



## *Seismic Safety*



Despite to moderate seismic hazards in Switzerland, earthquakes with expected losses of between CHF 7 billion and CHF 60 billion are possible. The Confederation intends to further strengthen earthquake preparedness in its area of responsibility: At its meeting on 11 December 2020, the Federal Council took note of the activities of the period 2017 to 2020 and updated the programme of measures for 2021 to 2024. The priorities include intensifying cooperation with the cantons, further developing precautionary planning in the event of an earthquake and quality assurance in earthquake-friendly construction in the area of responsibility of the Confederation.

The ISO 14001 standard also establishes an internationally recognized standard for environmental management systems based on two essential principles:

- Continuous improvement of environmental performance.
- Compliance with relevant environmental regulations, including earthquake safety regulations and recommendations.



## Introduction

Since 1989, SIA standards on earthquake-resistant construction have existed in Switzerland. The aim is to ensure that a building does not collapse even in the event of a strong earthquake or that only minimal damage can occur.

In new buildings, the additional costs for meeting the standard for earthquake-proof construction are less than 1% of the new construction costs. The fact that there are official controls in a few cantons shows that the importance of the applicable standards for earthquake-proof construction is underestimated or even ignored.

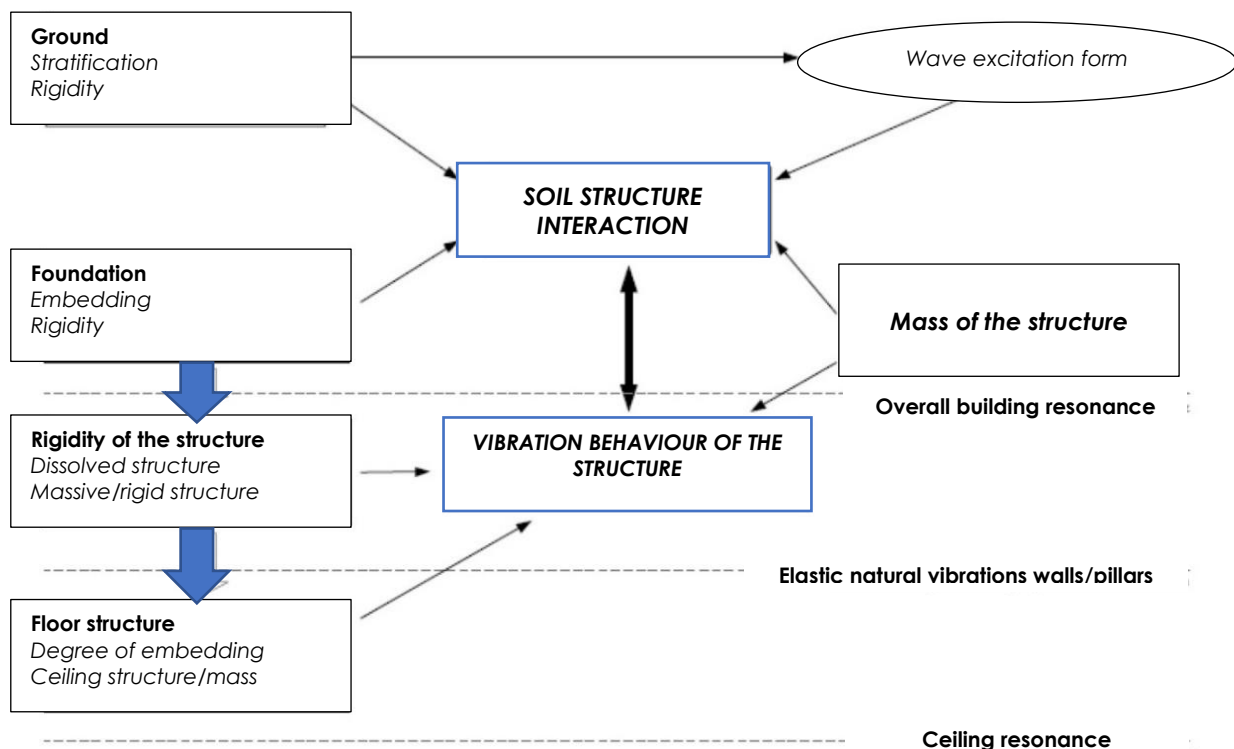
A large part of the building stock was built before the introduction of earthquake standards. It has therefore an unknown earthquake resistance.

The "Foundation for Structural Dynamics and Earthquake Engineering" and the "Federal Office for the Environment BAFU" therefore recommend that facilities and buildings that cause major consequential damage in the event of damage should be inspected as quickly as possible and that earthquake safety be checked. This should take place at the latest when a conversion or renewal of the building is pending.

The basis for improving the seismic safety of buildings is a concept that is tailored to the operating conditions of the property and the objectives of the owner.

## Verification of seismic safety

Checking the earthquake resistance of an existing building is a challenging task. This task is conducted by a specialized earthquake engineer. The costs for checking earthquake resistance amount to between five hundred and several thousand francs. Based on the SIA leaflet 2018, the criteria of proportionality and reasonableness form a clear, cost-oriented basis for decision-making to classify any measures.





The basis for the decision considers the subsoil, the seismic hazard zone, the use of the building and the type of construction of the building. From the criteria for weighting the hazard risk, the fulfillment factor is derived, which indicates how the seismic safety is met in percent. The minimum required fulfillment factor for residential buildings is 25%. This means that the risk with a probability of death is less than 1:100'000.

Since the first Federal Council resolution on "earthquake prevention", the federal construction and real estate bodies (BLO) have set up an earthquake risk management system. To date, the inventory of earthquake resistance of the important buildings and facilities of the Confederation and the control of compliance with the earthquake regulations of the SIA Structural Standards in the construction projects of the Confederation have been introduced, standardized, and systematized.

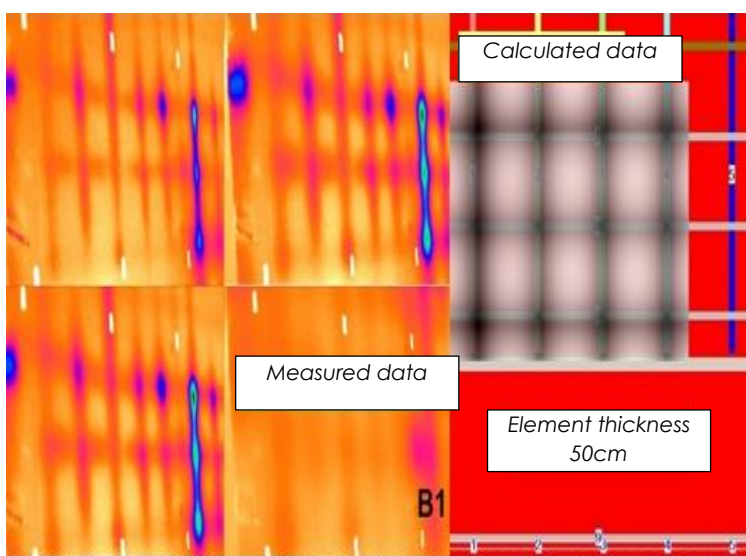
## **Obtaining information**

For the engineer to be able to objectively determine the fulfillment factor, reliable information on the reinforcement (number of reinforcing bars, position of the reinforcement and diameter) is necessary. Today, the information is obtained non-destructively in the event of missing or unreliable planning documents.

Because, for example, in storage halls, garages or industrial buildings, the smallest construction height with free passage is often sought by optimizing the use of space, it is advisable to objectively check the column head anchorage and the force introduction from a ceiling into the support.

Ceilings of garages occupy a special position in terms of safety, because they are often located next to the actual building, covered with earth, paths or roads lead over them or are used as a children's playground. While too much stress alone usually does not lead to the failure of a component, the simultaneous occurrence of various factors (corrosion, change of use, fire) increases the risk of component failure.

There is a considerable risk potential in the use of a garage ceiling, because a failure of the load-bearing structure with the simultaneous action of several reduction factors is not announced but can lead to the sudden collapse of the ceiling.



On the right side of the picture is the grid of the flaccid reinforcement.

The effective measurement result can be seen on the left side. The bright markings represent the measuring grid, and the dark stripes show the effective position of the reinforcement or the prestressing steels.

The planned and executed state can be compared with the means available today.

Even if any type of use of a garage ceiling is clearly regulated by

contract in order to avoid user misconduct, the engineer is obliged to take special care when designing the load-bearing resistance in flat ceilings and to attach the utmost



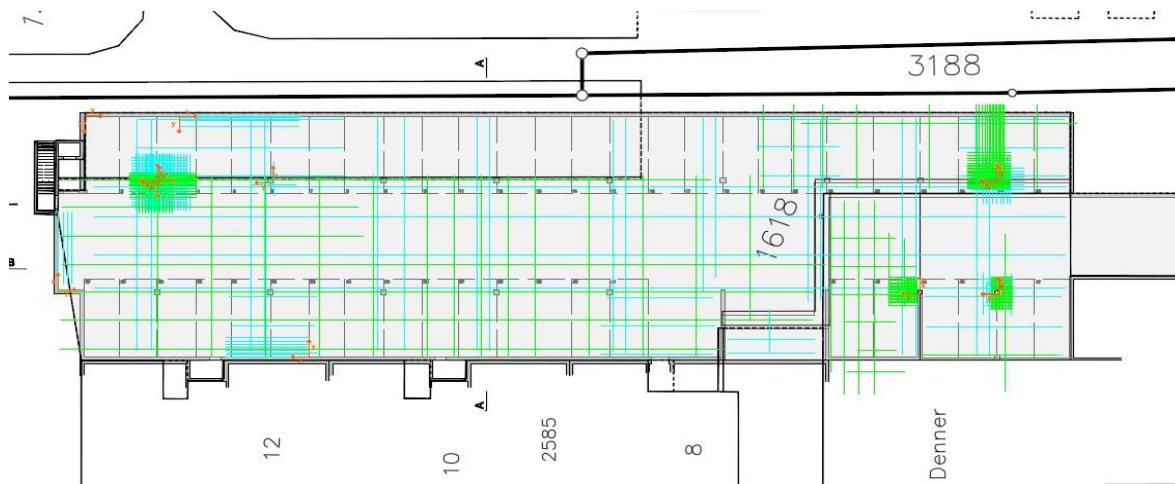
importance to the introduction of force from the ceiling into the supports. An overly optimistic or incorrect design of this zone can lead to a punch failure.

## **Acting before damage**

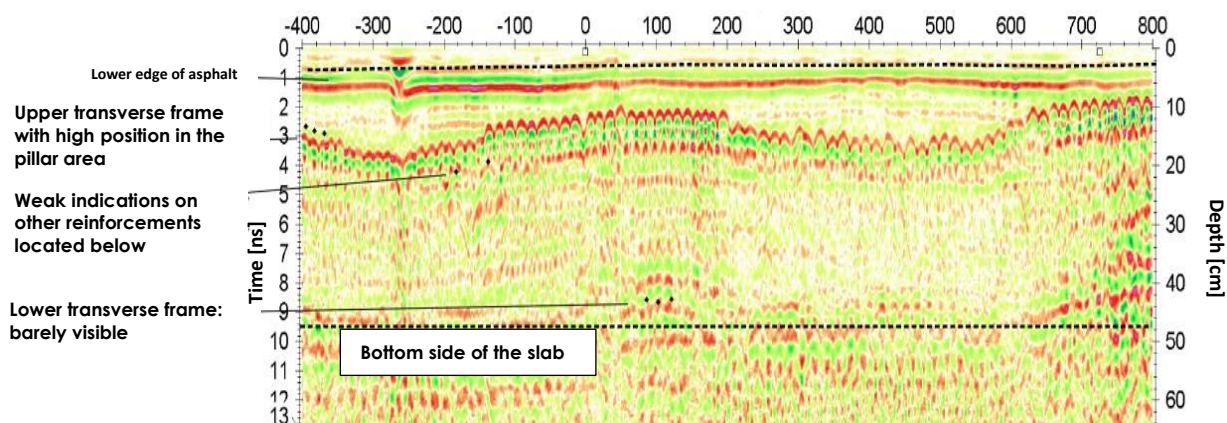
The documentation on "punching failure" prepared by the SIA shows how to proceed with a review of parking garages, or what needs to be considered in a new project planning. The documentation is based on the SIA standards project 269 "Preservation of structures" and serves the architect, creator, work owner or insurer to become aware of the dangers. In addition, plant owners are made aware of their obligation to periodically inspect the building.

## **Non-destructive measurement**

In reinforced concrete structures, visual inspections are not sufficient because ceilings or component connections, even if they look good, represent a high-risk potential due to brittle failure. To check an existing design, the qualified civil engineer needs non-destructive measurement methods that make the effective condition in the object objectively visible.



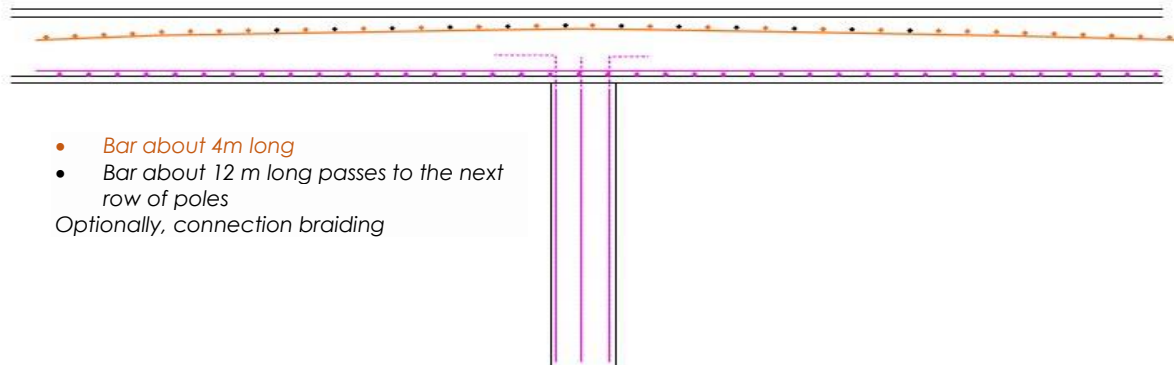
Measuring line on the upper side of the ceiling, from north to south, directly above two poles  
Distance [cm]



In order for the engineer to be able to make an objective assessment of a structure, in the case of existing buildings, he/she uses measurement results recorded on the object in addition to the planning documents for existing buildings.



In the support area, overlapping rebars or the course of the connection rebars are visible in detail, so that earthquake resistance can be verified on a reliable basis.



All important information for the engineer, such as the component thickness, the number, the position or the diameter of the reinforcements, as well as statements on connection irons or the column head anchorage are determined largely non-destructively on the object in a short time.

### **Structural measures**

In the case of "soft ground floors", i.e., structures that are mainly supported by columns, the bracing is achieved with concrete discs that prevent the columns from buckling.

In multi-storey skeleton buildings, bracing walls are installed over all storeys and connected to the storey ceilings. As a rule, two wall discs per main load-bearing direction are sufficient. Reinforcing wall plates can also be built outside the building, which is most easily done in combination with the renewal of the building envelope. In this way, earthquake resistance and the increased requirements for thermal insulation in the context of the energy transition are planned and implemented in one work step, which has a cost-saving effect. Buildings constructed with masonry walls can absorb high pressure loads, but not lateral or diagonal forces. They are reinforced by a steel truss, by carbon fiber lamellae or by steel lamellae. Of course, it is essential that the slats are carefully installed and anchored to the floor slabs, otherwise the stiffening is ineffective.

Measures become more expensive if the foundation or entire floor slabs must be reinforced.

The cost of improving the earthquake resistance of existing buildings is between 1 and 20% of the value of the building.

The "Foundation for Building Dynamics and Earthquake Engineering" and the "Federal Office for the Environment BAFU" have published two leaflets on this topic.

### ***Earthquakes are also possible in Switzerland, which is why the question arises as to who is liable for earthquake damage and in what form.***

In the event of a strong earthquake, building regulations help to limit the damage as much as possible. As a result, insufficient earthquake resistance in a building can have sensitive consequences under private law as well as criminal law.



## ***Liability of the architect or civil engineer***

Architects and civil engineers are obliged to comply with the recognized rules of construction due to the general duty of care. Due to the SIA standards, the earthquake resistance of a building must be checked and, if necessary, improved. If these standards are not adhered to by architects or civil engineers, they can be held liable. This applies even if the SIA standards have not been expressly made part of the contract or have even been expressly excluded.

## ***Liability of the homeowner***

However, if the respective homeowner refuses to comply with the corresponding SIA standards for earthquake safety during a new building or conversion, he is personally liable for the damage caused by earthquakes. In such a case, the architect or civil engineer will regularly demand written confirmation of this decision from the owner or warn him. The fundamental liability of the architect or engineer to pay damages is not excluded in every case but can at least be reduced. The homeowner thus assumes a risk. Due to the liability of the plant owner, a lack of earthquake resistance of a building in the case of a new building is considered a faulty system, in the case of an old building as inadequate maintenance, which is why the homeowner can be prosecuted.

## ***Binding clause SIA***

Although the degree of validity of the SIA standards is controversial, it can be assumed that in the event of a dispute, a court will consider the provisions of the SIA standards on earthquake resistance as recognized rules of construction. After the damage event, the judge thus checks whether the requirements of the SIA standards for earthquake-proof construction have been met or not. Even older houses and facilities should then meet today's requirements, regardless of the fact that these were not yet required at the time of their construction or were not so strictly tested. For the homeowner, a periodic safety check can therefore be useful. The court grants owners a reasonable reasonable response period to adapt their buildings to the latest regulations. The law also allows economic considerations, whereas in the case of static safety - especially earthquake safety - a stricter standard is applied to the measures to be taken for safety reasons.

## ***Legal responsibility***

In the event of an earthquake, the defective buildings could lead to a death in the worst case. In this context, the question of criminal liability due to negligent homicide arises. A negligent serious bodily injury caused by the defective building as a result of an earthquake would also be conceivable. Also, a punishment for endangerment by a violation of the rules of the building customer is possible. However, jurisprudence is reluctant to criminally convict homeowners.

All owners and owners of underground car parks and garages are advised to inspect their buildings and facilities. To this end, the SIA has published a leaflet entitled "Preservation of structures". After all, the liability in the event of an accident lies with the owner, which can have both civil and criminal consequences.

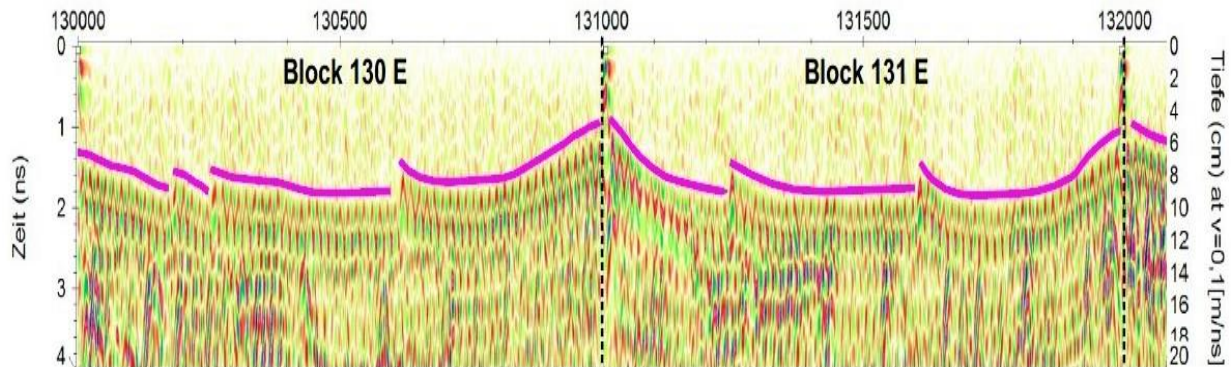


## ***Professional measurement technology from a single source***

Because the use of non-destructive measurement methods is technically demanding, requires a great deal of experience and the devices are very expensive, we offer "component and building scanning" as a service.

We show pipes laid in the ground, provide an insight into supporting structures, locate cavities in the concrete walls, or show the course of concreted tension cables.

### ***EFFICIENT - SAFE - INCORRUPTIBLE - NEUTRAL***



***We will show you how to specifically avoid increased risks, demonstrate punch-through safety and make installations in concrete visible.***