Buildings Acoustics

Acoustics and Vibrations

Securing the acoustic comfort for the occupants of buildings

Industrialisation and urbanisation have increased the nuisance level we face from noise. Measures are often indispensable to guarantee a minimum level of acoustic comfort in the working and living environment. The sources of noise nuisance generated outside buildings are road, rail and air traffic, industrial activities or neighbours. Internal sources may include technical installations and machines, as well as people's activities. Room acoustics inside premises can be improved, thereby ensuring not only better intelligibility, but also greater enjoyment of music.

A **problem-solving** approach has been devised. The services include not only measurements, calculations and simulations (using state-of-the-art techniques), but also assistance, advice, specifications, building and construction site control and inspections etc. Ample attention is also focused on economic feasibility, sustainability and practicality.

Noise criteria are imposed in laws, standards, guidelines, technical regulations, specific requirements or based on certain expectations, whereby the wishes of the designers, developers, prospective users etc. are taken into account.

Room acoustics

Acoustic requirements are determined by the use of the premises. In a classroom, auditorium, theatre or similar location, you want to have good speech intelligibility everywhere in the room. In a foyer, multi-purpose hall, restaurant, open-plan office etc. you want to be able to understand clearly the conversations in close proximity to you, but it is not the aim for everyone to be heard from a long distance away. In a room where musical performances and practices take place, you deal with requirements that will ensure maximum enjoyment.

In a room acoustics study these wishes are converted into specific criteria and conditions that need to be implemented in order to achieve the desired level of comfort. Furthermore, these criteria are turned into practical measures and provisions. Appropriate materials are chosen along with quantity, location etc.

A sonorisation study or a PA system analysis involves determining the ideal number and type of loudspeakers and their location. Masking effects may also be a possible option.

With specific calculation programs such as acoustic simulation models the most efficient, economical and sustainable solutions or options can be calculated.

Acoustic facade insulation

Passive protection measures for effective facade and roof insulation are mostly the only option for restricting the noise in the underlying rooms to an acceptable level. Examples of these measures are specific acoustical glazing, soundproofed ventilation systems, facade and roof structures with a high level of sound insulation etc. The glass compositions, type of ventilation grids, composition of the facade's woodwork elements, and light or heavy facade and roof components etc. will be described in detail, focusing specifically on connections of construction components and joint seals etc. On the other hand also the noise transmitted from a building to the outside environment needs to be reduced sufficiently in buildings in the case of parties, performances, dancing activities, machine rooms etc.

Simulations can be helpful to determine the acoustic properties of a room. The geometry of the room can be modelled in 3D. The acoustic properties of the surfaces are input. Rays are produced from the various sources (location, power, spectrum, directivity etc.) and their path is determined according to the reflections. In each receiverpoint, a reflectogram represents the reception of the various rays with a damped amplitude. Derived acoustical parameters are determined from this. The acoustical quality may be improved precisely by adapting the geometry, type or location of materials.

Installation noise

The sound pressure level generated by technical installations (ventilation, heating etc.) is checked in the premises to see whether it complies with the acoustical comfort limits. Possible options include adjusting the maximum air velocities in ducts, providing enclosures for devices, or isolating using appropriate pipe fixations. A description of how to arrange and attach sanitary equipment, and details of lifts can also be provided as well as sound-absorbing measures for ducts, cooling and heating systems, emergency power supply units etc. can be calculated. Furthermore also vibration-damping measures for vibrating devices and/or machines can be treated.

Technical equipment which is installed outside (roof fans, cooling equipment, chimneys etc.) or generates external emissions (ventilation openings) can also cause a noise nuisance to the external environment.

Measurement techniques

Sound pressure level measurements, sound monitoring (short or long term, level and spectral measurements, thresholds for audio recordings) reverberation measurements: airborne and impact noise measurements (ISO-140, ISO-717); MLS measurements (determining of room acoustical parameters such as Clarity C-80, Definition D-50, RASTI, LEF etc. via impulse response, obtained using a pseudo-stochastic noise source).

Building acoustics

Building acoustics Acoustics

Airborne & impact sound insulation

Human activities, devices and technical equipment inside a building can cause a noise nuisance inside adjoining rooms or buildings.

The requirements for a separating structure depend on the function of the rooms transmitting and receiving the noise and should be identified for the whole building. On this and other basis the separating structure's acoustical features can be determined.

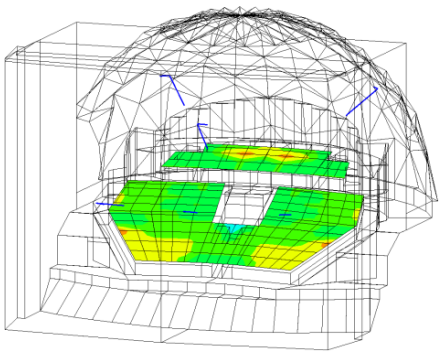
The presence of components such as doors, internal joinery, hatches etc. must also be taken into account. In addition, sound is also transmitted via continuous walls, floors, facades, raised floors, lowered ceilings etc. which are connected to these structures (flanking and circuiting transmission ISO-12354).

Connections between these separating structures and other structures may also weaken the overall sound insulation, not to mention cracks and openings. Transits for channels and pipes can transmit sound via the openings, the ducts or pipe walls themselves or even via the channel ducts.

Footsteps, the movement of tables and chairs, playing children, banging doors, switches etc. are examples of impact noise which is transmitted directly to the building's structure and needs to be tackled specifically not only in terms of the criteria but also in terms of the type of solution.

Applications

Typical applications are airports, apartments, atriums, auditoriums, conference rooms, interpreting booths, call centres, churches and chapels, cinemas, court buildings, cultural centres, educational institutions, embassies, events halls, government buildings, hospitals, hotels, industrial buildings, open-plan offices, libraries, office buildings, banks, institutional buildings, police stations, station buildings, recreational buildings, music practice rooms, recording and control rooms, residences, restaurants and cafeterias, shopping complexes, pools, technical rooms, TV studios, theatres, town halls etc.



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Railway Infrastructure Noise

Acoustics and Vibrations

Assure the acoustic comfort of passengers, operators and residents.

The sound management of rail infrastructure is an important issue of the integration of rail projects in urban and suburban landscapes.

The entire infrastructure, facilities and equipment involved in the development of a public transportation line are potential sources of noise.

It is therefore important to understand these phenomena in order to bring solutions and to assure the acoustic comfort of passengers, operators and residents.

We have over 100 years of experience in both the heavy and light rail area. We have developed methodologies and tools allowing us to optimize the acoustic comfort holding into account the tracks, technical and traditional buildings as well as control centres.

Rail and equipment

The traffic of rolling stock is a major source of noise. Particular attention is paid to identify and control the noise sources at the level of the rails (and wheels), the catenary and at the transformer stations. The objective is to meet the standards imposed by legislation and the ambitions envisaged by the railway company. We thus have an arsenal of methods and techniques to determine the necessary corrective measures to achieve the objectives. For example, at the level of the track, we can consider the use of ballast mats, under sleeper mats, adapted rail pads, floating track, ...

The track maintenance is also to be considered (for example to reduce the vibration of the rail ...).

Sites and buildings

Noise from road, rail and air traffic is a major and regular source of noise pollution in buildings. For heavy or light rail projects, we also take into consideration the technical buildings to be used as storage areas and/or maintenance facilities, office areas and control stations. Indeed, in the technical areas attention is paid to comfort of personnel and at the same time limiting the nuisance towards the environment.

The first step is to complete the diagnosis of the present situation. This assessment incorporates the measurements to be performed on site. We then model the site and the area to perform numeric simulations for the noise impact. These simulations incorporate the noise sources that the project will induce such of the traffic of rolling stock as well as maintenance works. We thus have the necessary elements to determine the existing and the future noise levels. These levels should at least meet the legislation and the ambitions are set out. If necessary, improvement measures are proposed as for example specific glass compositions, suitable types of ventilation grilles, details of the composition of the of the façade, a choice for the use of light and heavy construction for walls and roof. In detail the connections of exterior walls and the specific sizing of the joints are routinely performed. Detailed knowledge of the incident sound levels on the façade in combination with the detailed technical provisions in order to obtain the most economical solutions will result in a comfortable sound level at the interior.

Certifications

We are certified lab and engineers in the disciplines of noise and vibration in the three regions of Belgium. We can draw up environmental impact studies on all of this territory. This aggregation involves the application of the quality standards ISO-9001 extended with the ISO-17025 for a lab.

Dose-response relationships establish the link between the level of noise exposure and the level of discomfort. These relationships allow us to estimate, for example, the percentage of people annoyed or very annoyed based on the noise exposure level.

Missions

We provide the following tasks:

- Diagnostics of a site based on measurements and calculations
- 3D modelling and simulation of sound propagation
- Environmental Impact Assessments
- Noise maps
- Acoustic studies and proposals of noise protection (anti-noise walls, facade insulation, ...)
- Assistance in the drafting of specifications
- Manage construction site noise nuisance holding into account the circulation of vehicles, types of machines used, ...
- Construction follow-up and reception measurements and facilities.

Noise Mapping

The directive 2002/49/EC of the European Parliament and of the Council of 25 June 2002 on the assessment and management of the environmental noise aims to fight against noise perceived by people due to traffic.

The L_{den} and L_{night} noise indicators are used for the preparation of strategic noise maps. Other indicators may be used for planning purposes, noise zoning, black points and prioritization.

Dose effect relationships are used to evaluate the effects of noise on populations. The action plans provide noise management and include, if necessary, noise reduction schemes.

Numerical simulations

For the simulation of the environmental noise, the calculation methods are standardized (SRMII, XPS / 31133, ...) depending on the source and applied in software packages Geomilieu and IMMI.

Railway infrastructures

Acoustics & Vibrations

Legislation

A perfect knowledge of the legislation and its interpretation is imperative in the context of our studies. We master the noise criteria under applicable laws, standards and guidelines. Whether these are taken at a municipal, a regional (Vlarem II, Ordonnances Bruxelloises, Order of the Walloon Government of 13 May 2004 on the assessment and management of environmental noise, ...), federal or supranational (European Directives).

Acoustical indicators

There are a wide variety of acoustic descriptors: Energy based indices (LAeq and its derivatives such as LDEN), statistical indices (L10, L50 ...), peak indices (Lmax), Event indices (SEL Sound Exposure Level or NNE Number of Noise Events).

Also, a large proportion of low frequency components can significantly increase the discomfort.

The noise impact is a function of the intensities, the speeds, the vehicle type, the soil type and stratification, etc...

Environmental Impact Assessment (EIA)

During the construction of new lines, often noise barriers or walls are used or, if possible entrenchment (covered or not) to master the nuisance, which is estimated in the impact assessment review. This study measures the current situation, calculates the future situation, assesses the effects and proposes measures to mitigate the impact.

Sanitations

Sanitations aim to determine the protective measures to limit or eliminate the propagation of annoying noise according to the distance and the presence of objects (walls, shoulders, embankment,...). Protective measures can be absorptive or reflective. In some cases it is desirable to intervene at the source level. For example the placement of a ballast mat.

Acoustic measurements

Ambulant and unguided measurements of specific noise, spectral measurements (1/1, 1/3 octave bands), sound events recording, complementary radar measures, masts up to 6 m high, emission measurements according to ISO-3095, track decay rate measurements.

Vibration measurements

Vibration measurements are done according to DIN-4150, ISO-2631 or SBR with detailed recording of events. Measuring transfer functions with controlled shock impact. Specific measures with different sensors types, filters, conditioning, ...

Applications

North-South link Antwerp, HSL L2 Brussels to the German border, HSL L1 Brussels to the French border, Sloelijn Netherlands, Tram Flanders Expo in Ghent, Hoboken, Mortsel, Boechout, ..., Railway station Leopold, Tunnel Soumagne, Spartacus Tram Hasselt, Tunnel Liefkenshoek in Antwerp, GEN project in Brussels, Brabant tramnet in Brussels, Metro Sao Paulo Linha Leste Convurt European Project, Project Zaventem Diabolo in Mechelen, Coastal Tramways, Eurotunnel, Iron Rhine, railway noise mapping in Flanders, Environmental impact assessment Infrabel L50A - L55 - L36, Noise Action Plan of Antwerp, Noise mitigation Radisson Hotel above Paris Metro, ...

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Environmental Acoustics

Acoustics and Vibrations

Guarding noise nuisance in the external environment

Exposure to excessively high noise levels can result in hearing impairment. Long-term exposure to high noise levels increases stress and causes health problems (higher blood pressure, heart problems, DALY). At any rate, noise causes discomfort. Environmental noise needs to be restricted. Noise generated by the infrastructure (road, rail and air traffic) is part and parcel of our lives and a price to pay for our mobility requirements. Other major sources are industrial activities (mostly concentrated in industrial zones) or leisure activities (events, festivals). Permissible limits are set depending on the type of the source and the location and type of the receiver. Sometimes measures need to be taken at the source, in the transmission path or even at the receiver.

SOUND SOURCE

- Industrial sources (individual companies, industrial areas, shopping malls, wind farms)
- Road-, rail- and air traffic
- Recreational (music events, karting, shooting areas, ...)

>

TRANSFERT

- Distance
- Shielding objects
- Reflections
- Topography
- Soil absorption

>

RECEIVER

- Noise level at the facade of residential and office buildings
- Noise at working places
- Silent zones
- Criteria

Sound criteria

Sound criteria are set out in laws, standards and/or, guidelines. Laws may be introduced at local, regional (Vlarem II, Brussels Orders etc.), national (Royal Decree February 1977 on music noise regulations, draft Royal Decree 1991 on environmental noise, Royal Decree January 2006 on noise protection at work) or supranational (European) level.

Certification

Laboratories can obtain certification for carrying out sound and vibration studies throughout the whole of Belgium. Separate certification is required for carrying out environmental impact assessments. As part of the conditions, the quality concept of ISO-9001 is applied supplemented by ISO-17025 specifically to laboratories.

Remediation

Measures need to be considered first of all at the source (nature, type, enclosure), secondly in the transmission path (shielding) and finally at the receiver (hearing protection, increased roof and facade insulation).

Simulations can be used to calculate the impact of noise on the environment. This allows us to verify whether situations are acceptable. This highlights where there are possible excess levels and the extent of them. This gives a good idea about where improvements need to be made. A calculation model also allows us to implement measures and calculate their impact. The basis for transfer calculation between source and receiver is defined in standardised calculation methods (ISO-9613, SRM-II, INM). This takes into account the sound sources (type, location, size etc.), the existing buildings and structures (shielding and reflection), topography (absorption, shielding) etc.

Noise maps and action plans

A noise map is often a key tool in calculating and reducing the noise impact caused by industrial and infrastructure projects.

EU Directive 2002/49/EC makes it compulsory to produce large-scale noise maps for environmental noise (road, rail and air traffic and industrial sources within built-up areas).

GIS databases are used. Outdoor sound levels can be visualised using coloured maps. The number of buildings and inhabitants is counted according to the noise impact on the facade. Given the large scale of the process, the calculations are performed using dozens of processors based on client/server techniques.

The aim is to come up with action plans. This is based on the number of people affected (strictly defined and source dependant) and whose sleep is disturbed. Hot spot analyses determine the density of this nuisance. Noise sanitation measures are more effective in this case. This leads to setting priorities in terms of projects and resources.

Acoustic surveys

Institutions which have a statutory obligation to abide by noise regulations undergo an acoustic survey which examines their compliance, and any remedial measures should be worked out.

Environmental Acoustics

Acoustics and Vibrations

Worker protection

Workers' exposure to high noise levels should be restricted. This is first of all identified by carrying out suitable measurement campaigns. For people who move around a lot dosimetry provides additional information. Apart from reducing the noise source, other measures include zoning areas with notices indicating the noise impact, informing workers and providing or making it compulsory to wear personal protective equipment.

Environmental impact assessment

For numerous projects, the environmental impact needs to be calculated and discussed first before any building and environmental licence is granted.

Measurement techniques

At the receiver

For numerous projects, the environmental impact needs to be calculated and discussed first before any building and environmental licence is granted.

Determining acoustic source power (Stüber method) whether or not spectral with sound pressure or sound intensity; Statistical Pass By (SPB) and Close Proximity (CPX) measurements for road and rail traffic.

At the source

Determining acoustic source power (Stüber method) whether or not spectral with sound pressure or sound intensity; Statistical Pass By (SPB) and Close Proximity (CPX) measurements for road and rail traffic.

Linked

Source-specific immission is identified through additional measurements close to the source; transmission measurements (close to and far away from the source, in front of and behind a screen, between inside and outside), based on a level measurement or a predefined MLS sequence (less sensitive to background noise), possibly for determining the effectiveness of measures taken.

Applications

... environmental impact assessments, approved acoustic surveys, industrial noise, workplace noise, road, rail and aircraft noise, neighbourhood noise, noise remediation, recreational facilities (shooting ranges, karting etc.), noise zoning, quiet areas, musical facilities and events, shopping centres, wind farms (on- and offshore), noise maps and action plans, traction stations, transformer stations, energy plants etc.

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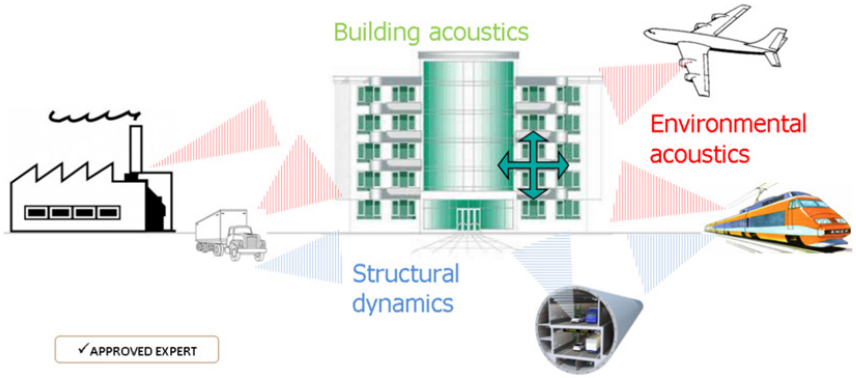
Acoustics and Structural Dynamics

Acoustics & Vibrations

Managing noise and vibration nuisance and improving acoustic quality



Environmental acoustics

Exposure to excessively high noise levels can result in hearing impairment. Long-term exposure to high noise levels increases stress and causes health problems. Environmental noise needs to be contained. Noise generated by road, rail and air traffic is a dominant presence virtually everywhere. Other major sources originate from industrial or leisure activities. Managing noise produced in the environment and having an impact on the environment resides under the field of environmental acoustics.

Building acoustics

On the other hand, implementing acoustic measures in and to a building falls under the domain of building acoustics. This takes into account both internal and external sources. The aim is to achieve a satisfactory level of comfort. In the case of larger meeting rooms, banquet halls, theatres or concert halls, good room acoustics enhances the experience.

Structural dynamics

Vibration in buildings, whether caused by internal or external sources, may not cause a nuisance. This also provides the basis for structural noise, which needs to be kept under control, especially in view of the more disruptive nature of low-frequency noise. On rare occasions, earthquakes can have an adverse effect on structural stability. Buildings where equipment is used that is sensitive to vibration should be largely protected against vibration impact. This is the field of structural dynamics.

SOURCES	TRANSMISSION	RECEIVER
• Industrial sources (individual companies, industrial zones, shopping malls, windturbine parks, ...) • Road-, rail- and arial traffic • Recreational (events, karting, shooting range, ...) • Internal sources (persons, techniques, machines, ...) • Sonorisation	• Distance • Screening objects • Reflections • Topography • Soil specifications • Constructions en structures • Spaces, areas	• Noise and vibration levels at and in buildings • Noise at the workplace • Acoustic experience • Vibration nuisance • Structure borne noise • Quiet ares • Criteria for comfort, nuisance, structural fatigue and integrity

Simulations can be used to calculate the impact of noise and vibration from and to the environment. This allows the verification whether situations are acceptable. It highlights the locations where possible excess levels exist, and in which extent, which gives a good idea as to where improvements need to be made. A calculation model also allows to implement measures and calculate the sanitizing effect. The applied calculation methods and packages vary between these disciplines. In building acoustics, ray tracing is one of the methods used, as implemented for instance in Raynoise and CATT Acoustics. Standardised calculation methods are used for environmental acoustics (ISO-9613, SRM-II etc.) and supplied in the packages Geomilieu, IMMI and INM (airplane noise). The finite element method is frequently used for structural dynamics in the form of the Ansys package.

Environmental Acoustics

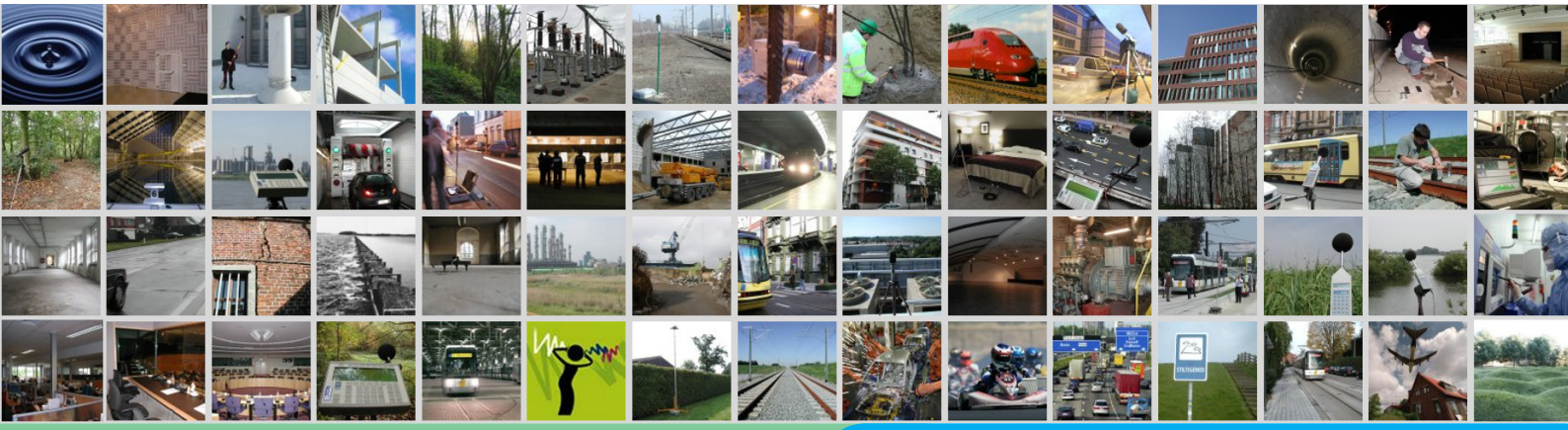
Worker protection; Environmental impact assessments; Acoustic analyses; Noise maps and action plans etc.

Building Acoustics

Installation noise; Acoustic facade insulation; Airborne and contact noise insulation; Room acoustics; Noise impact on the environment etc.

Structural dynamics

Seismic events; Vibration-free components and areas; Predictive maintenance; Vibration nuisance; Dynamic design of machines; Fatigue analyses; Civil constructions; Railway dynamics; Special applications etc.



Measurement techniques

Acoustics and Vibrations

Environmental Acoustics

Sound immission on an hourly basis, part of a day or 24 hours simultaneously for several measurement points and several days; overall measurement or spectral measurement; noise recordings of events; grid measurements at the workplace; alarm functions with smart triggers; Calculating acoustic source power; Statistical Pass By (SPB) and Close Proximity (CPX) measurements; Transmission and efficiency measurements; ISO-1793 Noise barrier absorption and isolation measurement.

Building Acoustics

Level measurements, reverberation time measurement: airborne and contact noise measurement (ISO-140, ISO-717); MLS measurements (calculating room acoustic parameters such as Clarity C-80, Definition D-50, STI+RASTI, LEF etc. via impulse response).

Structural dynamics

Vibration monitoring (DIN-4150, ISO-2631); Temporal (instant and gradual RMS) and spectral (narrow frequency, one-third octave and octave bands) vibration analysis in several places and in several directions simultaneously (BBN-VC, ISO-10816); Filter techniques; Operational Deflection Shapes (ODS); Transfer functions (drop weight excitation); Natural vibration frequencies and modes, modal behaviour.

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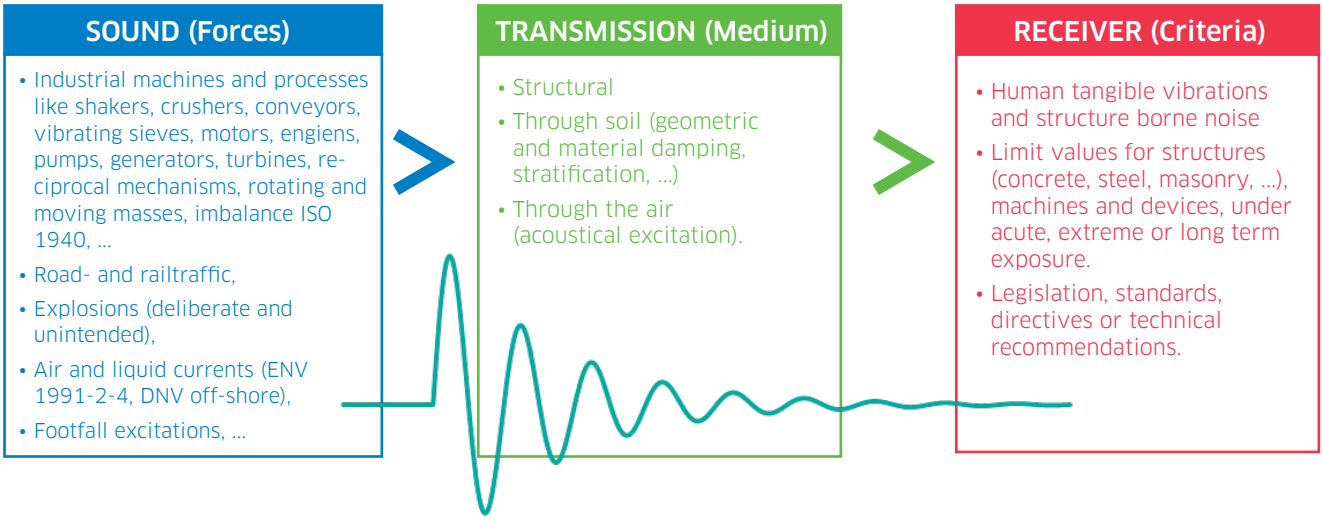
Structural Dynamics

Acoustics and Vibrations

Controlling vibrations of machines, in buildings towards people

People may be affected by vibrations in their homes (comfort), outside (footbridges, sport or event stadiums) or at work (pathological impact of exposure in the workplace). Sensitive machines may be prevented from operating properly (electron microscopes, lithographic machines, nano-scale projects etc.). The integrity of structures can be compromised both by severe incidents (explosions, seismic incidents affecting nuclear plants or parts of them), as well as by fatigue. Machines cannot withstand excessively high vibration levels (alignment, imbalance, suitable foundation etc.) and defects need to be detected promptly (bearings, gears, predictive maintenance etc.).



Vibrational Analysis

Vibration criteria are set out in laws, standards, guidelines or technical regulations.

Measurement methods are used to determine sources and their impact. Tests based on suitable criteria calculate the magnitude of the dynamic problem and provide details of the corrective actions to be taken. Controlled excitation provides information about structural behaviour and properties, as well as the transmission path.

The vibration impact can be **mitigated** by tackling the source, the transmission path or at the recipient, or by a combination of these (e.g. suitable foundations, arrangement or insulation of source or recipient, stiffening, weakening, diverting or screening the transmission path).

During **transmission** between the source and recipient, the impact of bridges, connections and joints are important (cavities, soil structure interaction etc.).

Models are used to calculate the impact of different possible modifications. A model is calibrated through measurements to reflect the existing situation.

Environmental impact assessments (EIA)

For projects requiring an EIA, the vibration impact on the environment is described in the EIAs carried out by accredited experts.

A model of the structure's dynamic behaviour simulates the impact of solutions. The type of calculations may include: modal, harmonic, spectrum, transient and shock, linear and non-linear, plastic, fatigue (rain flow techniques for complex loads) etc. In the case of numerical analyses (multiple mass-spring-damper systems, Matlab, Visual Basic etc.), the finite element method is used for a larger number of degrees of freedom.

Dynamic design of buildings

The vibration level in a building is restricted to a level of comfort and/or allowable level. At first, the internal vibration sources are to be provided with adequate insulation. The next step involves dimensioning the structure to prevent any dynamic amplification. Additional measures should be taken to mitigate vibration generated by external sources (e.g. station buildings and buildings in the direct proximity of railways or explosion-proof industrial buildings etc.).

Dynamic design of machines

The return of machines with rotating and moving components improves with a higher production capacity but is limited by the dynamic behaviour at higher velocities and forces.

Fatigue analyses

fatigue (e.g. weld joints in relation to Eurocode 3-9) and need to be sized appropriately during the design stage (e.g. wind turbines with a variable wind load and a 20-year certificate; water structures such as locks, weirs, flood gates etc. may be stimulated dynamically by the flow).

Civil structures

Large-scale architectural structures such as high buildings, chimneys and bridges with large spans (also slender structures like footbridges) have a large mass and can deflect significant at low frequencies. The structure's dynamic behaviour is analysed in combination with the wind and variable load.

Railway dynamics

This involves determining the nuisance towards the environment by rail traffic and tailoring measures by modified track design of trains, trams and metro systems, both above ground and underground.

Seismic events

Architectural structures need to be able to withstand earthquakes (Eurocode 8). The calculation is based on an spectrum excitation at foundation level. The assessment takes into account the modal superposition of the structural natural modes of vibration (e.g. nuclear industry).

Vibrationless rooms

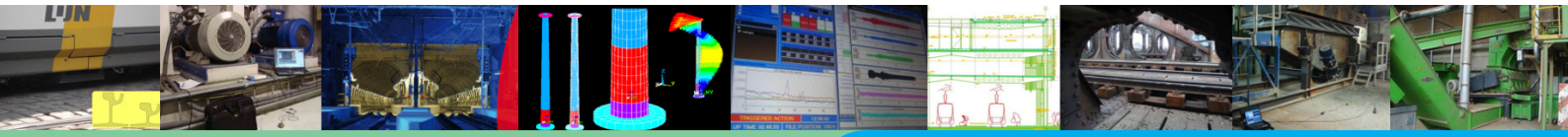
Some sectors use extremely vibration-sensitive machines (e.g. micro-electronics, nano-technology, hotels, hospitals, concert halls etc.). Radical structural measures need to be implemented for these locations, oriented at the structure, the foundations and the location of nuisance sources in the immediate vicinity.

Predictive maintenance

Industrial processes are regularly and/or constantly monitored so that, when changes in vibration levels occur, problems can be predicted diagnostically (such as alignment, imbalance, bearings, gears etc.) and the necessary maintenance or replacement works can be scheduled to avoid unwanted breakdowns.

Vibration nuisance

People can be affected by road or rail traffic or by heavy industrial activities in the immediate vicinity (industry, construction sites etc.). Hand-arm and body vibration are restricted at the working location.



Measurement Techniques

Acoustics & Vibrations

Vibration monitoring

In-situ autonomous measuring system (+24 hour) compliant with DIN 4150 Part II and III or ISO 2631 with evaluation.

Transfer functions

With a controlled, known source (e.g. shaker, hammer, drop weight etc.) the transfer function (spectral) can be measured between two structural points.

Resonance frequencies can be identified. With a larger number of measurement points, the natural modes of vibration can be represented (= modal behaviour).

Operational deflection shape

By combining a large number of measurement points during operation, the harmonic movements of the whole structure can be visualised for selected frequencies.

Vibration analysis

Temporal (instant and gradual RMS) and frequential (narrow frequency, one-third octave and octave bands) analysis in several places and in several directions simultaneously (e.g. BBN VC, ISO 10816). Applying specific filtering methods. Selection of sensors (type, sensitivity, noise floor, frequency range etc.), conditioning, supply, filtering and acquisition details.

Special applications

For example, the monitoring of structural integrity based on changes in dynamic properties (e.g. bridges); product sorting based on dynamic properties (e.g. quality of eggs).

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