Conférence Européenne des Directeurs des Routes
Conference of European Directors of Roads

CEDR TRANSNATIONAL RESEARCH PROGRAMME 2020

funded by Denmark, Ireland, Netherlands, Norway, Sweden, Switzerland, and the United Kingdom

PROCEEDR
OPTIMISING RESOURCE USE FOR ROADSIDE INFRASTRUCTURES

Practical guideline with a recommendation for industrial stakeholders to assess the use of different materials in roadside infrastructure

Deliverable D1.3 (including also D2.3)

Version 1.0

Date: 19.09.2023

Dissemination level: public

AIT AUSTRIAN INSTITUTE OF TECHNOLOGY

CHALMERS UNIVERSITY OF TECHNOLOGY

ERF

TRL

This page is intentionally left blank

CEDR TRANSNATIONAL RESEARCH PROGRAMME

Call 2020: Resource Efficiency and the Circular Economy

PROCEEDR
OPTIMISING RESOURCE USE
FOR ROADSIDE INFRASTRUCTURES

D1.3 & D2.3 - Practical guideline with a recommendation for industrial stakeholders to assess the use of different materials in roadside infrastructure

Work package / task: WP1 & WP2

Dissemination level of the document: public

Due date of deliverable: 30.06.2023

Actual submission date: 19.09.2023

Author(s) of this deliverable:

Giovanni Brero (European Union Road Federation, ERF)

Marco Conter (AIT Austrian Institute of Technology GmbH)

Reviewer of this deliverable:

Alison Hewitt (TRL Limited)

This page is intentionally left blank

Table of contents

"This project has received funding from the CEDR TRANSNATIONAL ROAD RESEARCH PROGRAMME Call 2020Resource Efficiency and the Circular Economy"

Background

An increasing quantity of **roadside equipment has been installed** over the last few decades. Some are installed at construction, such as vertical signages, lighting columns, gantries (overhead structures that span across the road and support signs, signals, cameras, or other devices). Others such as **noise and safety barriers** cover huge lengths of the road network and may also **involve foundation works**.

Different scenarios have been envisaged about how this equipment will evolve in the future.

As the focus of this document is on noise and safety barriers, the following questions are relevant:

- *How will **electric vehicles reduce** overall noise emissions thus changing the need for erecting **noise barriers alongside the roads**?*
- *Will **autonomous driving** prevent vehicles from deviating from the carriageway thus **minimizing the need for safety barriers**?*

Answers provided by the scientific community confirm that it's unlikely that safety and noise barriers will be unnecessary in the future unless there is a major change in the way we travel or use the road space.

These devices are installed for a variety of **purposes including as safety, information, guidance, control and noise reduction.** They are meant to improve the road conditions and the quality of life for the road users and nearby communities. Unless there is a better alternative that can achieve the same or better outcomes, it is unlikely that these devices would be removed completely. Some could be **integrated with other systems or technologies**, such as smart sensors, wireless communication, or renewable energy sources. Some can be designed to blend in with the natural or urban landscape, or to enhance the aesthetic appeal of the road environment. There is an overarching need for all of them to be made more **durable, efficient, adaptable, or recyclable**.

If vehicles are quieter, fewer noise barriers will be needed but there are some factors to be considered in more detail; according to specific studies, electric and hybrid vehicles are not completely silent, especially at higher speeds. They still produce noise from tires, brakes, wind and other components. Moreover, some electric and hybrid vehicles are required to have sound systems that produce artificial noise at low speeds or when reversing, to alert pedestrians and other road users of their presence. Therefore, **noise barriers might still be useful to reduce the overall noise impact of road traffic** on nearby residents and environment.

However, it is possible that the function or design of noise barriers will change in the future, depending on the development of technology and society. For example, **noise barriers may be integrated with other systems or devices**, such as solar panels, sensors, cameras or communication modules. It is also likely that some noise barriers will be made of new materials or structures that can improve their performance or sustainability. In addition to this, some specific noise barriers may be adapted to different types of roads or vehicles, such as autonomous or connected vehicles.

With regards to **safety barriers,** it may be the case that fewer are needed if autonomous vehicles are prevented from deviating from the road, but there are some factors to consider.

Autonomous vehicles still face many challenges to achieve full automation and widespread adoption including incompatible infrastructure, liability issues, ethical dilemmas, consumer support and awareness, cybersecurity threats and technical limitations.

Therefore, **safety barriers might still be useful to protect autonomous vehicles and other road users from potential hazards or accidents.**

However, changes are anticipated for the function or design of safety barriers in the future, depending on the development of technology and society.

An obvious need is that safety barriers will need to be adapted to cope with different types of roads or vehicles; specifically heavier vehicles that may be digitally connected. which will affect the energy associated with an impact. **Integration with other systems or devices**, such as sensors, cameras or communication modules is foreseen also for safety barriers. It is also highly likely that the use of new materials will be explored to improve their performance or sustainability.

According to these future scenarios, noise or safety barriers may become obsolete or replaced by more advanced or sustainable solutions.

Manufacturers are aware of these future needs and this document may support them in defining strategies for product development and the required resources.

1 Introduction: the PROCEEDR context

The roadside infrastructure of today is equipped with various devices all of which have an impact on the total amount of materials used for road construction. Over the last few decades, the amount of roadside infrastructure installed on road networks has greatly increased. At the same time, roadside infrastructure uses large quantities of natural resources, is a major generator of waste, as well as comprising assets with a lifespan of up to 100 years. Consequently, National Road Authorities (NRAs) decided to take a lead and encourage more responsible use of natural resources and materials, many of which are becoming scarce. Moreover, NRAs have already developed procedures and tools to assess the environmental and/or sustainability performance of construction projects. Hence, there is an incentive for suppliers of roadside equipment and materials to optimize their products and processes according to the requirements demanded and criteria assessed by these tools.

The PROCEEDR project aims to create two **tools** to enable NRAs **to identify innovative and sustainable solutions** to facilitate the transition from **linear to a circular economy** in the field of roadside infrastructure. Achieving a circular economy requires minimising the demand for primary resources and reutilizing resources in high-value applications. NRAs need a wider range of material options to support the transition from a linear to circular economy. At the same time, **critical functional demands and technical performance** requirements such as safety, acoustic, structural and maintenance still need to be met.

New innovative and sustainable options could be bio-based, use renewable resources (such as wood or composites with natural fibres) or use recycled/recyclable materials. Therefore, the scope of the project is to present an **overview of innovative and sustainable solutions in the roadside infrastructure sector, focusing on noise and safety barriers** and provide relevant tools to enable the selection of the most suitable and cost-effective solutions.

Noise barriers are a key asset in road infrastructure for this research project because they are made from a large variety of materials and solutions which varies from the most classical options (wood, concrete, or metallic cassettes) to the most innovative ones (cassettes in recycled PVC, sound-absorbing natural fibres, reed, loam, etc.). The assessment of technical performance is based on tests and calculations according to the product standard EN 14388 where acoustic, structural, safety, fire and durability characteristics are considered. Noise barriers also offer the chance to **explore innovative solutions for foundation works** which are always required for their installation alongside roads. Roughly one-third of the total economic value of the noise barrier is represented by traditional foundation works and alternative solutions, such as ground screws or metallic poles hammered into the ground, can be used instead of concrete kerbs and ground cementation.

Nowadays, the performance of **safety barriers** is assessed according to crash tests of different vehicle types according to the product standard EN 1317-5. Given the high technical constraints to achieve minimum levels of performance required, the use of materials other than steel or concrete has rarely been considered. Timber can be used for safety barriers installed alongside rural roads where lower containment levels are required. Furthermore, for the scope of the present research, considering safety barriers enables us to evaluate the impact of additional materials that could be used for improving the impact of steel or concrete on sustainability. Even a limited improvement achieved by **using new materials and/or improving the corresponding industrial processes** may lead to a significant impact on the overall sustainability of road infrastructure given the extensive use of safety barriers alongside roads, providing the functional properties are satisfied.

Assessing the sustainability of safety barriers must be extended to include the life cycle stages after the production stage.

The software tool being developed within this project will enable comparisons to be made between different installation methods or direct manufacturing techniques for the product on site. An example of this is the new-jersey safety barriers that can either be cast in situ or manufactured in the factory and transported to the installation site.

With reference to noise and safety barriers, special attention should be given to innovative products where both functions are integrated and placed on the market as a unique system. These products have more functional constraints as they need to fulfil requirements set for the two individual systems but may perform better overall in terms of sustainability and may provide opportunities to reduce the number of structures on bridges or land use required for installation at ground level.

Nowadays, the size and complexity of **noise and safety barrier** projects confirms the **need to apply the concept of sustainability to these construction activities** as well as to the resources required to produce, install, maintain, monitor and finally, if required, to remove barriers once they have reached the end of their life cycle. This highlights that noise and safety barrier projects require many resources and tend to have a **very high impact on sustainability of the built environment** like any other large built structure.

In general, the assessment of noise and safety barrier sustainability should be based on an **environmental life cycle approach taking into consideration cradle-to-cradle impacts**, including resource impacts, transportation, the installation stage, as well as the long-term environmental performance, maintenance, and end of life (also called decommissioning stage). **Social aspects** should also be considered, for example transparent noise barriers are generally preferred by residents as it helps to minimize the impact of the barrier on the landscape; or some noise barrier materials are preferred over others as they help minimize the heat island effect in the screened zone.

To ensure a **holistic life cycle engineering** approach, the following issues should be considered: security of supply, adaptability, lifespan extension options, high value recycling/reuse options, carbon capture capacity, and finally overall barrier cost and other **economic indicators** should be considered.

This **framework of technical and functional aspects represents the basis for the further sustainability assessment** of a noise or safety barrier, and is based on the calculation and/or measurements of the following parameters:

1. ***environmental impact***
2. ***social impact***
3. ***economic impact.***

2 European regulations: the current sustainability approach

This chapter summarizes the European regulations and the state of the art on sustainability, with specific reference to noise and safety barriers. The following main questions are addressed:

4. *How are noise and safety barriers currently regulated in Europe?*
5. *Which kind of standards, directives and regulations are available and how is their implementation and applicability assessed?*
6. *How has the topic of sustainability been addressed in the historic and current design and construction of noise and safety barriers?*
7. *How has the topic of sustainability been addressed in historic and current research projects?*

2.1 European regulations and standards

In Europe, construction products are regulated by the so-called **CPR** (Construction Products Regulation)[1] that governs their **introduction into the common market**.

According to the CPR, manufacturers, or their representatives, are requested to declare and guarantee the performance of road network infrastructure products such as noise or safety barriers, according to a **common set of technical standards** developed by technical commissions established within CEN[2].

The **product performance is declared** for the so-called **essential characteristics** of the road network infrastructure product, which are listed in the CPR as follows:

(i) Mechanical resistance and stability

(ii) Safety in case of fire

(iii) Hygiene, health, and the environment

(iv) Safety and accessibility in use

(v) Protection against noise

(vi) Energy economy and heat retention

(vii) Sustainable use of natural resources.

By affixing the **CE marking** to a product, the manufacturer attests the **conformity of the construction product with the declared performance in relation to the essential characteristics**, covered by the harmonised standard or by the European Technical Assessment which relates to the construction product.

CE marking indicates to the appropriate bodies that **the product may be legally offered for sale** in their country and gives companies easier access into the European market to sell their

[1] CPR Regulation (EU) No 305/2011 of the European Parliament and of the Council of 9 March 2011 laying down harmonised conditions for the marketing of construction products.

[2] CEN TC 226 Road Equipment WG6 Anti-Noise Devices.

products without adaptation or rechecking.

The **technical committee CEN/TC 226 for Road Equipment** is working under a specific Mandate of the EU Commission, and several working groups (WGs) have been convened to deal with different type of products.

With reference to the products that are considered within the PROCEEDR research work (safety barriers and noise barriers) **WG 1 *Road restraint systems* and WG 6 *Anti-noise devices*** are the CEN working groups drafting the relevant published standards. The Mandate issued by the EU Commission refers to the **essential characteristics 4 (Safety in use) and 5 (Protection against noise).** This means that the manufacturer, when placing the product on the common market, is requested to declare the performance of the product according to these characteristics.

The following harmonized product standards governing the **procedure of CE marking have been developed:**

- ***hEN 14388:2005*** *Road traffic noise reducing devices – Specifications*
- ***hEN 1317-5:2012*** *Road restraint systems — Part 5: Product requirements and evaluation of conformity for vehicle restraint systems*

NOTE: within this document the following will apply:

- **noise barrier** will be used with the same meaning as Road Traffic Noise Reducing Devices (RTNRD). The wording NRD is commonly used in the CEN standardisation process, while noise barrier is more commonly used in the manufacturers and tendering process.
- **safety barrier** will be used with the same meaning as Road Restraint Systems (RRS).

2.1.1 European standards on noise barriers

The following European standards provide **methods for testing or calculating the performance on a product sample of noise barrier**:

- *EN 1793-1:2020, Road traffic noise reducing devices - Test method for determining the acoustic performance – Part 1: Intrinsic characteristics of sound absorption under diffuse sound field conditions.*
- *EN 1793-2:2020, Road traffic noise reducing devices - Test method for determining the acoustic performance – Part 2: Intrinsic characteristics of airborne sound insulation under diffuse sound field conditions.*
- *EN 1793-4:2020, Road traffic noise reducing devices - Test method for determining the acoustic performance – Part 4: Intrinsic characteristics - In situ values of sound diffraction.*
- *EN 1793-5:2020, Road traffic noise reducing devices - Test method for determining the acoustic performance – Part 5: Intrinsic characteristics - In situ values of sound absorption under direct sound field conditions.*
- *EN 1793-6:2020, Road traffic noise reducing devices - Test method for determining the acoustic performance – Part 6: Intrinsic characteristics - In situ values of airborne sound insulation under direct sound field conditions.*

- *EN 1794-1:2020, Road traffic noise reducing devices - non-acoustic performance – Part 1: Mechanical performance and stability requirements.*
- *EN 1794-2:2020, Road traffic noise reducing devices - non-acoustic performance – Part 2: General safety and environmental requirements.*
- *EN 14389-1:2020, Road traffic noise reducing devices - Procedures for assessing long term performance – Part 1: Acoustical characteristics.*
- *EN 14389-2:2020, Road traffic noise reducing devices - Procedures for assessing long term performance – Part 2: Non-acoustical characteristics.*
- *EN 14388:2005 Road Traffic Noise Reducing Devices – Specifications.*

2.1.2 European standards on safety barriers

The following standards provide **methods for testing or calculating the performance of a product sample of safety barrier.** EN1317 is divided into different parts, each of which focuses on different aspects or product:

- *EN 1317-1, Road restraint systems - Part 1: Terminology and general criteria for test methods*
- *EN 1317-2:2010, Road restraint systems - Part 2: Performance classes, impact test acceptance criteria and test methods for safety barriers including vehicle parapets*
- *EN 1317-3:2010, Road restraint systems - Part 3: Performance classes, impact test acceptance criteria and test methods for crash cushions*
- *EN 1317-5:2007+A2:2012 Road restraint systems Part 5: Product requirements and evaluation of conformity for vehicle restraint systems*
- *EN 16303: 2020 Road restraint systems validation and verification process for the use of virtual testing in crash testing against vehicle restraint system*
- *XP CEN/TS 17342: Road restraint systems - Motorcycle Road restraint systems which reduce the impact severity of motorcyclist collision with safety barriers*
- *XP CEN/TS 16786: Road restraint systems - Truck Mounted Attenuators - Performance classes, impact test acceptance criteria and test performance*

2.1.3 CPR implementation for noise and safety barriers

Harmonized product standards (hEN) also describe the procedure that needs to be followed to ensure the consistency of performance of the products placed on the market. Manufacturers are asked to implement a factory production control that may involve **surveillance and observation by a third party** (Notified Body).

For **safety barriers the Notified Body is periodically checking the FPC**[3] (relating to system 1 according to AVCP[4] in the wording of the CPR). In contrast, **noise barrier production is entirely under the control of the manufacturer** (relating to system 3 according to AVCP).

Over the last decade, manufacturers and laboratories have encountered difficulties as many technical standards have not been updated and alignment between references provided by

[3] FPC: Factory Production Control (FPC) is the permanent control of production exercised by the manufacturer.
[4] AVCP: Assessment and Verification of Constancy of Performance.

the product standards and the content of technical standards is missing.

For example, in the case of noise barriers the product standard hEN 14388:2005 has not been aligned with the updated versions of the technical standards EN 1793-n, EN 1794-n, EN 14389-n published in the last decade. Consequently, challenges for the market often emerge.

For safety barriers the valid hEN 1317-5 was published in 2012 but has not been updated and no official version of the standard has been published on the Official Journal (OJEU).

The situation is leading to a major **revision of the CPR**. The draft document circulated by the Commission highlights the intention of setting a **clear distinction between technical supporting standards developed by CEN** and the **product standards under the control of the Commission.**

The aim is to strengthen the process of creating a common market of construction products in Europe while National Authorities remain entirely responsible for setting threshold levels for product performance and the rules for their installation, use and maintenance.

It should be noted that **CPR does not govern the installation phase or the maintenance, dismantling, recycling, or reusing of construction products when the end of life is reached**. These phases fall outside the scope of the harmonization (common law) process and remain entirely under the control of National Authorities.

It is important to note that **threshold values for the product characteristics are defined at a national level**. For example, National Road Authorities define the acceptable noise levels to be achieved at residential properties because of installing a noise barrier. Similarly roadside safety levels in the case of errant vehicles, containment levels and the impact severity index of safety barriers maybe different from country to country, depending on road type.

Another area of harmonization to be aware of relates to **design rules**, i.e.; Eurocodes used for structural calculations and design rules for key construction materials. Similarly, the acoustic modelling of noise emitted by road traffic[5].

For all of the above reasons, there continues to be substantial variation between EU countries regarding cost, required levels of performance, maintenance activities and replacement criteria and end of life management for noise and safety barriers.

In some countries National Road Authorities prefer to use a unique safety barrier product (or set of products) with the aim of simplifying the procurement phase and maintenance activities.

In countries where the strategic road network is managed by **private/public concessionaires**, product standardization has been undertaken independently by each road manager.

In general, product standardization for noise barriers cannot be fully implemented as product adaptation to site conditions is often required for acoustic and structural reasons, as well as taking account of local roadside conditions.

In some countries national specifications have been published for commonly used materials and products. This is the case in Germany where the ZTV-Lsw 22[6] guidelines apply to the most used noise barrier product on the German road network. Such documents are a helpful

[5] Common noise assessment methods in Europe (CNOSSOS-EU) to be used by the EU Member States for strategic noise mapping following adoption as specified in the Environmental Noise Directive 2002/49/EC.

[6] ZTV Lsw 22 - Zusätzliche Technische Vertragsbedingungen und Richtlinien für die Ausführung von Lärmschutzwänden an Straßen (*Additional Technical Conditions Contract conditions and guidelines for the construction of noise barriers on roads*).

reference for the designer as generally only a few specific projects fall outside the remit of this national guidelines. It is also interesting to note that noise barriers have been installed extensively only on new roads where acoustic impact has been considered as part of the general evaluation of the environmental impact assessment.

For **existing infrastructure**, this European legislation[7] contributes to the **harmonization of noise mapping** activities and the preparation of action plan by Road managers. The implementation of the action plan, including noise barriers installation, remains under the exclusive control of Member States.

2.2 Environmental and sustainability topics in construction projects

In this section the Green Public Procurement (GPP) will be described. Furthermore, the regulation and draft proposal for standards concerning the application of GPP for noise and safety barriers will be presented. Finally, the results of previous research undertaken on this project will be merged by considering the 'Greek temple' approach to sustainability proposed by PROCEEDR.

2.2.1 Green Public Procurement (GPP)

The **Green Public Procurement (GPP)** criteria and its legal framework Public Procurement Directive 2014/24/EC incentivises the harmonization process of rules governing the sustainability of construction products in Europe.

The EU website on GPP[8] contains recommendations (the so-called GPP Criteria) on how to include **environmental/sustainability criteria in public tenders** for different sectors.

In recognising the challenge to provide more benefits to current and future generations, the road infrastructure sector has taken robust steps to embrace environmental objectives. On a voluntary basis this sector has continually **developed new solutions** that make greater use of existing materials through recycling and, at the same time, have generated new technologies for construction processes to extend the durability of the road network and reduce the use of virgin materials. In this respect, the road infrastructure sector is actively working to prolong the life cycle of the road network and to reduce the need for frequent maintenance interventions. These actions result in vital reductions in terms of **energy use, noise and CO_2 emissions and the use of raw materials** linked to road construction and maintenance operations.

The Directive also seeks to modernise the whole framework for public procurement to allow governments to adapt their tendering processes to current needs to facilitate the acquisition of greener and more innovative products and services. In addition, an updated set of rules will also enable new challenges, such as climate change, connectivity, limitation of natural resources, globalization to be addressed.

By encouraging public authorities to **modify their philosophy towards purchasing**, the industry is incentivised to **invest in research and innovation**. The combination of these two elements will benefit the whole of society by optimising public resources and delivering better and more durable roads for the general public.

The EU GPP criteria have been developed to facilitate the **inclusion of green requirements**

[7] END European Noise Directive Directive 2002/49/EC

[8] https://ec.europa.eu/environment/gpp/index_en.htm

in public tender documents, and include areas such as “Road Design, Construction and Maintenance”.

In addition to this, each Member state has been encouraged to draw up publicly available **National Action Plans (NAPs) for greening their public procurement**. The criteria used by Member States should be harmonized to **avoid a distortion of the single market and a reduction of EU-wide competition**. Having common criteria considerably reduces the administrative burden for economic operators and for public administrations implementing GPP. Common GPP criteria are of a particular benefit to companies operating in more than one Member State as well as SMEs (whose capacity to master differing procurement procedures is limited).

The basic concept of GPP relies on having clear, verifiable, justifiable, and ambitious environmental criteria for products, based on a life-cycle approach and scientific evidence base. A similar ambition has been expressed by the industrial sector represented by ERF.[9]

Sustainability of construction products is addressed by the CPR with the 7th **essential requirement as “Sustainable use of natural resources”**. However, a specific standard for the evaluation of environmental sustainability is being developed for only a few construction products, and the declaration of this characteristic remains voluntary within the CE marking scheme. The **CPR is currently under revision** and sustainability performance requires at least the same consideration by manufacturers as is given to the other essential requirements of structural, safety and acoustic behaviour. To measure the **sustainability performance in a fair way** a specific technical standard will be required and proper criteria for a third-party certification will be needed.

2.2.2 Sustainability approach for noise barriers

For **noise barriers a draft proposal of prEN 17383[10] standard has been developed**. This document presents the Key Performance Indicators (KPIs) that noise barrier manufacturers will have to use to express the performance of the barrier over all the phases of the entire life cycle of the product. This will help manufacturers gain a deeper understanding on how their product can be considered “sustainable”. This standard focuses on four sets of sustainability characteristics:

- technical
- environmental
- economic and
- social.

The declared KPIs will relate to the manufacturing process including the raw materials used and will consist of measurable quantities to **assess product sustainability**. Additional information will be provided by the manufacturer about all processes that are needed to transport, install, maintain, repair, remove and recycle the noise barriers.

This document is also intended to help manufacturers to identify the materials and product stages with the most important impact on different sustainability aspects.

[9] Promoting Sustainable Roads Through Public Procurement – ERF document – www.erf.be

[10] prEN 17383 Road traffic noise reducing devices —Sustainability: Key Performance Indicators (KPIs) Declaration.

Besides **manufacturers**, other users of the present standard are likely to include:

- *Designers when calculating the Life Cycle Analysis (LCA) of the product used.*
- *Third parties implementing infrastructure rating systems to determine how the project of the construction work has incorporated sustainability.*
- *Procuring entities can use the KPIs to promote in tender specifications more sustainable solutions and innovations.*
- *Private developers to use noise barriers on their own land like those used on public roads.*

Declared KPIs will coincide with those indicated in EN 15804:2019[11]. It is then anticipated that the declaration will be released by the manufacturer according to the scheme of the **Environmental Performance Declaration (EPD)** in the framework of the DoP[12] accompanying the product when placed in the market.

Moreover, for many applications, technical requirements cannot be a part of the selection process of the optimal choice through a Multi-Criteria Decision Making (MCDM) analysis. It is more likely that a minimum value of structural, safety and acoustic performances would need to be achieved by all noise barrier solutions.

This is the rationale behind the decision made in the PROCEEDR project to prefer another, more simplified, approach to sustainability as given in the following illustration presented in Figure 1.

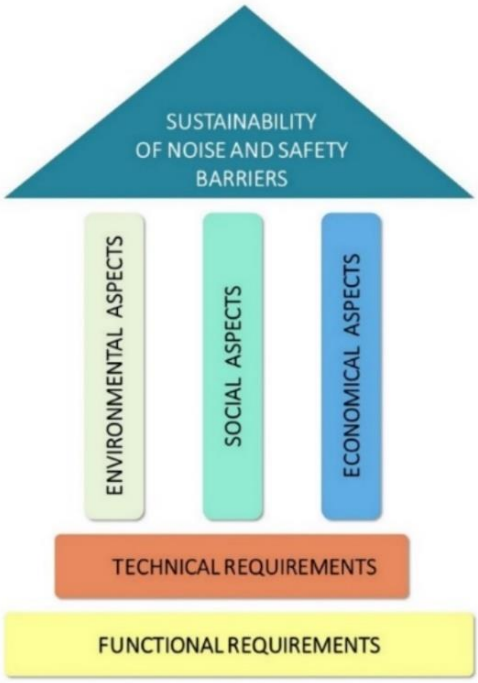

Figure 1: Approach for noise barrier sustainability assessment.

[11] EN 15804 2012+A2 :2019, *Sustainability of construction works — Environmental product declarations — Core rules for the product category of construction products.*

[12] DoP: Declaration of Performance.

Figure 1 shows that for a noise barrier project, the **technical and functional requirements represent the basement or foundation,** enabling the design technical specification to be fulfilled. In addition to this, for each project the **economic, social, and environmental requirements** also need to then to be considered as part of a holistic assessment of sustainability for a noise barrier.

More often for a noise barrier project, the economic aspects represent an additional constraint due to the limited budget available for National Road Authorities. The **optimal choice is finally based on the evaluation of social and environmental aspects**; social aspects being those related to the quality of the life of properties and residents requiring noise protection. Consequently, the installation of noise barriers may result in areas being in shadow during the day, cause a heat island effect, or result in unsafe hidden areas. They may also have additional positive social aspects such as protection from air pollution or improved pedestrian safety for example.

Regarding the environmental aspects, the provision of reliable data from manufacturers due to the so-called **EPD approach**, is essential in enabling the optimal choice to be made and will form the core of the software tools developed within the present PROCEEDR research.

Given the **high variability of products and materials** used for noise barriers some research has been undertaken on evaluating environmental sustainability considering the different indicators calculated for the whole life cycle.

Materials play an important role in the overall sustainability, construction and installation of a noise barrier and the required associated civil engineering works for ground foundations or kerb reinforcement when installed on bridges or containing walls. The **evaluation of the environmental aspects of the foundation works** forms a vital element of the information provided by the manufacturer. This evaluation can be carried out by the designer or by the contractor itself when proposing alternative solutions. The extension **of the working life of the barrier** is another way to enhance the sustainability of road infrastructure.

2.2.3 Sustainability approach for safety barriers

Assessing **sustainability for safety barriers** may be represented by the same approach to sustainability shown in Figure 1, but with the “social aspects” column removed, meaning that “*having two columns left, the construction stability is still guaranteed*”.

The approach to the maintenance of safety barriers is different compared to that for noise barriers. Substitution of the product is recommended in the case of accidents, loss of performance due to corrosion (in the ground or external environment) or even problems arising with the ground or the connection to the concrete kerb. **Safety must be guaranteed for the entire life cycle** of the product.

The key reason for this is that safety barriers are perceived to be an essential part of the road construction and road network as **they address strict safety requirements**.

Furthermore, residents are rarely involved in the product selection process for a safety barrier. An exception may be when selecting **wooden barriers that are often preferred to complete landscape protection** based on requests raised by local authorities. Nevertheless, the use of wooden safety barrier represents a low percentage of the total length of safety barriers installed alongside roads in Europe. The **steel reinforcement components** of a wooden safety barrier ensure that it can provide higher safety performance when necessary.

As a result of their extensive use, safety barriers may involve **relevant investments** by Road Authorities as the cost of safety barriers not only depends on the type of material used (steel or reinforced concrete), but also varies according to market indicators.

Transportation costs, installation and maintenance activities and related traffic disruption are all additional activities that need to be considered. Care also needs to be taken when carrying out **foundation works** (terrain or bridge kerb reinforcement) or when adapting an existing road surface ready for a new barrier to be installed, which might involve water removal from the road surface.

In order to further consider the environmental requirements in the sector of safety barriers, a complementary Product Category Rules document for **Guardrails and Bridge Parapets (cPCR[13])** has been published as part of the **framework of the International EPD System**. This document consists of a program for type III environmental declarations according to ISO 14025:2006. Environmental Product Declarations (EPD) **are voluntary documents to enable a company or organization to present transparent information about the life cycle environmental impact for their goods or services.** Some specific NRA's, e.g. Swedish Transport Administration and the National Road Administration of Norway are requiring EPD for certain steel products, among them is guardrail and this requirement is included in the contract clauses.

The cPCR for Guardrails and Bridge Parapets, mentioned above, cannot be used on its own but shall be used together with PCR 2019:14 Construction Products and the European standard EN 15804:2012+A2:2019, and has been developed with the support of both steel and precast concrete safety barrier industries.

The height of a safety barrier above the road surface influences its performance in terms of containment levels of errant vehicles, thus the choice of considering the linear dimension unit to calculate sustainability indicators enables different products to be compared.

When considering the general system boundaries, it appears that **all life cycle phases have been considered except for the "use stage"**. Compared with other construction products, for example building components that may affect the energy behaviour of the building, road equipment such as safety barriers remain passive throughout their life cycle. Nevertheless, the varying levels of maintenance activities required for these products could affect the total score of sustainability indicators.

Another secondary impact that should be considered is the **traffic disruption** associated with the following Life Cycle phases of safety barriers:

- Installation
- maintenance (when required), and
- the deconstruction phase.

Traffic disruption depends on the traffic intensity of different road types. **It is then a site dependent indicator**. However, information should be acquired to allow this secondary impact to be assessed and calculated. The Information required will relate to the installation and deconstruction rate, foundation works, type of equipment required, frequency and type of maintenance activities required both for an ageing safety barrier and for repairing/replacing barriers after accidents.

With reference to the cPCR for Guardrails and Bridge Parapets, a few EPDs have been registered by manufacturers and published on the website www.environdec.eu. Results provided in these documents will be considered in the next steps of the current PROCEEDR research project. The German Association of Manufacturers has published a document

[13] Complementary Product Category Rules (c-PCR) to PCR 2019:14 date 2021-04-23 – about guard-rails and bridge parapets.

describing an LCA study for **steel safety barriers**[14]. This study highlights how the impacts from raw materials dominate the overall sustainability score of the final product. The following actions could improve the sustainability of the final product:

(i) Make greater use of new materials. At present steel and concrete remains the only material options to ensure the fulfilment of essential structural requirements.

(ii) To identify new surface treatments of steel components.

(iii) Avoid transportation of materials over long distances.

A major issue seems to be the galvanization process that protects the steel from corrosion because of the zinc that is released into the ground.

Different approaches have been taken to address this:

(i) Reduction of zinc protection layer by using pre-galvanisation techniques.

(ii) Use of biobased materials [15], [16].

An EPD for **timber safety barriers**[17] has also been registered.

[14] Umwelt Produktdeklaration STUDIENGESELLSCHAFT FÜR STAHLSCHUTZPLANKEN e.V. – Stahlschutzplanken, EPD-SSS-20150286-IBE1-DE

[15] https://www.biobasedeconomy.nl/2015/05/15/testen-biobased-geleiderail-op-grevelingendam

[16] https://bg4us.eu/

[17] https://www.houtindegww.nl/wp-content/uploads/2020/04/houten-geleiderail-a-weg-rev1-201906211051-short.pdf

3 Classification of the most used noise and safety barriers

Noise barriers are produced using a wide variety of materials and construction processes. The diversity of solutions used is due to **the different approach in various countries based on different cultural background, design approach and industrial background**.

In some countries in **central and southern Europe (e.g., in Germany, Austria, The Netherlands, Belgium Switzerland and Italy)** noise barriers are based on standard schemes composed of structural elements (made of steel beams or concrete pillars) and acoustic elements (typically made of metal or timber cassettes or concrete panels). There is an increased use of transparent elements to help to minimize the visual impact of solid barriers or walls. Other products have been introduced on the market, such as PVC cassettes. This approach is typical in other **southern European** countries like Spain and Greece or in **Eastern EU countries** where the use of noise barriers has become more common over the last 10 years. A more architectural approach is evident in **France** where noise barriers are usually planned and designed by architects. In **Northern EU countries like UK, Sweden, Denmark, and Norway** green walls or earth berms are often preferred.

In the field of safety barriers, a more standard approach, mainly due the need to fulfil functional characteristics, is required; the main materials used in this case are steel, concrete and timber. Furthermore, there are also some specific devices such as crash cushions, which may be made of different materials.

Special attention should be also given to some unique products where both functions are integrated and placed on the market as a standalone system for being used as a **noise and safety barrier at the same time.** These products have more functional constraints as they need to fulfil the requirements set for the two separate systems, however it may perform better in terms of sustainability given the opportunity to reduce the number of additional structures on a bridge or reducing land use when installed in the ground for example.

A suggestion for classifying noise and safety barriers is presented in Table 1 below and aims to group the most common types of noise and safety barriers currently used in Europe into meaningful categories or classes and should be seen as a starting point for discussions in the PROCEEDR project. It should be noted that these proposed categories are not rigidly defined, however the classifications for noise barriers in Table 1 have been already used in other European research projects like QUIESST and SOPRANOISE.

Table 1: General classification of noise barrier types and safety barrier types currently used in Europe according to the EU project QUIESST and the authors of this report.

Noise barrier types (including road coverings and earth berms)		
	SC	Steel support structure + Concrete panels
	SW	Steel supporting structure + Wooden panels
	SM	Steel supporting structure + Metal panels
	ST	Steel supporting structure + Transparent modules
	SP	Steel supporting structure with plastic panels
	CB	Self-supporting concrete or brick system
	GB	Green barrier
	EB	Earth barrier (earth berm)
	RC	Road covering structure (including artificial tunnels)
Safety barrier types		
	SB	Steel safety barrier
	WB	Mixed wood steel safety barrier
	PB	Precast concrete safety barrier
	IC	In situ cast concrete safety barrier
	CC	Crash cushion
	IB	Integrated noise safety barrier

4 Implementation of sustainability policies for main stakeholders involved

This section provides a short description and breakdown of the different life cycle stages of noise and safety barriers and covers the following topics:

- The **manufacture of the road equipment** (noise or safety barriers) transforming the raw material into the final product to be placed on the market.
- **Installer or Contractor** is the company in charge of the installation works on or beside the road. This company may have the role of Contractor or may be a subcontractor of the manufacturer depending on the size of the contract, the type of product and the procurement regulations in different countries.
- **Road Authority** (e.g., NRAs) or the road manager having the role of setting requirements, procuring installations and maintenance work from contractors as well as preparing the tender specifications, governing the tender procedure, controlling the installation, and maintaining the road equipment during its working life until final dismantling.

4.1 Identification of the key stakeholders

When contracting for the supply and installation of noise and safety barriers, as with any road equipment, the following subjects need to be considered:

- The **Manufacturer** of the road equipment (noise or safety barriers) transforms the raw material into the final product placed on the market. It should be noted that some activities may be subcontracted or in some cases, raw materials may be pre-processed by the **raw material supplier**.
- The **Contractor** is the company responsible for undertaking the foundation works, procuring the products, and executing the installation works until the completion of the contract. In some cases, installation activities may be delegated to a specialized company, also known as the **Installer**.
- The **Road Authority** (e.g., NRAs) or the road Manager has the role of setting requirements, procuring installations and maintenance work from contractors as well as preparing the tender specifications, governing the tender procedure, controlling the installation, and maintaining the road equipment during its working life until final dismantling. The Road Authority normally outsources the **design** activities and the **direction of the works**.

This document is intended to provide guidance on addressing sustainability topics for the relevant industrial sectors involved in the manufacturing, installation and maintenance of noise and safety barriers. Therefore, recommendations are given for the following stakeholders:

1. **Raw material suppliers**
2. **Manufacturers**
3. **Installers.**

Additionally, the role of Road Authorities or Road Managers is considered to highlight how they can implement sustainability when dealing with noise and safety barriers.

4.2 Role of Road Authorities

When preparing projects for safety and noise barriers, the **Road Authority refers to the national legislation** that regulates the level of safety required at the roadside for safety barriers or for noise barriers, the maximum acoustic emission limit permitted to impact local residential properties.

The projects refer to technical specifications that in some countries are reported in voluntary technical standards (UNI[18] UNE[19]) or documents having mandatory or compulsory requirements (ZTV-Lsw[20]). These documents generally concern the specific technical characteristics of the products to ensure durability as well as aspects related to installation and maintenance.

Within the European Union, the **European Regulation on Construction Products (CPR)** is a mandatory reference for the evaluation of performance.

Given all of the above, the question has to be asked: **How can Road Authorities implement a market-oriented policy to achieve sustainability goals?**

In the case of safety barriers, an essential aspect is the adherence to the technical and functional requirements that **the product must meet to ensure the nationally mandated safety levels for roads.** Economic sustainability for safety barriers pertains to selecting interventions that optimize both installation and operational maintenance costs. Through the mechanism of a score-based tender, the Road Authority can reward the use of products that minimize environmental impact. However, it's important to emphasize that this action is effective only through cooperation with the bodies involved in formulating the technical specifications for approved materials for these products (such as steel and its alloys or concrete mix designs). The **incentive for improving the production system or construction site logistics has a lesser impact**.

The strategy for implementing policies for **noise barriers** is more diverse. Here too, it's important to uphold the functional or technical requirements aimed at achieving noise reduction goals. Nevertheless, it's worth noting that in some cases, these goals are negotiable. Some **national legislations allow for noise limits not to be met** at all receptors if achieving these goals would necessitate the construction of disproportionate barriers or interventions relative to the intended outcome. From an economic sustainability perspective, in addition to identifying interventions that primarily reduce maintenance costs, economic sustainability is considered at the design level when assessing the cost-effectiveness or cost-benefit ratio of noise barriers. It's increasingly common to seek secondary functions for noise barriers, such as energy generation through photovoltaics or spaces designated for advertising. For noise barriers, the analysis to be conducted at the design stages also involves **evaluating the social effects of the implemented interventions**. Barriers or even more complex interventions (such as noise-reducing tunnels) must undergo assessment in consultation with the local population, possibly via formalized public debate procedures.

Lastly, environmental sustainability is achieved through **material specifications**. In this case, except for materials for structural use, manufacturers have more leeway to propose innovative solutions while still meeting the required product performance standards. It should be noted that for both noise and safety barriers, the role of Road Authorities may be dependent on the

[18] UNI 11160
[19] UNE
[20] ZTV Lsw 22 - Zusätzliche Technische Vertragsbedingungen und Richtlinien für die Ausführung von Lärmschutzwänden an Straßen (*Additional Technical Conditions Contract conditions and guidelines for the construction of noise barriers on roads*).

contract scenarios that are foreseen as follow:

1. ***These road equipment may be part of a main contract where a new road infrastructure or the refurbishment or the enlargement of an existing one must be undertaken.***

   In this case a main contractor is generally appointed, and the choice of the manufacturer and the installer of noise and safety barrier is based on negotiations carried on by the main contractor with reference to the technical specification to be fulfilled. In this case, the sustainability of the whole construction contract can be measured and assessed by a third party according to specific tools [21]. In this situation the contribution of noise and safety barriers to sustainability is generally based on the declaration provided by the manufacturer and required by the NRA (or other client) about the product delivered to the construction site.

2. ***Noise and safety barriers are to be installed on existing infrastructure to mitigate the noise environment at specific receptors.***

   In this second situation, noise and/or safety barriers are the main scope of the work of the contract. They may be purchased by the Road Authority (mainly due to a contract with an entrepreneur) and the sustainability of chosen product may play a role in the tendering process.

4.3 Recommendation for raw material producers

Considering Life Cycle Phases as defined in standard EN 15804, raw material producers can directly contribute to:

- Module A1
- Modules C3, C4.

It is important to consider the choice of raw material producers as they will have different sustainability policies and implement them in different ways.

When local producers of raw materials are used, this will have a positive effect on the sustainability score in module C4. An example of this is when noise barriers are made with locally produced materials.

Producers of raw materials are often industrial companies that are much larger in size compared to manufacturers of road equipment such as noise or safety barriers. Many of these companies implement sustainability policies for all possible applications of their materials in the construction market. In some cases, raw material producers develop dedicated policies for this sector, creating specific products used by the road equipment industry.

A distinction must be made between structural material for which real alternatives are not yet available or will only exist in the long term and other alternative raw materials than can be used for the construction of noise barriers modules. Figure 2 shows the life cycle phases where raw material producers are more involved.

[21] ENVISION: https://www.envision.com/

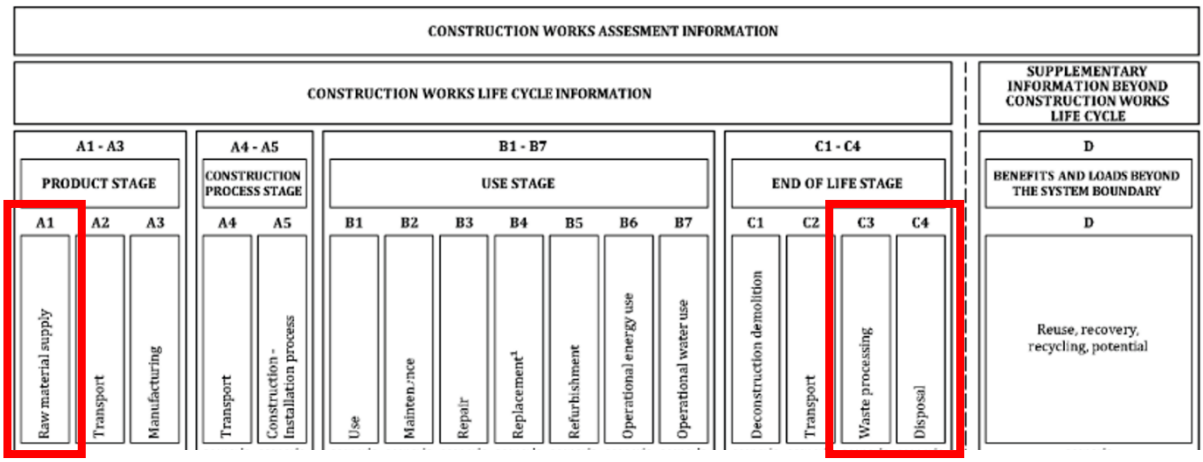

Figure 2: Life cycle phases where raw material producers are more involved.

4.3.1 Structural materials

Noise and safety barriers are structures that require the use of suitable materials to ensure their performance. Noise barriers need to have strong supporting elements to withstand the environmental loads, while safety barriers need to resist the impacts of errant vehicles. The main materials used for these structures are steel, concrete and timber (for limited applications), which are covered by the Eurocodes. The Eurocodes are a set of European standards for structural design, developed by CEN, that include the following materials:

- Concrete (EN 1992)
- Steel (EN 1993)
- Composite steel and concrete (EN 1994)
- Timber (EN 1995)
- Masonry (EN 1996)
- Aluminium (EN 1999)

The Eurocodes also provide the basis of structural design and the technical characteristics for structures for buildings and other civil engineering works. The Eurocodes are expected to evolve in the future, but not significantly in the short term. The **second generation of the Eurocodes will introduce some improvements and extensions, such as new design methods, new materials, new actions, and new structural types**[22] [23].

Some of the new materials that could be relevant for noise and safety barriers are structural glass and fiber-polymer composites (FRP). Structural glass could be used for noise barriers to provide transparency and lightness, while FRP could be used for both noise and safety barriers to offer durability and flexibility[24].

[22] Evolution of the EN Eurocodes | Eurocodes: Building the future (europa.eu)
[23] Eurocodes Homepage | Eurocodes (europa.eu)
[24] Second generation of the Eurocodes: what is new? | Eurocodes: Building the future (europa.eu)

Outside the European context, some materials are gaining attention as a sustainable and renewable alternative for construction. For example, there is a new international standard for engineered bamboo products, but it is not yet part of the Eurocodes [25].

With reference to sustainability for structural materials, reference needs to be made to the existing core Product Category Rules, which are the rules for developing Environmental Product Declarations (EPD) for construction products and services, according to EN 15804. This is the standard that provides the framework for assessing the environmental sustainability of construction products and services, based on life-cycle analysis. Some examples are:

- cPCR-001 Cement and building lime (EN 16908) [26]
- cPCR-003 Concrete and concrete elements (EN 16757)
- Part B: Designated Steel Construction Product EPD Requirements [27]

For structural materials, road equipment manufacturers have limited options:

- For **safety barriers**, most of the product consists of these materials (steel and concrete) and no viable alternatives are foreseen. Changes that can affect sustainability can be foreseen only for coatings used to ensure product durability. An example explored in current research is that of pre-galvanized steel for safety barriers external surface treatment.[28][29]
- For **noise barriers**, structural materials are used for the posts and supports. Some alternatives may be possible among the solutions permitted by the national laws and codes.

For both products, a general recommendation is to choose suppliers with a sustainability policy, i.e. an EPD according to the above specifications.

4.3.2 Non-structural materials

Non-structural materials are used sparingly for safety barriers. However, they are **more common for noise barriers**, where many components are of the self-supporting type and can be made of various materials. Acoustic panels or transparent sheets usually do not bear the load of the whole structure. They only need to support their own weight and possibly the weight of additional elements.

For noise barriers, raw material manufacturers can have a significant impact on achieving sustainability goals. This is the case for plastic materials used for transparent sheets. Polymethylmethacrylate (PMMA) or polycarbonate sheets are widely used in European markets. For both cases some **raw material suppliers have already implemented sustainability policies** by developing semi-finished products able to fulfil specific requirements for the noise barrier sector. This is the case of sound absorbing solutions or

[25] A Review of Codes and Standards for Bamboo Structural Design (hindawi.com)
[26] PCR Library | EPD International (environdec.com)
[27] 10010-34_Steel Products Public Comment.pdf (ul.com)
[28] https://constructalia.arcelormittal.com/files/Magnelis_book_EN-7ce049147e586796109b24ba2343fd9d.pdf

[29] https://www.wuppermann.com/en/sectors/vehicle-restraint-systems/

reinforced sheets that are able to resist vehicle impacts that may happen on the roads [30].

Some manufacturers also implemented sustainability policies and an EPD declaration have been made available[31]. Improving long term durability of these products (i.e.; resistance to UV) is part of the sustainability policy.

There are many cases of raw material producers who propose the use of their products for the construction of noise barriers. An example is the rubber recycled from vehicle tires[32] that can be used for the production of lightweight concrete products with sound-absorbing function.

Another example for metal-type noise panels is the use of recycled material from PET waste to produce polyester fiber panels.

In general, **the use of innovative raw materials in noise barrier construction can occur both as result of research carried out by the noise barrier manufacturer itself or due to the attempts of producers** belonging to other sectors who are looking for possible use of waste or by-products of their production cycles, or for the recycling of their products at the end of their life cycle.

4.4 Recommendation for manufacturers of roadside equipment

The choice of the raw materials is crucial for the sustainability assessment of the product on the market. However, some manufacturers are linked to a specific production chain that limits the change of the base material. In these cases, the base material should be more efficient, better quality or recyclable, or combined with other sustainable materials. Figure 3 shows the life cycle phases where manufacturers of roadside equipment are more involved.

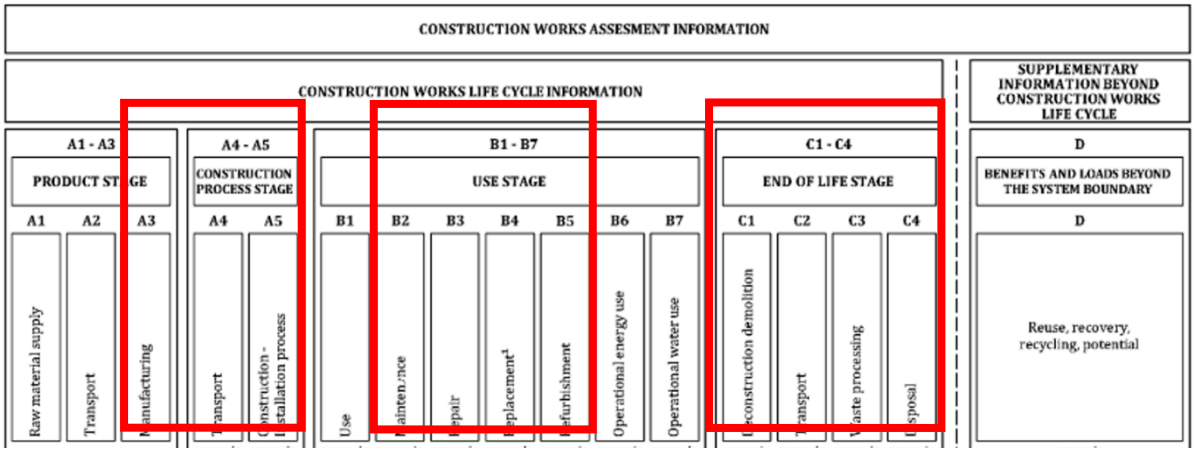

Figure 3: Life cycle phases where manufacturers of roadside equipment are more involved.

This applies mainly to safety barriers, which are often steel commodities or precast elements from concrete companies.

This may also apply to noise barriers, although the manufacturers of these products are more inclined to use a variety of different materials. There are cases of noise barrier manufacturers being part of a material chain who are considered to be winning in terms of environmental sustainability. This is the case for recycled PVC, which has seen the emergence of companies

[30] PLEXIGLAS® - The Original Acrylic - PLEXIGLAS®
[31] S-P-05711 - Hammerglass Clear single sheet 12 mm (environdec.com)
[32] E.g. the company Ruconbar: http://www.ruconbar.com/

engaged in the noise barrier sector using PVC obtained by recycling from other production chains (for example, the window industry). The choice of the base material is not an option in most cases for manufacturers and therefore it is necessary to rely on the sustainability policies implemented by the producers of raw materials.

The contribution of the manufacturers is therefore important for the subsequent phases of the life cycle. For phase C3 in Figure 4 above, many manufacturers direct their efforts to improving the energy efficiency of the production plant. In this regard, it is important to note how the production processes of noise or safety barriers do not involve very energy-intensive operations. These are mostly processing and assembly operations where energy consumption is focussed, and the use of renewable energy sources is to be expected. However, it is not considered that this choice is decisive in the improvement of the final sustainability score of the product.

For the manufacturer, the focus should be on improving the production process as this is likely to have the greatest impact on sustainability.

Here are some recommendations that will have a measurable effect on the sustainability of different phases of the product life cycle:

- **Minimize the movement of materials** or semi-finished products in the supply chain (A3);
- Identify **solutions that minimize the impact of product transport** from the factory to the construction site (phase A4). An example can be found in the prefabrication system of concrete noise barriers. The sound-absorbing surface can be obtained separately with the pre-casting of lightweight material tiles of different shape and composition. This solution allows for the production of acoustic panels in a normal prefabrication plant of concrete components because it avoids the more complex procedure of fresh casting on fresh concrete;
- Identify **solutions that facilitate assembly operations on site** (phase A5), especially considering the impact on traffic that these operations have for road equipment in general. An example of this is noise barriers with vertical metal posts with composite profile to avoid the insertion of the panels from above having to be done on site, which helps to minimize traffic delays.

The choices made by the manufacturer also influence the use phase of the product, especially when aimed at minimizing ordinary maintenance interventions (phase B2) made to ensure the durability of the product. For extraordinary interventions, related to accidents or choices of the road manager, the manufacturer must design the product to optimize the repair (B3), replacement (B4) or refurbishment (B5) phases.

Finally, for the end-of-life management of the product, the manufacturers can make technical choices to facilitate the dismantling (C1) and removal of materials from the construction site (C2). Again, indications from the supplier of raw materials becomes relevant again for the waste management (C3) and disposal to landfill (C4) phases.

4.5 Recommendation for installers

The on-site functionality of noise barriers and road safety barriers largely depends on correct assembly and installation. Figure 4 below shows the life cycle phases where installers are more involved.

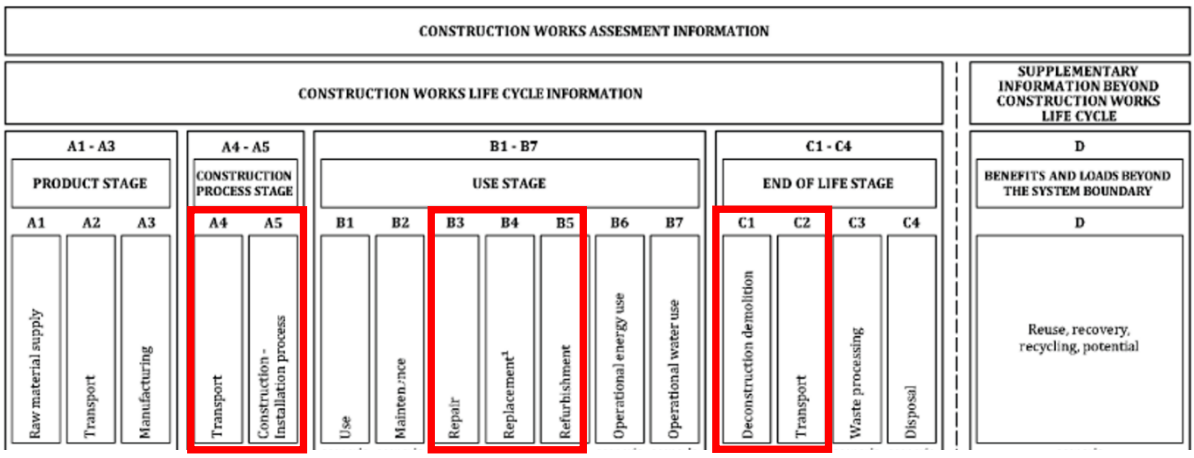

Figure 4: Life cycle phases where installers are more involved.

When placing the product on the market, manufacturers are required to prepare the installation manual containing all the instructions needed for the product assembly and its adaptation to the site conditions.

Therefore, training for installation companies is a crucial aspect to ensure their familiarity with the products and to guarantee the functionality through their activities. To complement this training activity, installer certification is provided in many countries[33]. In other countries the national legislation asks manufacturers to supervise and provide the final assessment of the correct assembly and installation[34].

This results in an ongoing relationship between manufacturers and installation companies that can also contribute to the improvements of the sustainability score of the installed products by:

1. Recommending specific solutions to simplify assembly procedures.
2. Optimizing transportation and unloading procedures on-site.
3. Developing machinery and procedures for the timely installation and inspection of installed products.
4. Providing innovative solutions for foundation works.

These latter solutions can have a significant environmental impacts, especially for noise barriers that require anchoring to the ground to withstand static and dynamic loads including wind and vehicle actions[35] [36].

[33] https://www.lantra.co.uk/national-highway-sector-schemes-nhss/austroads/operatives-installers
[34]http://www.unicmi.it/strumenti/prodotti_editoriali/ux79-procedura-emissione-certificato-di-corretto-montaggio-ed-installazione-dei-dispositivi-stradali.html UX79
[35]https://www.krinner.io/fileadmin/userdaten/Downloads/Englisch/Brochures-Flyer/Segm_Noise_Barrier.pdf
[36] https://www.fonsider.it/

5 Certification tools

The tool being developed by the PROCEEDR project can be used by different stakeholders to get acquainted with environmental sustainability evaluation before creating an **EPD** (Environmental Product Declaration). The tool also contains a database on Lifecycle Impacts (LCI) for products currently used for noise and safety barriers.

Different types of EPD, depending on the scope and level of detail of the information provided, can be used by manufacturers to declare the environmental performance of noise and safety barriers. The reference standard is EN 15804:2012+A2:2019, which provides the core rules and requirements for developing an EPD for any construction product or services.

This standard has been revised and aligned as much as possible with the “Product Environmental Footprint (PEF)”, which is a common method for measuring and communicating the environmental performance of products and organizations in the EU.

In addition, the product category rules (c-PCR-010 Guardrails and Bridge Parapets) has been published to define the scope and the methodology for sustainability assessment of safety barriers.

Manufacturers can use the PROCEEDR tool to inform an LCA analysis, the verification of which ensures that the EPD complies with the PCR and is based on reliable data and the subsequent publication, which makes the EPD available to the public. Note that the role of the manufacturers is to assess the **A1 to A3 stages** and they can provide information about the further life cycle stages. In a tender process this is the only **robust and relevant data** they can provide to the NRAs, which is important fin terms of the fairness and correctness of the tender procedure.

EPDs are mainly intended for use in business-to-business (B2B) communication. **There is no obligation for manufacturers to provide the environmental declaration when placing the product on the market unless the request for such a declaration is written in tender specifications** to implement the Green Public Procurement Directive. **Nevertheless, NRAs can, and do require EPDs to verify climate footprints.**

A new scenario is envisaged due to the revision of the Construction Product Regulation (CPR 305:2011) that the EU Commission undertaking with the clear intention of strengthening the importance of sustainability for the characteristics the manufacturer is requested to declare when preparing the Declaration of Performance (DoP) and affixing the CE marking to the product.

The CE marking indicates that a construction product conforms with its declared performance and that it has been assessed according to a harmonized European standard. It is a legal requirement for placing construction products on the EU market.

When this characteristic is acknowledged as one of the essential characteristics in the harmonized product standard, then the Environmental Product Declaration (EPD) will confirm that the tool that quantifiably demonstrates the environmental impacts of a product.

The tool developed in the PROCEEDR project can be used both for the voluntary EPD and for the future mandatory CE-marking where sustainability is expected to be included in the harmonized product standards.

5.1 EPD-Databases currently available

Whilst changes to the CPR are expected to provide a systematic inclusion of the environmental requirements among the performances that the **manufacturer must certify with the CE marking**, safety and noise barriers manufacturers are often asked for a **declaration of environmental sustainability through an LCA study**.

The first problem that arises is represented by the variability and the number of environmental sustainability evaluation protocols and databases available on the market.

The most part of them are based on the EPD declaration scheme according to EN 15804, however **many differences can be encountered** that may be due to both choices made at national legislation level (in fact, there is no harmonized legislation on this issue) and to the presence of different operators who independently develop different schemes.

The **costs related to an environmental sustainability assessment are variable**, depending both on the chosen evaluation scheme, the third-party certification and on the number of products to be evaluated. Considering that many road equipment manufacturers are small and medium-sized enterprises, the most obvious critical issues are listed as follows.

- **Lack of uniformity of protocols:** companies are forced to make a choice and therefore many remain waiting to see which protocol will have greatest influence on the market. All this creates a vicious circle that represent an obstacle to the acceptance of the sustainability approach.
- **Common rule for a common market:** the differences in protocols adopted in individual countries can create a barrier to the market, partly nullifying attempts at harmonization that have been going on for decades at least for the European market.
- **Overarching approach required** for sustainability evaluations within the same product family (products made with similar constituents and performance characteristics). This is the case for road safety barriers belonging to the same family that can vary only in weight and shape and that require individual declarations at very high cost to the manufacturers.
- **High costs** of some existing databases that coexist while alternative data bases are available for free.
- **Need to achieve familiarity with quantitative data resulting from LCA calculations.** The environmental impacts are measured for different impact categories and may vary a lot. Difficulty may arise when comparing different products on the base of LCA results. A helpful solution would be to have a calculation of a unique index of environmental sustainability of the product. An example is a tool already in use in The Netherlands [37] : it is single-score indicator expressed in Euros that unites all relevant environmental impacts into a single score of environmental costs, representing the environmental shadow price of a product or project.
- **Only LCA modules A1, A2, A3 based on primary data to be considered in tendering process.** When defining a scoring system, only robust data should be considered. If other Life Cycle Phases are considered relating to a unique scenario for transport to site or the installation phase for example, then these would need to be clearly defined to avoid unfair competition.

[37] Environmental cost indicator (ECI) https://ecochain.com/knowledge/environmental-cost-indicator-eci/

In the course of the background research for this project, the following databases were found. It is relevant to note that the list should not be considered as complete and that costs are for indicative purposes only:

- **GaBi** (Ganzheitliche Bilanzierung, USA/Germany) https://gabi.sphera.com/deutsch/datenbanken/gabi-datenbanken/baumaterialien/ Thinkstep (Germany) was acquired in 2019 by Sphera (USA), 1500$, big database but not only construction industry, (314 EPDs for Construction Materials)
- **SimaPro** (Netherlands) https://simapro.com/ 5500€, implements Ecoinvent database
- **Ecoinvent** (Switzerland) https://ecoinvent.org/the-ecoinvent-database/ 4400€ + yearly 1350€, big database but not only construction industry (916 datasets for Construction EN 15804)
- **Institut Bauen und Umwelt** (Germany) https://ibu-epd.com/veroeffentlichte-epds/ free, medium database (1621 EPDs for Construction Products)
- **OneClickLCA** (Finland/UK/US/France) https://www.oneclicklca.com/ free, medium database (130.000 “datapoints”)
- **ÖKOBAUDAT** (Deutschland) https://www.oekobaudat.de/no_cache/datenbank/suche.html free, medium database (1085 / 629+86 EPDs for Construction Products) based also on GaBi and Ecoinvent
- **Bau-EPD GmbH** (Austria) https://www.bau-epd.at/en/epd/list free, very small database (20 EPDs)
- **EPD International AB** (Sweden) https://environdec.com/library free, medium database (726 EPDs for Construction Products Europe)
- **Epd-Norway** (Norway) https://www.epd-norge.no/epder/ free, medium database (1852 EPDs for Construction Products Scandinavia)
- **KIWA** (Germany) https://www.kiwa.com/de/de/veroffentlichte-epds/ free, medium database (only products certified by KIWA)
- **ECO Platform** (Brussels) https://www.eco-platform.org/list-of-all-eco-epd.html free, medium database, based also on GaBi and Ecoinvent
- **GreenBook** (UK) https://www.greenbooklive.com/search/scheme.jsp?id=260 free, medium database (104 EPD holders!)
- **Digital Environmental Hub for Global Construction Products** (International) https://lcadatabase.com/ free, big database (4820 records)

6 Proposed scenario for sustainability implementation

The goal should be to reach a firm quantitative declaration across the different LCA phases - according to EN15804 - to highlight those that area most relevant for improving the overall sustainability of road noise and safety barriers.

The following relevant points should be addressed:

- **Producers of raw materials** should ideally **bring new solutions on the table.** There is a wide variety of new and innovative materials available to the noise barrier sector (phase A1-A3). In the safety barrier sector is more constrained at the moment and limited to concrete and steel.
- **Manufacturers should ideally bring questions to the producers** (phase A1-A3) and M should be flexible to implement new materials (e.g., to go beyond CE marking) phase A1-A3).
- Installers should ideally **communicate** and **interact with Manufacturers** and bring questions and solutions to them (phase A3-A5).
- Manufacturers should ideally respond to **new questions from the Installers** (phase A3-A5).
- Phase B is mainly limited to the Authorities, where strong links between all stakeholders are needed: manufacturers, installers, and producer of raw materials.
- Phase C is managed by the Authorities supported by producers of raw materials, installers, and manufacturers. Again, it should be noted that in the noise barrier sector there are many producers, and a wide variety of materials are available, while in the safety barrier sector there are a limited number of manufactures and limited choice of materials (concrete and steel) with varying levels of recyclability are present.

Improving the sustainability of road equipment is a complex and multifaceted challenge that requires a holistic and integrated approach. Both materials and processes are important aspects to consider for enhancing the environmental, social, and economic sustainability of road equipment.

The following suggestions are made to improve the sustainability of noise and safety barriers:

- Choosing **materials that have lower environmental impacts**, such as recycled, renewable or biodegradable materials, or materials that have lower embodied energy or carbon footprint.
- **Optimizing the design and function of road equipment**, such as using modular, adaptable or multifunctional components, or incorporating smart features or renewable energy sources.
- **Improving the construction and maintenance processes** of road equipment, such as using efficient methods, technologies and equipment, or minimizing waste, emissions and resource consumption.
- **Minimizing Transport distances** by making greater use of local materials**.**
- Adopting **new technologies for foundations works**.

It is vital that **greenwashing is avoided in the development of sustainability indicators and metrics to evaluate and monitor the performance of road equipment (including noise and safety barriers)** and transparency and openness is key to maintain the trust of consumers and industry**.**

"Greenwashing" is the practice of making misleading or unsubstantiated claims about the environmental benefits of a product, service, or activity. It is a form of deceptive marketing that can mislead consumers and harm the credibility of genuine sustainability efforts. In the context of improving and understanding the sustainability of noise and safety barriers the following points are made:

- It is possible that some road equipment manufacturers try to advertise the aspects of their products that have a major impact on sustainability, but they should do so in an honest and transparent way. They should **provide clear and accurate information about the environmental performance of their products**, based on reliable methods and data. They should also avoid exaggerating or omitting relevant facts that could affect the consumers' decisions.
- Road equipment manufacturers have a responsibility to communicate the aspects of their products that have a major impact on sustainability, but they should also be accountable for their claims. They should follow the principles and guidelines of ethical and sustainable marketing, such as **honesty, fairness, social responsibility and environmental stewardship**. They should also be open to feedback and scrutiny from consumers, regulators and other stakeholders.
- Road equipment manufacturers should not be engaged in greenwashing, as it would be harmful for both the environment and the society. Greenwashing can undermine the trust and confidence of consumers and investors in sustainable products and practices. It can also create unfair competition and discourage innovation and improvement among genuine sustainability leaders. It can also reduce the awareness and motivation of consumers and businesses to adopt more sustainable behaviours and choices.

References

WHO (World Health Organization): Environmental Noise Guidelines for the European Region. Copenhagen, 2018.

https://ec.europa.eu/environment/gpp/index_en.htm first accessed in September 2022.

Europäisches Parlament und Rat: "Richtlinie (EU) 2002/49/EG über die Bewertung und Bekämpfung von Umgebungslärm", Amtsblatt L 189 der Europäischen Gemeinschaft vom 18. Juli 2002, 25. Juni 2002.

Europäische Kommission: "Richtlinie (EU) 2015/996 zur Festlegung gemeinsamer Lärmbewertrungsmethoden gemäß der Richtlinie 2002/49/EG des Europäischen Parlaments und des Rates", Amtsblatt L 168 der Europäischen Gemeinschaft vom 1. Juli 2015, 19. Mai 2015.

ZTV Lsw 21 - Zusätzliche Technische Vertragsbedingungen und Richtlinien für die Ausführung von Lärmschutzwänden an Straßen.

M. Chudalla, F. Strigari and W. Bartolomaeus, SOPRANOISE Deliverable D3.1, “Final report on the main results of WP3 (including M3.1, M3.2 and M3.3) – In-situ inspection tools”; 2021.

J-P. Clairbois, M. Conter, M. Chudalla, F. Strigari, W. Bartolomaeus, M. Garai, N. Lebasi and C. Nicodème, SOPRANOISE Deliverable D5.2, “SOPRANOISE Final report -Guidelines for NB use and scientific report”, 2022

EN 1793-1:2020, Road traffic noise reducing devices - Test method for determining the acoustic performance – Part 1: Intrinsic characteristics of sound absorption under diffuse sound field conditions.

EN 1793-2:2020, Road traffic noise reducing devices - Test method for determining the acoustic performance – Part 2: Intrinsic characteristics of airborne sound insulation under diffuse sound field conditions.

EN 1793-4:2020, Road traffic noise reducing devices - Test method for determining the acoustic performance – Part 4: Intrinsic characteristics - In situ values of sound diffraction.

EN 1793-5:2020, Road traffic noise reducing devices - Test method for determining the acoustic performance – Part 5: Intrinsic characteristics - In situ values of sound absorption under direct sound field conditions.

EN 1793-6:2020, Road traffic noise reducing devices - Test method for determining the acoustic performance – Part 6: Intrinsic characteristics - In situ values of airborne sound insulation under direct sound field conditions.

EN 1794-1:2020, Road traffic noise reducing devices - non-acoustic performance – Part 1: Mechanical performance and stability requirements.

EN 1794-2:2020, Road traffic noise reducing devices - non-acoustic performance – Part 2: General safety and environmental requirements.

EN 14389-1:2020, Road traffic noise reducing devices - Procedures for assessing long term performance – Part 1: Acoustical characteristics.

EN 14389-2:2020, Road traffic noise reducing devices - Procedures for assessing long term performance – Part 2: Non-acoustical characteristics.

EN 14388:2005 Road Traffic Noise Reducing Devices – Specifications.

EN 1317-1, Road restraint systems - Part 1: Terminology and general criteria for test methods.

EN 1317-2:2010, Road restraint systems - Part 2: Performance classes, impact test acceptance criteria and test methods for safety barriers including vehicle parapets.

EN 1317-3:2010, Road restraint systems - Part 3: Performance classes, impact test acceptance criteria and test methods for crash cushions.

EN 1317-5:2007+A2:2012 Road restraint systems Part 5: Product requirements and evaluation of conformity for vehicle restraint systems.

EN 16303: 2020 Road restraint systems validation and verification process for the use of virtual testing in crash testing against vehicle restraint system.

XP CEN/TS 17342: Road restraint systems - Motorcycle Road restraint systems which reduce the impact severity of motorcyclist collision with safety barriers.

XP CEN/TS 16786: Road restraint systems - Truck Mounted Attenuators - Performance classes, impact test acceptance criteria and test performance.

prEN 17383 Road traffic noise reducing devices —Sustainability: Key Performance Indicators (KPIs) Declaration.

EN 15804: 2012+A2:2019, Sustainability of construction works — Environmental product declarations — Core rules for the product category of construction products.

QUIESST QUIetening the Environment for a Sustainable Surface Transport – Research project funded within the Seventh Framework Programme.