results obtained for each run by user's executing the ad hoc program "checksolvers".
7. Reference list of the program users, a set of highly qualified engineers and engineering firms, and a list of projects realized using the program.
8. Important contributions to research and to standards in Italy, come from the use and development of the program (main results in the field of steel structures, load combination rules, earthquake engineering), which prove the high level of the

software Author.

9. Internal use of the program by producer for structural consulting.
10. Program openness, which allows data transfer from and to the program.

In the following each key point will be shortly described.

1 The work done since 1990

Sargon is not a program just finished. It has been created in 1990 and since then it has been continuously developed and improved. Born in standard C it has then been partially rewritten (the interface) in C++ under WIN 32 shell (1994). This very long time span, from development standpoint, has allowed a deep testing of virtually all main program paths and functionalities. Some of the main program features have been used continuously for 17 years at november 2007. Program is developed in a strict contact with users, mostly composed by highly experienced structural engineers and firms.

2 Internal test executed by producer before each version release

As a general rule always followed by producer, no functionality is released without having first being tested by developers. This greatly reduces the probability of errors or misworking. Major improvements and program modules are extensively tested before being released, and only after this first level tests are actually released. Very often new functionalities are added to the program after being considered helpful in everyday consulting with the program itself, i.e., they are directly tested at a very deep level in real-work situation.

3 Published theoretical tests

Results obtained with the program have been extensively compared with those theoretically expected and with those obtained by other programs. Also design worked exempla have been used to test program correctness in a wide range of design situations.

Presently there are four books published in Italy (more than 4000 copies globally sold) which describe results obtained by parts of the Sargon program. Two more books related to Eurocode 3 are currently being written and are expected to be published in 2008.

The four books available are (in italics title translation into english);



Rugarli P. "Calcolo strutturale con gli elementi finiti", EPC LIBRI, Roma, 2003

Rugarli P. "Structural analysis via the finite element method", EPC LIBRI, Rome, 2003

<http://www.insic.it/libro.asp?id=70646&tipo=4&q=rugarli>

This book is an introduction to finite element analysis. Many theoretical test are here published, comparing Sargon results to exact or available ones. The book also has a limited version of the program (models up to 50 nodes). This book has sold till now more than 2,000 copies.



Rugarli P. "Analisi modale ragionata", EPC LIBRI, Roma, 2005

Rugarli P. "Reasoned modal analysis", EPC LIBRI, Rome, 2005

<http://www.insic.it/libro.asp?id=72379&tipo=4>

This book is an explanation of modal analysis, frequency response analysis, and response spectrum analysis. It embeds many Sargon tests about beams, plates, membranes, comparing frequencies to available closed formulae results, or to other programs results. It has sold more than 1000 copies till now. The book also contain a limited version of program Sargon, for models up to 50 nodes (modal analysis included).



Rugarli P. "Calcolo di strutture in legno", CD BOOK, EPC LIBRI, 2006

Rugarli P. "Wooden structures computation", CD BOOK, EPC LIBRI, 2006

<http://www.insic.it/libro.asp?id=72454&tipo=4>

This CD BOOK is an explanation of Eurocode 5. It embeds a beam program limited to straight elements, using Sargon automatic checker. It has sold more than 1,000 copies till now. Several worked examples using Sargon checker are included.



Rugarli P. "Strutture in acciaio. Eurocodice 3. La classificazione delle sezioni. Commento", CD BOOK, EPC LIBRI, Roma, 2007

Rugarli P. "Steel structures. Eurocode 3. Cross section classification. Comment.", CD BOOK, EPC LIBRI, Roma, 2007

<http://www.insic.it/libro.asp?id=72476>

This CD BOOK is a comment of the part of Eurocode 3 referring to section classification. It also embeds a program which has been got by Sargon eurocode 3 automatic checker, to perform section classification in the most general case of biaxial bending, plus axial force. The book has till now sold several hundreds of copies (less than one year since its birth). Also the book explains a new method (implemented in Sargon since 1992) to perform cross section classification in a general case.

4 Benchmark tests available in documentation and website

Sargon producer is continuously adding test schedules which are systematically added to "validation" Castalia srl website, for free. Before publishing the test schedules in the website, Castalia wishes to publish them into books, to give the highest relevance to this work, especially in fields, like code checking, where few or null results are available.

The Castalia srl website page related to validation is the following:

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Web: <http://www.castaliaweb.com>

Email: staff@castaliaweb.com

Ph.: +39 (0) 2 266 81 083

Fax: +39 (0) 2 266 81 876

<http://www.castaliaweb.com/ita/s/val/validazione.asp>

Presently two sections are available:

- Section “main beams” where 130 test schedules are available, proving static solver reliability (http://esercizistatica.it/schede/main_beams/statTotale.pdf)
- Section “nastran comparison” where a number of models have been run using Sargon solver and NX NASTRAN © and NE NASTRAN © solvers for comparisons purposes (<http://www.castaliaweb.com/ita/S/VAL/sargonvsnastran.asp>).

Currently a set of 100 test schedules, referring to EN 1993-1-1 tests, are waiting to be published in castalia web site: they will be first published in a new CD BOOK expected for print at the beginning of 2008.

5 Systematic use of a procedure to test each program version

A program named “checksolvers” has been prepared by Castalia, which is able to perform two different very important tasks:

- Checking automatically that the binary output files of a given model embeds the expected results into a given position, related to a given structural result (like node displacements or element stresses).
- Checking automatically that the binary results of a given model do respect general theoretical rules, like global equilibrium, Betti’s rules, forces resultant point of application, and so on.

The first functionality will be shortly described here, the second in the next paragraph.

Checksolvers can compare expected results to actually computed. It is a program undependent from the solvers: it merely reads an ASCII input file where “target” values are listed once for all, and compares them with “computed” values written in the binary output files by solvers like static solver, modal solver, of automatic checker like that according to Eurocode 3, at each program version. Since it can compare in a single run hundreds of

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different model results (many model at once), this procedure is the best to systematically test each version of the program, to catch unwanted possible new bugs.

A set of benchmarks has been created, and checksolvers is run before each new release to properly assess that results are those expected. Even more importantly, these kind of checks are available to each program user, who can set up his/her own set of tests, and get the same easiness in performing the checks which is available to developers.

6 Systematic independent check of each model run

Each time a user runs a model and gets static results, she/he can run checksolvers to judge results correctness. Checksolvers is a program independent from the solvers, it merely reads binary files to get results and input data, and then performs a set of internal checks to assess that the results do match theoretical rules, which is of course a necessary condition for results affordability. Checksolvers output file can be added to model documentation as a further proof of good computation. Results checked are comprehensive resultants, point of application of resultants, residuals, work of residuals, Betti's rule for mixed works, and more.

7 Reference list of program users and realized projects

Here is a list of some of Sargon users:

- ALSTOM POWER s.p.a. - Milano
- ACAI s.r.l. - Milano
- AGIP S.p.A. - Marina di Ravenna (RA)
- ALLIEVI DEL CORSO DI "TEORIA E PROGETTO DI COSTRUZIONI IN ACCIAIO" del Prof. Giulio Ballio al Politecnico di Milano
- ANIT s.r.l. - Genova
- ANSALDO INDUSTRIA s.p.a. - Genova
- AUSTIN ITALIA s.p.a. - Milano
- BOLDROCCHI s.r.l. - Biassono (MI)

- CARLO GAVAZZI IMPIANTI s.p.a. - Milano
- CATANIA PROF. ING. MARIO - Milano
- CENTRO RICERCHE FIAT - Orbassano (TO)
- CETA PONTEGGI TUBOLARI s.p.a. - Bergamo (BG)
- COGEFARIMPRESIT s.p.a. - Sesto S. Giovanni (MI)
- COIND sas (MI)
- COLOMBO s.p.a. - Como
- CO.MEC. s.p.a - Badoere di Morgano (TV)
- ECP ENICHEM POLIMERI s.r.l. - Ferrara
- ELC ELECTROCONSULT s.p.a. - Milano
- ENEL Direzione delle Costruzioni - Milano
- ENEL Direzione delle Costruzioni - Venezia
- ENEL Direzione delle Costruzioni - Roma
- ENEL D.P.T. - Torino
- EUROTECNICA CONTRACTORS & ENGINEERS s.p.a. - Milano
- FBM HUDSON ITALIANA s.p.a. - Milano
- FIAT ENGINEERING s.r.l. - Torino
- FILIPPO FOCHI ENERGIA s.p.a. - Bologna
- FIP PONTEGGI s.r.l. - Torino
- FV PROGETTI - Milano
- GP srl - Milano
- INSO s.p.a. - Firenze
- IRITECNA s.p.a. - Genova
- I.S.P.E.S.L. - Roma
- ITALTEL s.p.a. - Carini (PA)
- KEC International Limited – Jaipur (India)
- KIRCHNER ITALIA s.p.a. - Milano
- METALMECCANICA FRACASSO s.p.a. - Fiesso d'Artico (VE)
- NATIONAL POWER CORPORATION - Manila (Filippine)
- NUOVA CIMI MONTUBI s.p.a. - Vimodrone (MI)

- OCRIM s.p.a. - Cremona
- OCML s.p.a. - Carrobbio degli Angeli (BG)
- PILOSIO s.p.a. - Feletto Umberto (UD)
- POLITECNICO DI BARI - Bari
- PONTEGGI DALMINE S.p.a. – Milano (Marcegaglia Building & Storage)
- RAMBALDINI ING. ROBERTO - Olgiate Olona (VA) – Walley Design srl
- RECCHI s.p.a. - Torino
- SAIPEM s.p.a. - S. Donato Milanese (MI)
- SCIBILIA PROF. ING. NUNZIO Palermo
- SCL Ingegneria strutturale, Milano
- SIRTI s.p.a. - Cassina de' Pecchi (MI)ss
- SIFA s.p.a. - Reana del Rojale (UD)
- SOIMI s.p.a. - Milano
- Studio Engineering Srl (Genova)
- TECHINT s.p.a. - Milano

Here is a link to a page reporting some of the projects designed using Sargon:

<http://www.castaliaweb.com/ita/P/SR/casi.asp>

8 Important contributions to research and standards in Italy.

Sargon development is carried on by highly specialized structural engineers, whose work has marked important results and contributions to research and Italian standard tuning.

The most important contributions are the following:

- Cross section classification method for generally loaded I shaped cross section, dating since 1992. This is a very important contribution to steel checking implementation.

- Load combinations formulae uncorrectness in italian DM 1996 denouncing, via a paper published in *Ingegneria Sismica*, (Seismic Engineering) an italian technical magazine. The rules have been subsequently modified.
- Several errors in italian Ordinanza 3274/2003 (ministerial decree 3274/2003), denounced in italian newspaper *La Repubblica*, and not embedded into program, no matter decree effectiveness. These errors were afterwards removed from the dectee in a later emission.
- The error factor response spectrum method, defined into “Analisi Modale Ragionata” and embedded into Sargon since 2005. Here illusoriness of modal analysis high precision in civil engineering is shown and managed via special “error factors”.
- The chapter 10 request of italian new structural rules (Norme Tecniche per le Costruzioni, 2007), in which cross check between different models run via different solvers is compulsory for relevant projects, has been hinted by Ing. Rugarli, Sargon’s Author. As well, Pushover Analysis limitation to one mode-dominant structures has been pointed out in several publications as compulsory by Ing. Rugarli and has finally been added to the standards.

9 Internal use of the program by producer for structural consulting.

Sargon is developed by people who use it in structural engineering every day. This is a very important point since the program is used as well as developed. In this way its development and quality testing is done at the highest level: programming is just another way of performing engineering by engineers, it is not an aesthetic operation to create special graphic effects of no engineering relevance, by programmers. Castalia srl, particularly, has used Sargon to model and or to run structures like cruise ships, of estimated value in the range of hundreds of million dollars. Highly specialized, proprietary dynamic linked libraries, joined to the Sargon project, have been used to create cruise ship finite element models, which have been tested and managed into Sargon to get intermediate as well as final results.

10 Program openness

Sargon is able to read in and write out a finite element model in many different file formats. This allows an easy data transfer from and to Sargon, which, in turn, makes very easy performing cross checks on complex structures. This concept, as already remembered, is at center in new structural italian code validation chapter. No secret, no closeness, no barriers which could limit the complete managing of the model and its results. Sargon also has a reader version which is free, allowing each thirdy party to properly read results in a graphic environment.