CEDR

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Noise management and abatement

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1 Executive summary and recommendations

1.1 Background and method

Noise is an important factor to be considered when it comes to developing, upgrading, and maintaining national road networks in Europe. Examples of such activities are included in this report. In some EU member states, significant financial resources are used to incorporate noise abatement measures into the development or upgrading of national roads. Therefore, there is a need to optimise and improve the way such resources are used. One way to ensure this is to encourage member states to share experiences on how noise and noise mitigation measures are treated in each individual member state.

The Conference of European Directors of Roads (CEDR) included the task 'To reduce road traffic noise' (Task C 3) in its Strategic Plan 2005-2009 [1]. Each CEDR member state was invited to appoint a member to the CEDR noise group. One of the main objectives of the CEDR noise group was to facilitate knowledge sharing on noise management and abatement issues among European national road administrations (NRAs). In order to reach these objectives, a comprehensive survey questionnaire was prepared and a survey was carried out on how noise issues are treated in NRAs around Europe. Based on legislative relevance criteria and prevailing significant noise issues, the following subject areas were selected for consideration.

1. Noise regulations for new and existing roads
2. Responsibility and noise management where community developments impact noise levels
3. Integration of noise in road maintenance
4. Noise abatement measures
5. Construction noise
6. Working with the European Noise Directive (END)
7. Communication of noise-related matters to the public

This report contains the findings of the survey, based on the responses received from 20 CEDR member states during the winter of 2006–07. Due to the progression of noise developments in Europe, it was deemed by the group that the information pertaining to the END Directive was obsolete and no longer relevant to the objectives of the CEDR strategy. The primary aim of this report is to make practical knowledge sharing on noise abatement and practical management of noise-related issues possible between the NRAs. It is hoped that this report will give member states the impetus to adopt an even more advanced approach to the treatment of noise and noise abatement measures in Europe. This should allow people who live in close proximity to road networks and are impacted by noise to benefit from such improved innovations.

1.2 Conclusions

There follows a summary of the results of the work:

- Noise limits and guidelines are very different from country to country. The two noise indicators L_{Aeq} and L_{den} are very difficult to compare because of different definitions and different computer models for noise calculations. The best way to overcome this problem is to introduce a common pan-European approach to noise calculations in the form of a European noise model.
- Detailed information on outdoor and indoor noise limits along national roads is given in Annex 2 and 3.
- When traffic increases because of new developments, the national road authority (NRA) is normally responsible for respecting the noise limits when upgrading the respective roads. However, roles should be better defined.
- Although noise is considered when deciding what type of pavement to use, noise is not normally included as a parameter in the pavement management system used. Noise-reducing pavements are on the market in 80% of the member states.
- Noise barriers are the dominant type of mitigation measure adopted in CEDR member states. Noise barriers may not always be the most appropriate or cost-effective method of mitigating noise. The mitigation measures used in CEDR member states differ greatly.
- The T-shaped noise barrier with an absorption top is the most efficient of the designs considered.
- The use of route selection to mitigate noise in the early planning phase could be encouraged in more member states.
- Although almost all member states have noise limits and time restrictions on construction works, there is no common pattern.
- NRAs are now commonly addressing the public when it comes to constructing new roads, upgrading existing roads or installing noise abatement measures on existing roads. Noise levels are presented in writing, noise maps and sometimes as sound examples.

1.3 Recommendations on good governance regarding noise

Based on the information received from the NRAs and the fruitful discussions within the CEDR noise group, fourteen recommendations for good governance regarding noise management and abatement are proposed:

1. In Europe, the main noise problems occur along the existing road network. Moreover, the magnitude of the problems increases with traffic volume. Therefore, noise abatement along these roads is crucial in order to launch a process whereby noise exposure is reduced in the long term.

2. For new road developments, it is important to include noise issues at an early planning stage. Adopting such an approach may help avoid future noise problems. The basis for such an approach is normally the national noise guidelines.

3. Noise should be included as an important parameter in projects where existing roads are improved to accommodate increasing traffic volumes or increasing speeds. This can improve the noise environment for people living in close proximity to the upgraded road.

4. When planning to incorporate noise abatement measures on new, existing, and reconstructed roads, it is important to adopt a time horizon of 20 to 30 years, when predicting future noise from increasing traffic volumes and planning noise measures. This will enhance the robustness of specific noise projects.

5. When road construction work is carried out in close proximity to residential areas, the construction noise generated when planning and realizing such works should be considered. People living close to the construction site should be provided with sufficient information.

6. In projects where noise abatement measures are planned and designed, it is recommended that a good communication strategy be developed to ensure a two-way communication process with the public. In this way, residents may take ownership of the project, which might mean that their expectations regarding the noise reductions that can be achieved through noise mitigation are more realistic.

7. Noise barriers erected on roads visually impact not only on the people living in close proximity to the road but also on drivers and passengers. It is therefore important to use barrier designs that are appropriate to the specific location where they are installed.

8. The use of noise-reducing pavements should be considered when selecting noise mitigation measures because such pavements are purported to be a cost-effective noise abatement tool. When upgrading existing roads, the use of noise-reducing pavements is often a low-cost noise abatement measure.

9. The inclusion of noise as an active component in pavement management systems can optimise the use of noise-reducing pavements in the ongoing road pavement renewal process.

10. In order to enhance the current market for noise-reducing pavements, the development and use of a noise labelling system in member states should be considered. Standards for such a system should be developed.

11. In order to reduce noise emissions from individual vehicles, it would be invaluable for individual NRAs to lobby at EU level to promote tighter noise limits for the EU type approval of new vehicles and tyres. Tackling noise at its source (i.e. at the vehicles) may be more cost effective and would benefit the entire road network.

12. Like all infrastructure elements, noise abatement elements such as pavements, barriers, façades, etc. need to be maintained on a regular basis.

13. There is a need for further research and development into improved and long-time durable measures of noise abatement like optimized noise-reducing pavements, tyres, vehicles etc. There is also a need for a better knowledge of the health effects of noise.

14. A continuation of international cooperation on noise abatement and management between the NRAs is value adding and fruitful. In the coming years, issues like noise mapping and noise action plans in relation to the European Noise Directive (END) will be highly relevant.

If these fourteen recommendations on good governance regarding noise management and abatement are followed, the consequences for the European Road Directors could be a further improvement of the NRAs' contribution to an improved quality of life for those living in proximity to Europe's national road networks. The recommendations could help to secure sustainable solutions that are cost-effective over the lifetime of the road.

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3 Introduction

The Conference of European Directors of Roads (CEDR) included the task 'To reduce road traffic noise' (Task C 3) in its Strategic Plan 2005-2009 [1]. Each CEDR member state was invited to appoint a member to the CEDR noise group. One of the main objectives of the CEDR noise group was to facilitate knowledge sharing on noise management and abatement issues among European national road administrations (NRAs). In order to reach these objectives, a comprehensive survey questionnaire was prepared and a survey was carried out on how noise issues are treated in NRAs around Europe.

This report contains the results of the survey that was conducted in the winter of 2006–07. The basic idea of this report is to make practical knowledge sharing on the practical management of noise and noise abatement possible between the national road administrations. It is hoped that this report will provide guidance on how to achieve an even better approach to noise abatement in Europe for the benefit of the people living in close proximity to the national road networks in particular and to all roads in general.

Senior researcher Hans Bendtsen from the Danish Road Directorate/Danish Road Institute was appointed chairman of the CEDR noise group and Helen Hasz-Singh, also from the Danish Road Directorate/Danish Road Institute, acted as secretary for the group. The noise group commenced work at a meeting at the Danish Road Directorate in Copenhagen in April 2006.

The noise group prepared a separate survey questionnaire on research needs in relation to road traffic noise as seen from the point of view of a national road administration. The results of the research questionnaire are published in a separate report entitled *Road Traffic Noise, Research Needs*. The report can be found on the CEDR homepage [2].

As the work of the noise group progressed, the CEDR Executive Board received frequent progress reports and in general, the Executive Board supported and approved the outcome of the reports.

The CEDR noise group would like to thank all staff members from the national road administrations who carried out substantial work in answering the questionnaires. The different chapters of this report have been drafted by the members of the CEDR noise group. Hans Bendtsen, Helen Hasz-Singh and Vincent O'Malley have edited the final report. The editors would like to express their warm thanks to the active members of the CEDR noise group for their dedicated work in producing this report. Most of the photos and examples in this report were supplied by the national road administrations.

This report can be used as a handbook on noise management and abatement.

4 Definition of the issues

Road traffic is now recognized as the main contributor to human noise annoyance in Europe. However, for many years, economic growth and traffic volume have developed according to the same pattern. Approaches to mitigating such noise on existing and new roads are and will continue to be a significant challenge for most CEDR member state governments. According to the European Commission's Green Paper on noise [4], approximately 20% of the Union's population (close to 80 million people) are subjected to noise levels that scientists and health experts consider to be unacceptable. Such high noise levels lead to annoyance, sleep disturbance, and adverse health effects. An additional 170 million citizens are living in so-called 'grey areas', where noise levels are such that they cause serious annoyance during the daytime.

In addition to health and quality of life implications within the European Union, it is estimated that the annual costs generated by noise pollution are between 0.2% and 2% of gross domestic product. As such, a best-case scenario means annual financial losses of more than €12 billion. Examples of elements that contribute to the economic damage include a reduction in residential property prices, lost labour days due to illness associated with noise, and reduced options for long-term sustainable land use planning. While the problems caused by road traffic noise exposure continue to grow, it is evident that a unified and consistent approach is needed for the management and control of the problem.

Thanks to European legislation and technological progress, a reduction of noise from individual sources can be achieved quite easily. According to the Green Paper [4] on future noise policy from the Commission of the European Communities (1996), noise from individual cars and lorries has been reduced by 85% and 90% respectively since 1970. However, despite thirty years of source reduction policy by means of type approval, the emission of traffic noise has not decreased. The growth of traffic has surpassed technological improvements regarding noise emission from traffic on national roads. As a result, there has been no reduction in community exposure to road traffic noise [4].

Figure 4.1: The ring road around Copenhagen in Denmark is being widened from four to six lanes through a densely built-up residential district. In order to reduce noise, noise-reducing thin layer pavements and 4-m high noise barriers are included in this large road reconstruction project.

Since one of the most important tasks of the CEDR noise group is to facilitate knowledge sharing on noise abatement between the national European road administrations, it was decided to produce a survey questionnaire in order to collect all relevant information from CEDR member countries. The objective was to compile the retrieved information in a report that can be used as a guide by the national road administrations in Europe.

At the first meeting of the noise group in April 2006, a discussion was initiated in order to identify the themes that were considered relevant for knowledge exchange on the basis of the most topical noise abatement trends. Here, experiences regarding the implementation of the European Noise Directive (END) [3] were one of the highlighted topics. At the end of the discussion and a process of prioritisation, the following themes were selected:

(a) **Noise regulations for new and existing roads**. The basis for noise work when planning road construction within the road administration is standards, legal noise limits, and policy noise goals for road traffic noise.

(b) **Responsibility and noise management** where community development has an effect on noise levels on national roads. When a municipality develops a new area, this development can result in new extra traffic from the new area on some roads, which might result in higher noise levels for the inhabitants along these roads and maybe result in a call for road administrations to take noise abatement measures.

(c) **Integration of noise into road maintenance.** In the ongoing process of road maintenance, it may be relevant to include noise as an active parameter in order to improve noise abatement.

(d) **Noise abatement measures**. Many means of noise abatement are used throughout Europe such as noise-reducing pavements, barriers, façade insulation etc. Interesting examples have been compiled.

(e) **Construction noise**. In the process of constructing or rebuilding a road, the construction noise can cause nuisance to the neighbours of the road. An investigation of how construction noise can be handled and abated is considered relevant.

(f) **Working with the European Noise Directive (END)**. The END directive [3] is being implemented in Europe's national road administrations. An investigation of how this is done in the different countries is considered relevant. Ultimately, it was decided not to include this part in the final report because a lot of practical noise mapping and drafting of action plans has taken place in Europe since the winter of 2006–2007 when the survey questionnaire was returned.

(g) **Communication**. In many road and noise abatement projects, public hearings, meetings and other forms of public involvement are held. It is important to be able to communicate information on noise in a relevant way to the public.

At the second meeting of the CEDR noise group in Dublin in September 2006, the detailed survey questionnaire was drafted on the basis of contributions from the members of the group. It was decided to draw up a separate survey questionnaire on the need for noise research in the national road administrations and to publish the results in a separate report. This research questionnaire was developed in parallel.

Figure 4.2: The Dublin Port Tunnel project is now complete. The purpose was to lead heavy traffic to Dublin Port and away from the congested city centre main road network. The reduction of heavy goods vehicles is also expected to reduce noise along the existing road network.

The final survey questionnaire was compiled by the secretary and sent out to the deputy directors of the national road administrations that are members of CEDR in December 2006. The general survey questionnaire is included in Annex A.

By the end of March 2007, 20 countries (80% response) had answered the survey questionnaire. These countries are listed in the table below.

Countries that replied to the general survey questionnaire	
Austria	Italy
Belgium-Flanders	Latvia
Denmark	Lithuania
Estonia	Luxemburg
Finland	The Netherlands
France	Norway
Germany	Poland
Greece	Portugal
Iceland	Slovenia
Ireland	Sweden

At the third meeting in Paris in March 2007, the noise group analysed and evaluated the responses received. The group has relied on the information provided by the NRAs. On this basis, the members of the working group drafted chapters of the current report, which were subsequently discussed and amended at a meeting in Vienna in September 2007 before being finally approved at a meeting in Copenhagen in March 2008.
The objective of this report is to share information and provide guidance for the work on noise management and noise abatement. There may be some minor uncertainties or misunderstandings in the compilation of a few of the results from the individual member states, but this does not change the overall objective of the report.

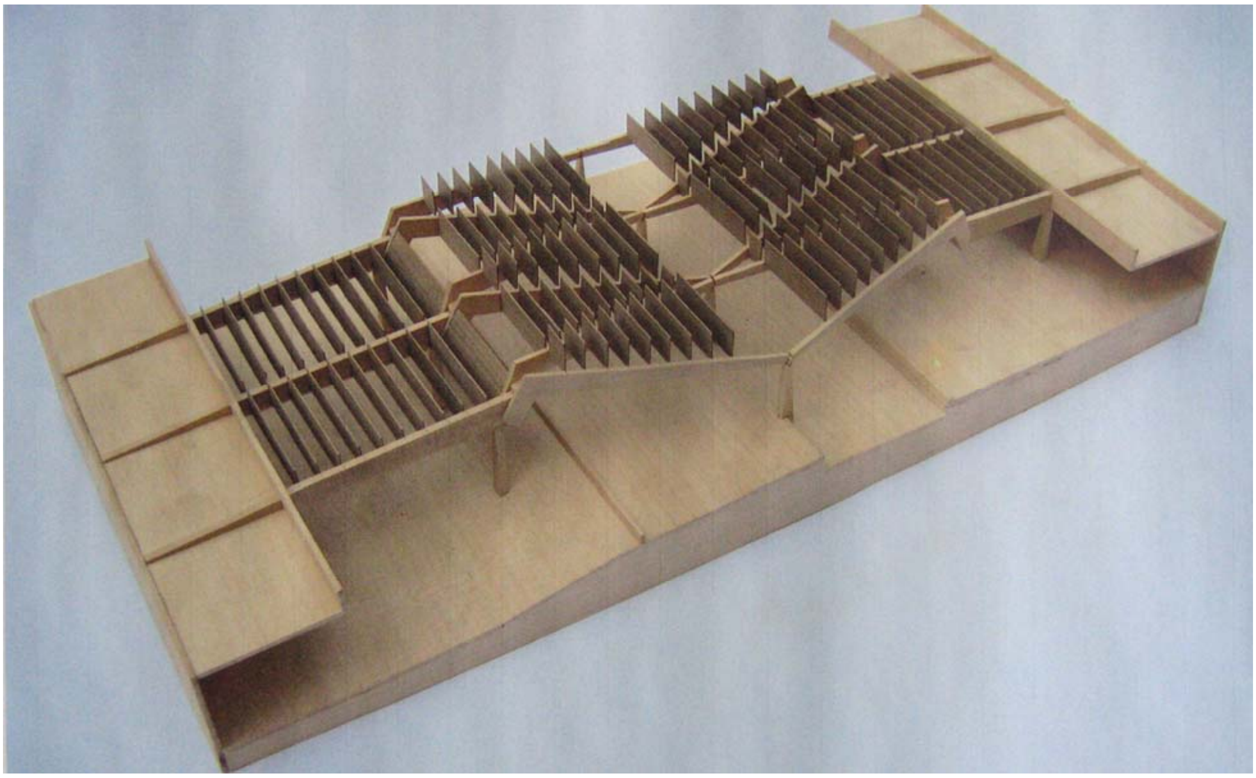


Figure 4.3: An intersection to a new highway is being constructed on one section of the A86 highway south-east of Paris N. As a result of this project, part of the A86 will be widened from six to fourteen lanes close to a residential area with buildings up to five-storeys high and around 3,000 inhabitants. In order to reduce noise levels, high noise barriers are being erected and the highway partly covered over a 340-m long section. The above photo shows a model of this measure.

All the noise levels and guidelines etc. mentioned in this report are A weighted (see noise literature) but the notation dB or dB(A) is used randomly!

Figure 4.4: The highway from Vienna to the international airport has been widened with extra lanes. On a long section, the highway passes a residential area. In order to reduce the noise a 5.5 m high noise barrier in a curved shape bending over the road has been constructed.

5 Noise limits and noise levels along national roads in Europe

5.1 Introduction

This chapter focuses on the issue of noise limits and noise levels throughout Europe. It is based on the responses provided by 21 CEDR member states. This chapter provides a summary of the answers received. More detailed information can be found in the three annexes belonging to chapter 5. The first annex outlines all information relating to the questions. The second annex provides detailed information about outdoor noise limits along national roads in Europe. Finally, the third annex provides information about indoor noise limits.

5.2 Legislation, policy, and guidelines

CEDR member states have emission limits for noise exposure in sensitive areas. The status of these limits can vary, taking the form of legislation, policies, or guidelines. From a legal perspective, there is quite a difference between these possibilities. Legislation means that there is a statutory obligation, and people can go to court in order to ask the national road administration (NRA) or the government to respect the limits. Policies and guidelines, however, are more or less an expression of the intention of the NRA or the government to remain within certain noise limits. The NRA and the government undertake to do their best to observe such noise limits; however, they cannot be compelled to fulfil a policy or guideline by the courts.

The survey undertaken by the CEDR noise group shows that in most CEDR member states, the noise limits have a legal status (Figure 5.1). In most Scandinavian countries, the status of guidelines is more or less similar to legislation.

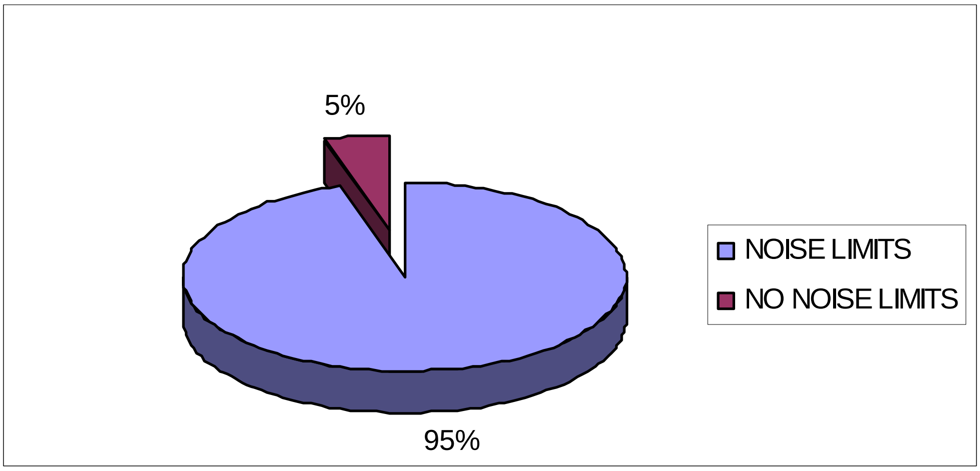


Figure 5.1: The status of noise limits for new national roads in CEDR member states

NRAs not only have to develop new national roads, they also have to modify and maintain the existing national road network. The status of noise limits, for the modification of existing national roads, is more or less the same as for new national roads. However, there may be conditions or circumstances where the NRA does not have to respect such noise limits. Half of CEDR's member states have conditions where they do not have to fulfil the noise limits along new and existing national roads. In most cases these conditions have to do with the cost-effectiveness of noise measures or, in the case of an existing national road, the increase of the noise levels due to the road project, especially in urban or alpine areas.

5.3 Noise limits

Noise indicators and day periods

Several indicators are used to define noise limits and calculate and measure noise levels. Most noise indicators use specific periods over a full day to calculate or measure noise. In the 2002 European Noise Directive (END), for instance, these periods are:

- the day period (L_{day}): from 07.00 to 19.00;
- the evening period ($L_{evening}$): from 19.00 to 23.00 (member states may, however, shorten the evening period by one or two hours and lengthen the day and/or night period accordingly);
- the night period (L_{night}): from 23.00 to 07.00.

All three periods combined, with an extra 5 dB for the evening period and an extra 10 dB for the night period, result in the equation for L_{den} in dB given by the END for the assessment and management of environmental noise.

$$L_{den} = 10 \lg \frac{1}{24}\left(12 * 10^{\frac{L_{day}}{10}} + 4 * 10^{\frac{L_{evening}+5}{10}} + 8 * 10^{\frac{L_{night}+10}{10}} \right)$$

Figure 5.2: The default END equation for L_{den}

Normally, the indicator L_{Aeq} for road noise does not take these 'dB-corrections' for the evening and night periods into account. The indicator L_{Aeq} is explained in noise literature.

The most widely used noise indicator in CEDR member states is the L_{Aeq}. However, several countries use the L_{den} noise indicator in accordance with the END (see Figure 5.3). Some member states are currently proposing to change from the L_{Aeq} to the L_{den} indicator.

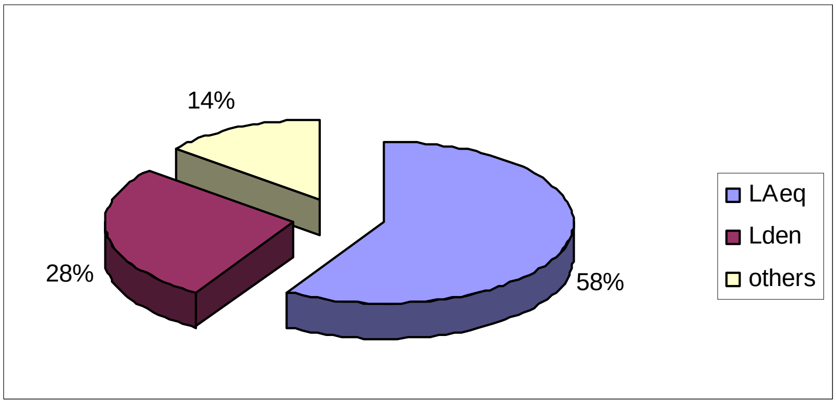


Figure 5.3: The noise indicators in CEDR member states

It is important to note that there is a considerable difference in the specifications of the periods used to calculate or measure noise using the L_{Aeq} indicator (Figure 5.4). In brief, there are four possibilities. The most simple is a L_{Aeq} based on a 24-hour average of a full day: the $L_{Aeq,24h}$. The most complicated is a L_{Aeq} based on a full day divided into three periods: day, evening, and night. To make things even more complicated, there are slight differences in the beginning and ending of the day, evening, and night periods. The third possibility only has two periods, daytime and night-time. In the last possibility, some CEDR member states use a specific period of a full day, for instance the period between 08.00 and 20.00.

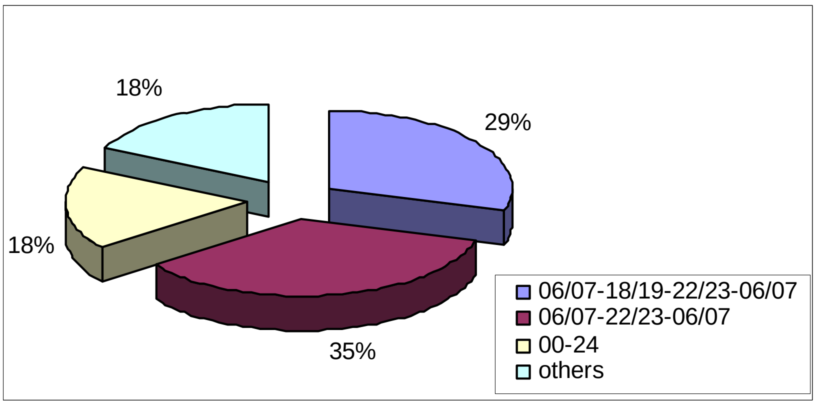


Figure 5.4: The day periods of the indicator L_{Aeq} in CEDR member states

Due to the different definitions of the L_{Aeq} indicator throughout Europe, the same amount of noise can result in different L_{Aeq} noise levels. As a result, one can never be sure that noise with a level of, for instance, 55 dB(A) L_{Aeq} in one country will give the same result in dB(A) in another country. The use of different day periods in the definition of L_{Aeq} also complicates the relation between L_{Aeq} and L_{den}. In fact, there is no European standard for the relationship between L_{Aeq} and L_{den} noise levels. In Denmark and France [5], for instance, they use the equation $L_{den} = L_{Aeq} + 3$. In the Netherlands, however, they use the equation $L_{den} = L_{Aeq} – 2$. This means that 50 dB L_{den} is 52 dB(A) L_{Aeq} in one European country, but 47 dB(A) L_{Aeq} in other countries.

When a new national road is built or an existing national road is modified, the question arises as to what planning horizon (or point of time in the future or design period) should be used to apply noise limits and to define noise mitigation measures in situations where noise limits are exceeded. For example, one can take the (traffic) situation 10 years after opening as representative. Noise measures, like barriers and noise-reducing pavements, are applied before opening in order to fulfil noise limits at a certain moment in time (in this example 10 years after opening). To make such an approach effective, traffic predictions have to be accurate. In the case of modification of an existing road, it is also possible to take the situation at the moment of opening as representative for checking noise limits and defining noise measures. Most CEDR member states take the future increase of traffic into account (Figure 5.5).

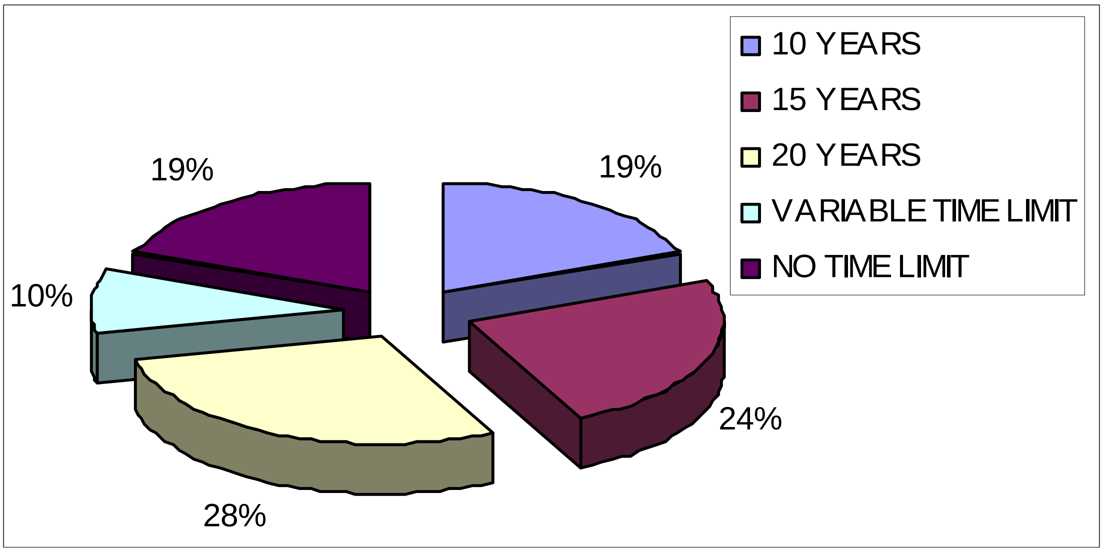


Figure 5.5: The planning horizon for noise limits used in CEDR member states

A range of different planning horizons are used across member states. These vary from 10 to 30 years after opening. The most common planning horizon is 20 years and there seems to be no difference between the planning horizon used for new national roads and the planning horizon used in the case of existing road modifications.

At the opening of a new or modified national road, noise mitigation measures have been realised to ensure the fulfilment of noise limits for a certain future design period (e.g. 20 years after opening). All these measures depend on how well future traffic volumes are predicted. If traffic volumes increase in accordance with predictions, i.e. 20 years after opening, then noise levels should be similar to the original calculated values. Alternatively, what happens if traffic volumes are greater than predicted, and noise levels 20 years after opening are higher than originally calculated? In cases where traffic volumes increase at a slower rate than predicted, the moment where noise limits are exceeded will be several years beyond the 20 year period. Whatever the situation, there will always be a moment in time where the originally calculated noise levels will be exceeded and the original noise measures will not be sufficient. Regarding the traffic flow, there may be no need to modify the existing national road or to build a new road. The only problem is the constant increase of the noise levels. In regulations, policies, or guidelines, there may be possibilities to address these noise problems due to the steady increase of traffic in situations where the NRA do not have any intention to build a new national road or to modify the existing road. If traffic volumes increase more than the predicted levels and noise limits are exceeded, then almost half of the member states put noise mitigation measures in place to address noise issues, even if there is no necessity to modify the existing national road. Several member states do not address noise issues as long as a national road is not modified, even when traffic volumes are greater than the predicted levels and noise limit values are exceeded.

Noise-sensitive buildings such as houses, schools, and hospitals often have to deal with noise from a range of different noise sources. Noise from traffic on national roads is one such source, but there may be other noise sources, such as railways, industry, and noise from traffic on secondary roads. In most CEDR member states, noise at noise-sensitive locations is determined by noise from national roads only. In some countries, the contribution of noise from other noise sources is taken into account.

The assessment location is the point where noise levels are calculated or measured. The noise level at the assessment point will be compared with the noise limit to ascertain whether or not the noise limit is exceeded. All CEDR member states have assessment locations outside noise-sensitive buildings. Outdoor assessment points are often at different heights. In several countries, there are not only outdoor assessment points, but indoor assessment points too. As for the reflection of noise from building façades, most countries do not take this factor into account; therefore, in calculating noise levels, only incident noise is relevant.

Outdoor noise limits

To establish whether or not there is a noise problem along a national road, calculated or measured noise levels have to be compared with the noise limits outlined in legislation, policies, or guidelines. For noise-sensitive buildings, mainly residential houses, these noise limits vary considerably (Figure 5.6).

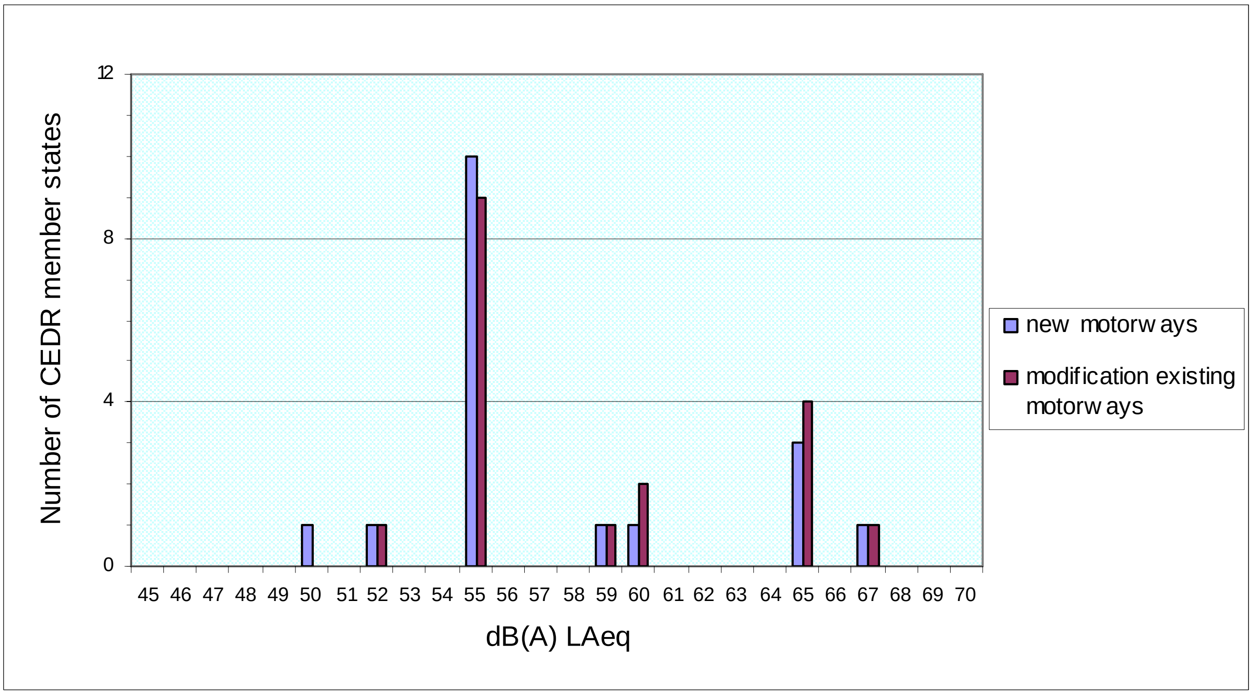


Figure 5.6: The outdoor noise limits in dB(A) L_{Aeq} in the day period for national roads in CEDR member states[1]

Almost all CEDR member states have L_{Aeq} outdoor noise limits for the day and night periods. For new national roads, the L_{Aeq} outdoor noise limit for the day period varies between 50 and 67 dB(A). The most common outdoor limit is 55 dB(A) L_{Aeq} in the period 06.00/07.00–18.00/22.00. For the modification of existing national roads, the L_{Aeq} outdoor noise limits for the day period are almost the same as for new national roads.

Not all CEDR member states have statutory L_{Aeq} outdoor noise limits for existing national roads. In cases where outdoor noise limits exist for existing national roads, these limits are often the same as for new national roads or the modification of existing national roads. In situations where they do not have legal outdoor noise limits, some countries have policy goals. Most CEDR member states also have L_{Aeq} outdoor noise limits for the night period. Often these night limits are 10 dB(A) lower than the limits for the day period. The noise limits for the night period vary between 45 and 55 dB(A) L_{Aeq}, the most common outdoor night limit being 45 dB(A) L_{Aeq} in the period 22.00–06.00. Some countries use L_{den} as the indicator for their noise limits. For new national roads, outdoor noise limits based on L_{den} range from 48 to 60 dB. The most common L_{den} outdoor limit for new national roads is 55 dB.

[1] Outdoor noise limits in dB L_{den} are converted into dB(A) L_{Aeq} according to different equations, such as $L_{den}=L_{Aeq}+3$ dB for member states using the French and Nordic model, $L_{den}=L_{Aeq}-2$ for member states using the Dutch model, and $L_{den}=L_{Aeq}+5$ for member states using the British model.

In several member states there are circumstances in which standard noise limits are exchanged for other noise limits. In town centres, for instance, noise limits can be higher than standard limits. In new housing areas, noise limits can be lower.

Indoor noise limits

Half of CEDR member states not only have outdoor noise limits, but also indoor noise limits (Figure 5.7). In most cases, they are valid for all rooms inside a house. In some countries, the application of indoor limits is restricted to bedrooms.

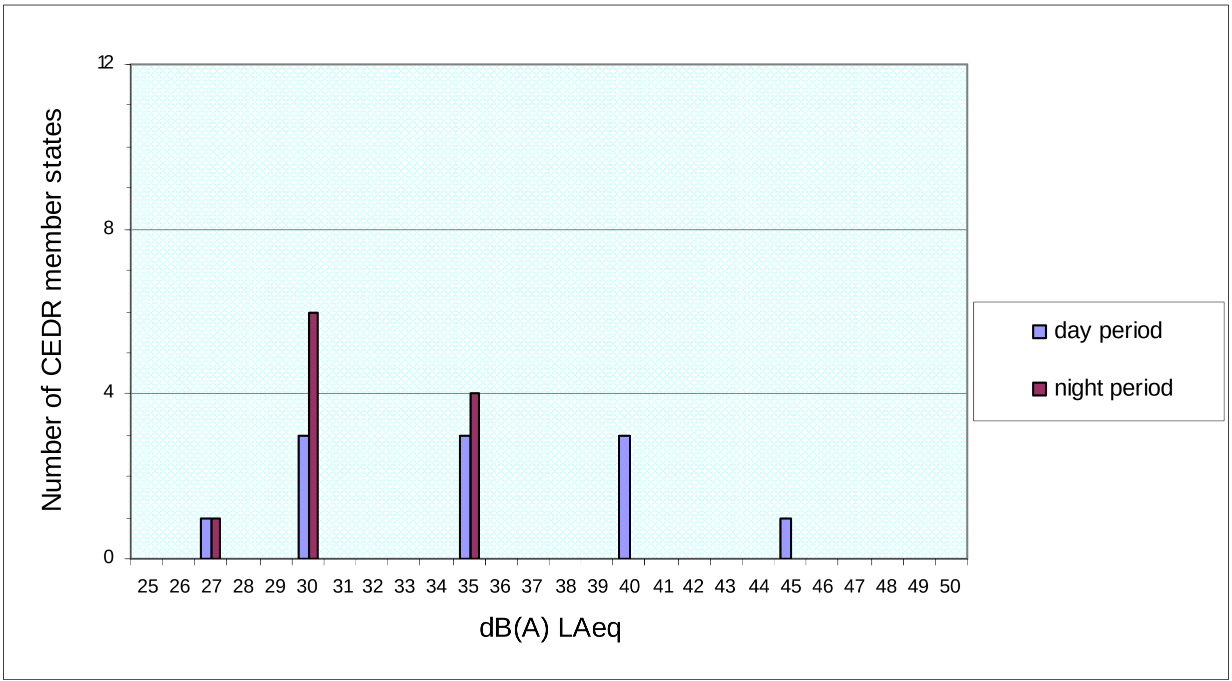


Figure 5.7: The indoor noise limits in dB(A) L_{Aeq} for new national roads in CEDR member states[2]

The L_{Aeq} indoor limits for the day period vary between 27 and 45 dB(A) for new national roads. The L_{Aeq} indoor limits for the night period are 5 to 10 dB(A) lower than for the day period. In the case of modifying existing national roads, indoor noise limits are in some situations higher than for new national roads, but in most cases they are the same. This situation also applies to existing national roads.

In several countries, there are circumstances in which standard noise limits are exchanged for higher noise limits. In cases where new houses are built along national roads, indoor noise limits can be lower than the standards.

[2] Indoor noise limits in dB(A) L_{den} are converted into dB(A) L_{Aeq} according to different equations, see footnote 1.

5.4 Noise indicators in the Environmental Impact Assessment process

During the Environmental Impact Assessment (EIA) process and the preparation of the Environmental Impact Statement (EIS), noise levels at residential houses are often a major issue. Noise annoyance is one of the issues that has to be investigated when preparing an EIS. Annoyance has been defined by the World Health Organisation [11] as 'a feeling of displeasure evoked by a noise' and by the Health Council of the Netherlands [9] as 'any feeling of resentment, displeasure, discomfort and irritation occurring when a noise intrudes into someone's thoughts and moods or interferes with activity'. The way the NRAs handle noise annoyance in EIS reports differs considerably. There is no generally accepted way to address noise annoyance, although some CEDR member states use the research of Miedema [6] (TNO, the Netherlands) for the dose-effects relations between noise levels and noise annoyance (Figure 5.8).

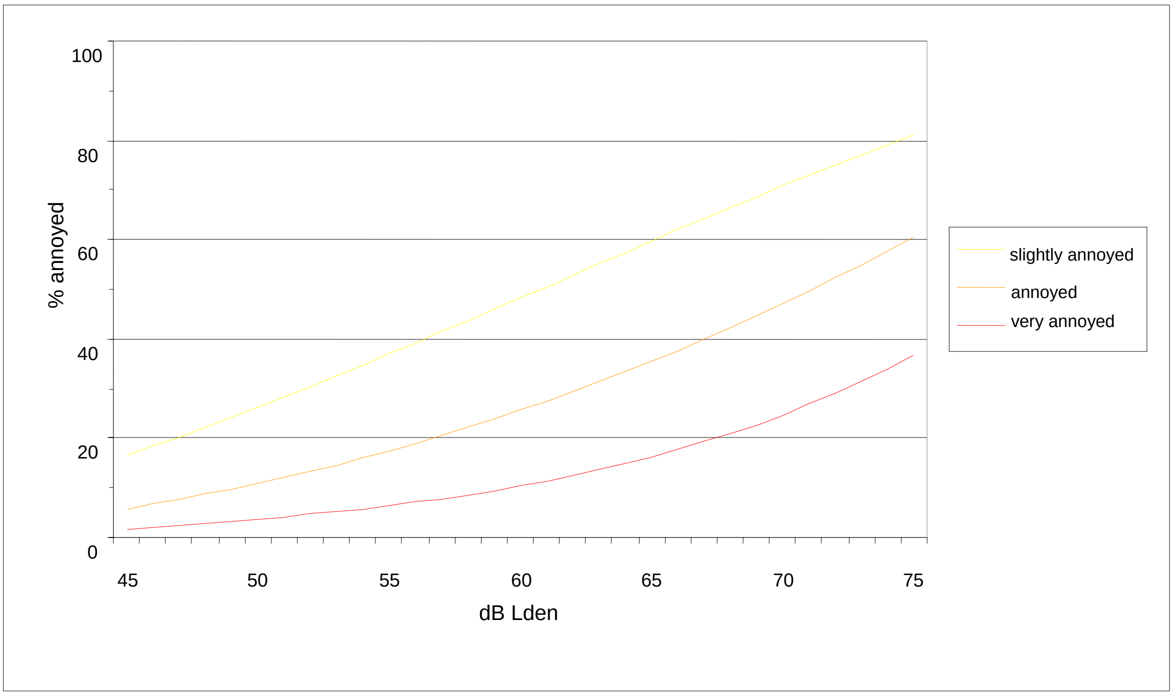


Figure 5.8: The relation between annoyance and noise levels due to road traffic [6]

Noise is also considered to be a serious health hazard. The WHO recognizes community noise, including traffic noise, as a serious public health problem. Health effects are one of the issues that could be investigated in EIS reports by the NRAs. In several CEDR member states, health effects are an issue in EIA reports, but there is a need for more knowledge of the dose-effect relations. There is no generally accepted methodology regarding the dose-effect relations between road traffic noise levels and health effects, even though different suggestions have been made. This also applies to the monetary evaluation of noise annoyance.

5.5 Noise models

To calculate noise levels, various prediction methodologies have been developed. Different computer models are in use in CEDR member states (Figure 5.9).

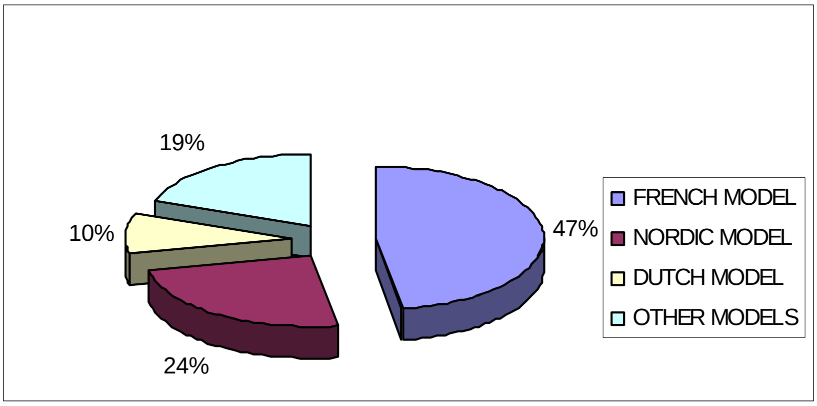


Figure 5.9: The noise calculation models in use in CEDR member states

The French model (NMPB-Routes-96/XPS 31-133) is used in 10 CEDR member states; five member states use the Nordic model (Nord2000); two use the Dutch model (SRMII).

5.6 Comparing noise levels and noise limits at European level

According to [8] and [10], the national calculation models used in European countries can differ by up to 10 dB(A) in calculating the same situation. This is caused by unintentional differences between the various calculation models. All these models have a noise emission and a noise transmission component. The main difference seems to occur in the noise emission component, for instance, the definition of the different traffic categories, the relationship between speed and noise emission, and in the correction due to different pavements. The differences in the noise transmission component—such as meteorological conditions, noise reduction by barriers, and façade reflections—are smaller. As long as different noise models with different indicators continue to be used in Europe, comparing noise values at European level will remain complicated, to say the least. Since a noise limit is a noise level with a legal status, the same goes for comparing noise limits. As a consequence, the European comparison of figures based on different national noise models, for instance within the framework of the European Noise Directive (END), can be problematic. The best way to overcome this problem is to introduce a common pan-European approach to noise calculations in the form of a European noise model.

Until a common European noise model is adopted for END noise mapping, the European member states may use the national methods laid down in their legislation. However, the member states must demonstrate that those methods give equivalent results to the results obtained using the recommended interim method (for road traffic noise: the French method NMPB-Routes-96/XPS 31-133). The results of the comparison of the French and Dutch models are given in [7].

Based on the outcome of the HARMONOISE and IMAGINE projects [12], a common European noise calculation method shall be established by the European Commission. The HARMONOISE project has produced methods for the prediction of noise levels caused by road and railway traffic. These methods are intended to become the harmonized methods for noise mapping in Europe. Although the HARMONOISE project is finished, according to [13] an additional effort is still needed to turn the existing model into an accepted, trusted, and freely accessible common European calculation method. The HARMONOISE project is closely linked to the IMAGINE project. The IMAGINE project focuses on the implementation of the harmonised noise calculation methods in Europe.

At first sight, the noise calculation method from the HARMONOISE/IMAGINE projects is a solution for a European issue: END noise mapping and action plans. This does not mean it will have to be used throughout Europe for all kinds of noise level calculations. At the moment, in the case of national road projects and noise measures, national road authorities use the noise model stipulated by their own national legislation. In the long run, however, things might change as a result of the advantages of having a more accurate European noise calculation method. That being said, it may take several years to implement HARMONOISE/IMAGINE in the noise legislation of individual European member states in a way that the use of this method would not only be prescribed for END purposes.

5.7 Conclusions

Most CEDR member states have legislation on noise, while others have noise policies or noise guidelines. Although, the legal status of these documents may differ, they all use noise limits to control noise along European national roads. Two noise indicators, L_{Aeq} and L_{den}, are used to calculate and measure noise levels and to define noise limits. Due to different definitions of the indicator $L_{Aeq,}$ the same amount of noise can result in different L_{Aeq} noise levels around Europe. Moreover, noise levels and noise limits expressed in L_{Aeq} differ from noise levels and noise limits expressed in L_{den}. In some European countries, a L_{den} noise level is 3 or 5 dB(A) higher than the L_{Aeq} noise level; in others, it is 2 dB(A) lower.

Almost all CEDR member states have L_{Aeq} outdoor noise limits. For new and existing national roads, these limits vary between 50 and 67 dB(A) L_{Aeq}. The most common outdoor limit is 55 dB(A) L_{Aeq}. Some member states use, or are going to use, L_{den} as a noise indicator. For some member states, the most common noise limit is 55 dB L_{den}. Half of CEDR member states also have indoor noise limits. The L_{Aeq} indoor limits for the day period vary between 35 and 45 dB(A); for the night period they are 5 to 10 dB(A) lower.

At least seven different national computer models are used across CEDR member states to calculate noise levels. The French and Nordic models are the most popular models. However, using different noise models affects a comparison of noise levels throughout Europe. First, one must always keep in mind the different definitions of the L_{Aeq} indicator and the difference between the noise indicators L_{Aeq} and L_{den}. Another important factor is that the difference in noise levels calculated by the different European noise models can be as great as up to 10 dB(A). Because these noise levels are formalized, these differences also apply to noise limits. In practice, this means that comparing noise levels and noise limits at European level is, to say the least, complicated. The best way to solve this problem is to have and use the same European noise calculation method for road traffic, like the method from the HARMONOISE/IMAGINE projects.

6 Urban development and noise impact

6.1 Introduction

In many urban areas there is an ever increasing demand for new housing and businesses in central locations. These areas are in demand because they already have existing infrastructure that can be used by new inhabitants and employees. From that perspective, there is great potential for new construction. However, in the past, areas such as these would not be considered suitable construction sites because they were often exposed to high noise levels from road traffic. Today, municipalities have to strike a balance between the demand for new housing and living space and the requirements of dwellings with good noise standards. Exposure to high noise levels poses an increasing threat to human health.

Figure 6.1: Area exposed to noise, with potential for development (Thorsten Alm, Sweden)

The building of structures such as new shopping centres, airports, tourist and industrial centres, and associated activities generates more traffic on existing national roads and consequently higher noise levels.

What protection is in place for those exposed to noise along existing national roads when others engage in development and enterprises that affect noise levels? This chapter summarises the responses received from seven of the CEDR member states that responded to the survey questionnaire on this issue.

The questions were related to the two different situations outlined below:

Situation A – New housing in areas already exposed to high noise levels from traffic on (national) roads.

Situation B – Industrial or commercial development that generates more traffic and thus higher noise levels for people who live near the road.

The questions concerned:

- the process involved in planning/decision-making in relation to development projects affecting noise,
- the targets, indicators, figures, and limit values used to define need for noise mitigation measures,
- the responsibility for protecting those exposed to/disturbed by noise along national roads,
- which of the above-mentioned measures/processes work well/less well and which proposals/actions for improvement could be made?

6.2 Situation A – New housing

In situation A, municipalities/local planning authorities run the planning process, and if noise levels are going to exceed limits, the municipalities ensure that the noise levels comply with the relevant legal limit values or guidelines. The local planning authorities/municipalities are, in most cases, responsible for calculating noise levels and are also the decision makers. In some CEDR member states, the process is undertaken in cooperation with the national road administration if it is necessary to install noise mitigation measures. There are also examples from some countries that an agency other than the NRA or the administrative board can object to the plans if they give rise to negative health effects or if there are significant impacts on the environment.

For instance:
The municipality must make sure that outdoor noise levels are below the noise limit (guideline value) for new housing and that sufficient preventive measures are taken (Denmark).

The government's local representative classifies all roads whose AADT > 5,000 in 5 categories according to their noise emission. Sectors are defined along these roads, the width of which depends on the noise category (up to 300 m). Any new dwelling built in such a sector must respect the noise limits. (France).

6.3 Situation A – Indicators and noise limit values

The noise indicators and limit values used during the planning process vary among member states. Some CEDR member states have only outdoor levels, while others have both indoor and outdoor indicators. Some member states even vary their outdoor limits to accommodate different dwelling façades. Also, some member states have noise limit values that are dictated by the location of dwellings while others have special indoor and outdoor limits for the night period.

In Iceland, for instance, the following applies: *'Outside flats, the limit is L_{Aeq} 70/55 dB. That means L_{Aeq} 55 dB has to be fulfilled outside half of the 'dwelling rooms' and L_{Aeq} 70 dB for the rest.'*

For new dwelling houses in the Netherlands, the municipality has to comply with the following limits:

- *preferred noise limit: 48 dB L_{den}*
- *highest allowable noise limit: 58 dB L_{den}*
- *indoor limit: 33 dB L_{den}*

For further information about limit values and how difficult it is to compare various limit values, see Chapter 5.

Figure 6.2: People, traffic, and houses in an urban environment (photo: Marie Swartz, Sweden)

6.4 Situation A – Noise abatement and measures

In general, the contractor pays for preventative measures in order to get approval for its building plans. Some CEDR member states have guidelines, regulations, or standards that must be met in order to meet indoor noise level requirements:

- In the Netherlands, the sound isolation of walls has to be at least 20 dB.
- In Norway, guidelines require that bedrooms should be located on the quiet side of the building in order to reduce indoor noise. Moreover, there are detailed specifications on the design of walls, windows etc.
- In Iceland '*the positioning of the houses is the first measure. The second measures include the location of open windows and finally mostly soil barriers and walls made of concrete, iron, fibre glass or wood*' are used to ensure that indoor noise levels are not exceeded.
- In France, a technical handbook including measures to reduce noise was published by Cetur in 1981.
- In the Netherlands, an order of preference is given:
    1. Measures at the source, e.g. pavements
    2. Measures in the propagation area e.g. barriers
    3. Acoustic insulation at houses.

6.5 Comments about Situation A

The survey questionnaire revealed that CEDR member states have different approaches to situation A, where the construction of new housing is planned in areas already exposed to high noise levels from traffic on (national) roads. In some countries, it is the construction contractor who must ensure that the limit values are complied with; they normally have to pay for the installation of such noise-reducing measures. This is not always the case because it can depend on the status of the noise limits, i.e. if they are stipulated in legislation or guidelines. If noise limits have a statutory standing, the responsibility for meeting the noise limit requirements is clearly defined.

Some of the issues in situation A should be managed in a new way. One example relates to the discussion about the cost of noise measures, especially the maintenance and future replacement of noise barriers. There is a need to clarify and separate responsibilities. Municipalities allow new houses close to main roads, owners do not maintain barriers, but the NRA is responsible. CEDR member states have come up with a number of different solutions. In Denmark, evaluation methods are developed to ensure that noise limits (guideline values) are complied with. In France, the purchaser of lands is always informed that the site is located in a 'noise sector' and that future housing will therefore have to comply with noise requirements.

Noise barriers are usually used to respect noise limits. There are also examples where other buildings are used as noise barriers. In the Netherlands, for instance, commercial buildings along national roads are designed as noise barriers.

Another measure that is becoming more widespread is the creation of 'quiet sides'. This means that a higher noise level is accepted on one side of a dwelling, provided it is substantially quieter on the other side. In this regard, there is a difference in what the various countries consider to be suitable levels.

A low-noise road surface is another type of measure being adopted. Some cases in the survey questionnaire showed that local authorities had assumed the additional cost of a low-noise road surface, obtaining permits to build housing in places previous exposed to high noise levels. That is something that most CEDR member states would otherwise consider to be the responsibility of the road owner.

6.6 Situation B – Development that generates more traffic

There are usually no regulations or guidelines for reducing noise emissions in cases where new activities result in an increase in traffic and noise (situation B). Road authorities are responsible for the noise and have to pay for measures when upgrading the national road due to increased traffic. In one CEDR member state (Ireland), attempts are made to handle the situation somewhat differently. The NRA normally objects to planning applications for development in close proximity to existing national roads and encourages local authorities to ensure that noise commitments are included as conditions if planning approval is granted.

Guidelines are not available on how these situations should be managed and which body is responsible for ensuring that noise limits are complied with. Guidelines/regulations are definitely needed, especially as regards the entity that is responsible for paying for the measures.

Measures that are used when upgrading the road include barriers or insulation measures, new windows in houses, or quieter road surfaces.

Figure 6.3: Heavy traffic in a residential area (photo: Bjarne Holmgren, Sweden)

6.7 Conclusion

- The municipality/construction contractor is responsible for staying within the noise limit when building new houses.
- Guidelines/regulations are not available for those cases where traffic increases because of new activities.
- In cases where traffic increases as a result of new activities, the road authorities are often responsible for staying within the noise limits when upgrading the road.
- Measures that are used to respect noise limits include noise barriers, insulation measures, and low-noise road surfaces.

7 Integration of noise into road maintenance

7.1 Introduction

Road maintenance is an ongoing task for all European countries. This work includes either the repair of parts of the pavement of a road section or the total renewal of the wearing course by applying a new top-layer pavement. The type of pavement used has an impact on the tyre/road noise level on a given road. Therefore, in principle, noise abatement can be integrated into road maintenance procedures. The objective of this section of the CEDR survey questionnaire regarding the integration of noise into road maintenance was to investigate:

- whether the noise parameter is used as a criterion for selecting which roads need repair, and
- whether noise-reducing pavement types are applied as a part of road maintenance.

A total of eight questions covering this subject area were answered by 20 European national road administrations. The main results are presented in this chapter.

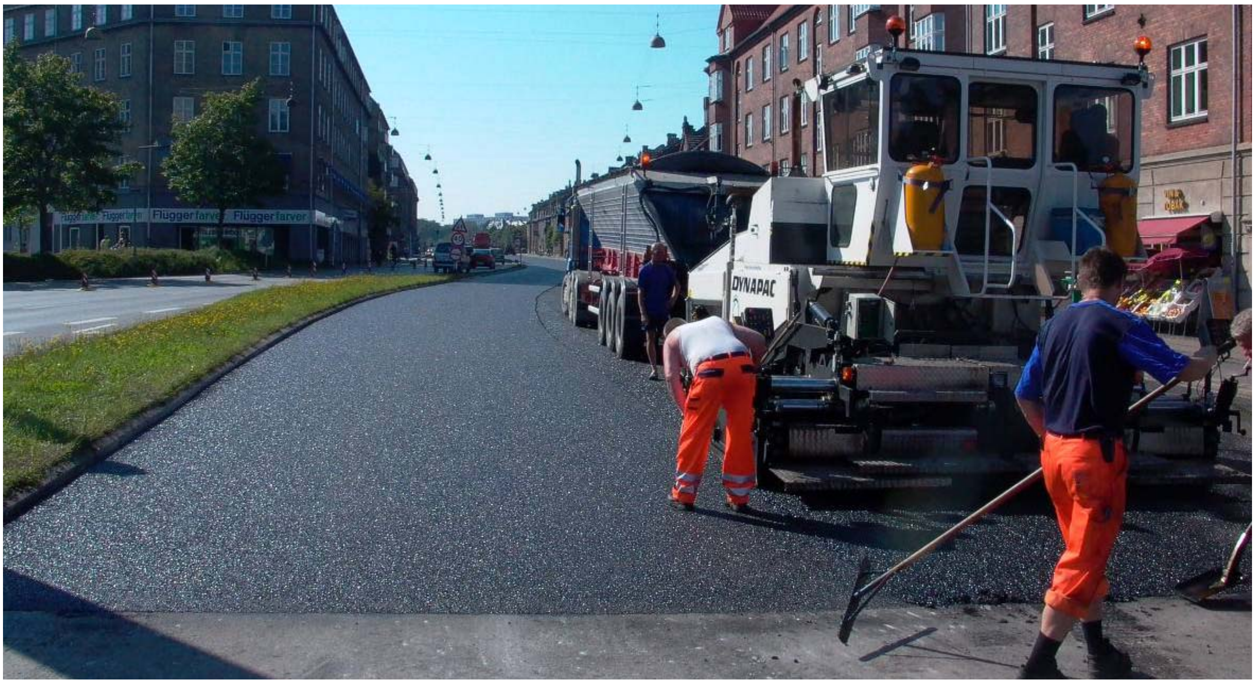


Figure 7.1: The type of pavement used has an influence on the tyre/road noise level on a given road. Here, a noise-reducing two layer porous pavement is applied on top of an existing main road in Copenhagen, Denmark, as a part of the ongoing road maintenance process.

7.2 Road maintenance

The first question in the survey questionnaire sought to establish whether noise was one of the criteria used for selecting roads that require maintenance or a new pavement. The responses received from CEDR member states clearly indicate that this is generally not the case; 95% of member states answered 'no'. Even though this is the general situation, some member states pointed out that although noise is taken into consideration, it is not a main criterion and there are no general rules for the use of noise-reducing pavements. It would appear that low-noise pavements are only applied on a case-by-case basis and their use is still rather rare. One member state pointed out that pavement maintenance is one of the solutions selected when people complain about noise disturbances.

Following on from the initial question, the focus of the second question was to establish whether noise was a parameter considered when selecting a pavement type for a road that needed resurfacing. In response to this question, 65% of member states answered 'yes'. In some responses it was noted that financial criteria can prevent noise-reducing pavements from being used and that low-noise pavements are avoided in situations where they are expected to perform poorly. The responses received appear to suggest that one member state is currently developing guidelines for the use of noise-reducing pavements.

7.3 Pavement management systems

One formal way of handling noise is to use noise as an active parameter in pavement management systems. With regard to the question as to whether noise was included as a parameter in member states' pavement management systems, 90% of member states responded that noise was not included in their respective pavement management systems. One response stated that 'the national pavement management system is entirely based on other technical indicators like ravelling, cracks, friction, and evenness'. Of the 10% that answered 'yes' to the question, it was noted that although noise was included in the pavement management system, it was an option that was never used.

In a comprehensive planning approach, different parameters such as noise, price, traffic safety, durability, drivers' comfort etc. are often evaluated/balanced against each other. In five of the countries, the noise parameter was evaluated/balanced against other parameters. In one country, development was underway to produce a system capable of balancing price, rolling resistance/CO_2 emissions, noise, safety, durability, and driver comfort against one another with help of socio-economic costs evaluations. In another country, the use of porous asphalt is the national standard pavement on national highways, for a number of reasons including noise reduction. Other advantages of porous asphalt include less splash and spray, resulting in higher road capacity during rainfall. These advantages outweigh disadvantages such as its higher price and shorter life-cycle.

7.4 Guidelines for the use of noise-reducing pavements

The use of noise-reducing pavements can be promoted by introducing guidelines, legislation, or recommendations on how and when to use such pavement types in the construction of new roads or the maintenance of existing roads. In 20% of CEDR member states, noise-reducing pavements were included in guidelines, strategies, or a document with similar status. In some member states, work was ongoing on the development of such guidance. One member state had an information leaflet that provides qualitative recommendations on the use of noise-reducing pavements, while another member state had recommended guidelines in their design manual for roads and bridges. It is the policy of one NRA to use porous asphalt as the standard pavement, especially on national roads with a maximum speed of 120 km/h. In this country, two-layer porous asphalt is reserved for use in places where there no other solutions can be used to address severe noise problems.

Figure 7.2: In the Netherlands, the use of porous asphalt on highways is a national policy guideline. In 2008, around 80% of the network featured porous asphalt

7.5 Procedures for the acoustic labelling of road surfaces

In order to launch noise-reducing pavements on the market and to be in a position to include noise as a parameter when tendering pavement work, it would be an advantage to have a system of acoustic labelling for pavement products. In 20% of CEDR member states, some kind of procedure exists for the acoustic labelling of road surfaces. In some member states, work is underway to develop relevant procedures. In one member state, an experimental procedure is being tested which combines the ISO measurement methods Statistical Pass Bypass (SPB) and the Close Proximity (CPX) on at least two roads with the same pavement product.

In Denmark, a first iteration of a procedure has been developed using a consensus process by the NRA in cooperation with the regions and the pavement industry [14]. According to this procedure, a CPX noise measurement must be conducted on a pavement product constructed by a contracting company on a test road. If the measured noise level is under certain defined standards, the pavement can be classified by the contracting company as either:

A. Highly noise reducing
B. Very noise reducing
C. Noise reducing

This means that in a tendering process, the road owners can ask for a pavement that meets the requirements of one of these noise classes. This ensures that a noise-reducing pavement will be applied during construction.

In the EU project, SILVIA, methods for acoustic labelling as well as methods for testing the conformity of production in relation to noise have been suggested. This is described in the SILVIA *Guidance Manual for the Implementation of Low-Noise Road Surfaces* [17].

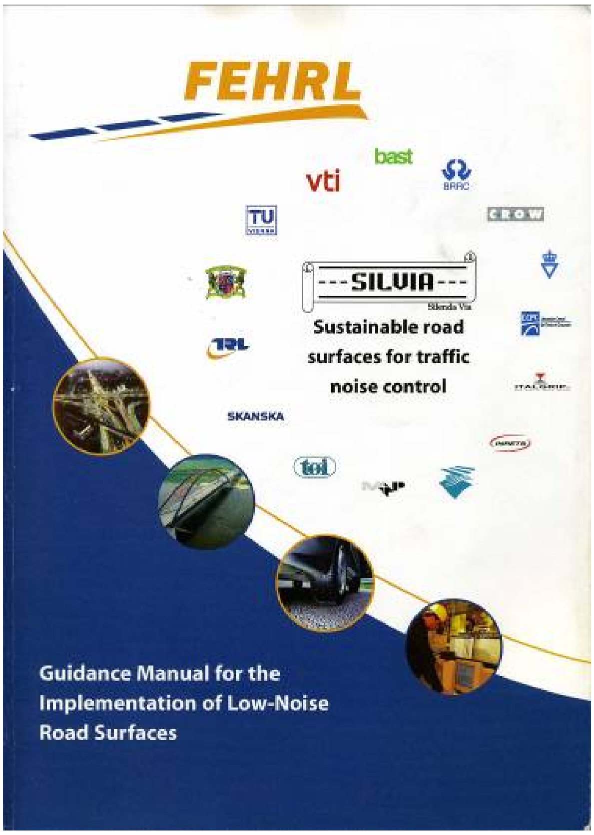


Figure 7.3: CPX noise measurement trailers can be used to monitor noise on newly laid pavements. To the left, a 'deciBellA' open CPX trailer from the Danish Road Directorate/Danish Road Institute and to the right, a closed CPX trailer from the Technical University of Gdansk in Poland.

In order to ascertain whether a newly laid road pavement meets some defined noise criteria, a system of controlling the acoustic conformity of production should be applied. In response to the survey questionnaire, 16% of CEDR member states stated that they apply some form of procedures to check the acoustic conformity of production of a road surface after the pavement has been laid. One example is work on the implementation of the SILVIA methodology [7.4] with a combination of SPB (Statistical Pass By) and CPX (Close-Proximity) measurement methods.

7.6 Availability of noise-reducing pavements

Even though only a few member states have formal requirements for the use of noise-reducing pavements, these pavements are available on the market in 80% of the member states. The different types of noise-reducing pavement available in member states are listed in Figure 7.4. This figure shows that porous-type pavements together with thin pavements and split mastics asphalt (SMA) are the dominant types of pavements available. The definition of a noise-reducing pavement can vary from country to country. This may be the reason for the broad range of pavement types in Figure 7.4. This part of the survey questionnaire did not cover the noise-reducing effect in decibels or the price and durability of these pavements. For additional information, see Chapter 8.

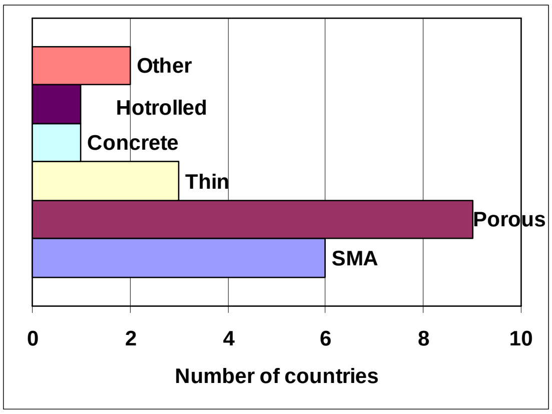
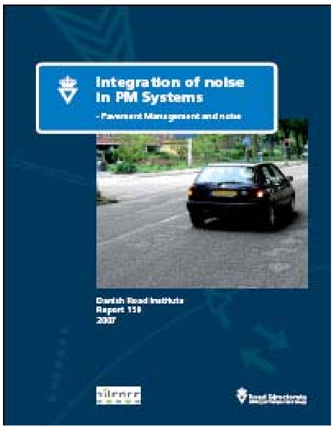


Figure 7.4: The different types of noise-reducing pavements available on the market in the different member states

7.7 Noise pavement management systems

As a part of the EU project, SILENCE [15], the Danish Road Directorate/Danish Road Institute, the French LCPC, and the Austrian (Arsenal) Road Institute analysed how noise can be integrated into pavement management systems as an active parameter [16]. The suggestion is to start in a pragmatic way by developing two types of approaches:



- a simple system
- an advanced system

The simple system is based on annual visual inspections and systematic registrations of the actual condition of the pavement on the road network. Digital photos and video systems for the registration of pavement conditions are currently being developed. Different types of damage such as potholes, ravelling, cracking etc., can lead to increased noise emissions, sometimes up to 3 dB. The suggestion is to operate with 3 classes of pavement conditions:

- Good: + 0 dB
- Acceptable: +1 dB
- Unacceptable: +2 to 3 dB

These classes should be used as the estimate for increased noise emission as pavements get older. It is also necessary to establish relations between the standard noise emissions from the different pavement types used. The suggestion is to subdivide pavements into 5 noise classes:

- Very noisy (reference pavement +3 dB or more)
- Noisy (reference pavement +1 to 2 dB)
- Normal (reference pavement)
- Less noisy (reference pavement –1 to 2 dB)
- Noise-reducing (reference pavement –3 dB or more)

On the basis of the pavement noise class and the condition of a pavement, the relative noise emission for all road sections of a road network can be predicted very easily. This information on noise can be registered in a pavement management system. With such noise information, different maintenance strategies can be developed as a supplement to the local strategies used already. For example,

- over a certain period of time (e.g. ten years), very noisy pavement classes should not be used on the road network;
- over a time period of approximately six years, only noise-reducing pavements should be used on roads in areas with multi-story residential buildings;
- over a certain period of time (e.g. ten years), only less noisy pavement types should be used on roads in areas with detached residential properties.

In residential areas where noise levels have been shown to increase, the road surface should be visually inspected in order to establish the reason for the increase. Any deficiencies identified in the pavement should be repaired or other relevant action taken within two years.

It is anticipated that in an 'advanced system', noise emissions should be measured directly on the whole road network using the CPX trailer noise measurement system (see Figure 7.3). With such measurements, the noise emissions from each road section in a network are registered and can be included in the pavement management system, just like friction measurements, etc. If the measurements are repeated each year or every second year, the noise information in the pavement management system will always be up to date.

7.8 Conclusion

Noise is not generally one of the criteria used to determine which roads need maintenance and which roads need new pavements. Nevertheless, in 65% of CEDR member states, noise is a parameter that is used when it comes to deciding which type of pavement to use when a road needs to be repaired and a new pavement laid. Despite this, noise is included as a parameter in the pavement management systems of a limited number of member states. In the EU project SILENCE, ideas for integrating noise into pavement management systems have been developed.

In 20% of member states, the use of noise-reducing pavements is included in guidelines or similar documentation. In 20% of member states, some kind of procedures for the acoustic labelling of road surfaces are used. Acoustic labelling of road surfaces should be established as standard, and CEDR's TG Standardisation should take the initiative. In 16% of member states, procedures are applied in some cases to check the acoustic conformity of production of a road surface after the pavement has been laid. Even though only a few countries have formal requirements for the use of noise-reducing pavements, these types of pavements are available on the market in 80% of member states. Porous types together with thin pavements and Split Mastic Asphalt (SMA) are the dominant types of paving materials.

8 Noise abatement measures

8.1 Introduction

There is an urgent requirement to reduce traffic noise. In addition to noise-reducing pavements, there are currently a wide range of practical road traffic noise mitigation measures available, including the restriction of land use, source orientation (altering the orientation of the road to minimize traffic noise), traffic management, façade insulation, and infrastructural measures such as the erection of noise barriers. The following chapter focuses primarily on noise barriers, particularly the makeup, construction, and maintenance of proprietary noise barriers on existing and new roads. Noise barriers are by far the most widely used road traffic noise mitigation tool.

As part of the CEDR pan-European noise survey, an assessment of noise mitigation measures was undertaken in order to ascertain the most prominent types of mitigation measures used to reduce noise levels on existing and new national road schemes. Where noise barriers are in use, the composition of other measures was also assessed, including the approaches to the construction and maintenances of such measures.

8.2 Noise barriers

A noise barrier consisting of a relatively simple earth berm (Figure 8.1) or a proprietary noise barrier (Figure 8.2) is commonly used in road construction to reduce exposure to road traffic noise at sensitive noise locations. Noise barriers reduce noise by interfering with the propagation of sound waves from source to receiver. With proper acoustic design, site location and appropriate selection of materials, the noise reaching a sensitive receptor would be primarily reduced through diffraction of noise over the top of the barrier and around its edges.

Figure 8.1: A vegetative earth berm acting as a noise barrier in Denmark

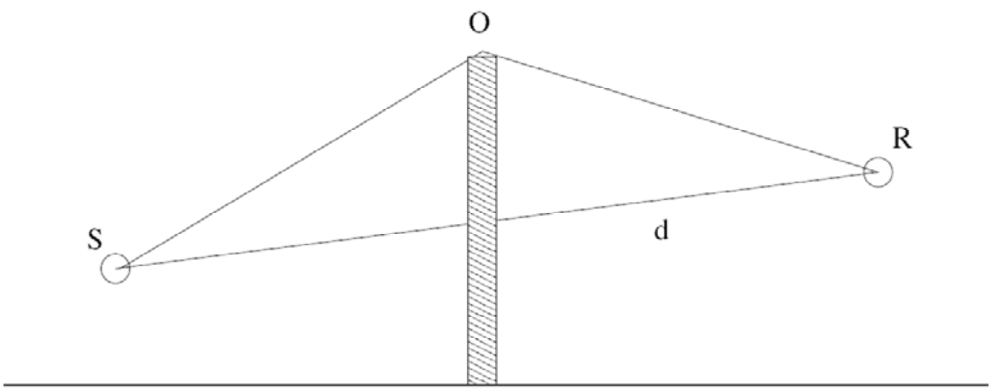
Figure 8.2: An example of a concrete noise barrier. The aesthetic of such barriers can be improved by promoting the growth of vegetation over the top of the barrier, however, this may have implications for the ability of the barrier to mitigate noise.

An acoustical 'shadow zone' is created behind the barrier where noise levels are substantially lowered. To function well, the barrier must obscure the line-of-sight between the noise source and the receiver. Effective noise barriers normally have the potential to reduce noise levels by as much as 12dB(A). Proprietary noise barriers normally used across CEDR member states range from simple reflective structures such as wood or concrete to a sophisticated arrangement of barriers, e.g. Figure 8.3, which may include enclosed absorbent and reflective barriers made up of a variety of materials, e.g. woodcrete, aluminium etc.

Generally, noise will reach a receiver by diffraction over the top of the barrier, diffraction around the side of the barrier or by direct transmission through the barrier. The transmitted noise level depends on barrier material properties while the diffracted noise depends on the location, shape, and dimensions of the barrier. For a barrier to be fully effective, the amount of sound energy passing through it must be significantly less than that diffracting over, or around, it. In this case, the overall sound at the receiver will be primarily influenced by the sound diffracting over the barrier.

Figure 8.3: Sophisticated arrangement of noise barriers in an urban setting in Italy

The degree of screening is generally calculated from the path difference, δ, of the diffracted ray path and the direct ray path. Figure 8.4 shows how to calculate the path difference for the case of a simple barrier. Noise prediction methods can be used to predict the noise-reducing effect of noise barriers depending on barrier height, distance to the road and receiver, etc.



$$\delta = SO + OR - d$$

Figure 8.4: Propagation path of noise diffracting over a barrier

Noise barriers should also be considered as architectural features. Depending on the choice of materials and the location of a barrier, it has the potential to have a severe impact on the surrounding area and, as such, the visual quality of noise barriers is a critical factor. It is thus quite important to consider how the barrier will affect both the communities' and the road users' view. Some barriers may be designed with particular regard to the surrounding environment, e.g. Figure 8.5, while some may perform multiple functions, as shown in Figure 8.6.

Figure 8.5: Above is an example of a barrier in Vienna, Austria, carrying a mural of the scenery it obstructs

Figure 8.6: In this example, the noise barrier is constructed using solar panels, therefore, playing a dual role in mitigating noise and generating electricity for road use or the grid

However, it should be noted that the introduction of a noise barrier to a specific area may not result in cost-effective noise mitigation. Alternatively, addressing the noise at *source* may be many times more cost effective, and may benefit the entire road network, not just one localised area. Sometimes there is a need to combine different noise abatement measures like f.x. barriers and noise-reducing pavements.

8.3 Traffic management

Altering the traffic flow in a town or city may also reduce the level of noise in an area. Imposing a ban on heavy vehicles in an area (e.g. Dublin City Council imposed a ban on 5-axle vehicles in Dublin City in February 2006) may reduce noise levels. This view is generally widely accepted by the community [19], although this may be due to a combination of a slight reduction in noise levels combined with the perceived recognition of an absence of heavy vehicles in the area, other measures (such as imposing a slower speed limit in an area), roundabouts, or reducing the road width may all serve to reduce the overall level of road traffic noise.

8.4 Low-noise surfaces

Road traffic noise arises chiefly from the interaction between the tyre and road surface. This means that altering the type of road surface can also reduce the noise levels. Information on noise-reducing pavements can be found in Chapter 7.

Figure 8.7: An example of a new low-noise surface in Copenhagen: the low-noise surface on the left is 6 dB(A) lower than the dense asphalt on the right [20]

8.5 Façade insulation

In the case of façade insulation, it is generally the number, size, location, and selected materials of the windows, doors, and walls of a building that dictate the amount of external noise entering the building. Generally, insulation placed between the vertical members of an external wall will play a significant role in reducing sound transmission through the wall. Additionally acoustic glazing will also attenuate the sound transmitted through windows, although attenuated ventilation must also be considered in order to ensure good acoustic insulation.

8.6 Survey questionnaire and assessment methodology

In order to undertake an assessment of the type and composition of noise mitigation measures in use in CEDR member states, questions were devised covering topics such as types of mitigation measures, construction materials, technical specifications, experimental design, and maintenance measures. The following eight questions were included in the overall noise survey questionnaire:

Mitigation measures
(1) What are the most prominent mitigating measures used to treat noise exposure on existing roads, e.g. noise-reducing pavements, traffic management, noise barriers etc.?
(2) What are the most prominent mitigating measures used to treat noise exposure on new roads, e.g. noise-reducing pavements, traffic management, noise barriers etc.?
Construction materials for noise barriers
(3) Where noise barriers are used, approximately what percentage is constructed using wood, concrete, glass, or transparent materials, brick walls, full cover, e.g. tunnel, other, e.g. woodcrete, acrylic, aluminium?
Technical specifications
(4) Do technical specifications exist for the construction of noise barriers on new and existing roads?
(5) Are noise barriers constructed in accordance with specifications stipulated in the following European standards: EN 1793, EN 1794?
Experimental design
(6) Do you have any experience of using experimental designs for noise abatement measures?
(7) Please give examples, e.g. top-edge devices for noise barriers to improve attenuation (how was the efficiency assessed, e.g. laboratory measurements, on-site measurements, simulations?)
Maintenance
(8) Does a protocol exist for the maintenance of noise barriers on existing roads?

A total of 20 CEDR member states responded to the survey questionnaire. Because of the nature of the questions, a generic approach was adopted in the assessment of the section addressing noise mitigation measures. The principle objectives of the assessment were to establish:

(a) the main noise mitigation measures adopted by various CEDR member states in order to minimise human exposure to noise on existing and new national roads, and
(b) in those cases where proprietary noise barriers are used, what the composition of such barriers is and whether CEDR member states have technical specifications for the design, construction, and maintenance of such barriers?

8.7 Mitigation measures

What are the most prominent mitigating measures used to treat noise exposure on existing and new roads, e.g. noise-reducing pavements, traffic management, noise barriers etc.?

The responses to the questions were combined and discussed. The results are presented in Figures 8.8 and 8.9. These questions were designed to assess the type and number of noise mitigation measures used to treat noise on existing and new roads in CEDR member states.

Noise barriers including proprietary barriers, walls, earth berms, façade insulation, and noise-reducing pavements are the most prominent mitigation measures used to treat noise on existing roads (Figure 8.8). In addition to these measures, 20% of member states use traffic management to address noise issues.

On existing roads, 75% of member states use proprietary noise barriers either alone or in combination with other measures. The other prominent measures used either in isolation or in combination with other measures include façade insulation (40%) and road pavements (30%).

With regard to new roads, again, noise barriers including proprietary barriers, walls, earth berms, façade insulation, and pavements are the predominant measures used to address noise issues. Over 90% of member states tend to use proprietary noise barriers, while the use of noise-reducing pavements is the second most prominent measure. The use of proprietary barriers, walls, earth berms, and pavements, increased by 15% compared to the same measures used on existing roads. However, the use of façade insulation and traffic management measures decreased by 5%. Unlike existing roads, the use of tunnels and route selection during the planning phase are additional noise-reducing measures open to member states as a means of mitigating noise. However, only 10% and 35% of member states respectively consider these two options during the planning phase of new national road schemes.

Over 55% of CEDR member states use two or more types of noise-reducing measures to treat noise on existing roads. Only 5% of member states use a combination of four different types of measures, 25% use a combination of two measures, and a further 25% use a combination of three measures (Figure 8.9). The remaining 35% of member states rely on one type of mitigation measure, while 10% of the respondents do not use any noise mitigation measures on existing roads.

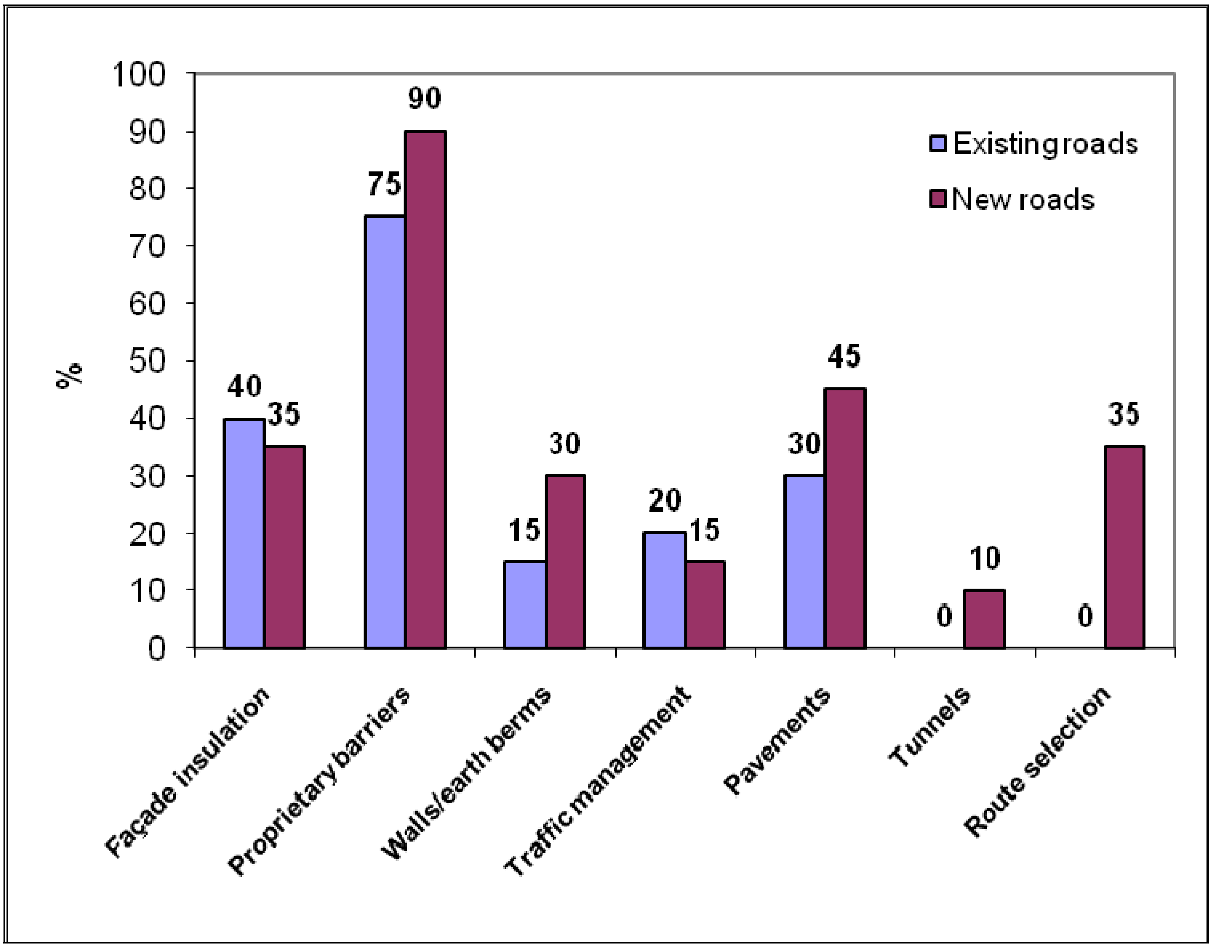


Figure 8.8: The types of noise mitigation measures used to reduce noise impacts on existing and new roads in CEDR member states

When it comes to addressing noise measures on new roads, 80% of CEDR member states use two or more types of noise-reducing measures (10% use five, 15% use four, 20% use three, and 35% use two) to treat noise on new national roads (Figure 8.9). All CEDR member states have procedures in place to treat noise issues on new roads. A greater variety of options are available for the treatment of noise on new road schemes. The results show that a higher percentage of CEDR member states use a greater variety of measures on new roads than on existing roads. The route selection process for new roads is viewed by some member states as an opportunity to avoid environmental impacts. However, it was surprising to see that only 35% of member states use this option as a means of mitigating noise.

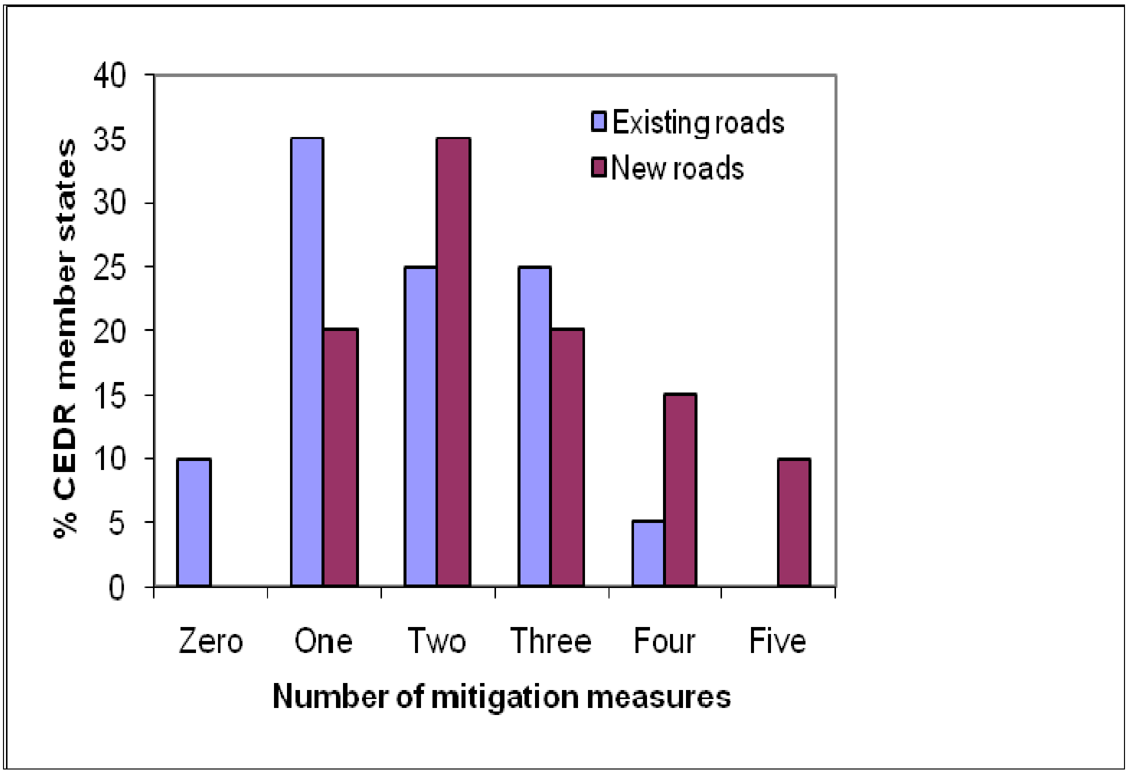


Figure 8.9: The number of mitigation measures used by CEDR member states to mitigate noise on existing and new roads

8.8 Construction materials for noise barriers

Where noise barriers are used, approximately what percentage is constructed using wood, concrete, glass, or transparent materials, brick walls, full cover, e.g. tunnel, other, e.g. woodcrete, acrylic, aluminium?

The results of the survey highlighted that a wide range of materials is currently available for the construction of noise barriers across CEDR member states. The results showed that noise barriers comprising wood, woodcrete, concrete, glass/glasscrete, stone/brick, aluminium/steel, and acrylic could be found in individual member states. However, despite the availability of the various types of construction materials, the market place appears to be dominated by three prominent barrier types: concrete, wood, and aluminium (Figure 8.10).

The survey results show that over 80% of CEDR member states use either a combination or any one of the three main barriers types identified in the survey, i.e. concrete, wood, or aluminium. Examples of such barriers are shown in Figures 8.11 to 8.13.

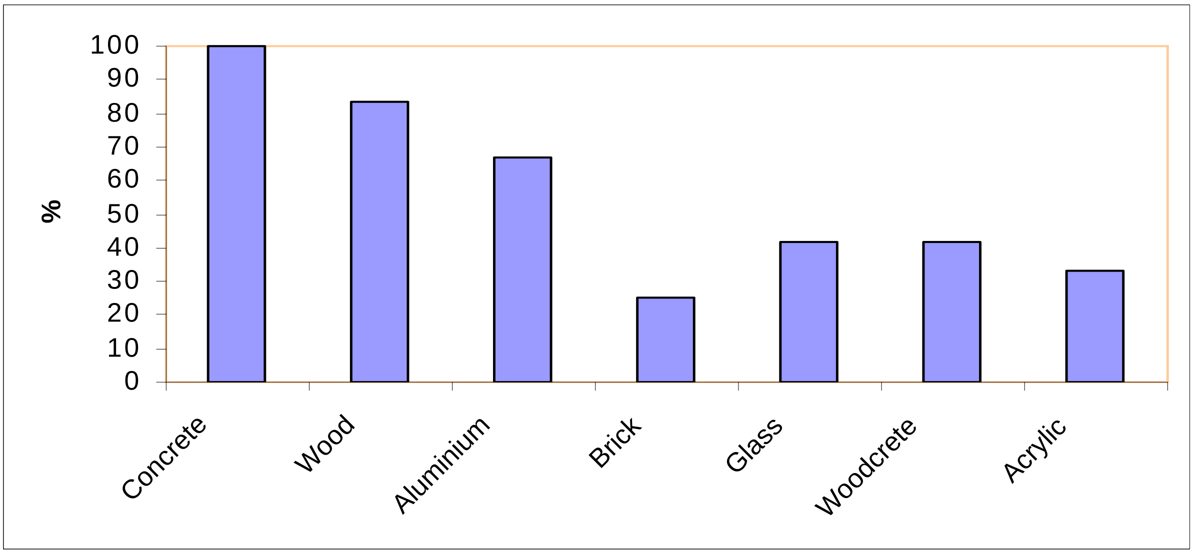


Figure 8.10: The composition of noise barriers and the percentage of CEDR member states using that barrier type, e.g. all CEDR member states use concrete, whereas only 25% use brick

Figure 8.11: An example of a concrete noise barrier with vegetation growing over the top of the barrier. The vegetation on the top of the barrier may have the potential to impact on its acoustic properties.

Figure 8.12: An example of a timber noise barrier

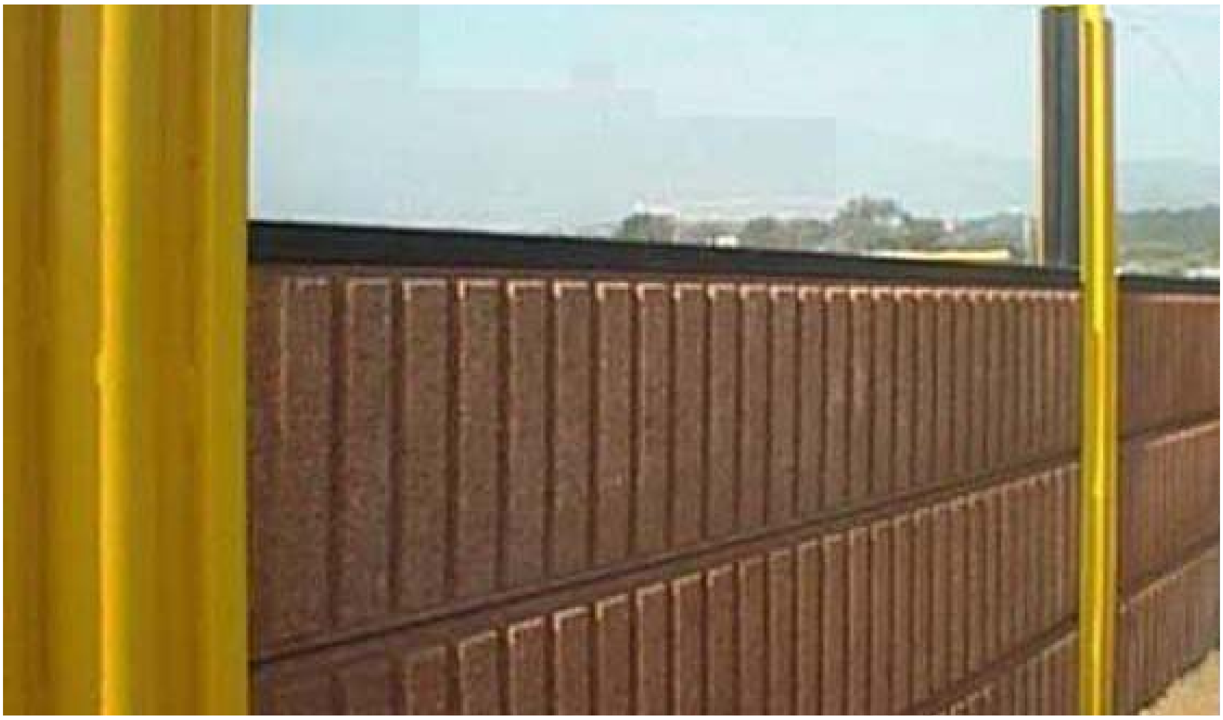


Figure 8.13: A noise barrier made with woodcrete with a transparent section on the top of the barrier. Note the robust support posts. Woodcrete is made from concrete mixed with wood and can be colour rendered to match the environment

Despite the variety of noise barriers available (e.g. Figure 8.14), only one barrier type seems to dominate the marketplace in most member states. This may suggest that the initial barrier type used by an individual member state on earlier schemes may set a precedent for the choice of barrier on future national road schemes. It may also suggest that there may by contractual issues surrounding the choice of noise barriers in member states. However, there are indications from the results obtained from two CEDR member states that suggest that this situation may change in the future, because they have reported a good mix of barrier types used in their respective countries (Figure 8.15).

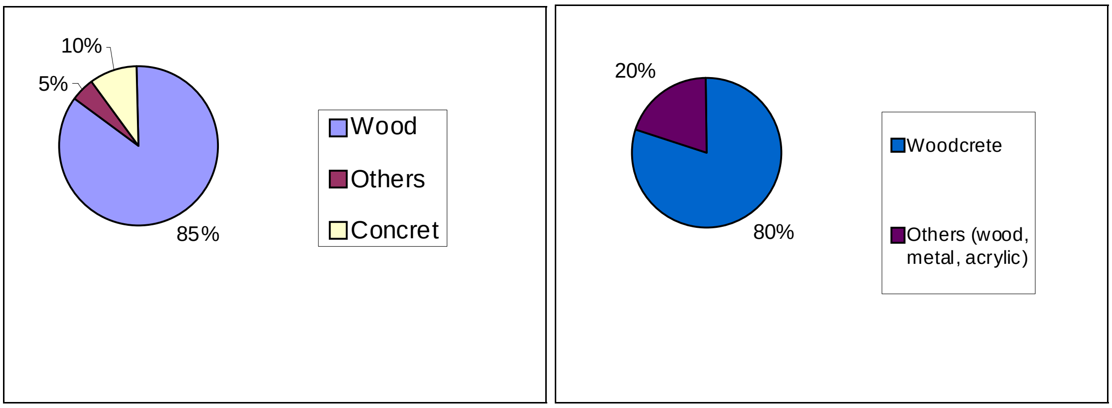


Figure 8.14: Examples of member states where one barrier type is most prominent

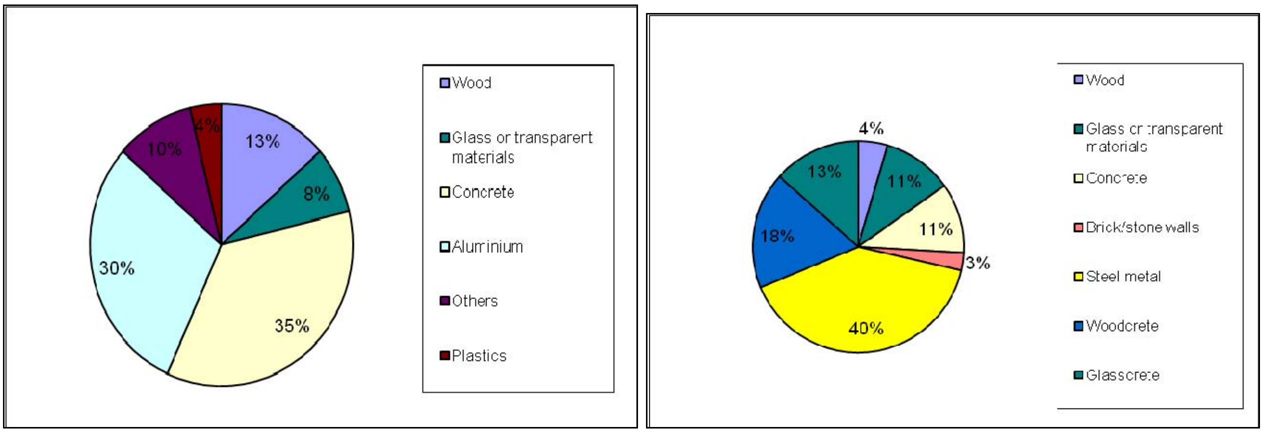


Figure 8.15: Examples of member states where there may be a shift away from the prominence of one barrier type to the use of a range of barrier types

8.9 Technical specification

Do technical specifications exist for the construction of noise barriers on new and existing roads?

The effectiveness of noise barriers at reducing noise is predicated on their design and how well they are constructed during the construction stage. In the absence of national technical standards, the quality of construction can vary, resulting in barriers that are unable to achieve the desired noise standards, goal, or guideline limit values. The integrity of construction also has ramifications for the longevity of the barrier in achieving the desired noise limits for a specific design year, which can be up to 15–20 years post opening. Typical issues associated with barriers include inappropriate location, poor installation, shrinkage, and general design features such as poor fitting access doors, if required (Figure 8.16). All access doors should be well sealed as depicted in Figure 8.17.

Figure 8.16: Example of a timber noise barrier showing a poorly fitted access door; note the opening over the top of the door

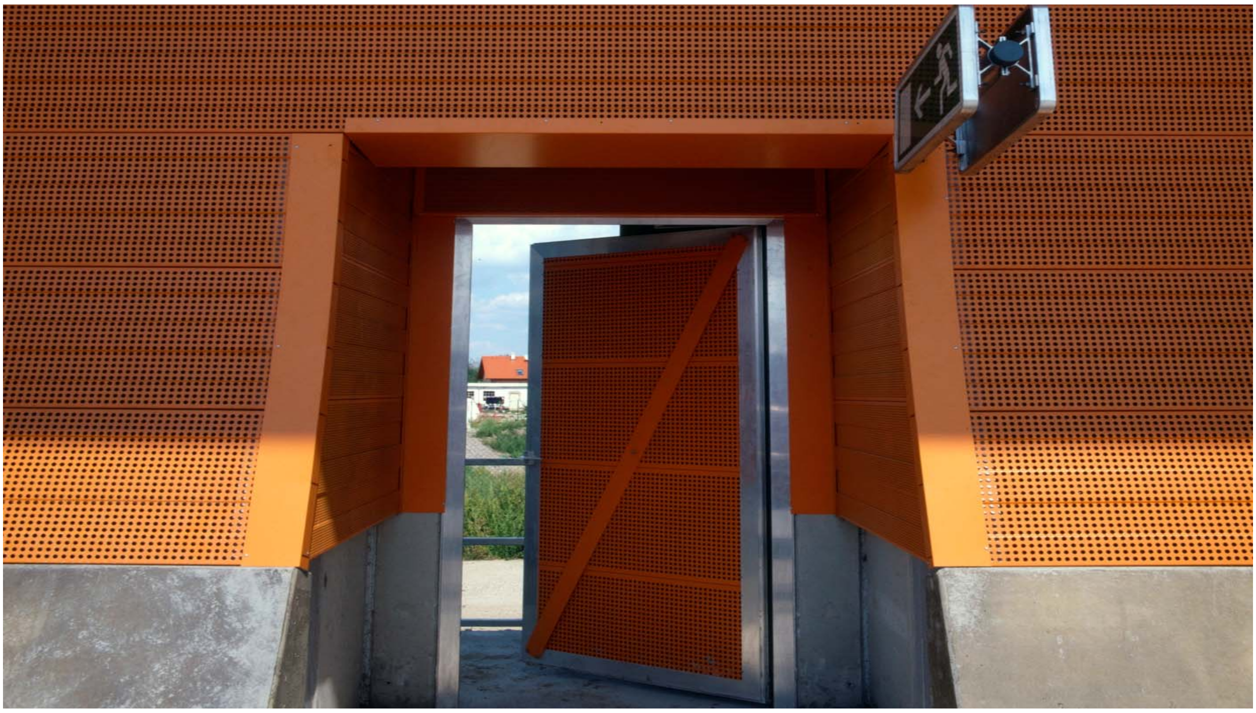


Figure 8.17: Example of a well-constructed access door; this door is completely sealed when closed

75% of CEDR member states have some form of national technical standards for the construction of noise barriers (Figure 8.18). It is anticipated that these technical standards form part of the contract works for road construction in the respective member states. Where member states do not have national technical standards, it would appear that noise barriers are then constructed in accordance with the specifications outlined in the European Standards EN 1793 and 1794.

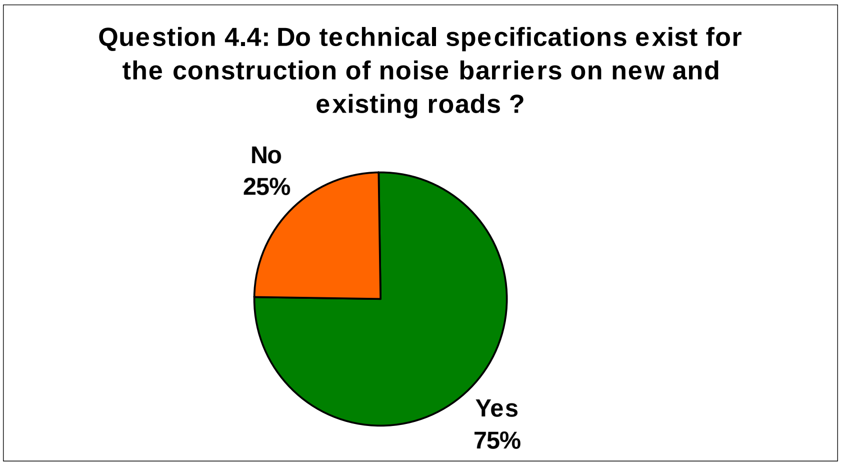


Figure 8.18: The percentage of CEDR states implementing technical specifications for noise barrier construction

Are noise barriers constructed in accordance with specifications stipulated in the following European standards: EN 1793, EN 1794?

The European standards for road traffic noise-reducing devices contain a number of acoustic and non-acoustic performance standards for noise barrier products. These standards were devised to help facilitate a fair trading market for noise barriers across Europe. Of the CEDR member states that responded to this question, 90% have incorporated these European standards into national standards (Figure 8.19). Where the European standards are not used, national standards tend to take precedence.

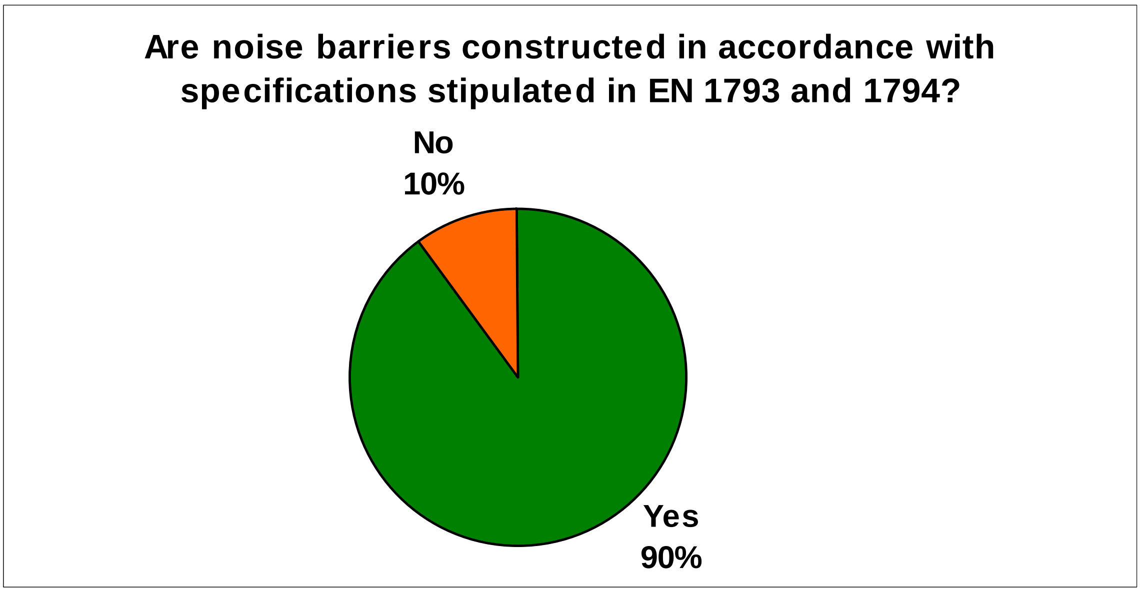


Figure 8.19: The percentage of CEDR member states adopting European standards for acoustic and non-acoustic properties of noise barriers

8.10 Experimental design

Do you have any experience of using experimental designs for noise abatement measures? Please give examples, e.g. top-edge devices for noise barriers to improve attenuation (how was the efficiency assessed, e.g. laboratory measurements, on-site measurements, simulations?)

The height of an existing noise barrier can be increased in order to improve its noise-reducing capabilities. However, this can often be an expensive option because in most cases, the foundations of the barrier will also have to be modified. While increasing noise barrier heights has the desirable effect of reducing noise, it may have undesirable consequences in terms of the visual impact on the users and surrounding residents.

Over the past few years, the use of experimental barrier top designs on proprietary noise barriers has become evident on national road schemes. This innovation consists of installing a specially designed top on an existing noise barrier in order to improve the barrier's ability to reduce noise e.g. Figure 8.20. It is expected that there will be no need to take additional measures with respect to the foundations. In a study carried out by the Transport Research Laboratory (TRL) in the UK, which evaluated the effectiveness of some novel noise barrier designs, it was found that the T-shaped barrier with an absorptive top performed most efficiently compared to the other designs considered [18].

Figure 8.20: Example of a variation of the T-top design; this example shows a barrier with an octagonal top

Based on the results of the CEDR survey, it is apparent that experience with the use of experimental designs is very limited, with 25% of CEDR countries having relatively little experience in the use of experimental top designs, and the remaining 75% having no experience in the use of such designs (Figure 8.21).

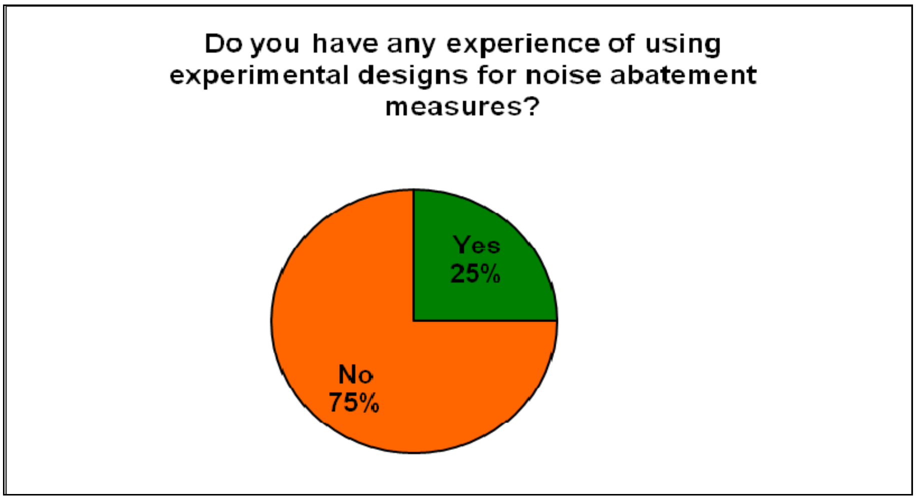


Figure 8.21: Percentage of countries that have adopted experimental designs

Based on the survey, the Dutch have acquired the most experience in the adoption and use of barrier top experimental designs. Conclusions from their work suggest that the best noise reduction in a practical situation can be expected from the use of T-top designs. This is in line with the findings of the TRL study.

Noise reductions are achieved with a T-top design noise barrier where the edge of the barrier is moved one metre closer to the source resulting in a second diffraction edge been created (Figure 8.22). In addition, the absorbent core in the top of the barrier absorbs certain noise frequencies.

Figure 8.22: Example of T-top noise barrier design used in the Netherlands

Noise barriers may be designed in many different ways to best suit the surrounding environment and mitigate noise to maximum effect. Figures 8.23 to 8.28 show some designs in use across Europe.

Figure 8.23: Example of a curved noise barrier in Vienna that will affect the propagation of noise

Figure 8.24: Another example of a curved noise barrier in the Netherlands, in this case, partially enclosing the road. Barriers may be designed to provide additional mitigation in areas with sensitive receptors nearby.

Figure 8.25: Example of a partially enclosed road in Italy with a noise barrier constructed overhead; note the vertical alignment of the barriers overhead

Figure 8.26: Example of a road completely enclosed for noise reduction purposes

Figure 8.27: Example of a curved noise barrier with staggered height; barrier dimensions may vary depending according to the location

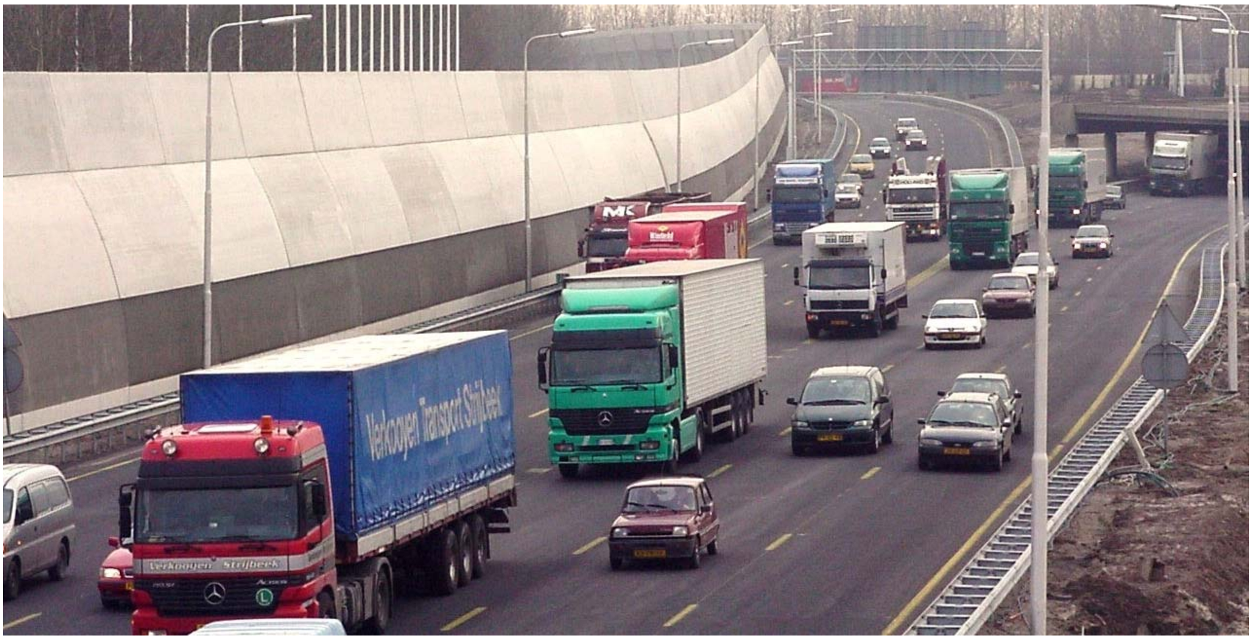


Figure 8.28: In this case, the noise barrier is constructed to a height of approximately 8m, thus providing a greater degree of noise attenuation

8.11 Maintenance

Does a protocol exist for the maintenance of noise barriers on existing roads?

The maintenance of noise barriers, particularly timber barriers on existing roads, is vital in order to ensure optimum performance and to ensure that any necessary repairs resulting from natural weathering or physical damage are made. While most CEDR member states have some form of general maintenance programme for maintaining existing roads, only 20% of them have specific protocols for the maintenance of noise barriers (Figure 8.29).

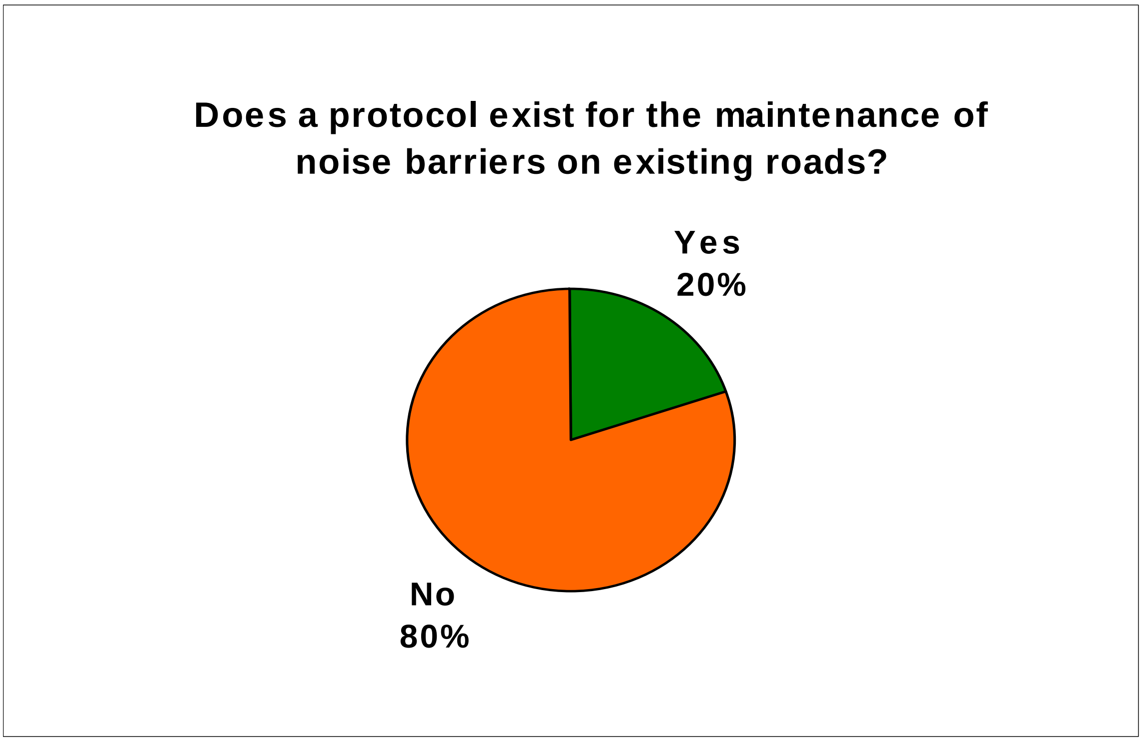


Figure 8.29: The existence of protocols for the maintenance of noise barriers

8.12 Critical analysis

Mitigation measures

The objective of the questions was to establish what types of noise mitigation measures were predominantly used in CEDR member states for new and existing roads. In the questions, three sample measures were given: noise-reducing pavements, traffic management, and noise barriers. From the reported results, it would appear that some of the respondents interpreted this as an exhaustive list and did not consider any further options such as façade insulation. This may have influenced the reported results. Despite this anomaly, the results did, however, clearly outline that a broad range of mitigation measures is in use in CEDR member states.

Construction materials

The questions on construction materials were designed in such a way as to establish the types of materials that are used for the construction of noise barriers and the dominant types used in member states. Once again, examples were given; once again, based on the results of the survey, some of the respondents interpreted this to be an exhaustive list of materials. This may have limited the range of materials indicated as actually being in use, although it is clear that concrete, timber, and aluminium are the primary materials adopted for the construction of noise barriers. Other materials, e.g. woodcrete, acrylic, and aluminium, were also given. Many respondents combined these three materials as 'others' rather than identifying and quantifying the amount of each individual type of material used, therefore, precluding quantification of these material types.

Technical specifications

Technical specifications are essential to ensure that noise barriers achieve specified design goals or noise level standards. Most CEDR member states have adopted the European standards for road traffic noise-reducing devices but most also consider it necessary to introduce their own national technical standards to ensure that other environmental factors specific to those countries are met.

8.13 Conclusions and recommendations

Noise barriers, including earth berms, are the dominant type of mitigation measure adopted in CEDR member states to reduce road traffic noise on both existing and new road schemes. It should be noted, however, that noise barriers may not always be the most appropriate or cost-effective method for mitigating noise at a particular location. It is, therefore, important that an acoustic specialist undertake a comprehensive assessment of noise-sensitive locations to investigate alternative and potentially more cost-effective noise reduction measures. While mitigation measures such as façade insulation, traffic management, and the use of noise-reducing pavements are used by some member states, there appears to be no consistent pattern in their use.

Addressing the noise at source (i.e. at the vehicles) may be more cost effective and benefits the entire road network.

When it comes to building new roads, noise can be mitigated using the route selection process. However, the results of the survey clearly demonstrate that this option is only used by a limited number of member states. The use of route selection in the early planning phase should be encouraged in more member states.

A wide range of construction materials is used in the construction of noise barriers. However, the main material types are concrete, timber, and aluminium. The types of material in use will obviously depend on availability, but it should be noted that barriers can also be constructed from recyclable materials. This could be of benefit to countries where material such as timber is not always accessible. It is also clear that an acoustic engineer must ensure that both the materials used have the necessary acoustic properties and that the construction is carried out in an efficient manner, and design goals are met. Most countries have adopted their own national standards for the construction of noise barriers in addition to using European standards for acoustic and non-acoustic properties. Very few countries have any experience of experimenting with current noise barrier designs to improve noise attenuation. The Netherlands is conducting research in this area. It is possible that considerable savings could be made in this area in the future.

Some member states have found it necessary to introduce their own specifications in relation to noise barriers in addition to European standards. This may have been driven by local environmental concerns. Experience gained in implementing any approach that targets other environmental factors as well as noise mitigation would be of benefit to all member states because it could help create a pan-European environmentally driven noise mitigation policy.

Finally, the survey demonstrated that over 80% of CEDR member states do not have procedures in place for the maintenance of proprietary noise barriers on existing roads.

9 Construction noise

9.1 Introduction

Noise caused by construction works during the building of national road schemes and railways can be a considerable problem for the people exposed to such noise. Public departments and contractors are now more aware of their responsibility regarding environmental issues connected to the construction phase. Nevertheless, little is known about construction noise.

9.2 Noise limits

The response to the survey questionnaire indicated that 68% of CEDR member states have limit values for construction noise. Of these, 69% can be classified as guideline values, while the limit values in the remaining 31% of member states have a legal status. Most of the legislations/guidelines are specifically aimed at the construction sector, while four member states use their general noise limit values to cover noise from the construction industry.

The averaging times vary for the different noise limits outlined below. Consequently, it is very difficult to make a direct comparison of the various noise limits. There is also the possibility that differences could arise as a result of façade reflections/free field. Some countries point out that the follow-up of the limits vary or that there is a lack of information about how the guidelines work in practice. The survey highlighted the following:

- Many CEDR member states have separate **night limits**; in most member states an L_{night} of 45 dB(A) is adopted. In the Netherlands, no noisy activities are generally allowed during the evening and night periods. Latvia and Norway have also adopted evening limit values of $L_{evening}$ 45–55 dB(A) and $L_{evening}$ 60 dB(A) respectively.

- **Day limits** vary from L_{eq} 50 dB(A) to L_{eq} 73 dB(A). Some member states have separate limits for weekends and holidays, while others have separate limit values for schools and kindergartens. In Italy, the limit values depend on type of area.

- A few member states have limits for **maximum noise level**. A few member states have limits for **maximum noise level**. Ireland's limits are L_{max} 65–80 dB(A), depending on the day in question. In Denmark, limits for peak value during the night are specified in the Specification for Construction Sites. In some cases where noise limits cannot be met, the project owner must provide an application for exemption.

- A few member states have **indoor limits**. Latvia's limit values are: L_{Day} = $L_{Evening}$ = L_{Night} 35-55 dB(A). Norway's indoor limits are: L_{day} 40 dB(A); $L_{evening}$ 35 dB(A); L_{night} 40 dB(A).

- Norway has stricter limits if the construction period exceeds 7 weeks: < 6 months (+ 3 dB), 7–12 months (+ 6 dB), 13–24 months (+ 8 dB) and > 2 years (+ 10 dB).

Limits may be **exceeded** under certain (some time-specified) conditions: in Finland, this applies if overrun time is less than a certain percentage of the total operating time. In the Netherlands, the limit is increased by 5 dB if work is finished within a month, while in Norway, the night limit can be increased to 50 dB(A) if work is finished within two weeks and to 55 dB(A) if finished within one week.

In addition to the outdoor/indoor limits, many CEDR member states have limits on noise from **equipment and machinery**, according to both work environment and dwellings. Figure 9.3 shows an example of noise labelling on production machinery.

Almost all member states that responded to the survey questionnaire have **time restrictions** on construction works. Whenever possible, evening and night work should be avoided.

9.3 Abatement measures

A range of approaches are currently being adopted by CEDR member states to reduce construction noise. One-third of member states use **low-noise equipment,** and another third use **noise barriers** (temporary or permanent) as a means of reducing noise nuisance. In some situations it may be possible to erect permanent noise barriers before any construction work commences or as soon into the construction process as possible.

Some of the member states' guidelines emphasise the importance of providing the public with information. Such information should be available during the planning stage and regularly during the construction phase. Whenever night work is scheduled, the people likely to be affected by such activity should always be notified. If limits are to be exceeded, notice should be given well in advance (see chapter 10).

Figure 9.1: An example of a noisy activity: use of spike hammer (photo: Norwegian pollution control authority)

Figure 9.2: Construction activity in a densely built-up area (photo: Norwegian pollution control authority)

It is possible for NRAs to include noise emission requirements for vehicles and machines in contract documents. The Swedish NRA has specified air pollution emission requirements for vehicles and machines in their contract documentation. These requirements have led to some older vehicles being replaced by newer machines and, therefore, as a result, probably by less noisy vehicles and machines.

No member state indicated that it has any knowledge of the effects of construction noise in terms of annoyance and health. There may be a need for some research to be conducted in this area in order to increase knowledge. In general, there is a growing emphasis on the health effects of noise during the evening and the night and sleep disturbance. If possible, work during the night should be avoided, and if such work is necessary, it should be minimized.

Figure 9.3: Example of noise labelling on production machinery

9.4 Conclusions

- Most CEDR member states have separate limit values for construction noise, and most of these are guideline values. Moreover, many of the member states have night limit values to protect against sleep disturbance.
- There is a need to know more about how these guidelines are followed up.
- There appears to be a range of approaches for controlling construction noise. Some member states use time restrictions while approximately one third of member states use low-noise equipment and another third use dedicated noise barriers or walls. Some member states have restrictions on working hours during the night.

10 Communicating noise levels during the planning and construction phase

10.1 Introduction

In times where road traffic volumes are growing at a rapid rate, noise has increasingly become a more important issue on the agenda at public meetings. In general, most CEDR member states hold public meetings in connection with road scheme planning and the compulsory Environmental Impact Assessment (EIA) process.

Normally, national road administrations (NRAs) are required to consult the public when new roads are being planned or where existing roads have to be modified. Consultation is also required if noise abatement measures need to be established to meet certain noise criteria. It is, therefore, important to communicate information to the public in a format that is easy to understand.

NRAs often present noise impacts by predicting noise levels based on model calculations, which can be described as the 'acoustic soundscape'. On the other hand, the residents' starting point is the perceived soundscape, i.e. where noise levels can vary depending on the time of day or weekday they are at home. The challenge for a good communication strategy is to link these different types of soundscapes. At the end of the chapter, the recommendations of the group are presented on how to set up a communication strategy that will link these two fundamental principles.

The survey questionnaire included six questions concerning the communication of noise during the planning and construction of national road schemes. Based on the responses received, it appears that the NRAs mostly use maps to describe the predicted noise levels, see descriptions below.

Figure 10.1: A public meeting on the environmental impact assessment of a road project in Denmark

10.2 Addressing the public

It would appear from the survey questionnaire that most CEDR member states consult the general public on noise issues. Almost all member states indicated that they consult the general public before constructing a new road or noise barrier. Only three member states do not present noise information to the public, and one member state does so, only if required. Several member states refer to the EU Directive on Environmental Impact Assessment (EIA), which stipulates an assessment of noise impact in specified cases.

In Copenhagen, for example, there was a proposal to widen a ring motorway from four to six lanes. The motorway carries 125,000 vehicles per day and there are 30,000 dwellings in close proximity to the motorway. During the consultation process, it transpired that noise issues were of the greatest concern to the general public. In order to address the noise issues, it was agreed to construct 18 km of noise barriers and use a noise-reducing pavement along the entire length of the scheme. In addition to this, dwellings that were identified as having noise levels in excess of 60 dB on the façade were offered financial contributions towards the installation of façade insulation.

During the planning phase for the upgrade, *neighbourhood forums* were established and representatives from the house owners' association and other residents' associations were invited to participate. The purpose of the forums was to provide selected groups of residents with information about the ongoing project. The participants were also invited to information meetings where the status of the project was outlined by the project management. The residents also had the chance to pose questions and point out problems that needed to be addressed by the project management. In addition, a newsletter was sent to all 30,000 residents with general information about the project.

Figure 10.2: New noise barrier constructed as part of the modifications to the Motorring 3 in Copenhagen, Denmark

10.3 Presentations

All CEDR member states that responded to the survey questionnaire stated that the noise levels associated with a specific project were presented to the general public at public meetings. Many member states use a combination of word description together with noise maps while other use sound examples. In the Netherlands, for example, noise is presented to the public using a 'noise simulator' (i.e. a computer with an interactive programme and loudspeakers) to demonstrate the impact of road traffic noise and ultimately show the effects of mitigating such noise using, for example, a barrier.

Figure 10.3: An interactive noise programme on a PC with loudspeakers and mouse; a 'noise simulator', is used at public meeting in the Netherlands

France indicated that 'sound examples', played in a meeting room for instance, are not considered representative of the actual situation roadside resident experience. France also indicated that it is better to use a comparable situation, for example, bringing residents who will be impacted by a proposed road project to an area that currently has a similar configuration and traffic volume to the proposed project so that they can experience noise impacts in a real life situation.

In Portugal, the impact of noise is communicated to the general public in writing. However, attempts are also made to give some examples, e.g. showing the differences between music and noise or giving examples of noise coming from road traffic, trains, and aircrafts as well as giving examples of measuring units. This shows that different sound levels do not annoy the listeners (residents) in the same way, even though the energy level of the sound is the same.

Figure 10.4: A poster on noise from a road project exhibition in Denmark

Portugal also demonstrates the annoyance caused by high noise levels. This is done by showing the areas where high noise levels will be experienced and highlighting the benefits of implementing a planned solution.

Almost all CEDR member states use noise maps to present noise levels at public meetings or oral hearings. These noise maps are sometimes combined with drawings and photos.

All member states provided information regarding the point in time at which information should be presented to the general public. In this situation, almost all member states stated that noise impacts are presented during the planning phase, which gives the public an opportunity to influence the project. In Denmark and Sweden, a project is presented to the public several times during the planning and design phases.

Figure 10.5: A workshop on the use of noise-reducing pavements in Denmark

10.4 Existing roads

Based on the responses received from CEDR member states, it would appear that noise issues are treated differently on new roads and on existing roads. With regard to existing roads, several member states stated that noise abatement is not implemented during maintenance. However, if there is a requirement for noise abatement on existing roads, the noise levels are presented to the general public in writing and in the form of noise maps, similar to the practice undertaken during the planning phase for new roads.

In Sweden, the national road administration is more proactive with regard to communicating with the general public. Letters are normally sent out to the general public outlining the works to be undertaken on a road. In some cases, a noise assessment plan is included and is given to all property owners who could potentially be impacted by the road project.

Figure 10.6: Example of the brochure sent to residents living alongside national roads in Norway

In Norway, the Norwegian Road Administration has prepared a brochure on the rights of residents living in close proximity to road traffic noise to apply for noise-reducing measures. The brochures are designed to assist those who are building new houses close to a road or those who are currently living in close proximity to an existing road. In addition, the brochure can be used by residents who are currently in close proximity to a proposed road under planning.

All brochures contain information on road traffic noise and the statutory regulations and guidelines covering noise. The brochures are also sent to inhabitants who request information from municipalities. All brochures can be found on the Norwegian Road Administration's website site. They are also normally distributed at public meetings.

The NRA's experience with this form of information is very good. There is a great need for more knowledge about noise and the rights of residents.

10.5 Conclusions and recommendation

Based on the results of the survey, it would appear that communication with the general public is very important when undertaking works on national road schemes. The purpose of good communication is to link the acoustic soundscape to the perceived soundscape. Noise maps are generally used to show the acoustic landscape. Such maps are normally produced using model calculations. However, the greatest challenge is to make connections to the perceived soundscape in a reliable and consistent manner.

In some situations, where communication fails or other conditions influence the project, residents complain even though the project has resulted in a considerable noise-reducing effect. For this reason, the CEDR noise group recommends that a communication strategy should include the following key elements:

1. A connection between the acoustic and perceived soundscape
It is important to recognise that residents live in a variable soundscape. The challenge is to explain how this soundscape is considered in noise mapping. It is possible, and sometimes a good idea, to use audio demonstrations from the local environment (soundscape). This is done in order to illustrate that the proponents of the scheme have visited the area and understand what the residents are experiencing. Such an approach gives the road administration good credibility.

2. Management of noise abatement expectations: noise is reduced, not removed
When noise barriers or other type of noise abatement measures are incorporated into a road scheme, residents expectations on what such measures can deliver in terms of noise reduction are high, sometimes too high. It is therefore important to ensure that residents understand that noise will be reduced but not removed.

Sometimes, residents may complain when there is a change in the sound composition, which means that heavy traffic and/or traffic on other roads in the vicinity is more audible. Sound examples with different noise levels could be a very good way to illustrate the effect of the planned noise abatement.

3. An explanation of what noise is and how it is generated and propagated
Sound and noise are measured in decibels (dB). It is a challenge to explain noise in an easy-to-understand way. There is often a demand from the general public for general information on the Internet or in booklets (brochures).

Traffic noise varies between 40 and 80 dB. One way of describing the variation is by giving examples of noise levels on different road types or specific roads in the community. Another way is to compare different noise levels to other known machines, e.g. to a washing machines or dishwashers. The problem is that we do not have the same control on traffic noise, so the annoyance is much higher because we just cannot turn it off.

It is also possible to describe noise from a specific road or in a specific area by relating the exposure to noise annoyance. It may be easier to understand how many persons are annoyed by noise than the exact noise level.

4. An explanation and demonstration of the extent to which different types of preventive measures reduce noise
Residents or interested parties often believe that reducing traffic volumes and/or speed limits are good ways of reducing road traffic noise. However, the effect can often be limited. It is important that information on different road traffic noise reduction measures is provided. An indication of the size of the expected noise level reduction should also be included. When using such an approach, it may often become evident that one single solution may not be adequate to reduce certain noise sources. Generally, it is widely accepted that a range of measures is necessary in order to deliver considerable reductions in road traffic noise levels.

11 Final conclusions

Based on the assessment of results obtained from the noise survey, the following general conclusions are made:

- In most CEDR member states, some form of noise legislation exists, while other member states have noise policies or guidelines addressing various noise issues. Although the legal status of these documents may differ, they all introduce noise limits to control noise along European national roads; most of these are outdoors limits. Two noise indicators, L_{Aeq} and L_{den}, are used to calculate and measure noise levels and to define noise limits. Noise limits in CEDR member states vary and are very difficult to compare. In CEDR member states, there are at least seven different national computer models in use for the calculation or prediction of noise levels. The French and Nordic models are generally the most widely used models. In practice, this means that at the moment, comparing noise levels and noise limits at European level is, to say the least, complicated. The best way to overcome this problem is to introduce a common pan-European approach to noise calculation in the form of a European noise model.

- The municipality/construction contractor is normally responsible for fulfilling the noise limits when constructing new residential housing. Guidelines/regulations are not available in any member state for situations where traffic increases as a result of the introduction of new developments such as industry, commercial areas, shopping centres etc. When traffic increases because of new developments, the NRAs are normally responsible for fulfilling the noise limits when upgrading the respective roads.

- Noise is not generally one of the criteria used when determining which roads need maintenance or new pavements. Nevertheless, in 65% of the member states, noise is considered when deciding on the type of pavement to be used when a road needs repairs or a new pavement. At the time of the survey, only a few member states included noise as a parameter in a pavement management system. It was also established that 20% of the member states had incorporated the use of noise-reducing pavements in guidelines or a similar document. Also, in 20% of the member states, some type of procedure for the acoustic labelling of road surfaces is used. In 16% of member states, procedures are applied in certain circumstances to check the acoustic conformity of a road surface after the pavement has been laid. Although only a few member states have formal requirements for the use of noise-reducing pavements, such pavements are currently available on the market in 80% of member states. Porous-type pavements, thin-layer pavements, and Split Mastic Asphalt (SMA) pavements are the dominant types of noise-reducing pavements available in member states.

- Noise barriers, including earth berms, are the dominant type of mitigation measure adopted on both existing and new road schemes in CEDR member states. A wide range of construction materials is used in the construction of noise barriers. However, the main materials types are concrete, timber, and aluminium. It should be noted, however, that noise barriers may not always be the most appropriate or cost-effective method for mitigating noise at a particular location. It is, therefore, important that an acoustic specialist undertake a comprehensive assessment of noise-sensitive locations to investigate alternative and possibly more cost-effective noise reduction measures. While mitigation measures such as façade insulation, traffic management, speed limits, and the use of noise-reducing pavements are used by some member states, there appears to be no consistent pattern in their use.

- Most countries have adopted their own national standards for the construction of noise barriers in addition to using European standards for the acoustic and non-acoustic properties of noise barriers. There is very limited experience in experimenting with current noise barrier designs to improve noise attenuation. The T-shaped noise barrier with an absorptive top performs most efficiently compared to other designs considered. Over 80% of CEDR member states do not have procedures in place for the maintenance of noise barriers on existing roads.

- When it comes to building new roads, noise can be mitigated using the route selection process. However, the results of the survey indicate that this option is only used by some member states. The use of route selection in the early planning phase could be encouraged in more member states.

- 68% of CEDR member states have limit values for construction noise. Averaging times vary. It is, therefore, very difficult to make a direct comparison between the various national noise limits. In addition to the outdoor/indoor noise limits, many CEDR member states have limits on noise from equipment and machinery, according to both the environment for the construction workers as well as the surrounding residential areas. Almost all member states have time restrictions on construction works and whenever possible, evening and night work should be avoided. A range of approaches are currently adopted to reduce construction noise such as the use of low-noise equipment and noise barriers (temporary or permanent). Some of the member states' guidelines emphasize the importance of providing the public with information.

- NRAs are now commonly addressing the public when it comes to constructing new roads, upgrading existing roads, or installing noise abatement measures on existing roads. It is therefore important to provide information to the general public in a format that is easy to comprehend. All member states that responded to the survey questionnaire stated that noise levels are presented in writing in those cases where noise is introduced at public meetings. Many member states combine words with noise maps and some even include sound examples. The Netherlands, for example, uses a 'noise simulator' (i.e. a computer with an interactive programme and loudspeakers) to show the effect of a barrier.

12 Recommendations on good governance regarding noise

Based on the information received from the NRAs and the fruitful discussions within the CEDR noise group, fourteen recommendations for good governance regarding noise management and abatement are proposed:

1. In Europe, the main noise problems occur along the existing road network. Moreover, the magnitude of the problems increases with traffic volume. Therefore, noise abatement along these roads is crucial in order to launch a process whereby noise exposure is reduced in the long term.

2. For new road developments, it is important to include noise issues at an early planning stage. Adopting such an approach may help avoid future noise problems. Such an approach is normally based on national noise guidelines.

3. Noise should be included as an important parameter in projects where existing roads are improved to accommodate increasing traffic volumes or increasing speeds. This can improve the noise environment for people living in close proximity to the upgraded road.

4. When planning to incorporate noise abatement measures on new, existing, and reconstructed roads, it is important to adopt a time horizon of 20 to 30 years, when predicting future noise from increasing traffic volumes and planning noise measures. This will enhance the robustness of specific noise projects.

5. When road construction work is carried out in close proximity to residential areas, the construction noise generated when planning and realizing such works should be considered. People living close to the construction site should be provided with sufficient information.

6. In projects where noise abatement measures are planned and designed, it is recommended that a good communication strategy be developed to ensure a two-way communication process with the public. In this way, residents may take ownership of the project, which might mean that their expectations regarding the noise reductions that can be achieved through noise mitigation are more realistic.

7. Noise barriers erected on roads visually impact not only on the people living in close proximity to the road but also on drivers and passengers. It is therefore important to use barrier designs that are appropriate to the specific location where they are installed.

8. The use of noise-reducing pavements should be considered when selecting noise mitigation measures because such pavements are purported to be a cost-effective noise abatement tool. When upgrading existing roads, the use of noise-reducing pavements is often a low-cost noise abatement measure.

9. The inclusion of noise as an active component in pavement management systems can optimise the use of noise-reducing pavements in the ongoing road pavement renewal process.

10. In order to enhance the current market for noise-reducing pavements the development and use of a noise labelling system in member states should be considered. Standards for such a system should be developed.

11. In order to reduce noise emissions from individual vehicles, it would be invaluable for individual NRAs to lobby at EU level to promote tighter noise limits for the EU type approval of new vehicles and tyres. Tackling noise at its source (i.e. at the vehicles) may be more cost effective and would benefit the entire road network.

12. Like all infrastructure elements, noise abatement elements such as pavements, barriers, façades, etc. need to be maintained on a regular basis.

13. There is a need for further research and development into improved and long-time durable measures of noise abatement like optimized noise-reducing pavements, tyres, vehicles etc. There is also a need for a better knowledge of the health effects of noise.

14. A continuation of international cooperation on noise abatement and management between the NRAs is value adding and fruitful. In the coming years, issues like noise mapping and noise action plans in relation to the European Noise Directive (END) will be highly relevant.

If these fourteen recommendations on good governance regarding noise management and abatement are followed, the consequences for the European Road Directors could be a further improvement of the NRAs' contribution to an improved quality of life for those living in proximity to Europe's national road networks. The recommendations could help to secure sustainable solutions that are cost-effective over the lifetime of the road.

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Annexes to the report

Questionnaire

CEDR questionnaire on noise abatement

The questionnaire below covers eight different subjects concerning various noise abatement issues. You are requested to complete and return the questionnaire electronically to Helen Hasz-Singh at hhz@vd.dk no later than 22 December 2006.

1. Noise regulations for new and existing roads		
1.1 Noise and road planning		
1.1.1 Does your National Road Authority apply noise limits for traffic noise: - on new roads? - on a modification/reconstruction of existing roads? (if so, please specify what kinds of modifications are addressed) - on existing roads?		
1.1.2 For each of the three fields listed above: Are these limits required by legislation, by guidelines or a noise policy? Are there conditions where you do not have to comply with these limits (clarify these conditions)?		
1.1.3 Do these limits apply only to the road network managed by your National Road Authority, or do they apply to any road authority?		

1.2. Noise indicators		
1.2.1 Do these limits apply to the noise contribution of the road or to the overall noise (all sources considered) at the assessment location (e.g. houses, recreational areas (urban, rural), summer cottages, schools, offices)?		
1.2.2 What noise indicators are used to express the limits? Please specify: - the type of indicator (LA_{eq}, LA_{max}, L_{den}, percentile, etc.) - the periods, - the assessment location (indoors, outdoors), - for outdoor limits: does the noise level include the reflection from the building façade?		
1.2.3 Are the meteorological conditions specified in your limits? If so, which meteorological conditions are considered for the noise level assessment? (e.g. neutral – homogeneous atmosphere ; conditions favourable to propagation, sometimes referred to as “downwind” ; long-term conditions, i.e. a combination of several conditions according to their occurrences; etc.)		

1.3. Noise limits		
1.3.1 Please state these limits for each situation considered (new road / modification / existing road, kind of premises, period, etc.):		
1.3.2 Do the indoor noise limits apply to all rooms or only some of them (e.g. bedrooms for night-time limits)? Do the outdoor noise limits apply to all room façades or only some of them?		
1.3.3 For new and modified roads: Do these limits apply only when the road is opened to traffic, during a given period after it is opened to traffic, or is there no time limit? What is the planning horizon? What happens if traffic increases faster than predicted due to traffic development?		
1.3.4 For existing roads: How do you handle traffic increase and therefore noise increase on existing roads?		

1.4. Content of the Environmental Impact Assessment (EIA)		
1.4.1 Does the EIA have to assess the noise impact of a new road project on the existing road network (induced or redirected traffic, changed speed limits etc.)? If increased noise is predicted on the existing network, must anything be done to lower it – who must pay?		
1.4.2 Must the EIA include an assessment of the noise-annoyance effects of the road project? If so, what are the dose-effect relations used?		
1.4.3 Must the EIA include an assessment of the noise-related health effects of the road project? If so, what are the dose-effect relations used?		
1.4.4 Must the EIA include a monetary valuation of the annoyance due to noise before and after the building of the road project? If so, how is the noise value estimated?		
1.5. Miscellaneous		
1.5.1 Is it allowed to comply with the outdoor noise limits by adding additional acoustic insulation to building façades? If so, how is the required insulation calculated? (in other words: what is the corresponding objective for the indoor noise level?)		
1.5.2 Is compliance with the limits checked by on-site measurements? If so, what is the consequence if the measured noise level exceeds the limit?		
1.5.3 Which prediction method is used for prediction of noise levels?		

2. Responsibility and noise management where community development impacts noise levels			
Introduction The demand for industrial and land development and new housing generates more traffic; these are examples of what can have an impact on noise levels and disturbance along roads. What protection is arranged for those exposed to noise when other players in society engage in community development /enterprises that affect noise levels on existing national roads? These questions concern • the process involved for planning /decision-making in relation to development projects affecting noise, • the targets, indicators, figures and limit values used to define need for noise mitigation measures, • who is responsible to do what for protecting those exposed to/disturbed by noise along national roads, • which of the foregoing functions well/less well and what proposals/action for improvement could be done. The answers are found in laws, guidelines or agreements. Although the questions should be answered based on two exemplified situations, please feel free to specify any other situation on which to base your answers.			
Questions **– Please, highlight if the answer is according to laws, guidelines, agreements or proposals**	**Situation A** New housing in areas already exposed to high noise levels from traffic on (national) roads.	**Situation B** Industrial or commercial development that generates more traffic and thus higher noise levels.	**Situation C** Other situations covered by laws, guidelines, agreements or proposals - please describe
2.1 How are the processes for planning and monitoring each situation? Who are the players and decision-makers in the processes and how do they interact?			
2.2 What are the indicators and limit values on noise emission at the planning and monitoring stage?			

2.3 What responsibility do the players and decision-makers have concerning noise-mapping?			
2.4 What measures are taken to reduce increasing noise due to increasing traffic in the three situations?			
2.5 Which organisations (private or public) are responsible for respective noise abatement measures (who pays for the noise abatement)?			
2.6 Are there any regulations/guidelines on how buildings should be designed to reduce noise levels? (barriers, facades, bedrooms facing a quiet side of the building, the size and location of buildings etc to reduce noise propagation)			
2.7 Are there any regulations/ guidelines for reducing emissions? (noise reducing pavements, speed adaptation, traffic regulations to limit traffic, etc.)			
2.8 What works well or poorly within the foregoing question areas? Why? Any proposals for improvements?			

3. Integration of noise in road maintenance:		
3.1 Is noise one of the criteria for selecting which roads need maintenance and new pavements? If yes, please describe how?		
3.2 Is noise a parameter when deciding which type of pavement will be used when a road needs repair and new pavement?		
3.3 Is noise a parameter in the Pavement Management System? If yes, please describe how?		
3.4 Are noise considerations evaluated/balanced against other parameters (price, traffic safety, durability, drivers comfort etc.)? If yes, please describe how?		
3.5 Are there any guidelines/legislations/recommendations on how and when to use noise reducing pavements? If yes, please describe how?		
3.6 Do you apply procedures for the acoustic labelling of road surfaces? If yes, please describe how?		
3.7 Do you apply procedures to check the acoustic conformity of production of a road surface after laying? If yes, please describe how?		
3.8 Are noise reducing pavements available in your country and if yes, which products?		

4. Noise abatement measures		
4.1 What are the most prominent mitigating measures used to treat noise exposure on **existing** roads e.g., Noise Reducing Pavements, Traffic Management, Noise Barriers etc.?		
4.2 What are the most prominent mitigating measures used to treat noise exposure on **new** roads e.g., Noise Reducing Pavements, Traffic Management, Noise Barriers etc.?		
4.3 Where noise barriers are used, what percentage approximately is constructed of Wood, Concrete, Glass or transparent materials, Brick walls, Full cover e.g., Tunnel Other e.g., woodcrete, acrylic, aluminium		
4.4 Do technical specifications exist for the construction of noise barriers on new and existing roads?		
4.5 Are noise barriers constructed in accordance with specifications stipulated in the following European Standards: EN 1793 –1:1998, Road Traffic Noise Reducing Devices – Test Method for Determining the Acoustic Performance – Part 1: Intrinsic Characteristics of Sound Absorption EN 1793 –2:1998, Road Traffic Noise Reducing Devices – Test Method for Determining the Acoustic Performance – Part 2: Intrinsic Characteristics of Airborne Sound Insulation EN 1793-3:1998, Road Traffic Noise Reducing Devices – Test Method for Determining the Acoustic Performance – Part 3: Normalised Traffic Noise Spectrum EN 1794-1:2003 Road Traffic Noise Reducing Devices – Non Acoustic Performance - Part 1: Mechanical Performance and Stability Requirements. EN 1794–2:2003 Road Traffic Noise Reducing Devices – Non Acoustic Performance - Part 2: General Safety and Environmental Requirements.		

4.6 Do you have any experience in using experimental designs for noise abatement measures? Please give examples, like top edge devise for noise barriers to improve attenuation (how was the efficiency assessed e.g., laboratory measurements, on-site measurements, simulations?)		
4.7 Does a protocol exist for the maintenance of noise barriers on existing roads?		

5. Construction noise		
5.1 Does your National Road Authority apply noise limits for construction noise? If so, please specify the limits and, if possible, please send us a copy. Under which legislation are these limits written?		
5.2 Do these limits have a legal status or are they guidelines? In other words: is their compliance mandatory or may the noise level exceed them under given conditions (clarify these conditions)?		
5.3 If no official limits – does the National Road Authority have its own internal guidelines?		
5.4 Do these limits apply only to construction noise, or do they include noise from the nearby traffic?		
5.5 Which noise abatement measures are most commonly used for construction noise (e.g. time restrictions on activity, low noise equipment, barriers etc.)?		
5.6 Do you have knowledge about the effects of construction noise on annoyance or health? If so, please give us a link to any reports which may be of interest.		

6. Working with the European Noise Directive (END)		
6.1 When was the END implemented in your country?		
6.2 Who is responsible for the data transmission to the EU?		
6.3 Can you describe in which way you have organized the collection of data and the work on the noise maps? - Who is responsible? - Is the work divided into regions or different organisations within the country? (If there are more than one responsible, please describe in which way the results are combined?)		
6.4 Can you describe some problems during your work on the noise maps? - base data? - topographic measurement? - individually related data? - other problems?		
6.5 In which way is the work on END financed?		
6.6 According to the END-directive from EU, the noise mapping in 2007 must be published, how do you plan to communicate the results of the noise mapping to the public (folders, exhibitions, meetings etc?) Please describe. (If information material is already available please send copies)		
6.7 Is the timetable in the END is practicable?		
6.8 Would you think it could be helpful for your upcoming work on noise action plans if you could obtain information about the work in other countries?		

7. Communication:		
7.1 Do you present noise consequences to the public or the neighbours, for example, before constructing a new road, a noise barrier or in other cases. If yes please continue with questions 3.2 to 3.7:		
7.2 How do you explain noise/sound, for example, source emission, propagation and decibels? a. In words b. With sound examples In other ways, please describe		
7.3 When do you present the project to the public? a. In the planning phase, where the project could be changed, if needed b. Other times, please describe e.g. evaluation		
7.4 In the planning process, how do you present noise impacts to the public?		
7.5 During maintenance of roads, how do you present noise impacts to the public?"		
7.6 When implementing noise abatement along existing roads, how do you present noise impacts to the public?"		
7.7 Do you have good examples with easy-to-understand information on noise, which could be useful for other authorities? Please describe - and kindly send a copy.		

8. Name and affiliation of the person who answered this questionnaire			
Name: Organisation: Address: E-mail:	Title: Department/division: Telephone: Homepage:		

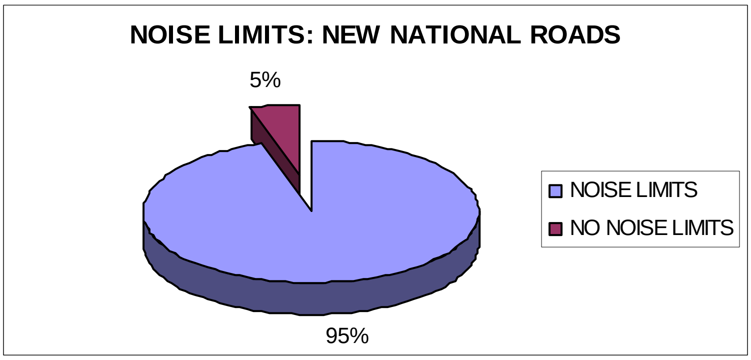
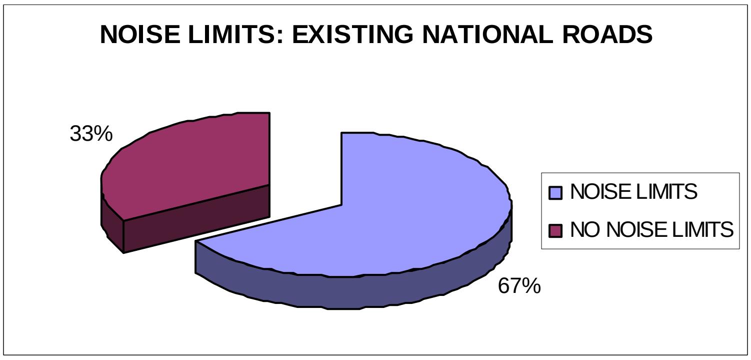
Annexes to chapter 5

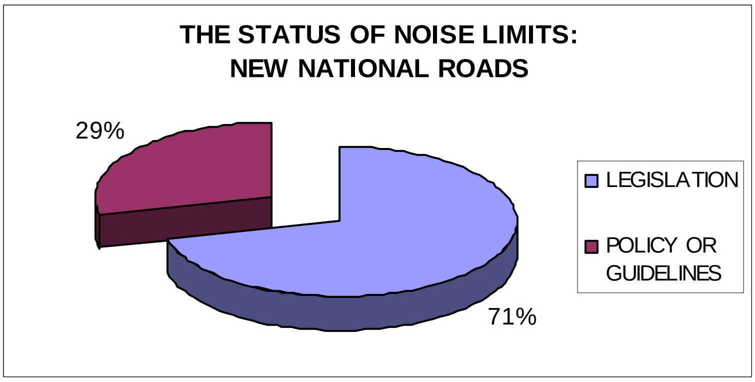
Annex 1: Information on the different answers

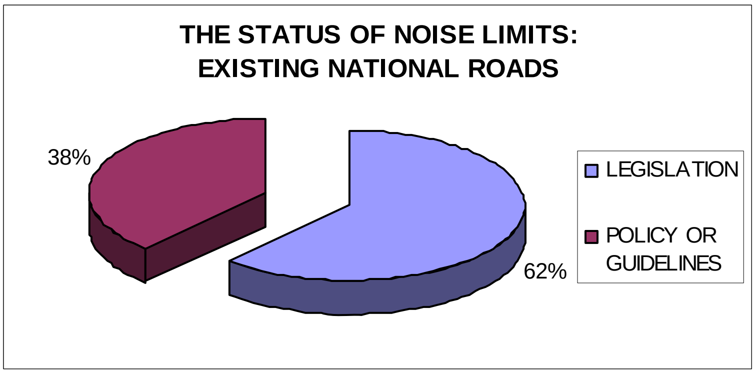
Annex 2: Detailed information on outdoor noise limits along national roads

Annex 3: Detailed information on indoor noise limits along national roads

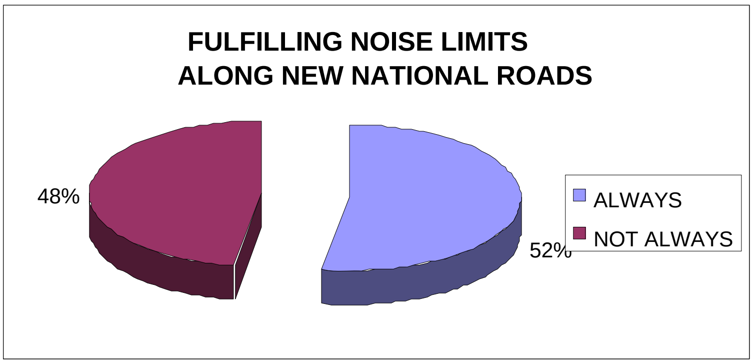
Annex 1: Information on the different answers regarding noise regulation

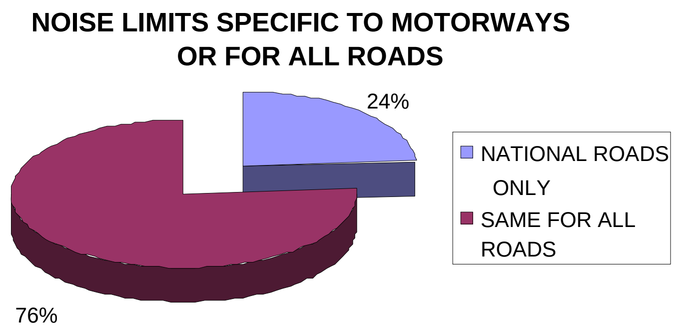
TOPIC 1.1	**NOISE AND NATIONAL ROAD PLANNING**
QUESTION 1.1.1	Does your National Road Authority apply noise limits for traffic noise: - on new roads? - on a modification/reconstruction of existing roads? (if so, please specify what kinds of modifications are addressed) - on existing roads?
EXPLANATION	This question is about having noise limits for national roads.
ANSWERS	 
CONCLUSIONS	- Almost all CEDR member states have noise limits for new national roads. - As for the modification of existing national roads, almost all CEDR member states have noise limits, but sometimes there are certain constraints (see remarks). - In the case of existing national roads, most CEDR member states have noise limits. - The countries without legal noise limits use the noise limits stipulated by their guidelines.
REMARKS	Examples of constraints include: - a noise increase of 2 or 3 dB(A); - an increase in the number of traffic lanes; - the upgrading of a road section with a specified length.

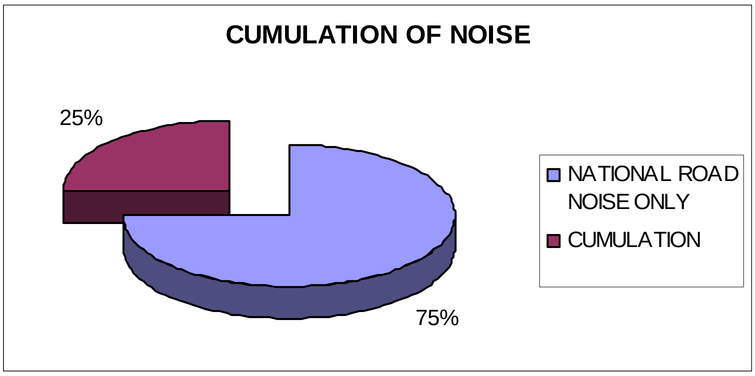
<table>
<tr><td>TOPIC 1.1</td><td>NOISE AND NATIONAL ROAD PLANNING</td></tr>
<tr><td>QUESTION 1.1.2.a</td><td>Are these limits required by legislation, by guidelines or a noise policy?</td></tr>
<tr><td>EXPLANATION</td><td>This question is about the (legal) status of the noise limits. The status of these limits can vary, taking the form of legislation, policies, or guidelines. From a legal perspective, there is quite a difference between these possibilities. Legislation means that there is a statutory obligation, and people can go to court in order to ask the national road administration (NRA) or the government to respect the limits. Policies and guidelines, however, are more or less an expression of the intention of the NRA or the government to remain within certain noise limits. The NRA and the government undertake to do their best to observe such noise limits; however, they cannot be compelled to fulfil a policy or guideline by the court. Legislation, however, involves a responsibility to achieve a certain result.</td></tr>
<tr><td>ANSWERS</td><td>


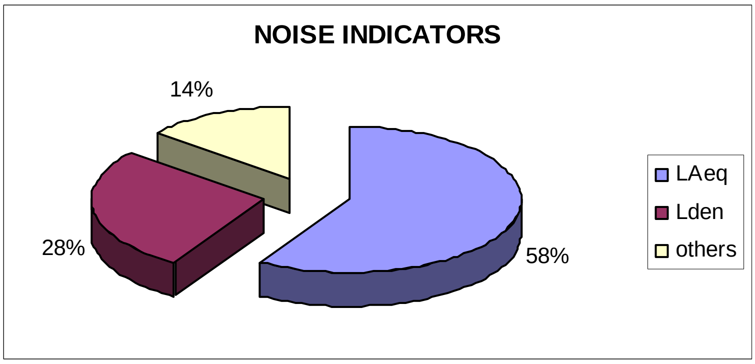
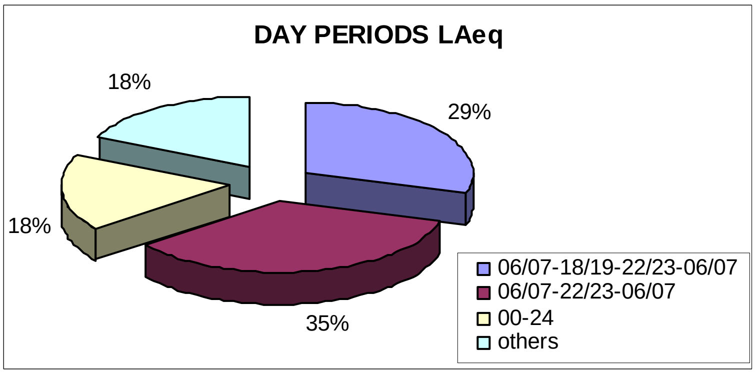


</td></tr>
<tr><td>CONCLUSIONS</td><td>- In most CEDR member states, noise limits have a legal status.
- Regarding the status of the noise limits, there is hardly any difference between the new and (the modification of an) existing national road.</td></tr>
<tr><td>REMARKS</td><td>In most Scandinavian countries, noise limits do not have legal status, but the status of their guidelines is more or less the same.</td></tr>
</table>

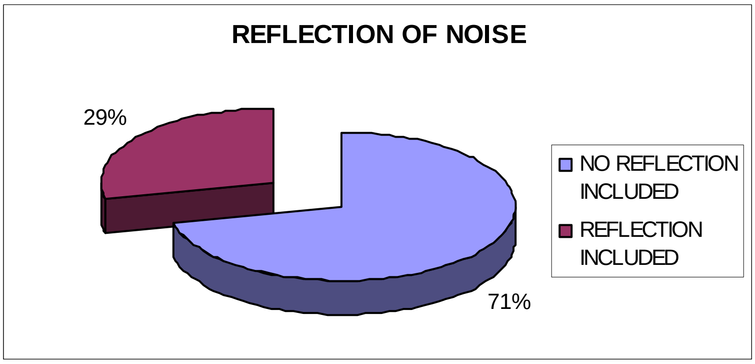
TOPIC 1.1	NOISE AND NATIONAL ROAD PLANNING
QUESTION 1.1.2.b	Are there conditions where you do not have to comply with these limits (clarify these conditions)?
EXPLANATION	There may be circumstances where the NRA does not have to respect the noise limits. In those cases where the NRA always has to respect noise limits, the answer is NO. In those cases where there are subsequent conditions, the answer is YES. When the answer is YES, an indication of the subsequent conditions is given.
ANSWERS	
CONCLUSIONS	- In more than half of CEDR member states, the NRA always has to respect noise limits along new and existing national roads. - In those cases where there are conditions where the NRA does not have to respect the noise limits, these conditions relate to the cost-effectiveness of noise measures or the increase in noise levels (e.g. in the case of an existing national road) due to the road project, especially in urban or alpine areas.

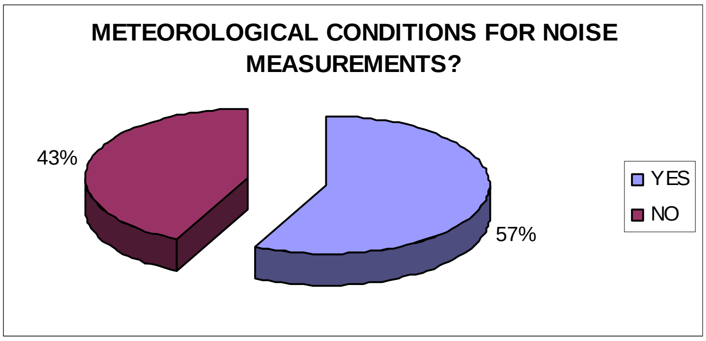
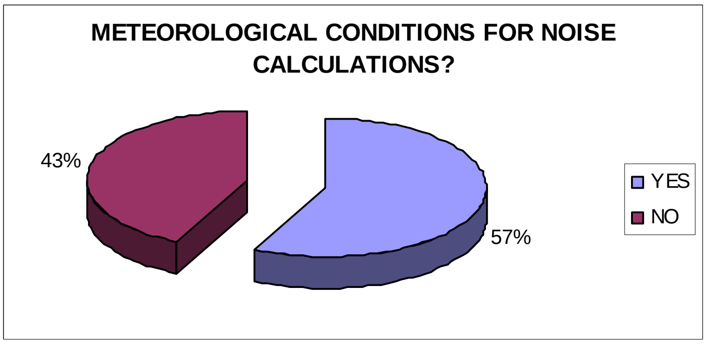
TOPIC 1.1	NOISE AND NATIONAL ROAD PLANNING
QUESTION 1.1.3	Do these limits apply only to the road network managed by your National Road Authority, or do they apply to any road authority?
EXPLANATION	The noise limits for national roads can be different from noise limits for other roads. However, it is also possible that there is no difference between the two limits, which means that noise limits are the same for all kind of roads.
ANSWERS	
CONCLUSIONS	The legal noise limits are the same for all kind of roads in most CEDR member states.

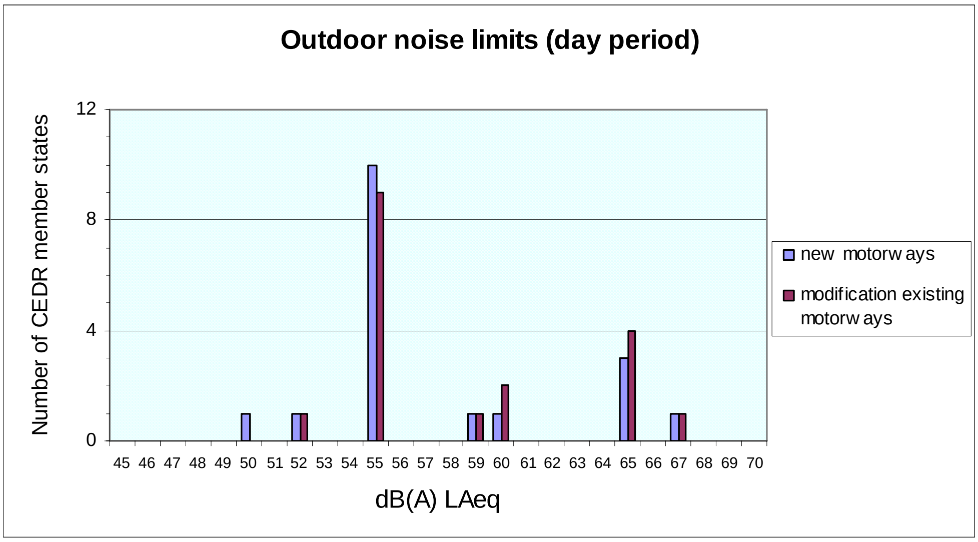
TOPIC 1.2	**NOISE INDICATORS**
QUESTION 1.2.1	Do these limits apply to the noise contribution of the road or to the overall noise (all sources considered) at the assessment location (e.g. houses, recreational areas (urban, rural), summer cottages, schools, offices)?
EXPLANATION	Noise-sensitive locations like houses often have to deal with noise from different noise sources. Noise from traffic on national roads is one source, but there may be other noise sources such as railways, industry, and noise from traffic on other roads. This question deals with the possible cumulation of noise from different sources.
ANSWERS	
CONCLUSIONS	- In most CEDR member states, noise at noise-sensitive locations is determined by noise from national roads only. - In some countries, accumulation of noise from other noise sources is taken into account.

TOPIC 1.2	**NOISE INDICATORS**
QUESTION 1.2.2.a	What noise indicators are used to express the limits? Please specify: - the type of indicator (L_{Aeq}, LA_{max}, L_{den}, percentile, etc.) - the periods.
EXPLANATION	Several indicators can be used to calculate or measure noise. Most noise indicators use specific periods of a full day to calculate or measure noise. In the European Noise Directive (END), for instance, these periods are: - the day period: from 07.00 to 19.00; - the evening period: from 19.00 to 23.00 (member states may, however, shorten the evening period by one or two hours and lengthen the day and/or night period accordingly); - the night period: from 23.00 to 07.00. All three periods combined and provided with an extra 5 dB for the evening period and an extra 10 dB for the night period, result in the default END equation for L_{den}. $$L_{den} = 10\lg\frac{1}{24}\left(12*10^{\frac{L_{day}}{10}} + 4*10^{\frac{L_{evening}+5}{10}} + 8*10^{\frac{L_{night}+10}{10}}\right)$$ There are, however, other noise indications and other specifications of the periods in use.
ANSWERS	 

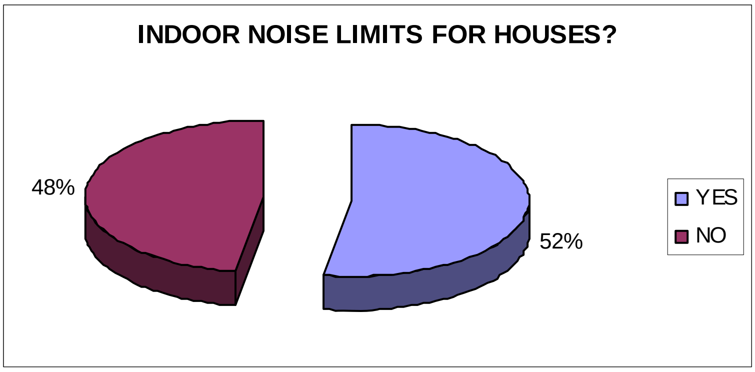
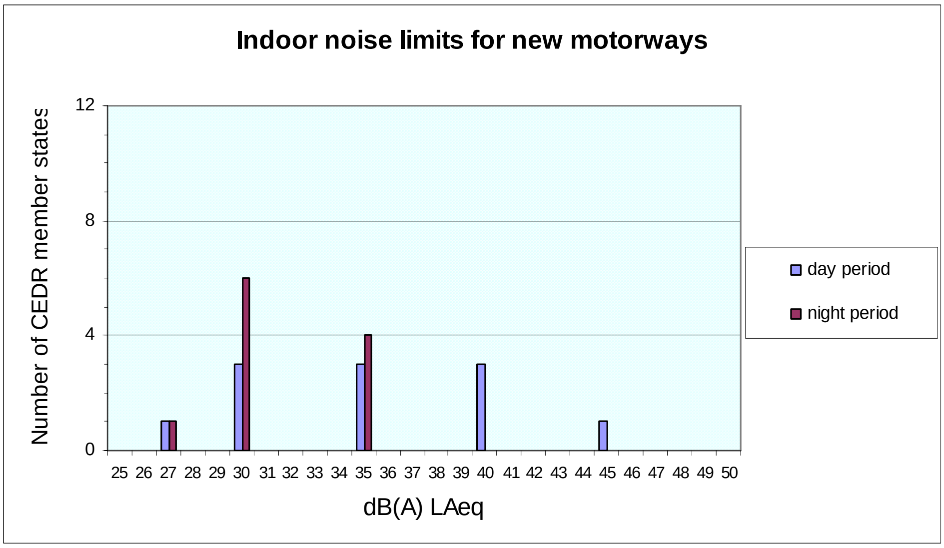
CONCLUSIONS	- The noise indicator most widely used in CEDR member states is the L_{Aeq}. - Several CEDR member states already use the noise indicator L_{den} according to the END; in others countries, the change from L_{Aeq} to L_{den} is scheduled. - There is a considerable difference in the specifications for the periods when using the L_{Aeq} indicator. Most countries divide the full day into three periods, while others use two periods. Some use a period of 24 hours (L_{Aeq},24h). - The fact that different noise indicators or different day periods are used makes it very difficult to compare European noise levels. A 50 dB L_{den} is not the same as a 50 dB L_{Aeq} in the period 07.00-19.00.
REMARKS	- Several countries use more than one noise indicator. - In some countries, the change from L_{Aeq} to L_{den} is scheduled.

TOPIC 1.2	**NOISE INDICATORS**
QUESTION 1.2.2.b	Please specify: - the assessment location (indoors, outdoors), - for outdoor limits: does the noise level include reflection from the building façade?
EXPLANATION	The first question is about the assessment location. The assessment location is the point where the noise level is calculated or measured. The noise level at the assessment point will be compared with the noise limit to determine whether or not the noise limit is exceeded. It is important to know whether these points are inside or outside buildings. The second question deals with the noise reflected at the façade of the building under consideration. As a general rule, this implies a 3-dB correction for noise calculations. Computer models that are used to calculate noise levels can take the reflection of noise into account, but can also neglect noise reflection and consider incident noise only.
ANSWERS	
CONCLUSIONS	- All CEDR member states have assessment locations outside noise-sensitive buildings. The outdoor assessment point can be at different heights. - Several countries have both outdoor and indoor assessment points. - As for the reflection from building façades, most countries do not take reflection into account. This means that when calculating noise levels, only incident noise is relevant.
REMARKS	In the Netherlands, the result of a measured noise level in front of a façade is the measurement minus 3 dB (because of building façade reflection).

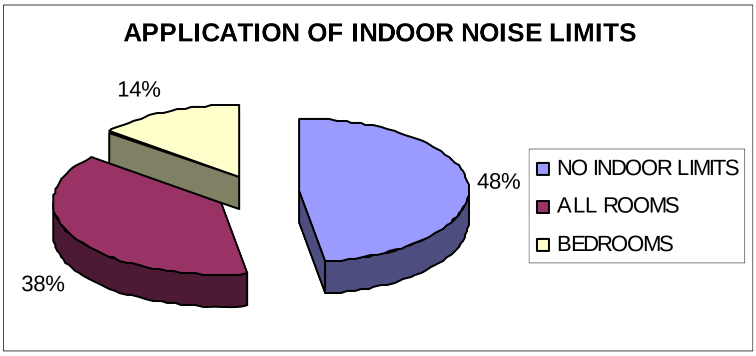
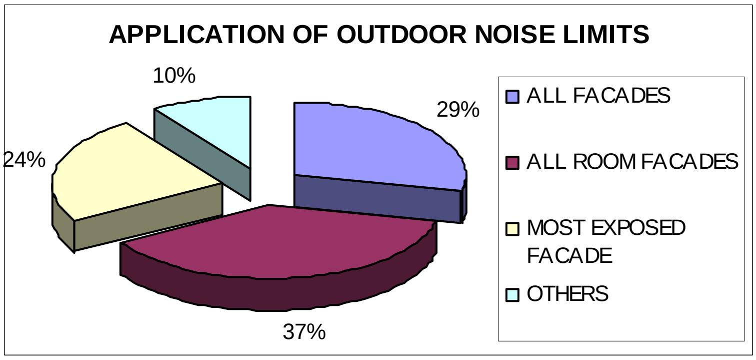
TOPIC 1.2	**NOISE INDICATORS**
QUESTION 1.2.3	Are the meteorological conditions specified in your limits? If so, which meteorological conditions are considered for the noise level assessment? (e.g. neutral – homogeneous atmosphere ; conditions favourable to propagation, sometimes referred to as “downwind” ; long-term conditions, i.e. a combination of several conditions according to their occurrences; etc.)
EXPLANATION	Among other factors, the propagation of noise depends on meteorological conditions. Conditions like downwind or upwind, for instance, will have a considerable effect on noise levels. Noise calculation models can take into account certain meteorological conditions, but they can also neglect these influences. The same goes for noise measurements. Rain or wind direction, for instance, will influence the results of a noise measurement. The effect of meteorological conditions on noise measurements can be minimized by formulating specific meteorological conditions during the noise measurements.
ANSWERS	 
CONCLUSIONS	- The way meteorological conditions are taken into account differs throughout the CEDR member states. In more than half of CEDR member states, noise measurements and calculations deal with meteorological conditions; in the others, they do not. - The difference in dealing with meteorological conditions does not simplify the European comparison of noise levels.
REMARKS	In the Netherlands, calculations and measurements use a correction term (Cm) based on: Cm = - (3.5 - 35*((Hb+Hw)/R)) if R > 10*(Hb+Hw), otherwise Cm = 0, with: - R: distance between calculation point and road, - Hb: height of the noise source above the mean local surface level in the noise source area (if Hb<0, Hb=0) - Hw: height of calculation point above the mean local surface level in the calc. point area (if Hw<0, Hw=0)

TOPIC 1.3	**NOISE LIMITS**
QUESTION 1.3.1.a	Please state the **outdoor** limits for each situation considered (new road / modification / existing road, kind of premises, period, etc.)
EXPLANATION	To see whether or not there is a noise problem along a national road, calculated or measured noise levels have to be compared with the noise limits from legislation, policies, or guidelines. This question deals with the **outdoor** noise limits for noise-sensitive buildings, mostly houses or dwellings. To make comparison possible, it is necessary not only to give figures, but also the noise indicator and the used time period(s).
ANSWERS	 For the complete table with outdoor noise limits for new and (the modification of) existing national roads, see annex 2.
CONCLUSIONS	- Almost all CEDR member states have L_{Aeq} outdoor noise limits for the day and night period. - For new national roads the L_{Aeq} outdoor noise limit for the day period varies between 50 and 67 dB(A). - The most common outdoor limit is 55 dB(A) L_{Aeq} for the period 06.00/07.00–18.00/22.00. 65 dB(A) L_{Aeq} is also used as a limit. - In the event of the modification of an existing national road, the L_{Aeq} outdoor noise limits for the day period are almost the same as for new national roads. - For existing national roads, not all CEDR member states have legal L_{Aeq} outdoor noise limits. In those cases where they have, outdoor noise limits for existing national roads are often the same as for the new national roads or the modification of existing national roads. In those cases where they do not have legal outdoor noise limits, some countries have policy goals.

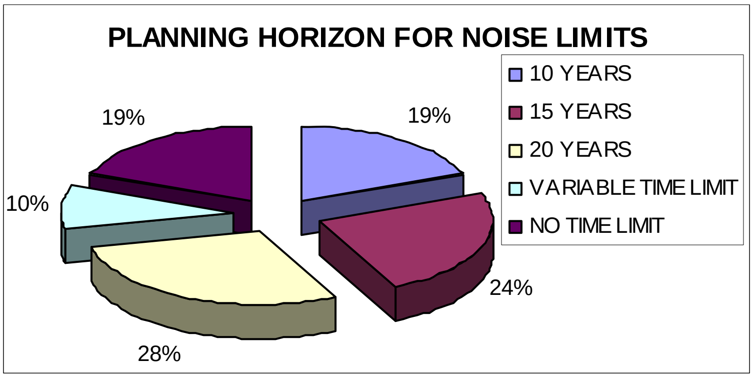
	- Most CEDR member states also have L_{Aeq} noise limits for the night period. Often these night limits are 5 or 10 dB(A) lower than the limits for the day period. - The noise limits for the night period vary between 45 and 55 dB(A) L_{Aeq}. The most common outdoor night limit is 45 dB(A) L_{Aeq} for the period 22.00–06.00. - Some countries use L_{den} as the indicator for their noise limits. For new national roads, outdoor noise limits based on L_{den} range from 48 to 60 dB. The most common L_{den} outdoor limit for new national roads is 55 dB. - In general, it is not easy to compare the noise limits in CEDR member states. One must always keep in mind the difference between the noise indicators L_{Aeq} and L_{den}. Because there are different definitions of the L_{Aeq} time periods, there are also different relationships between L_{den} and L_{Aeq}. In Denmark for instance they use the equation: $L_{den} = L_{Aeq}$,24h +3. In the Netherlands, in practise, they use the equation: $L_{den} = (L_{Aeq}$,night+10) –2. In the CEDR member states using the British calculation method (Calculation of Road Traffic Noise: CRTN), the relationship between their usual $L_{A10,18h}$ and the new L_{den} is more complicated (see remarks). The different definitions of the time periods, the different ways of dealing with meteorological conditions, reflection from façades, and other calculation or measurement characteristics, make it difficult to compare standard noise limits. In short, although all noise limits of 55 dB(A) might initially look the same, they can, in fact, be quite different. - To sum up, the most frequent standard noise limits for new national roads are: 55 dB(A) L_{Aeq} during the day period; 45 dB(A) L_{Aeq} during the night period; 55 dB(A) L_{den}. For (the modification of) existing national roads, these noise limits are the same in most CEDR member states.
REMARKS	In several countries, there are circumstances in which the standard noise limits are exchanged for other, higher ones. In town centres, for instance, noise limits can be higher than standard limits. For the extensive list of these exceptions and differences, see the remarks in annex 1. Based on the equations given by Abbott & Stephenson in their DEFRA report from 2006 called 'Method for converting the UK road traffic noise index $L_{A10,18h}$ to the EU noise indices for road noise mapping', one can make the following relation between $L_{Aeq,16h}$ and L_{den}: $L_{den} = L_{Aeq,16h + 5}$.

TOPIC 1.3	**NOISE LIMITS**
QUESTION 1.3.1.b	Please state the **indoor** limits for each situation considered (new road / modification / existing road, kind of premises, period, etc.)
EXPLANATION	To see whether or not there is a noise problem along a national road, calculated or measured noise levels have to be compared with the noise limits from legislation, policies, or guidelines. This question deals with the **indoor** noise limits for noise-sensitive buildings, mostly houses or dwellings. To make comparison possible, it is necessary not only to give figures, but also the noise indicator and the used time period(s).
ANSWERS	  For the complete table with indoor noise limits for new and the modification of existing national roads, see annex 3.
CONCLUSIONS	- About half of CEDR member states have indoor noise limits. - Most indoor noise limits are based on the L_{Aeq} indicator. In a few countries the L_{den} indicator is used. - The L_{Aeq} indoor limits for the day period vary between 27 and 45 dB(A) for new national roads. Most widely used are the indoor limits of 30, 35, and 40 dB(A) L_{Aeq}. - The L_{Aeq} indoor limits for the night period are 5 to 10 dB(A) lower than for the day period.

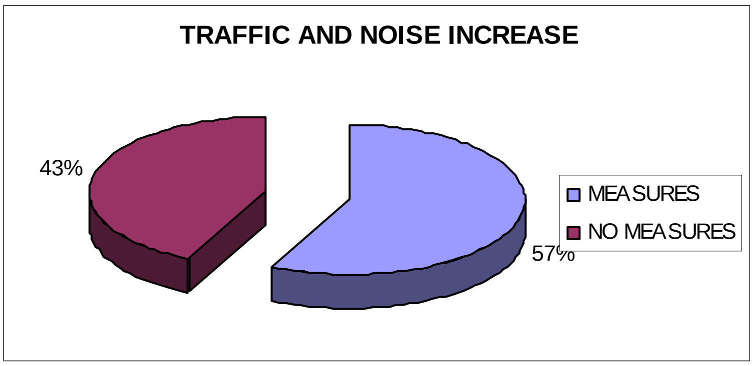
	- In those cases where existing national roads are modified, indoor noise limits are the same in most countries. This also applies to existing national roads. - As is the case with the outdoor limits, it is not easy to compare the indoor noise limits in CEDR member states.
REMARKS	In several countries there are circumstances where standard noise limits are exchanged for other, higher ones. In those cases where new houses are built along national roads, for instance, indoor noise limits can be lower than the standard.

TOPIC 1.3	**NOISE LIMITS**
QUESTION 1.3.2	Do the indoor noise limits apply to all rooms or only some of them (e.g. bedrooms for night-time limits)? Do the outdoor noise limits apply to all room façades or only some of them?
EXPLANATION	The application of the indoor and outdoor limits is often restricted. In the case of indoor limits, it is a question of those rooms inside the building (house) that are considered noise sensitive according to the applicable legislation, policies, or guidelines. The same can be said for outdoor limits, because legislation, policies, or guidelines may differentiate between the façades of a building.
ANSWERS	 

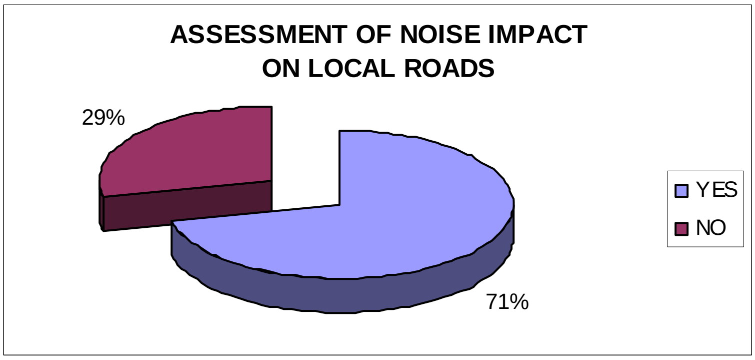
CONCLUSIONS	- Half of CEDR member states have indoor noise limits; in most cases they are valid for all rooms inside a house. In some countries the application of indoor limits is restricted to bedrooms. - As for the outdoor limits, the application of outdoor noise limits varies greatly. In most cases, they are valid for all façades with a bedroom or living room behind the façade. Others countries apply their outdoor limits to all façades of the most exposed façade.

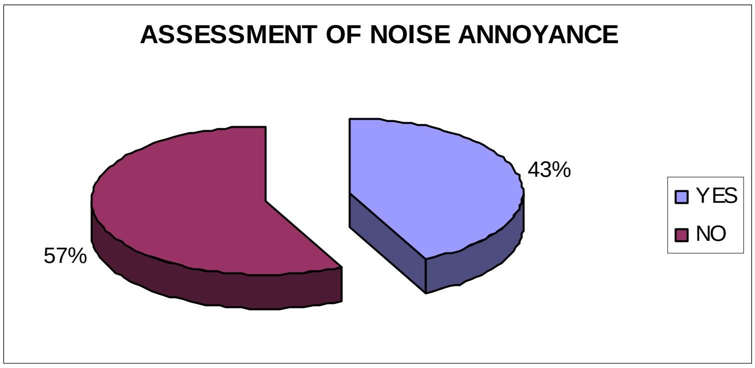
TOPIC 1.3	**NOISE LIMITS**
QUESTION 1.3.3	For new and modified national roads: Do these limits apply only when the road is opened to traffic, during a given period after it is opened to traffic, or is there no time limit? What is the planning horizon? What happens if traffic increases faster than predicted due to traffic development?
EXPLANATION	When a new national road is built or an existing one is modified, the question of the planning horizon (or point of time in the future) used to apply noise limits and to define noise measures in cases where noise limits are exceeded arises. For instance, one can take the (traffic) situation 10 years after opening as representative. Noise measures, like barriers and silent pavements, are applied before opening in order to remain within noise limits at a certain moment in time (in this example, 10 years after opening). To make such an approach effective, accurate traffic predictions are essential. In cases where existing national roads are modified, it is also possible to take the situation at opening as representative when checking noise limits and defining noise measures.
ANSWERS	

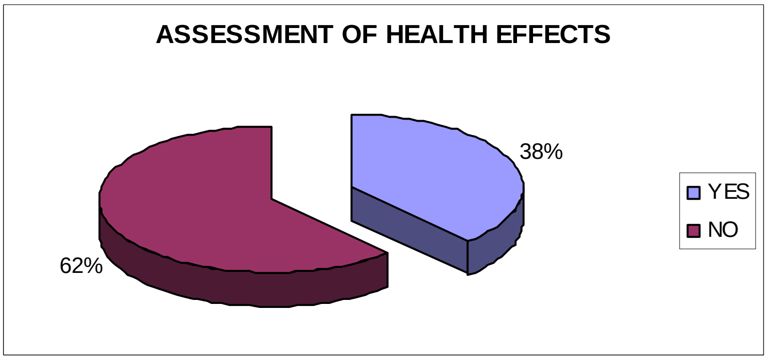
CONCLUSIONS	- Most CEDR member states take into account the future increase of traffic before a national road is opened. This planning horizon is set at different moments in time, it varies from 10 to 30 years after opening. - The most common planning horizon is 20 years. - There is no difference between the planning horizon for new national roads and the planning horizon for existing national roads that have to be modified.

TOPIC 1.3	**NOISE LIMITS**
QUESTION 1.3.4	How do you handle traffic increase and therefore noise increase on existing roads?
EXPLANATION	At the opening of a new or modified national road, noise measures are taken to ensure that noise limits are respected at a given moment in time (e.g. 10 years after opening). Everything depends on accurate traffic forecasting. If the traffic increases in line with the forecast, 10 years after opening, noise levels will be the same as originally calculated. However, what happens if traffic increases more or faster than predicted and noise levels 10 years after opening are much higher than originally calculated? In those cases where traffic increases much more slowly than predicted, the moment where noise limits are exceeded will be several years beyond the period of 10 years. One way or the other, there will always be a moment in time where the originally calculated noise levels are exceeded and the original noise measures are not sufficient. Regarding the traffic flow, there might be no need to modify the existing national road or to build a new one. The only problem is the constant increase of traffic and noise levels. In legislation, policies, or guidelines, there might be ways of dealing with noise problems due to the steady increase of traffic in situations where the NRA does not have any intention of building a new national road or modifying an existing one. This question asks what happens in such a situation.
ANSWERS	

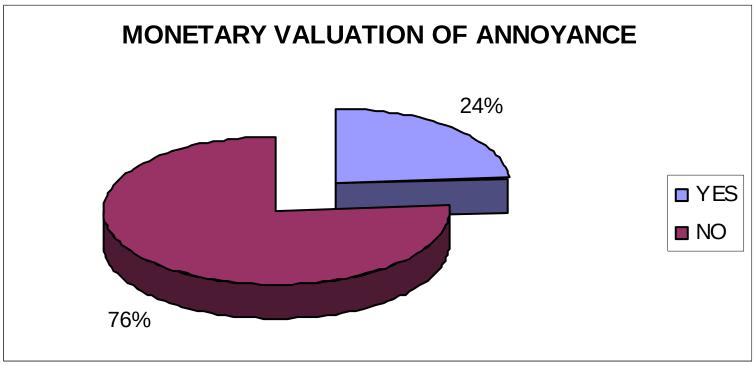
CONCLUSIONS	- In most CEDR member states, measures are taken if traffic increases more than forecast and noise limits are exceeded without any need to modify the existing national road. - Some countries do not take measures as long as the existing national road is not modified, even when traffic increases more than forecast and noise limits are exceeded.
REMARKS	In those cases where noise levels exceed a certain high level, like 65 dB L_{den}, some countries take noise abatement measures along existing national roads.

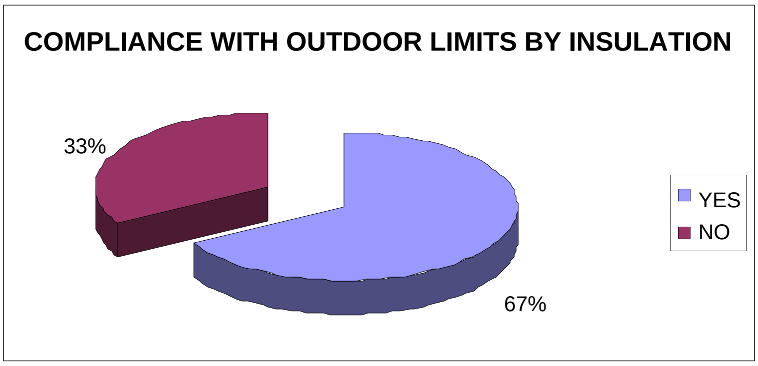
TOPIC 1.4	**ENVIRONMENTAL IMPACT ASSESSMENT (EIA)**
QUESTION 1.4.1	Does the EIA have to assess the noise impact of a new road project on the existing road network (induced or redirected traffic, changed speed limits etc.)? If increased noise is predicted on the existing network, must anything be done to lower it – who must pay?
EXPLANATION	Building a new national road or modifying an existing one has an impact on the traffic using the underlying road network. The traffic on the underlying network can either increase or decrease. The change in traffic flow has implications for noise levels along the underlying road network. This change might be an issue in the environmental impact assessment. The second question deals with noise measurements along the underlying road network. If necessary, somebody must pay for these measures.
ANSWERS	
CONCLUSIONS	- In most CEDR member states, the EIA process and report deal with the effect of the shift in traffic using the underlying road network on noise levels along the underlying road network. In some cases, there are restrictions regarding the effect in dB(A) on the noise levels along the underlying road network or the size of the area investigated. - In most cases, the national road authority pays for any necessary noise measures along the underlying road network.
REMARKS	In the Netherlands, it is only in cases where the traffic increase will result in a noise increase of 2 dB or more along the local roads that the National Road Authority might pay for noise measures.

TOPIC 1.4	**ENVIRONMENTAL IMPACT ASSESSMENT (EIA)**
QUESTION 1.4.2	Must the EIA include an assessment of the noise-annoyance effects of the national road project? If so, what are the dose-effect relations used?
EXPLANATION	In the EIA process and report, noise levels at houses are a major issue. There may, however, be other issues. Noise annoyance is one of the possible issues to be investigated in an EIA report. Annoyance has been defined as 'a feeling of displeasure evoked by a noise' and 'any feeling of resentment, displeasure, discomfort and irritation occurring when a noise intrudes into someone's thoughts and moods or interferes with activity'. This question not only asks whether or not EIA deals with noise annoyance, but also deals with the dose-effect relations used to investigate this issue.
ANSWERS	
CONCLUSIONS	- In almost half of CEDR member states, noise annoyance is an issue that has to be investigated when drafting an EIA report. - The manner of handling noise annoyance in EIA reports differs considerably. There is no generally accepted way of dealing with noise annoyance in an EIA report, although some countries use the research of Miedema (TNO, the Netherlands) for dose-effect relations.
REMARKS	Denmark uses the following equation for dose-effect relations: SBT = 0.11*Ba+0.22*Bb+0.45*Bc+0.93*Bd+1.92*Be, where: SBT is noise impact value; B(a) stands for number of houses with noise levels 55–59 dB(A); B(b) stands for number of houses with noise levels 60–64 dB(A); B(c) stands for number of houses with noise levels 65–69 dB(A); B(d) stands for number of houses with noise levels 70–74 dB(A) and B(e) stands for number of houses with noise levels >= 75 dB(A).

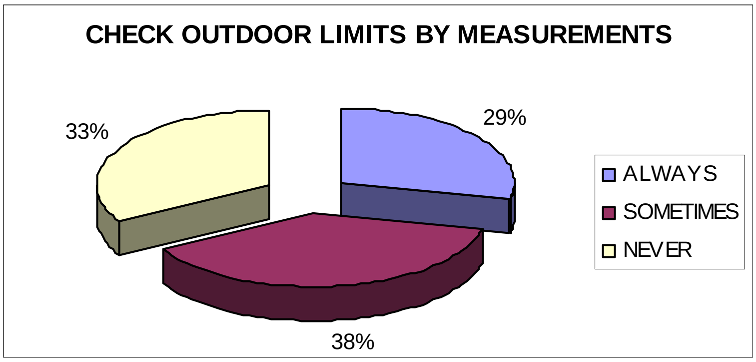
TOPIC 1.4	**ENVIRONMENTAL IMPACT ASSESSMENT (EIA)**
QUESTION 1.4.3	Must the EIA include an assessment of the noise-related health effects of the national road project? If so, what are the dose-effect relations used?
EXPLANATION	In the EIA process and report, noise levels at houses are a major issue. There may, however, be other issues. Noise is also a serious health hazard. The WHO recognizes community noise, including traffic noise, as a serious public health problem. Health effects are one of the possible issues to be investigated in an EIA report. The second part of this question deals with the dose-effect relations between noise and health.
ANSWERS	
CONCLUSIONS	- In several CEDR member states, health effects are an issue in EIA reports. - In those cases where health effects are investigated in EIA reports, there are problems regarding dose-effect relations. There is no generally accepted methodology regarding dose-effect relations.

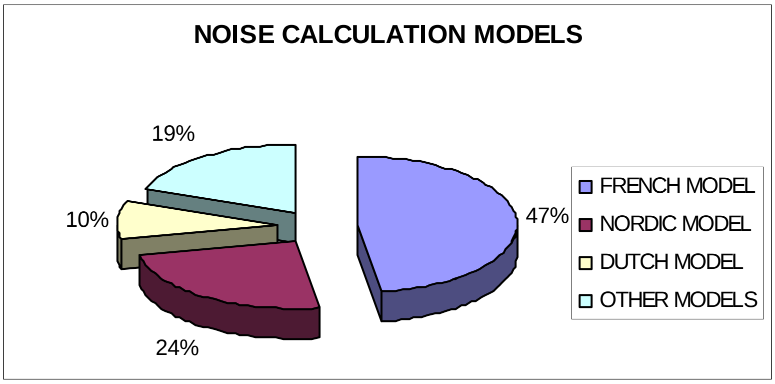
TOPIC 1.4	**ENVIRONMENTAL IMPACT ASSESSMENT (EIA)**
QUESTION 1.4.4	Must the EIA include a monetary valuation of the annoyance due to noise before and after the building of the national road project? If so, how is the noise value estimated?
EXPLANATION	In the EIA process and report, noise levels at houses are a major issue. There may, however, be other issues. Monetary valuation of annoyance (or traffic noise in general) is one of those issues. This is a rapidly developing area and studies are being taken forward to obtain monetary values for noise, like residential property value or health effects. The second part of this question deals with the dose-effect relations for monetary valuation.

ANSWERS	
CONCLUSIONS	- In some CEDR member states, monetary valuation is an issue in EIA reports. - In those cases where monetary values are investigated in an EIA report, there are problems regarding dose-effect relations. There is no generally accepted methodology.
REMARKS	In France, the valuation of annoyance includes a depreciation rate that is applied to the rental value of a dwelling.

TOPIC 1.5	**MISCELLANEOUS: outdoor limits and insulation**
QUESTION 1.5.1	Is it allowed to comply with the outdoor noise limits by adding additional acoustic insulation to building facades? If so, how is the required insulation calculated? (in other words: what is the corresponding objective for the indoor noise level?)
EXPLANATION	There may be circumstances where it is not possible or not cost-effective to use noise measures (such as silent pavements or noise barriers) to remain within out-door noise limits. Sometimes the legislation, policy, or guidelines allow for the use of insulation as a noise-reducing measure to solve problems with outdoor noise limits by respecting indoor limits.
ANSWERS	
CONCLUSIONS	- In most CEDR member states, it is possible to use sound insulation to solve problems with outdoor noise limits as long as indoor noise limits are re-spected. - Several countries have restrictions regarding the use of sound insulation to comply with the outdoor limits.

REMARKS	Examples of the restrictions are: - in Estonia, the noise level in bedrooms at night must be 30 dB(A) $L_{pA,max}$ (23-07); - in Sweden, at least one façade has to be below the outdoor limit; - in Germany in case noise barriers are disproportional; - in France, the indoor level must be 25 dB(A) lower than the outdoor limit; - in Finland, house owners can use financial compensation to improve insulation.

TOPIC 1.5	**MISCELLANEOUS: noise measurements**
QUESTION 1.5.2	Is compliance with the limits checked by on-site measurements? If so, what is the consequence if the measured noise level exceeds the limit?
EXPLANATION	This question focuses on the difference between noise calculations and noise measurements. To check whether or not noise levels are in accordance with the noise limits, noise measurements can be taken. However, checks are not always necessary. It all depends on how this issue is formalised in legislation, policies, or guidelines. In cases where noise measurements are carried out, the question arises as to what happens if the measured noise level exceeds the noise limit.
ANSWERS	
CONCLUSIONS	- The issue of fulfilling noise limits by checking noise levels using noise measurements varies throughout the CEDR member states. In several countries, noise level are never checked, while in others, they are on occasion checked. In some countries, noise measurements are always taken to check noise calculations. - In almost all cases, if the measured noise level exceeds the noise limit, additional noise measures are taken.

TOPIC 1.5	**MISCELLANEOUS: noise models**
QUESTION 1.5.3	Which method or model is used for prediction of noise levels?
EXPLANATION	National computer models are used to calculate and forecast noise levels. The models used in CEDR member states vary, so the question is simple: which one.
ANSWERS	
CONCLUSIONS	- Several different national computer models are used to calculate and predict noise levels in CEDR member states. - The French model (NMPB-routes-96) is the most frequently used model; it is used in 10 CEDR member states. The Nordic model (Prediction model revised 1996) is used in five countries. Only a limited number of countries use the Austrian, British, Dutch, or German models.

Annex 2: Detailed information on outdoor noise limits along national roads

Question 1.3.1.a	**Outdoor noise limits, goals, and guidelines (for buildings (houses)):**			
Country:	*New motorways*	*Modification existing motorways*	*Existing motorways*	
Austria: day	55 dB(A) LAeq (06-19)	60 dB(A) LAeq (06-19)	60 dB Lden (1)	AT
Austria: night	45 dB(A) LAeq (22-06)	50 dB(A) LAeq (22-06)	50 dB(A) LAeq (22-06)	AT
Belgium (NL): day	65 dB(A) LAeq (07-19)	65 dB(A) LAeq (07-19)	65 dB(A) LAeq (07-19)	BE
Denmark: full day	50 dB(A) LAeq (00-24) (2)	50 dB(A) LAeq (00-24) (2)	65 dB(A) LAeq (00-24)	DK
Denmark: full day	55 dB(A) LAeq (00-24) (3)	55 dB(A) LAeq (00-24) (3)	65 dB(A) LAeq (00-24)	DK
Estonia: day	60 dB(A) LpA,eq,T (07-23) (4)	60 dB(A) LpA,eq,T (07-23) (4)	no limits	EE
Estonia: night	55 dB(A) LpA,eq,T (23-07) (5)	55 dB(A) LpA,eq,T (23-07) (5)	no limits	EE
Finland: day	55 dB(A) LAeq (07-22)	55 dB(A) LAeq (07-22)	55 dB(A) LAeq (07-22)	FI
Finland: night	50 dB(A) LAeq (22-07) (6)	50 dB(A) LAeq (22-07) (6)	50 dB(A) LAeq (22-07) (6)	FI
France: day	60 dB(A) LAeq (06-22) (7) (8)	60 dB(A) LAeq (06-22) (10)	for instance: 68 dB(A) Lden (12)	FR
France: night	55 dB(A) LAeq (22-06) (7) (9)	55 dB(A) LAeq (22-06) (11)	for instance: 62 dB(A) LAeq (12)	FR
Germany: day	59 dB(A) LAeq (06-22) (13)	59 dB(A) LAeq (06-22) (13)	70 dB(A) LAeq (06-22) (15)	DE
Germany: night	49 dB(A) LAeq (22-06) (14)	49 dB(A) LAeq (22-06) (14)	60 dB(A) LAeq (22-06) (16)	DE
Greece: day	67 dB(A) LAeq (08-20)	67 dB(A) LAeq (08-20)	67 dB(A) LAeq (08-20)	GR
Iceland: full day	55 dB(A) LAeq (00-24)	65 dB(A) LAeq (00-24)	no limits	IS
Ireland	60 dB(A) Lden (17)	60 dB(A) Lden (17)	no limits	IE
Italy: day	65 dB(A) LAeq (06-22) (18)	65 dB(A) LAeq (06-22) (18)	70 dB(A) LAeq (06-22) (19)	IT
Italy: night	55 dB(A) LAeq (22-06) (18)	55 dB(A) LAeq (22-06) (18)	60 dB(A) LAeq (22-06) (20)	IT
Latvia: day	55 dB(A) LAeq (07-19) (21)	55 dB(A) LAeq (07-19) (21)	55 dB(A) LAeq (07-19) (21)	LV
Latvia: evening	50 dB(A) LAeq (19-23) (21)	50 dB(A) LAeq (19-23) (21)	50 dB(A) LAeq (19-23) (21)	LV
Latvia: night	45 dB(A) LAeq (23-07) (21)	45 dB(A) LAeq (23-07) (21)	45 dB(A) LAeq (23-07) (21)	LV
Lithuania: day	65 dB(A) LAeq (06-18) (21)	65 dB(A) LAeq (06-18) (21)	65 dB(A) LAeq (06-18) (21)	LT
Lithuania: even.	60 dB(A) LAeq (18-22) (21)	60 dB(A) LAeq (18-22) (21)	60 dB(A) LAeq (18-22) (21)	LT
Lithuania: night	55 dB(A) LAeq (22-06) (21)	55 dB(A) LAeq (22-06) (21)	55 dB(A) LAeq (22-06) (21)	LT
Luxembourg	to be determined	to be determined	to be determined	LU
Netherlands: f.day	48 dB Lden (preferred limit) (22)	53 dB Lden (preferred limit) (22)	65 dB Lden (23)	NL
Netherlands: f.day	58 dB Lden (highest limit) (22)	68 dB Lden (highest limit) (22)	65 dB Lden (23)	NL
Norway: full day	55 dB(A) Lden (24)	55 dB(A) Lden (24)	no limits	NO
Poland: day	55 dB(A) LAeq (06-22) (25) (26)	55 dB(A) LAeq (06-22) (25) (26)	55 dB(A) LAeq (06-22) (25) (26)	PL
Poland: night	45 dB(A) LAeq (22-06) (25) (27)	45 dB(A) LAeq (22-06) (25) (27)	45 dB(A) LAeq (22-06) (25) (27)	PL
Portugal: day	55 dB(A) LAeq (07-22) (28)	55 dB(A) LAeq (07-22) (28)	55 dB(A) LAeq (07-22) (28)	PT
Portugal: night	45 dB(A) LAeq (22-07) (29)	45 dB(A) LAeq (22-07) (29)	45 dB(A) LAeq (22-07) (29)	PT
Spain: day	not yet fixed	not yet fixed	not yet fixed	ES
Spain: night	not yet fixed	not yet fixed	not yet fixed	ES
Slovenia: full day	55 dB(A) Lden (30) (31) (32)	55 dB(A) Lden (30) (31) (32)	55 dB(A) Lden (30) (31) (32)	SI
Sweden: full day	55 dB(A) LAeq (00-24) (33)	55 dB(A) LAeq (00-24) (33)	55 dB(A) LAeq (00-24) (33)	SE

REMARKS:

1. In AT: L_{den} periods are 06-19, 19-22, and 22-06
2. In DK: in recreational areas in the open country (holiday house areas, green areas and camp sites)
3. In DK: in residential areas or public institutions (hospitals and schools)
4. In EE: in new planning areas, 55 dB(A)
5. In EE: in new planning areas, 45 dB(A)
6. In FI: when planning new housing areas, 45 dB(A)
7. In FR: for dwellings in moderate noise climate zone (<65 dB(A) daytime and <60 dB(A) night-time)
8. In FR: in other cases, 65 dB(A) L_{Aeq} (06-22)
9. In FR: in other cases, 60 dB(A) L_{Aeq} (22-06)
10. In FR: when traffic noise before modification is lower than limit for new roads, otherwise 65 dB(A)
11. In FR: when traffic noise before modification is lower than limit for new roads, otherwise 60 dB(A)
12. In FR: national noise policy on 'hot spots': above certain noise levels with different indicators
13. In DE: for housing areas; for urban centres, village areas, and mixed areas: 64 dB(A)
14. In DE: for housing areas; for urban centres, village areas, and mixed areas: 54 dB(A)
15. In DE: for housing areas; for urban centres, village areas, and mixed areas: 72 dB(A)
16. In DE: for housing areas; for urban centres, village areas, and mixed areas: 62 dB(A)
17. In IE: L_{den} periods are 07-19, 19-23, and 23-07
18. In IT: for motorways and main roads in zone of 250 m (competence area)
19. In IT: for motorways and main roads in zone of 100 m (A-zone); in B-zone (150 m) 65 dB(A)
20. In IT: for motorways and main roads in zone of 100 m (A-zone); in B-zone (150 m) 55 dB(A)
21. In LV and LT: also maximum noise levels (5 dB(A) higher)
22. In NL: L_{den} periods are 07-19, 19-23, and 23-07
23. In NL: for existing roads policy goal
24. In NO: L_{den} periods are 07-19, 19-23, and 23-07
25. In PL: for one-family dwellings; in case of multi-family houses 5 dB(A) higher
26. In PL: in town centres, 65 dB(A) L_{Aeq} (06-22)
27. In PL: in town centres, 55 dB(A) L_{Aeq} (22-06)
28. In PT: in noise-sensitive zones, otherwise 65 dB(A) L_{Aeq} (07-22)
29. In PT: in noise-sensitive zones, otherwise 55 dB(A) L_{Aeq} (22-07)
30. In SI: L_{den} periods are 06-18, 18-22, and 22-06
31. In SI: for quiet regions; other regions have higher limits
32. In SI: there are limits for $L_{Aeq,day}$ (06-18) 55 dB(A), evening (18-22) 50 dB(A) and night (22-06) 45 dB(A)
33. In SE: there is a limit for $L_{AFmax,outdoor}$ (70 dB(A))

Annex 3: Detailed information on indoor noise limits along national roads

Question 1.3.1.b	**Indoor noise limits, goals, and guidelines (for buildings (houses)):**			
Country:	*New motorways*	*Modification existing motorways*	*Existing motorways*	
Austria	no indoor limits	no indoor limits	no indoor limits	AT
Belgium (NL)	no indoor limits	no indoor limits	no indoor limits	BE
Denmark: full day	30 dB(A) LAeq (00-24) (1)	30 dB(A) LAeq (00-24) (1)	no indoor limits	DK
Estonia: day	40 dB(A) LpA,eq,T (07-23) (2)	40 dB(A) LpA,eq,T (07-23) (2)	40 dB(A) LpA,eq,T (07-23) (2)	EE
Estonia: night	30 dB(A) LpA,max (23-07)	30 dB(A) LpA,max (23-07)	30 dB(A) LpA,max (23-07)	EE
Finland: day	35 dB(A) LAeq (07-22)	35 dB(A) LAeq (07-22)	35 dB(A) LAeq (07-22)	FI
Finland: night	30 dB(A) LAeq (22-07)	30 dB(A) LAeq (22-07)	30 dB(A) LAeq (22-07)	FI
France	no indoor limits	no indoor limits	no indoor limits	FR
Germany	no indoor limits	no indoor limits	no indoor limits	DE
Greece	35 dB(A) LAeq (00-24)	35 dB(A) LAeq (00-24)	35 dB(A) LAeq (00-24)	GR
Iceland	30 dB(A) LAeq (00-24) (3)	40 dB(A) LAeq (00-24) (4)	?	IS
Ireland	no indoor limits	no indoor limits	no indoor limits	IE
Italy	no indoor limits	no indoor limits	no indoor limits	IT
Latvia: day	40 dB(A) LAeq (07-19)	40 dB(A) LAeq (07-19)	40 dB(A) LAeq (07-19)	LV
Latvia: evening	35 dB(A) LAeq (19-23)	35 dB(A) LAeq (19-23)	35 dB(A) LAeq (19-23)	LV
Latvia: night	30 dB(A) LAeq (23-07)	30 dB(A) LAeq (23-07)	30 dB(A) LAeq (23-07)	LV
Lithuania: day	45 dB(A) LAeq (06-18) (5)	45 dB(A) LAeq (06-18) (5)	45 dB(A) LAeq (06-18) (5)	LT
Lithuania: even.	40 dB(A) LAeq (18-22) (5)	40 dB(A) LAeq (18-22) (5)	40 dB(A) LAeq (18-22) (5)	LT
Lithuania: night	35 dB(A) LAeq (22-06) (5)	35 dB(A) LAeq (22-06) (5)	35 dB(A) LAeq (22-06) (5)	LT
Luxembourg	no indoor limits	no indoor limits	no indoor limits	LU
Netherlands: f.day	33 dB Lden	43 dB Lden	(6)	NL
Norway	30 dB(A) Lden	30 dB(A) Lden	42 dB(A) Lekv	NO
Poland	no indoor limits	no indoor limits	no indoor limits	PL
Portugal	no indoor limits	no indoor limits	no indoor limits	PT
Slovenia: day	40 dB(A) Ld	40 dB(A) Ld	40 dB(A) Ld	SI
Slovenia: night	35 dB(A) Ln (7)	35 dB(A) Ln (7)	35 dB(A) Ln (7)	SI
Spain	no indoor limits	no indoor limits	no indoor limits	ES
Sweden	30 dB(A) LAeq (00-24) (8) (9)	30 dB(A) LAeq (00-24) (8) (9)	30 dB(A) LAeq (00-24) (8) (9)	SE

REMARKS:

1 In DK: building regulations require an indoor limit at 30 dB(A) when new houses are build
2 In EE: in new planning areas, 35 dB(A)
3 In IS: for flats only and for summer cottages areas, 45 dB(A)
4 In IS: for flats only and for summer cottages areas, 45 dB(A)
5 In LT: also maximum noise levels (10 dB(A) higher)
6 In NL: in practice there is an outdoor policy goal that implicates an indoor goal of about 45 dB L_{den}
7 In SI: the night level means the highest hourly level in the night period
8 In SE: there is a limit for $L_{AFmax,indoor}$ (45 dB(A))
9 In SE: in cases where indoor noise levels >10 dB(A) above indoor guidelines, action must be taken

Ref: CEDR report 2010/05 TDConstruction2010 / RoadNoise

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