Issue 2 - October 2011

CityHush

CityHush – Accoustically Green Road Vehicles and City Areas

About CityHush

The CityHush project will support city administrations with the development and implementation of noise action plans according to the directive EC 2002/49. Noise action plans made with existing technology suffer from major shortcomings: there is a poor correlation between hot spots and annoyance and complaints, most measures lead to increased emissions, and only indoor noise comfort is addressed.

In order to reduce noise in city environments, CityHush develops suitable problem identification and evaluation tools and designs noise reduction solutions for hot spots that show a high correlation with annoyance and complaints. The innovative solutions and tools under development are listed below.

Urban planning & noise score rating systems

- Q-zones;
- parks embedded in Q-Zones;
- improved indoor noise score rating models integrating low-frequency noise and the occurrence of high noise single events;
- noise score rating models for the outdoors.

Vehicles, tyres & road surfaces

- objective and psychoacoustic evaluation tool for low noise low emission vehicles;
- mathematical synthesis tool for noise from low noise low emission vehicles;
- general performance noise specifications for low noise low emission vehicles;
- novel concepts for low noise roads based upon dense elastic road surfaces;
- novel concepts for low noise roads based upon grinding of asphalt top layers;
- novel concepts for tyres for low noise vehicles, including heavy vehicles;
- criteria for use of low noise motorcycles;
- active and passive noise attenuation measures within the tyre hood.

Building design & noise barriers

- solutions for high low-frequency absorption at facades of buildings;
- solutions for high low-frequency isolation in the propagation path.

The CityHush project is co-funded by the European Commission under the 7th Framework Programme for RTD.

Duration: January 2010 - December 2012

Budget: appr. 5 m€

13 partners in 7 countries

www.cityhush.eu

Editorial

We are happy to present this second issue of the CityHush newsletter. The project is half way now, and in this newsletter we want to share the first CityHush results with you. You will read about the potential of Q-zones, the refined noise score rating model for residents, the impact of electric and hybrid vehicles on noise, our laboratory and field tests on optimised road texture for low-noise road surfaces, and modelling approaches for mitigating vibrations through isolating screens.

To provide you with more detailed insights into the tools that CityHush is developing, the project is organising its first dissemination seminar on Wednesday 23 November in Brussels.

Go to **www.cityhush.eu** and register to our mailing list to ensure you are kept informed!

We wish you a pleasant read and hope to see many of you on 23 November!

In this issue...

Acoustically green city areas

A major focus within CityHush, is inner-city areas with restricted access for noisy and polluting vehicles, thus creating acoustically green areas, referred to as quiet zones or "Q-Zones". Q-zones can not only have positive environmental effects in terms of noise health issues, but also with respect to the reduction of chemical exhaust pollution from vehicles, planning for sustainable cities, promoting the development of environmentally friendly vehicles, etc. CityHush also takes the concept one step further by studying the benefits of recreational areas, like parks and culture facilities, within the Q-Zone.

Restricting access in a relatively small area is a complex region-wide traffic planning issue. CityHush is studying its effects by varying a multitude of parameters. Calculations are made, using both well-established European calculation standards and methods improved or developed within the project, to thus determine the effects of the size of Q-Zones, various restriction strategies, and different distributions of low-noise vehicles for 7 large European cities, not only within the area but in the whole region. The coordination and data handling of the study is in itself a large undertaking that has called for the development of several novel methods and technical solutions, which can also benefit future studies.

Refined Noise Rating Model for Residents

One of the objectives of the EU Environmental Noise Directive is to assess the impact of environmental noise on residents in large agglomerations. So far, the assessment of the impact of noise on residents has been based solely on façade levels of dwellings as obtained from the noise maps. Therefore, measures directed towards a quieter outdoor situation, as far as they are not reflected in the yearly average façade levels, will not show up in health assessment indicators, nor will measures that primarily influence the indoor levels, the peak levels or the frequency spectrum.

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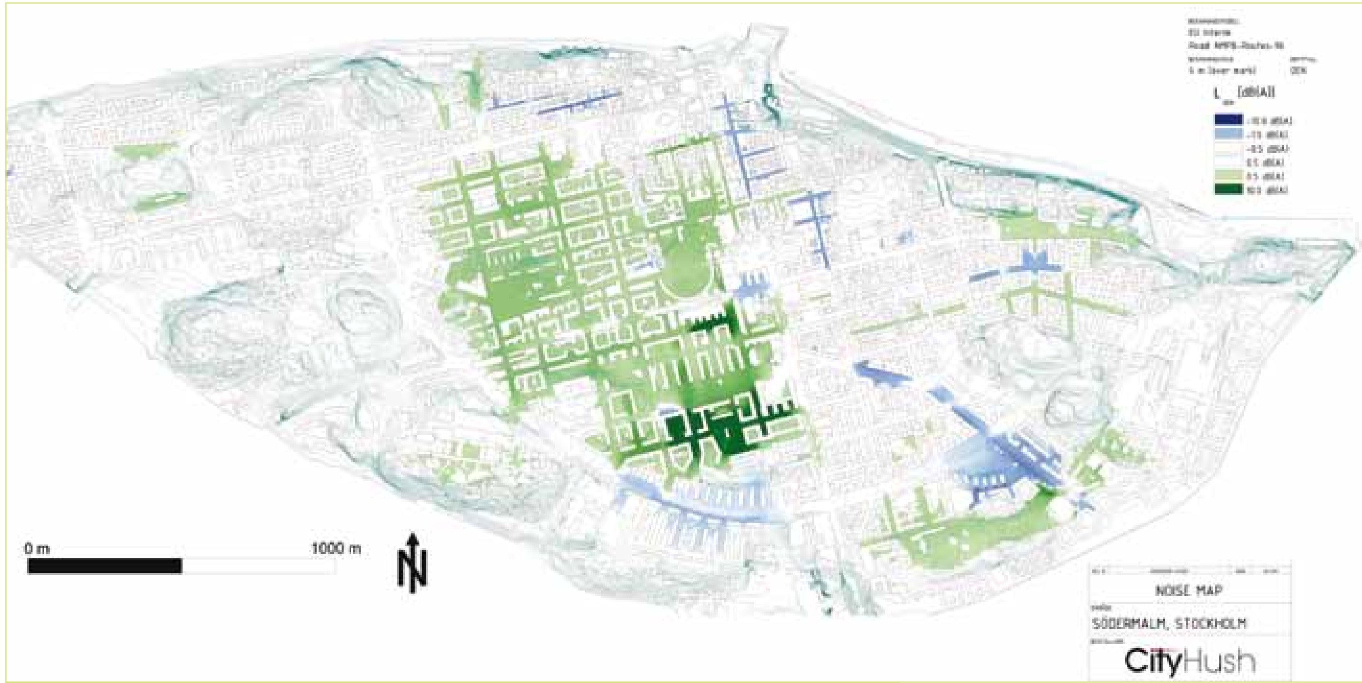
Within CityHush, the noise score rating model for residents as previously developed within the QCITY project, is being refined and evaluated based on current knowledge. In this model, several characteristics of noise besides the yearly average noise level at the façade are incorporated to better quantify the expected effect of environmental noise on residents.

The model incorporated the effect of ambient noise in the immediate vicinity of the dwelling (quiet façades) and outdoor noise in the neighbourhood, as well as the effect of insulation of the dwelling. However, indicators for these effects were not yet adequately based on scientific literature or research. An inventory of the literature, which is used to evaluate the outdoor environment component in the noise score rating model for residents, is now providing the empirical basis for these indicators. In addition, the inclusion of other aspects is explored, such as the influence of spectrum characteristics and the influence of the rate of occurrence of individual events.

The refined rating model for residents may be used to predict the overall annoyance response, i.e. the percentage and number of residents that are expected to be annoyed by noise in a given area.



Example from an early result of a difference plot (before and after introducing the Q-Zone) for the Södermalm region in Stockholm. Positive effects within the Q-Zone are 10 – 12 dB(A)-units of noise reduction (light green-dark green colour). Some positive effects can also be seen in other areas, as well as some negative effects (light blue) just outside the Q-Zone, caused by noisy vehicles making a detour to avoid the gate-fee.

Modified test method for type approval electric vehicles

The measurement procedure in the new ECE R51 method B (similar to ISO 362:2007) is based on an estimation of partial throttle operation at 50 km/h for light vehicles. It seeks to approximate real urban driving conditions (partial throttle operation) with a weighted average of a full acceleration test, e.g. wide-open throttle (wot), from 50 km/h and a constant speed test at 50 km/h. This ensures a better consideration of all noise sources emitted by road vehicles in urban traffic, compared to what was achieved by the earlier applied ECE R51 method A (based on ISO 362:1998).

The main idea of the wot test (or full acceleration test) from 50 km/h is to simulate a worst-case scenario with a focus on driveline noise, while the idea of the constant speed test at 50 km/h is to focus on tyre/road noise. The weighted average (Lurban) is then a combination of both driveline and tyre/road noise so that all relevant noise sources during normal urban driving are considered. However, this may not be the case for low-noise hybrid or pure electric vehicles with weak engines.

Measurements reveal that for electric vehicles with a low power-to-mass ratio (quantity used for calculation of acceleration according to the equation: PMR = Pn/m x 1000 [kW/t], where Pn is the engine power in kilowatts and m is the test mass in kilograms; e.g. PMR<40), the main focus at wot test (or full acceleration test) from 50 km/h will be mainly on tyre/road noise instead of driveline noise because of the quiet driveline. The weighted average that will resemble normal urban driving (Lurban) is then mainly considering tyre/road noise.

This may be correct for urban traffic conditions at main streets with a speed limit of 50 km/h and with very few traffic lights and no congestion. However, this does not give a fair picture of the noise reduction potential for electric vehicles in other situations, e.g.:

- when acceleration normally starts from speeds below 50 km/h;
- when the vehicle will accelerate from standstill at traffic lights;
- for residential streets with a speed limit of 30 km/h.

Normally, the general traffic speed will also be lower when traffic is congested. Traffic speed could for example be 35 km/h or even lower. A wot test (full acceleration) with a lower start speed would then give a better picture of the actual driveline noise at the acceleration phase. Therefore, it is recommended that the full acceleration test for electric vehicles is performed at a lower start speed, e.g. 20 or 30 km/h.

One of the components of traffic noise is generated by the interaction between motor vehicle tyres and the road surface. The amplitude and frequency content of this noise is a function of many parameters, including the road surface texture, tyre dimensions, tyre materials, and construction and the tread pattern design.

Tyre/road noise generation contributes to the interior vehicle noise as well as to the exterior noise. At low acoustic frequencies (below 500 Hz), the transmission of forces from the tyre/road contact zone to the vehicle body is related to the interior vehicle noise, especially on rough road surfaces. At high frequencies, the noise originating from the vibration of the tyre surface also contributes to the noise perceived in the environment, which becomes most intense in the frequency range around 1000 Hz.

In CityHush, engineers of the Goodyear Innovation Center Luxemburg are developing a prototype tyre specifically aiming to fulfil the distinctive requirements of future electric vehicles. The design of the concept tyre will be uniquely suited to complement the performance requirements of electric vehicles. Electric engines often provide a relatively high torque, even at very low speeds, which increases the acceleration performance of an electric vehicle in comparison to a vehicle with a similar internal combustion engine. This required the development of a modified tread design in combination with a new tread compound to ensure reduced noise generation, excellent grip on wet roads and low rolling resistance.

Sound of road traffic in the future

Electric motors will continuously replace combustion engines within the next decades, although conventional drives will remain in use for a longer period. The expected increase of quiet vehicles results in new opportunities regarding a substantial reduction of road traffic noise in urban areas. However, in order to fully utilise the noise reduction potential, holistic noise and vibration abatement approaches must be applied, addressing issues like tyre-road noise, vehicle-type-

Online noise map with interactive listening to selected spots.

Examples of electric vehicles; Pictures: Tyréns AB

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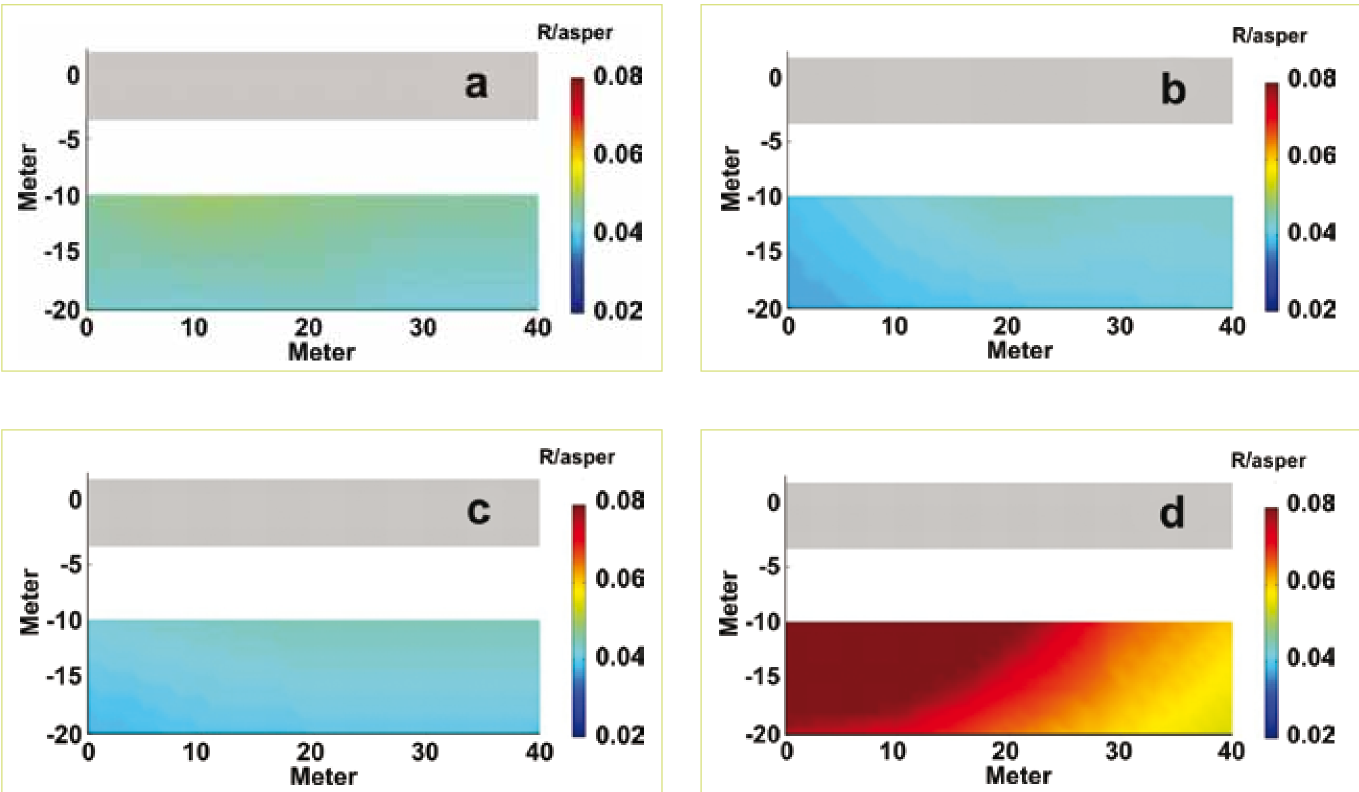
oriented access concepts, psychoacoustic analyses, and infrastructures as well as comprehensive emission considerations.

CityHush deals with these topics and will propose incremental solutions to substantially reduce noise in city environments. One major issue concerns the detailed acoustical analyses and psychoacoustic evaluations of hybrid and electric vehicles under various running conditions.

Moreover, by using extensive measurement data, a traffic noise synthesizer for the generation of complete traffic scenarios with different vehicle types and numbers is developed. This synthesis tool not only allows for calculating acoustical indicators of virtual road traffic scenarios, but also for the binaural auralisation of the resulting noises.

Based on measurement data and simulation, it is possible to perform acoustical analyses of vehicle exterior noise simulations of hybrid and electric vehicles in comparison to exterior noise of vehicles equipped with combustion engines. The traffic noise synthesizer offers many possibilities with regard to urban planning. The following figure shows, as an example, the possible influence on the sound of road traffic (here roughness change) caused by additional warning signals for electric cars required for pedestrian safety.

Other applications include the effect of banning a part or all conventional-powered two-wheelers on complex traffic scenarios in cities, replacing them with electric driven powered two-wheelers, or the acoustical benefit of roundabouts versus traffic lights.



Traffic scenario „Traffic light" at „0 m" (road is shown as grey bar); vehicles stand still at the traffic light and start after the traffic light indicates green to the right; roughness maps (time-averaged values, the scenario lasts about 20 seconds) according to the Hearing Model of Sottek [1] for various vehicles with combustion engines (a), and with electrical motors (b: no warning signal, c and d: different additional warning signals for pedestrian safety).

[1] *Sottek, R., Genuit, K., "Models of signal processing in human hearing", Elsevier, Int. J. Electron. Commu. (AEÜ) 59, p. 157-165 (2005).*

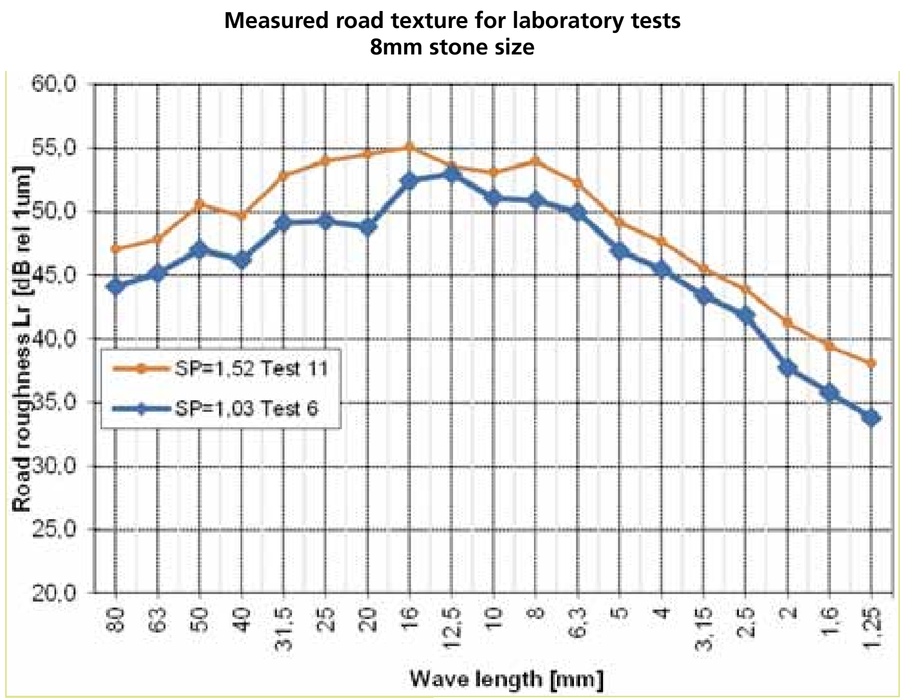
The traffic flow simulation for complex traffic scenarios is performed by commercial software. The resulting data (position, velocity, vehicle type) are provided for further processing, e.g. binaural auralisation to the traffic noise synthesizer, taking into account the appropriate driving condition (especially important in the case of hybrid cars), and statistical as well as individual (related to a specific vehicle) models of sound generation.

Optimized road texture for low noise road pavements

One way of reducing tyre/road noise is to optimise the road texture in order to reduce the noise excitation. The texture is designed to reduce the noise excitation and radiation at dominating frequencies of tyre/road noise. Therefore, the optimal texture also depends on the vehicle speed. During the process, it is also important that the road friction of the pavement is within its limits. This is measured using the "sand patch" method, where fine grained sand is distributed over the road surface texture. The diameter of the sand area is then proportional to the friction characteristics of the road surface.

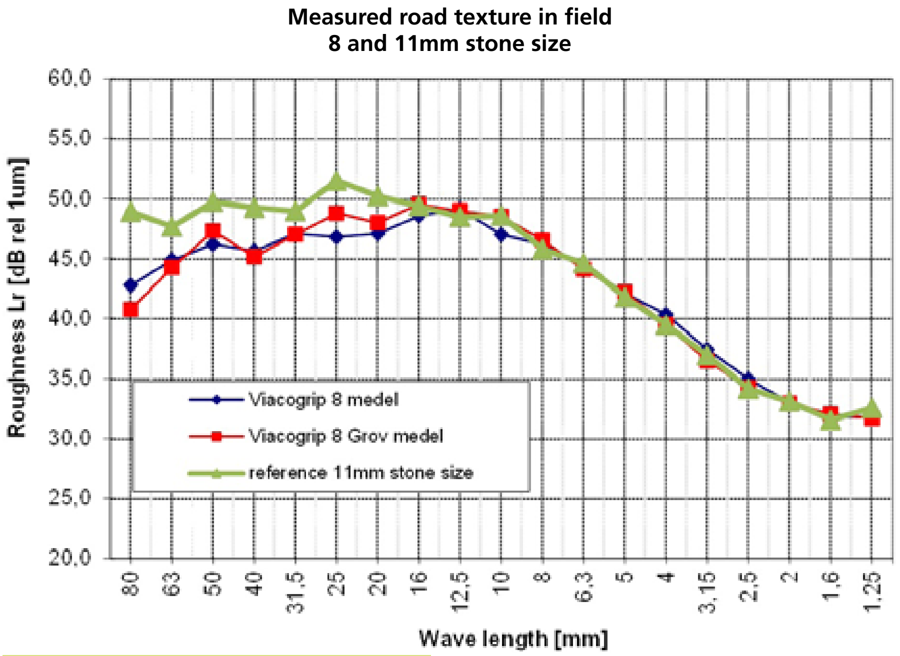
In the first stage, laboratory tests were carried out using a laser scanner (developed within the project) as can be seen on the right.

Measurements indicate that it is possible to create different textures, while keeping the same stone size. At low frequencies (long wave length) there is a big potential for noise reduction. This is for example the case for indoor tyre/road noise transmitted through façades where low frequencies would dominate the sound level in dB(A).



Road roughness level rel to 1 µm for two road surfaces both with 8mm max stone size as measured in the laboratory.

This figure shows the texture as measured at Brahegatan in Gothenburg. It can be seen that the texture at small wave lengths has a lower value compared to the laboratory tests (typically 45 -47 dB at 4 mm wavelength for the laboratory test compared to about 40 dB at 4 mm wavelength for the field tests). The reason for that are the small gaps that have been filled with dirt. At longer wavelengths, the texture seems to remain more stable when compared to laboratory tests.



Road roughness level rel. to 1 µm for road surfaces with 11 mm and 8 mm max stone size as measured during field tests in Brahegatan in Gothenburg.

A conclusion that can already be drawn from texture measurements both in the laboratory and during field tests is that there seems to be a potential for noise reduction indoors for the road surfaces with smaller stone size of 8 mm compared to 11 mm max stone size

In a second stage, the pavements are tested in the field, where both the tyre/road noise as well as the road surface texture will be measured.

This should answer three questions:

1 - Is it possible to get the same results from the texture measurements performed in the laboratory and in the field?

2 - How long will the pavement maintain its texture (or road surface roughness)?

3 - Will the spectral shape for the tyre/road noise and the texture be reasonably the same?

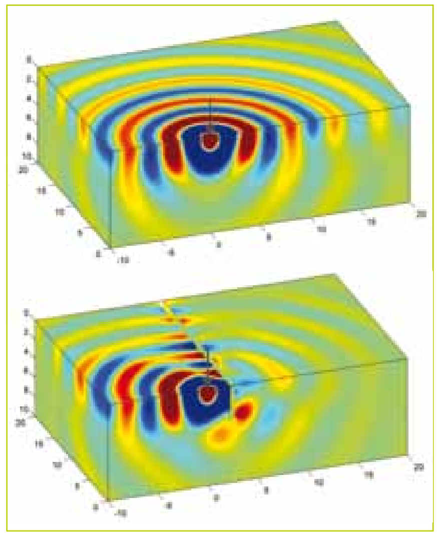
The first field test was carried out at the end of 2010 and the cold weather caused some problems. Therefore, the texture (or road surface roughness) did not show up as expected. A second try (with three different pavements/ textures) took place in September 2011.

A conclusion that can already be drawn from texture measurements both in the laboratory and during field tests is that there seems to be a potential for noise reduction *indoors* for the road surfaces with smaller stone size of 8 mm compared to 11 mm max stone size. It remains to be verified however whether this effect can also be seen in the actual noise generation from the tyre/road system.

Vibrations mitigation by isolating screens

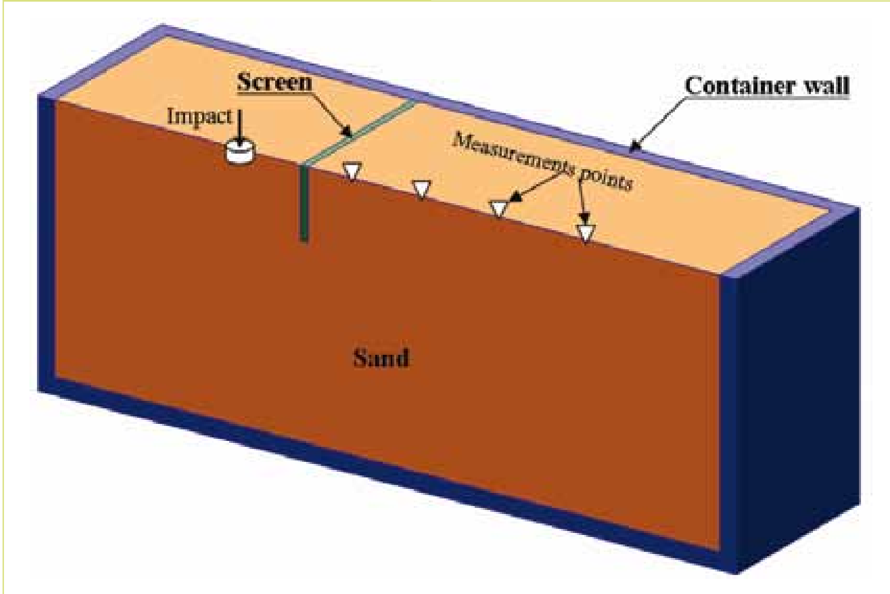
Ground-borne vibrations due to traffic may be harmful for sensitive equipment in nearby buildings and can cause annoyance to residents. In recent years, the mitigation of traffic induced vibrations and the vibration isolation of buildings has been in high demand by designers.

In general, the isolation of ground-borne vibrations can be achieved through the mechanism of interception, scattering, or diffraction of the incident waves using isolating systems such as screens (e.g. trenches or barriers), wave impeding blocks and a resilient mat under the road. Considering the position of the isolating systems with respect to the vibration source (the road), two categories are defined: (a) active isolation, when the isolation system is installed around the source (the road) and (b) passive isolation, when the isolation system is installed near the receivers (the buildings). Vibrations in the near field are dominated by body waves (compression and shear waves). In the far field, however, vibrations are dominated only by Rayleigh waves. The body waves are attenuated due to geometrical and material damping.



The effectiveness of an isolating system (barrier or trench) depends strongly on its dimensions (height and width) as well as its distance from the source and the wavelength (wave velocity/excitation frequency). In theory, the most effective system would be an open trench, but in practice, because of the stability problems, this open trench is filled by soft materials such as bentonite slurry or stiff materials such as concrete.

Overview of the test bench



To assess the efficiency of an isolating system, numerical modelling or experimental simulations can be performed. Although numerical modelling is very useful for a set of parametric and sensitivity studies, an experimental set up is more realistic and more reliable. Since a full-scale test is usually expensive and has some difficulties and limitations in terms of the soil conditions and isolating screen construction, smaller-scale tests with their inherent flexibility for selecting different soil conditions and properties are more relevant. A major difficulty facing the physical modelling of vibrations in the soil, is the repeatability of the test and the replication of the in-situ stress field. Other difficulties such as realising the boundary conditions in the infinity where there are no reflections, may be resolved by selecting an appropriate scaling factor or a relevant dimension for the soil container.

The test bench consists of a container filled with clean and classified fine sand and an isolating screen. To fill the container with soil, the pluviation or sand raining method is used, an efficient tool for providing a uniform and homogeneous sand specimen, and less operator-dependent and more repeatable than other methods.

Measurement configuration consists of a small foundation (excited by an impact) as the source of the vibration posed on the soil surface on one side of the screen and accelerometers mounted at measurement points at the other side of the screen.

As the reference case, a test set up without the barrier is performed and the soil responses are measured by accelerometers. To estimate the isolation efficiency of the screen, the results of this reference case are compared with those obtained in the presence of the isolating screen (the barrier).

European policy

EC proposal to amend legislation on noise emissions of vehicles

In last year's "Communication regarding a European strategy on clean and energy efficient vehicles", the Commission announced that it will present a proposal in 2011 to amend legislation to reduce the noise emissions of vehicles. The proposal, expected for this autumn, will introduce a new test method for measuring noise emissions and change the limit values for the type-approval of motor vehicles. It will also address for the first time the issue of the minimum noise level of electric or hybrid electric vehicles.

Noise emissions of four-wheel motor vehicles are addressed by Directive 70/157/EEC and the equivalent UN/ECE Regulation No. 51. Noise limits have been reduced several times. The last reduction in 1995 did not bring about the effects expected and subsequent studies showed that the measurement method does not reflect real world driving behaviour anymore. It was therefore decided to develop a new test cycle and bring the driving conditions for the noise test closer to real life driving operations.

The UN-ECE Working Group on Noise elaborated a new test method, which was published in 2007. During a period of three years this new method was used on a provisional basis in parallel with the existing test method, in order to obtain practical experience, to evaluate its qualities and to establish a database with measurement results. During the monitoring periods, the type approval authorities were obliged to execute the noise emission tests according to both methods and to submit the results of both tests to the European Commission.

On the basis of the results of the monitoring data, TNO executed a study, VENOLIVA, looking into the differences between the current type approval test method and the new test method. The study revealed that the benefits to society of stricter vehicle noise standards would outweigh the costs by 20 to one. The Commission will therefore soon present its proposal for a revised Vehicle Noise Directive that would introduce a better assessment method and tighten vehicle noise limits.

More information: http://ec.europa.eu/enterprise/sectors/automotive/environment/noise/index_en.htm

FIRST CityHush DISSEMINATION SEMINAR
Brussels, 23 November 2011, 2 pm – 5.15 pm

On Wednesday 23 November, CityHush is organizing its first dissemination seminar. Now that the project is halfway, partners will share intermediate results on Q-zones, noise score rating models, low-noise vehicles, low-noise road surfaces, and noise barriers. The seminar targets urban transport noise experts from the industry, research and public sector. For more information, visit **www.cityhush.eu.**

External Events

Date	Event	Place
12-13 January 2012	Transportforum	Linköping, Sweden
19-22 March 2012	38th German Conference on Acoustics (DAGA2012)	Darmstadt, Germany
10-12 June 2012	Euronoise	Prague, Czech Republic
18-20 June 2012	Joint Baltic-Nordic Acoustics Meeting	Odense, Denmark
08-12 July 2012	19th International Congress on Sound and Vibration (ICSV19)	Vilnius, Lithuania
19-22 August 2012	InterNoise 2012	New York, USA

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