

Software solutions for the Eurocodes

Introduction

The arrival of the Eurocodes is announced in the European Member States for a while now. These changes have an unprecedented impact on the construction sector in general. Although the deadline for the replacement of the National Codes by the Eurocodes was March 2010, more Member States are just now about to finish the transition phase. However, for the majority of the countries the deadline for final implementation of the Eurocodes will take place this year.



Are you ready?

Nemetschek Scia already has as a software supplier for engineering applications for over 20 years of experience with the Eurocodes.

Typo, you say? No, it's correct, more than 20 years experience in the area of these Euro Standards.

Let me give you a short overview of the history: In 1975 the Eurocodes were initiated due to the desire for harmonization of technical specifications. A decade later, in 1984, the first versions of the Eurocodes were published by the European Commission. Subsequently the ENV Eurocodes came and these standards already allowed the Member States to apply corresponding national documents. Early 2000s the well known EN Eurocodes with associated National Annexes were announced as the new global standard for the construction sector in Europe. The Eurocodes were at that time not entirely unknown in the construction industry. Today, early 2012, these documents can be found in the closet (read also as: computer) of virtually any engineering firm in Europe.

So, returning to the first sentence of this storey: Nemetschek Scia offers you a software solution for easier handling and use of the Eurocodes. This software is called Scia Engineer.

Scia Engineer is a graphical software platform for design, analysis and code check of structures. This for a huge range of material types (concrete, steel, timber, composite and aluminum) and construction types (buildings, steel halls, plants, bridges, tunnels, art, etc...).

Next to this several standalone applications are available to be used for more specific Eurocode calculations.

Below an overview of the solutions for each Eurocode part.

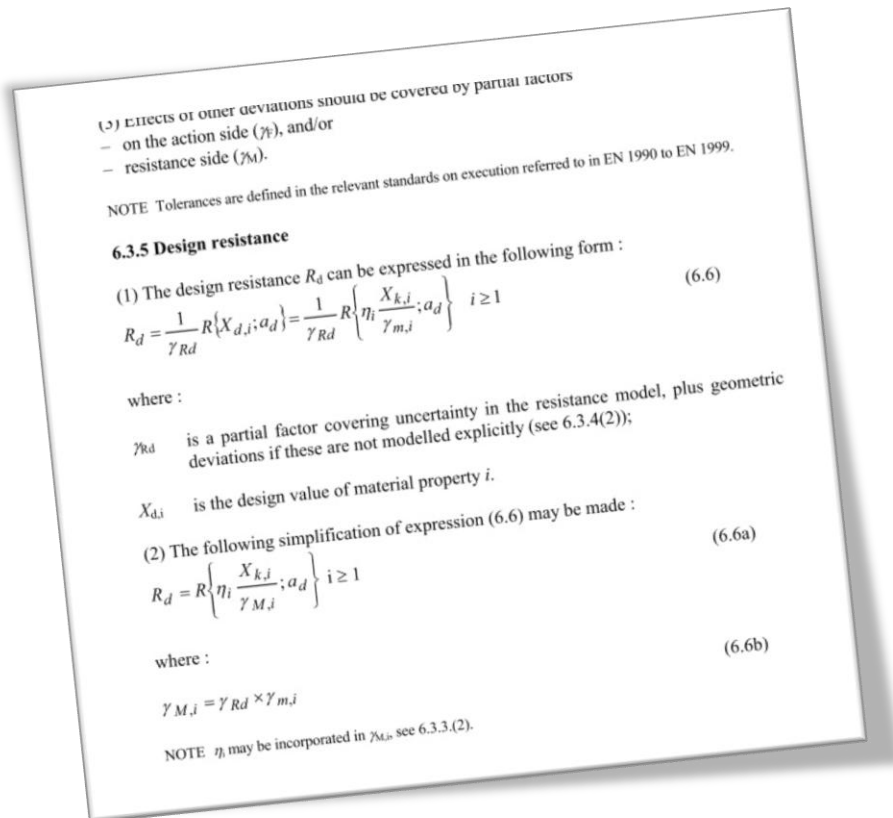
Summary

	Software	Features
Eurocode 0	Scia Engineer	Load combinations
Eurocode 1	Scia Engineer	<ul style="list-style-type: none"> • Standard loads (self weight, permanent and variable loads) • Load panels • Soil and water loads • Temperature loads • Snow load generator (2D) (EN 1991-1-3) • Wind load generator (2D & 3D) (EN 1991-1-4)
Eurocode 2	Scia Engineer ECtools Frilo statics: <ul style="list-style-type: none"> • B2: Concrete section • B5: Concrete column • B6: Punching check • B7: Stairs • DLT: Continuous beam 	<ul style="list-style-type: none"> • Check and design according to EN 1992-1-1: <ul style="list-style-type: none"> ○ 1D & 2D reinforcement design ○ Punching check ○ Prestressing ○ Posttensioning • Fire resistance check (EN 1992-1-2) • (Seismic) design for concrete buildings (ECtools)
Eurocode 3	Scia Engineer Frilo Statics: <ul style="list-style-type: none"> • DLT: Continuous beam • STS: Steel column • STT: Steel beam • BTII: Lateral torsional buckling 	<ul style="list-style-type: none"> • Steel code check (EN 1993-1-1) • Fire resistance check (EN 1993-1-2) • Cold-formed sections (EN 1993-1-3) • Scaffolding check (EN 12811-1) • Plated elements (EN 1993-1-5) • Design of connections (EN 1993-1-8) • Autodesign (Optimization)
Eurocode 4	Scia Engineer	<ul style="list-style-type: none"> • Check of composite beams (EN 1994-1-1) • Check of composite columns (EN 1994-1-1) • Fire resistance check (EN 1994-1-2)
Eurocode 5	Scia Engineer Frilo Statics (under construction): <ul style="list-style-type: none"> • HO13: Timber joint • HO14: Single fastener timber joint 	<ul style="list-style-type: none"> • ULS and SLS check according to EN1995-1-1 • Autodesign • Timber connections (Frilo Statics)
Eurocode 6	Frilo Statics: <ul style="list-style-type: none"> • MWX : Masonry design ECtools	<ul style="list-style-type: none"> • Masonry design of individual walls according to EN 1996-1-1 (Frilo) • EC6 Check of masonry structures modelled in Scia Engineer (ECtools)

Eurocode 7	Scia Engineer	<ul style="list-style-type: none"> • Pile design (EN 1997-1, NA Netherlands) • Pad foundations (EN 1997-1)
Eurocode 8	Scia Engineer Etools	<ul style="list-style-type: none"> • Input of a seismic spectrum (system database) • Calculation of eigenvalues & eigenmodes • CQC and SRSS method • Output of accelerations and displacements • Output of modal participation factors • Capacity check and design of concrete and masonry buildings according to EN 1998-1-1
Eurocode 9	Scia Engineer	<ul style="list-style-type: none"> • Aluminum code check (EN 1999-1-1) • Aluminum scaffolding check (EN 12811-1) • Autodesign (Optimization)
National Annexes	Scia Engineer Frilo Statics Etools	<p>Available National Annexes</p> <ul style="list-style-type: none"> • Scia Engineer: Standard EN, BE, NL, FR, PL, CZ, UK, DE, AT, SK, SI, FI, IE, GR, RO • Frilo: CZ, NL, BE, DE (varies per module) • Etools: Standard EN, GR, BE, IT, DE, FR, RO, CZ, CY, AT, SI

Eurocode 0

Eurocode 0 contains the **general rules** for the calculation of the **limit states**. It is therefore the basis for structural design. Naturally these basic rules are included in Scia Engineer and this is reflected in the **load combinations** which are automatically generated by the program. The category of the structure and the type of load case to which the structure is subjected are taken into account.



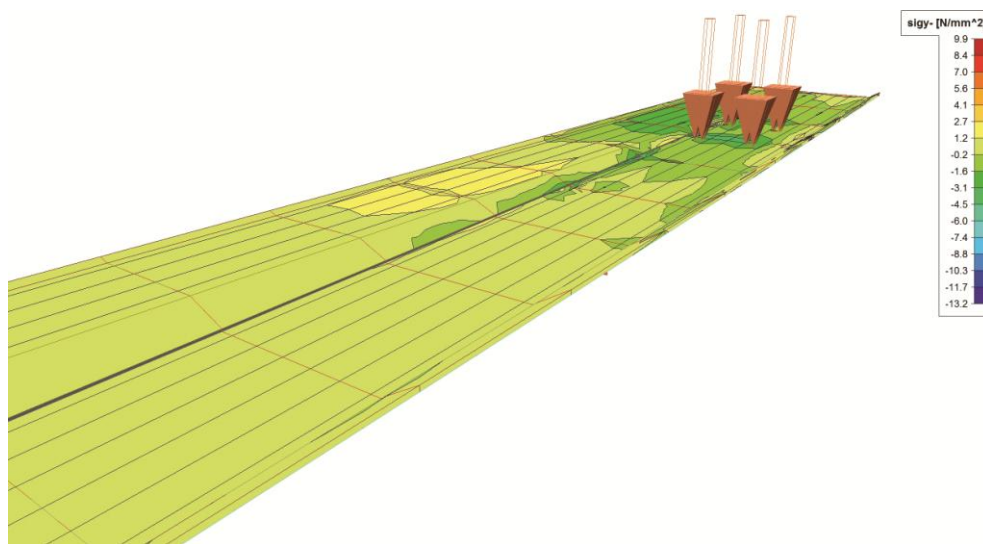
Picture: Screenshot of article 6.3.5 of ECO

Eurocode 1

Eurocode 1 deals with the calculation values of the loads. Scia Engineer provides the possibility to input different types of loads, from **self weight** to **variable live loads**.

Next to this, **load generators** are available which generate automatically loads on the structure. For instance it is possible to generate automatically **snow-and windloads** according to Eurocode 1 (part 1-3 and part 1-4).

Also mobile loads and temperature loads are available.

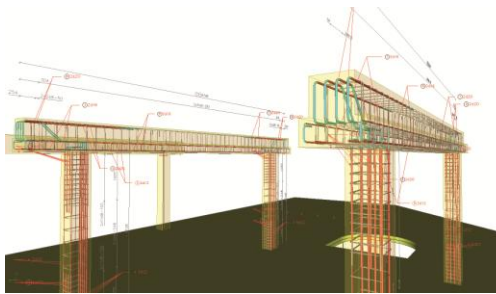


Picture: Mobile load on pedestrian bridge De Gilden (Dronten, Netherlands) - Ingenieursbureau Oranjewoud B.V.

Eurocode 2

Scia Engineer provides a wide range of possibilities to **design concrete structures** conform the regulations of EC2. These type of structures can be very diverse, from basic to more complex buildings, prefab structures (such as hollow core slabs), prestressed concrete bridge decks, etc...

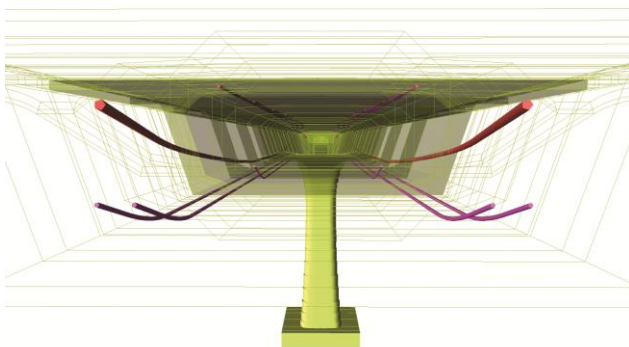
At first the solution for **1D members** is foreseen in order to design and check reinforcement (longitudinal and transverse reinforcement) in beams and columns. This can be retrieved both graphically as numerically. On one hand, the user retrieves results such as the recalculated internal forces, **theoretical reinforcement** and **long term deflections** and on the other hand, he can perform checks such as a **response- and capacity check**, **fire resistance** check or a **crack width** check.



Figuur: Praktische wapening in Scia Engineer

In addition, a solution is provided for **2D elements**, such as walls, plates and shells. Also in this case the theoretical needed reinforcement may be calculated and optionally, one can input practical reinforcement. Afterwards a crack check can be performed.

Moreover, there is the possibility in Scia Engineer to calculate and design **prestressed and post-tensioned** elements. Using a predefined library cables can be entered graphically. As a result one can view the cable losses and carry out a verification calculation to check whether the reinforcement is sufficient. This functionality is mostly used in combination with a staged calculation (**construction stages**) and a time dependent analysis (**TDA**).

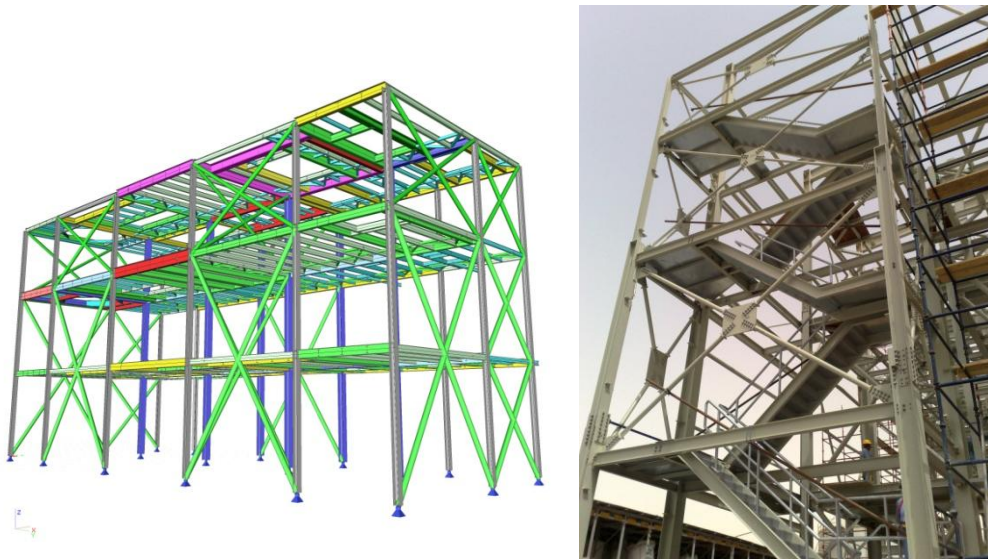


Picture: Prestressing in the bridge over the Berounka river valley (Prague, Czech Republic) - Novak & Partner, s.r.o.

Eurocode 3

Due to its excellent fabricability **steel** is one of the most used construction materials which is also reflected in the building industry. The steel solution of Scia Engineer is known for its full, robust and user-friendly interface. This module is integrated within the environment of Scia Engineer, which includes that structures made of different materials can be analyzed and designed by means of one software platform.

Scia Engineer has a **section and stability check**, as well as a fire resistance check according to EN 1993. Buckling lengths are automatically calculated. The checks can be performed for all profile classes, including class 4 profiles (eg. thin-walled sections). All stresses and instability effects are checked: buckling, lateral torsional buckling and local buckling due to lateral force. Optionally the output can contain cross-references to the used normative formulae and articles. The user can reinforce the profiles amongst others with buckling shorteners, steel deck... in order to obtain an optimal stress distribution. Next to this the user can optimize profiles via the autodesign functionality.



Picture: Expansion of the steel Proctor & Gamble Plant (Dammam, Saudi-Arabia) - Atelier P.H.A. s.r.o

Scia Engineer also includes a solution for the **scaffolding** industry and the **design of cold-formed** sections, including purlins.

In case steel connections need to be taken into account in the structure, this is of course no problem. **Steel frame connections, grid connections and bolted diagonals** may be entered and visualized. Design and verification of the connection is done according to the component method. The capacity of the node is checked with regard to the active internal forces and if required, the node can be further optimized in an interactive manner. Furthermore it's also possible to take into account the stiffness of the connection in the analysis model.

Eurocode 4

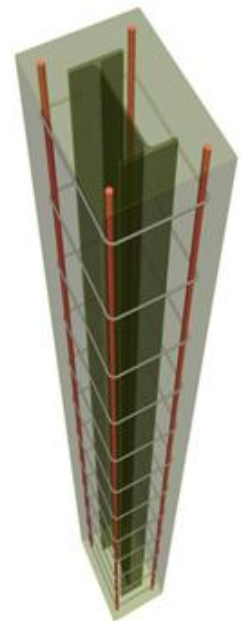
The recent years **composite materials made of steel and concrete** have increasingly gained popularity in the entire world. This is thanks to the many advantages of the material, namely the high strength, ductility, increased speed of construction, positive safety aspects and so on. In collaboration with CADS a solution was integrated in Scia Engineer for the calculation of this type of material.

Composite columns are created using a profile library with several types. Second order effects and imperfections can be taken into account in the analysis.

The design checks are based on the simplified method of EC4 which is applicable to **prismatic columns**. The performed checks are: resistance of elements in axial pressure, combined pressure and uniaxial bending, combined pressure and bi-axial bending, influence of shear force and fire resistance check.

For **composite beams** (as part of a floor) an extensive library is provided for different types of floor elements, namely solid slabs cast in-situ (with or without haunches), precast hollow core slabs and composite in-situ concrete and profiled steel deck.

Next to this libraries are available with the needed design parameters: 2D reinforcement mesh, insulations, profile decks, precast slabs and shear connectors. This functionality in Scia Engineer is suitable for the design of steel-concrete beams in the endstage (composed) and in the construction stage (not composed).



Eurocode 5

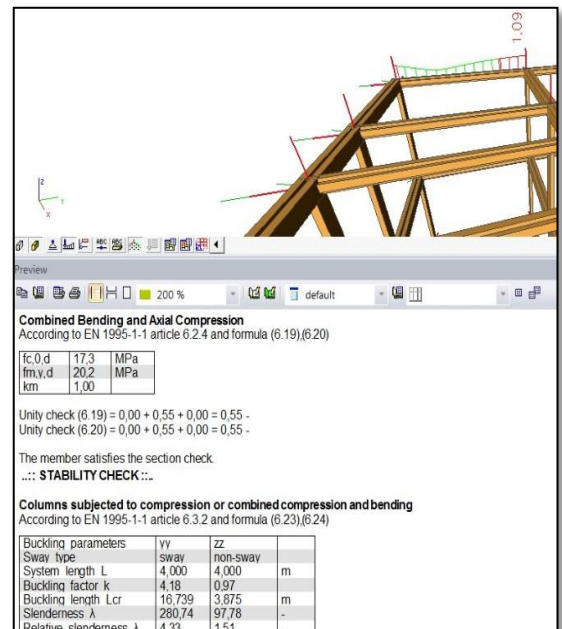
Timber is an important construction material and is often used in a lot of countries in the construction sector, such as roofing.



The design of timber structures according to the EC-ENV is already available for some time in Scia Engineer. But also design and checks according to EN 1995-1-1 will be available soon. This will be integrated in the interface of Scia Engineer and can be combined with other materials (steel, concrete, composite, aluminium).

This will contain:

- Material properties are available for solid and glue laminated timber.
- A first order as well as a second order analysis with reduced stiffness is possible
- The **ULS checks** are performed according to chapter 6 of EC5, namely tension/compression parallel to the grain, compression perpendicular to the grain, bending, shear force, torsion and combined bending with axial tension/compression
- The **SLS checks** are performed according to the article 2.2.3, both the instantaneous as well as the final relative deformations (inclusive creeps) are verified.
- Next to these checks an optimal design is possible via the **Autodesign** functionality. As a result the optimal section is automatically proposed.



Picture: Preview of the timber code check according to EC5 in Scia Engineer

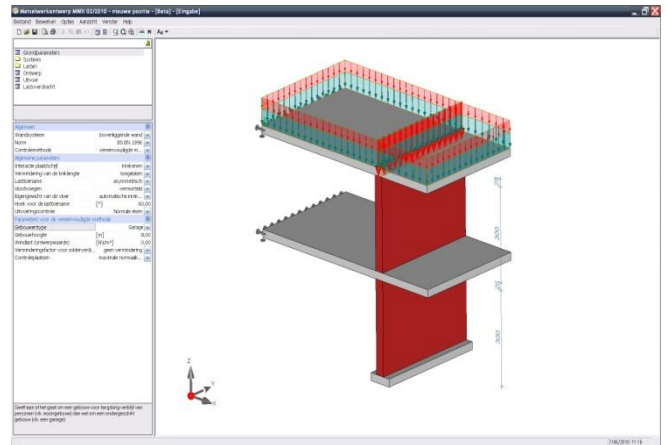
Eurocode 6

For the design of **Masonry structures** two solutions are foreseen for our users: Masonry design in Frilo Statics and Masonry check (including seismicity) in ETools.

Masonry design in Frilo Statics

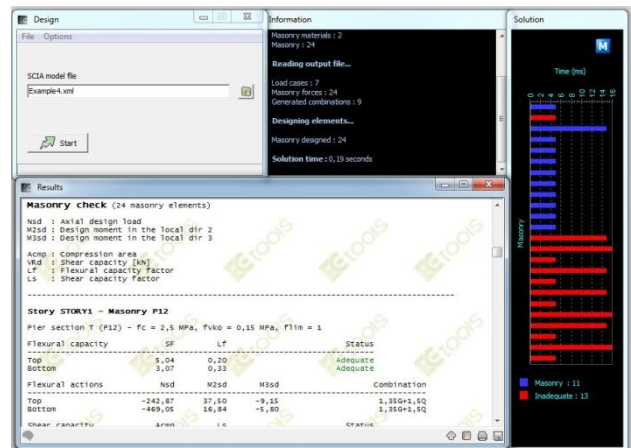
The standalone program MWX is a general design tool for the stability check of **individual walls with a rectangular section** and made of masonry. The check happens via a simplified method or via a more accurate calculation method.

Besides the masonry walls which are mainly loaded in compression, also walls can be checked which are horizontally loaded or in shell or plate direction.



Masonry design in ETools

ETools is a postprocessor which uses the results of Scia Engineer. The modelling and analysis of internal forces takes place in Scia Engineer, but a more specific calculation of EC2, EC6 and EC8 is done in ETools. This is possible for **unreinforced masonry buildings**. The masonry walls are checked for bending capacity and shear capacity.

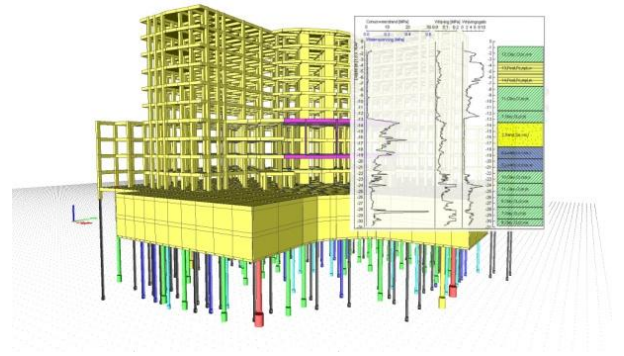


Eurocode 7

Scia Engineer provides a wide range of foundation types, namely pile foundations, pad foundations and elastic foundations for 1D & 2D. Besides this, there is also the possibility for the automatic generation of water and soil loads. This is of main importance for all users who want to take into account the interaction soil-structure.

Pile foundations

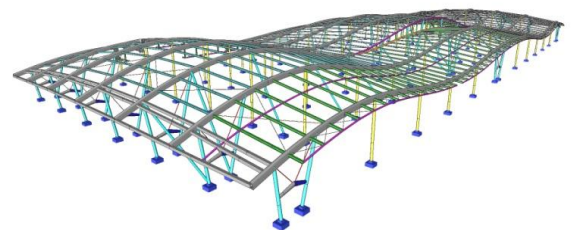
Piles are defined as a type of support in Scia Engineer and they are integrated with the structure model and soil profiles. These profiles are generated from the cone penetration test (CPT). The pile design functionality is a dedicated tool in Scia Engineer developed in co-operation with Deltares. By means of this tool the user can design bearing piles: the level of the pile tip and the bearing capacity at that level are calculated.



Besides this one can derive load-settlements diagrams from the ULS and SLS combinations and also calculate the settlement of the pile. These load-settlements diagrams can be converted into nonlinear functions which are attributed to the supports. This calculation happens in accordance with Eurocode 7, National Annex for the Netherlands.

Pad foundations

Pad foundations are used to support single columns, spreading the load to the ground below. They are generally square or rectangular in plan. The shape in plan is enforced by the arrangement of the columns and the load to be transferred to the soil.

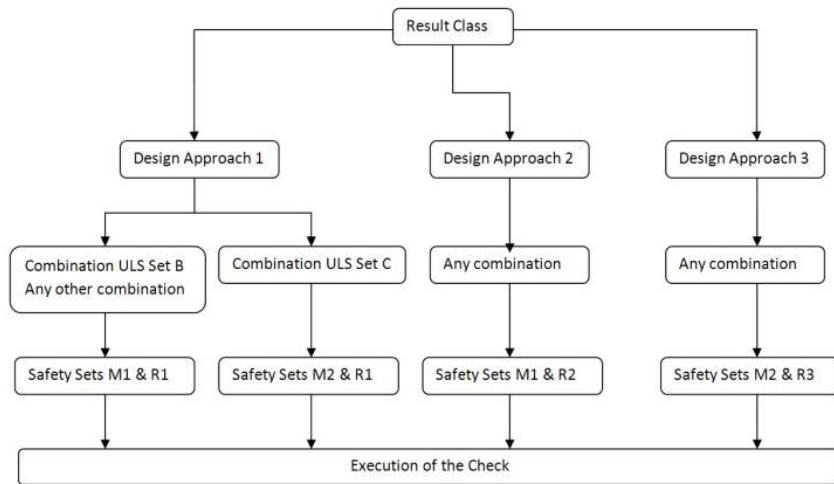


The functionality in Scia Engineer enables the user to perform a stability check of pad foundations in accordance with EC-EN 1997-1, inclusive numerous National annexes.

Three separate checks are performed:

- **Bearing** resistance check
- **Sliding** resistance check
- **Eccentricity** check

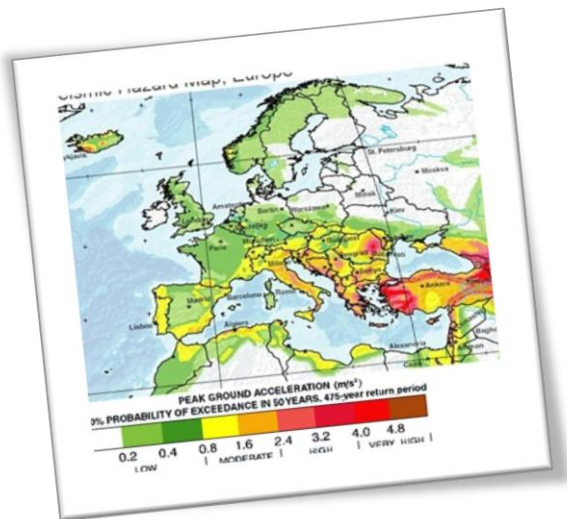
When executing the check, the safety and resistance factors which are applied depend on one of the 3 design approaches chosen in the geotechnics setup. The set of safety factors are read from the setup as follows:



Furthermore an **Autodesign** tool is available to optimize the dimensions of these foundations. This is possible for one or more parameters of the pad foundation.

Eurocode 8

With the arrival of the Eurocodes certain specific checks which were not applicable before are now imposed as a requirement. For instance design according to Eurocode 8 which became an obligation in more and more countries.



Picture: Map with seismic hazard regions

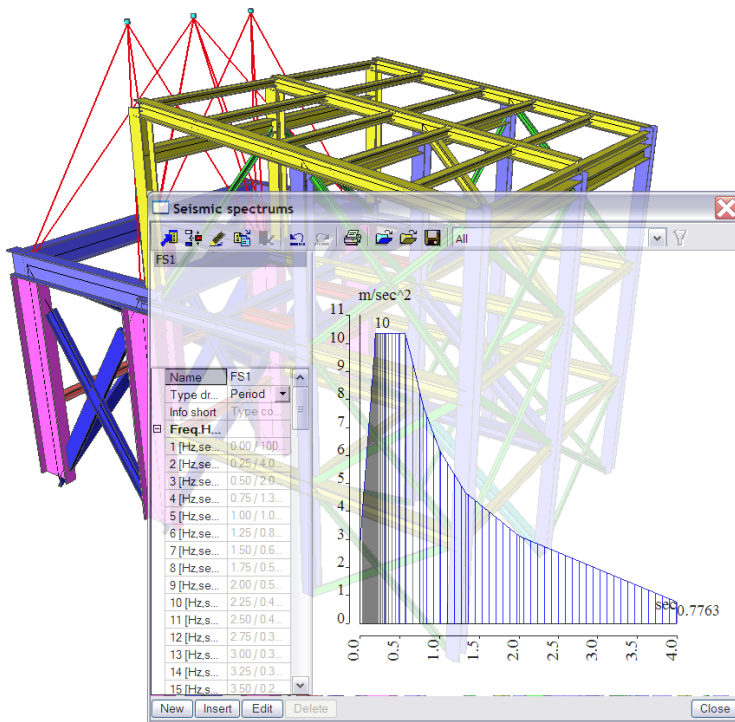
Eurocode 8 is a European code for the calculation of the resistance of structures against earthquake loads (or also: seismic loads). In many southern European countries with an increased risk of earthquakes, **seismic design** was already a standard check during the design of constructions. This should now be carried out according to EC8.

Nemetschek Scia provides several tools to satisfy these requirements.

First of all, there is the possibility to enter a **seismic spectrum**. The user has the choice to define the spectrum himself or to generate it automatically according to a specific code. The system database contains spectra according to Eurocode 8, PS 92, DIN 4149, SIA 160 and the Turkish standards. The modal analysis is done using the **SRSS** or the **CQC** method. When the masses are introduced, **eigen frequencies** and **eigen values** of the structure can be calculate as a result of the seismic load case. This can be displayed numerically, graphically or also through an animation mode. This latter shows the vibration of the structure as a result of the different frequencies.

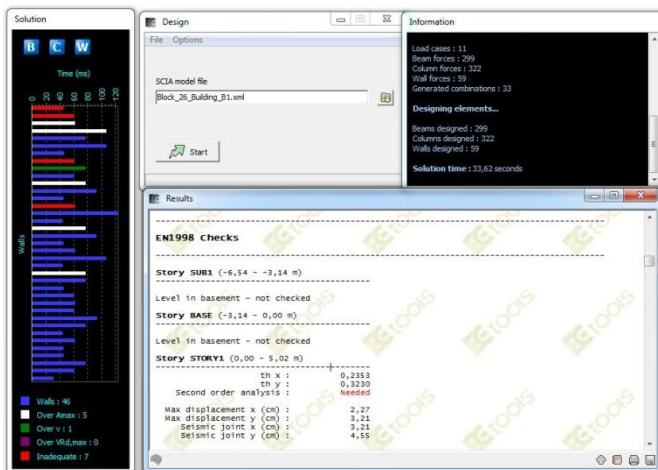
Besides this, it is also possible to display the **accelerations and displacements** as a result of the seismic load case. In the calculation protocol **modal participation factors**, sum of masses and other important data are shown.

Because of the arrival of the Eurocodes and in particular the importance of Eurocode 8 in many countries, Nemetschek Scia will focus in the near future on the expansion of this functionality for an optimal seismic design.



Building in picture: support silo – Geroldinger - Austria

Next to the solution in Scia Engineer, a plug-in is available for the design and/or assessment of concrete and masonry structures according to **EC2/EC6 + EC8**. This solution is foreseen through the software program ETools, a standalone postprocessor which uses the calculation results of Scia Engineer. It contains the **shear capacity design**, **joints capacity design**, **torsional response checks**, storey displacements and **drifts checks**, checks for **P-δ** and much more.



Picture: Design of a concrete building in ETools

Eurocode 9

The design of aluminium structures in Scia Engineer is done conform EN1999-1-1, including the design of transverse welds, aluminium slenderness, global and local imperfections.

The aluminium code check is implemented similarly to the steel code routines as implemented in Scia Engineer.

This contains:

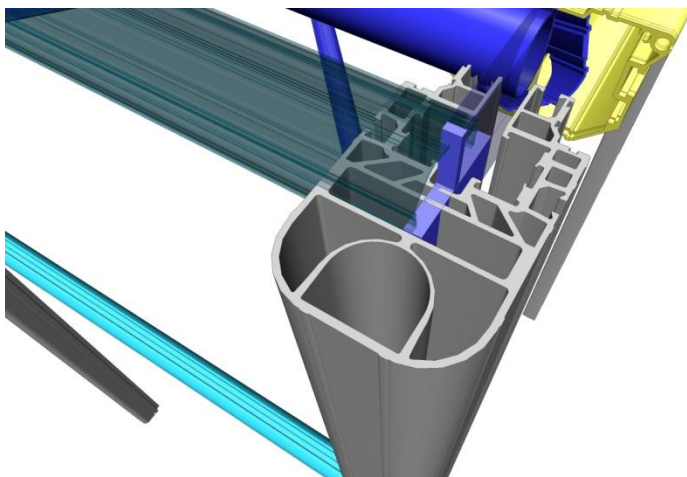
- Standard definition of buckling data and LTB data, LTB restraints, stiffeners and diaphragms
- Standard warping check, performed as an elastic stress check
- Detailed output with references to the used articles of Eurocode 9
- **Autodesign**

The support for slender sections (**class 4 sections**) and HAZ data, is realized by the definition of the initial shape and reduced section properties.

With thin-walled representation overlay for **general cross-sections**, showing the analytical section, any shape of the cross-section can be defined by the user.

Besides this it is also possible to define **transverse welds** as additional data. Transverse welds locally weaken a member and can thus have a large impact on the combined section/stability check.

The code check and optimisation can be done for one beam, one section or for the entire structure.



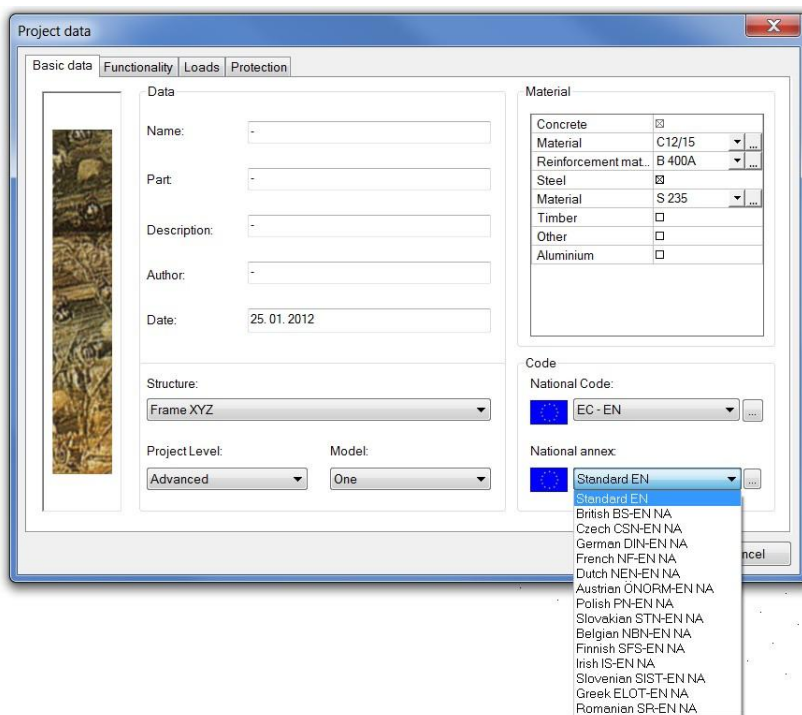
Picture: Aluminium profile of the buildingThe spectrum, Aluminium Space Frame Building – Tentech BV (Alkmaar, the Netherlands)

National Annexes

The National Annexes are an important part of the Eurocodes. These allow the user to use country-specific values, including geography, climate and traditional building practices.

For the most Eurocode subparts a National Annex is published. These indicates which value or formula should be used, or it refers to the recommended value of the standard Eurocode.

Scia Engineer contains a library of Nationally Determined Parameters and this for a big number of European Member States. This list will continuously expand in the future.



When the Eurocode is set as National code in the project data dialogue, the user has to choose subsequently the country of the structure. The parameters are automatically adjusted based on this choice.

It should be noted that if the desired country is not listed it can be solved by using the standard EN parameters. Parameters and values can be easily adjusted and it can be stored afterwards in a library for the usage in other projects.

