Low barriers for Railway Noise installed at Basque Country. Experience of Euskal Trenbide Sarea in Ermua

VAZQUEZ, Manuel[1]; ASPURU, Itziar[1]; SANTANDER, Alvaro[1]; FERNANDEZ, Pilar[1]
LÓPEZ, Cristina[2]
PEIRO, Pilar[3]
TORRECILLA, Jesús[4]

[1] Tecnalia Research & Innovation
Parque Tecnológico de Bizkaia, Edificio 700, 48160 DERIO, SPAIN
itziar.aspuru@tecnalia.com; manuel.vazquez@tecnalia.com; alvaro.santander@tecnalia.com; pilar.fernandez@tecnalia.com
[2] Euskal Trenbide Sarea
San Vicente 8 - 14ª planta, Edificio Albia 48001 – Bilbao
clopez@ets-rfv.eus
[3] BECSA
Pol. Ciudad del Transporte C/ Grecia, 31 12006 Castellón (Spain)
mppeiro@becsa.es
[4] ACUSTRAIN
Parque Científico y Tecnológico de Bizkaia Laida Bidea,Edificio 204. E-48170 Zamudio (Bizkaia)
info@acustrain.com.

Abstract

Railways lines crossing urban areas usually involve important acoustic impacts on adjacent dwellings, with the peculiarity of the proximity of the houses to the line and the complexity of addressing traditional solutions that do not imply a visual impact.

With this objective in mind, Euskal Trenbide Sarea (administrator of railway infrastructure in the Basque Country) has carried out a pilot project near Ermua station, installing low noise barriers alongside the tracks and between them. Thanks to this piloting the viability of implementing the solution in similar situations will be analysed.

For this purpose, Insertion Loss measurements have been made to quantify the effectiveness of the solution and to know the acoustic performance of low noise barriers compared to simulations made at the design phase.

At the same time, the effect of the installed solution has been simulated using the interim method of railway noise, to know the feasibility of simulating with commercial models the real effectiveness of low barriers.

Finally, Tecnalia and BECSA, as responsible for the development of the product, developed an analysis of the necessary improvements of the barrier, both in design and in implementation.

Keywords: noise, low barriers, insertion loss, railway.

1 Introduction

The European Environment Agency (EEA-33) has developed an environmental policy on noise based on the Environmental Noise Directive (END) which establishes noise quality goals for urban areas (55 dB Lden) and applicable regulations. This legislation requires Member States to elaborate noise maps to determine the noise exposure caused by major transport routes and industrial areas. The final goal is to implement plans to prevent and reduce exposure to noise.

According to EEA-33, 6% of the European population live in urban areas exposed to Lden noise levels above 55 dBA. Therefore noise reduction measures must be adopted to reduce exposition, for example, in the case of railway (trains and tracks).

Railways are the second major source of noise, after road traffic, in terms of people exposition: 19 million people are exposed to Lden noise levels above 55 dB in EEA-33. Aircraft noise is the third largest noise source, with more than 4.1 million people exposed to Lden levels above 55 dB, followed by industrial noise within urban areas, which affects 1.0 million people.

European Member States must approve Noise Action Plans to reduce noise levels by applying various types of measures, to be set out in this case by railway operators. Actions at the source are best considered, they could be focused on the tracks and on the trains, as noise generators. Also, future planning measures are considered, as well as protection measures for dwellings by façade insulation, or placing elements that reduce the noise propagation between source and receiver. According to the European Commission's "Noise in Europe 2020" [1] report those measures account for 20% of the practical measures to be carried out (excluding planning measures).

In the case of the Basque railway network managed by Euskal Trenbide Sarea (ETS), in compliance with applicable legislation, drawn up Strategic Noise Maps, as well as Noise Action Plans [2].

Railway noise is caused by the interaction of various elements at different heights, depending on the type of train, the infrastructure, and the running speed. At medium or low speeds, the main sources of noise are at lower height, and sources located on the train or aerodynamic noise are not relevant.

At this height, the main sources are those derived from wheel-track contact, in addition to those generated by the traction systems. This noise is emitted from the bottom of the train and even through the lower fairing.

Due to that, main actions to abate this noise emission are focused on i) minimizing rolling noise by reducing wheels and track roughness, always compatible with traffic safety; ii) reducing impact noise on zones with joints; iii) reducing squealing on curves; and iv) improving the designs of the lower fairing in new units to minimize traction noise and reduce the emission of noise generated from wheel-track contact. However, all these actions are generally not sufficient to ensure that noise levels generated do not disturb the environment and, therefore, action must be taken in the propagation path.

Traditional noise barrier reduction system consists on building a solid element in the propagation path between the source (lower part of the train) and the receiver. This element forces sound waves to cover a longer path around the barrier and, consequently, masks the source from the receiver (shadow zone).

Acoustic design of a noise barrier to protect a given point, based on geometry, implies that the greater the distance of the barrier from the source of the noise, the higher the element has to be, and, therefore, the greater the foundation to ensure its stability. Its foundations require a significant amount of space; can originate noise and vibration nuisance during installation works; and implies an increase in the costs. In addition, the higher the height, the greater the visual, architectural and accessibility impact.

Acoustically, the ideal solution is to bring the barrier closer to the source of emission. But location of traditional barriers depends on availability of space and mostly are located in areas outside the land owned by railway administration, entailing additional costs. Another limitation to the installation of noise barriers is the visual impact to residents or reduction of sunlight in surrounding buildings. Consequently, the acoustic effectiveness is notably reduced due to the greater distance to the source that can only be solved by increasing the height of the screen.

Low height barriers are based on applying this ideal solution of bringing the barrier closer to the train, to the nearest viable point. It implies acting in the track area, allowing the installation of an additional element that will provide, with a minimum height, similar noise reductions, or even better, than those obtained by a traditional high barrier. To this end, the element must meet the requirements of any element placed on the track. In this case, it must meet some premises, such as being effective without encroaching on the obligatory gauges for each section, depending on track radius of curvature and speed. Due to that it must be less than 1.5 m high. It should also be easy to install, without need of foundation work, respecting other track elements and track maintenance operations. In any case, its design makes it easy to remove, clean, replace and store, when necessary. And it could be placed both on slab and ballast track.

Despite the noise reduction measures implemented by ETS on its infrastructure and rolling stock, there are still issues that need to be solved to reduce as much as possible the population exposed to noise levels.

The goal of this project is to implement a solution, that is easy to install and of minimal dimensions, that will reduce noise levels in urban railway environments to reach the acoustic quality goals established in current legislation.

2 Ermua: priority area

The ETS Acoustic Noise Action Plan [2] defines priority areas where acoustic quality goals are not met. The municipality of Ermua is one of these areas being prioritised. A significant percentage of the population at Ermua is exposed to Lnight noise levels higher than 55 dB(A).

The construction of a new station and new tracks posed the need to address an overall solution to the problem. Therefore, it was proposed to test an innovative solution at Ermua: the installation of a new Low Barrier System.

The environment to be protected is complicated: a double track at the exit of the station where there is a curve with a very small radius (80 m) that generates squealing noise.

2.1 Environment

The project to modify Ermua station affects the surroundings of Abeletxe street, where there are buildings very close to the tracks. Railway noise, both rolling and squealing noise, has raised some complaints in the area.

The very tight curved scheme and the proximity to the tracks prevents the adoption of traditional acoustic shielding measures, while a low noise barrier solution is ideal, since the predominant focus is the noise generated by the wheel-rail contact.

Figure 1 – Pilot study (source Bing Maps)

2.2 Railway Traffic

Track 1. There are circulations of two lines. The first is the Eibar-Ermua line. It has two circulations per hour in each direction. The second is the Bilbao-Donostia line with an average periodicity of two circulations per hour, same direction as Eibar. On average there are six circulations per hour on this track, four in the direction of Ermua and the other two in the direction of Eibar.

Track 2. There are circulations of Bilbao-Donostia line towards Bilbao, in the direction of Ermua. The average frequency is two trains every hour.

In both direction running speed is below 60 km/h.

2.3 Typology of trains

- Electric train Serie 900 of 4 carriages Mc-R-R-Mc with a layout of axles Bo'+2'2'+2'2'+Bo'Bo' and a length of 69,458 m.
- Electric train Serie 950 of 3-car Mc-R-Mc with a Bo'+2'2'+Bo'Bo' axle arrangement and a length of 52,458 m.

2.4 Type of noise

Railway noise caused at this site is mainly characterized by a linear noise spectrum centered on medium frequencies (between 200 and 2KHz) without pure tones.

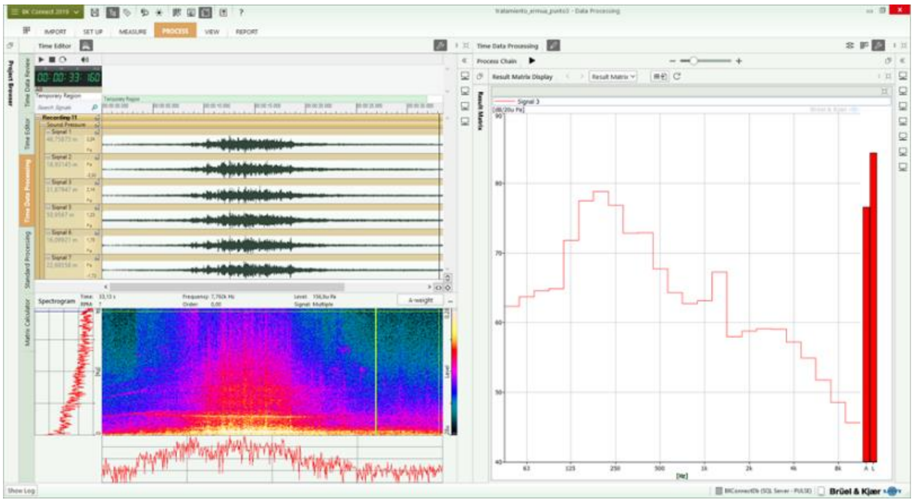

Figure 2 –Spectrum of a pass-by

As mentioned, there is a curve that usually generates squeal noise, both at arrival and departure of trains to the station, and on both tracks with a similar behavior. Euskal Trenbide Sarea has installed an irrigation system to reduce the squealing noise in this area.

The squeal effect consists of excitation at 1 kHz and in its harmonics: 2 kHz and 4 kHz. In some cases, usually when the train accelerates out of the station, there is an additional increase in the levels centered at 400 Hz.

In Figure 3 both effects can be seen on the linear noise spectrum. The effect of acceleration (2), when appears remains the whole pass-by, meanwhile the squeal (1) appears at the beginning or end of the pass-by depending on whether the train is running to or from the curve.

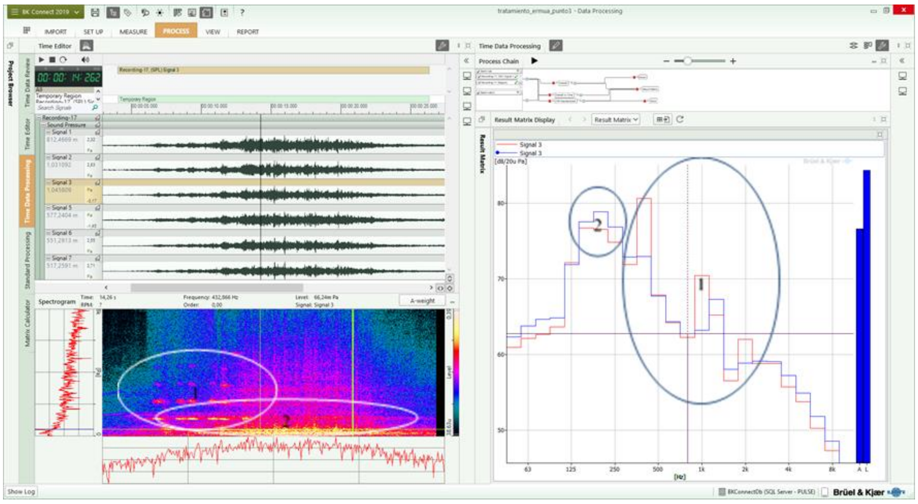

Figure 3 – Effects of the linear noise spectrum

The auxiliary equipment activated when the train is braking generates high noise levels at high frequencies, above 2kHz, blowing. Figure 4 shows this effect by comparing a pass-by with and without this blowing contribution from the braking system.

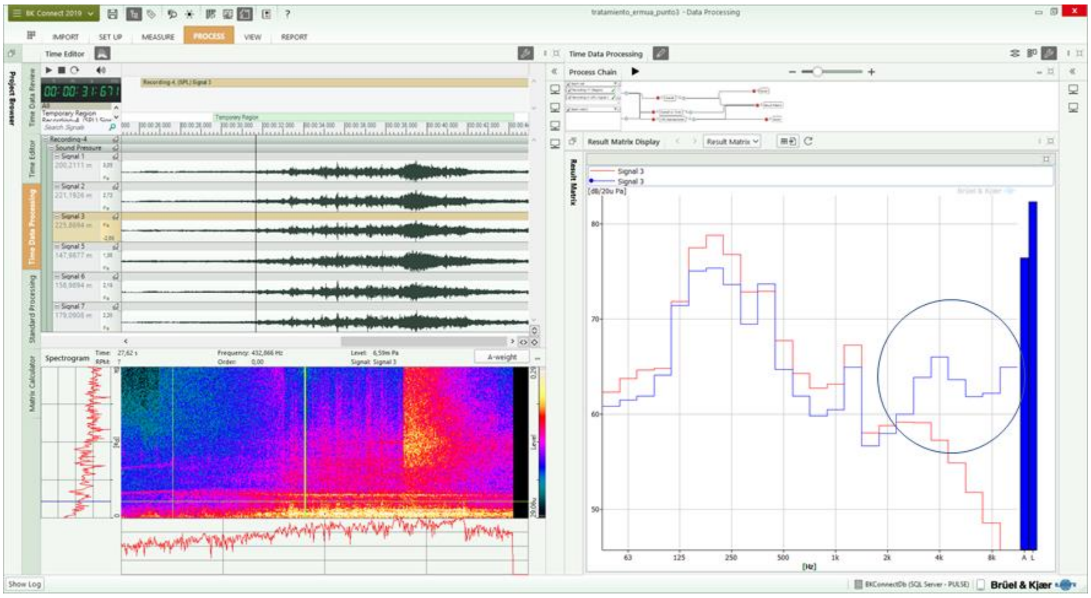

Figure 4 – Effects of auxiliary equipment in braking conditions

The evaluation of the effectiveness of the Low Noise Barrier System will take into account all types of noise to define the measurement conditions that can ensure, as far as possible, good repeatability of results.

2.5 Limitations to barrier installation

The Low Barrier System needs some requirements to have a correct acoustic performance:

1. The optimal acoustic effect, according to the calculations, occurs when the nearest edge of the barrier is positioned 1.3 meters from the nearest track lane.

2. Low Noise Barrier System should be positioned such as its higher point is 1 meter above the head track.

The environment of the newly built Ermua station had some limitations that could affect the layout of any solution, such as:

1. Curve (radius curve 80 m.), implying a dynamic gauge, greater than expected in design.
2. Existing underground installations and accessible pipelines, and
3. Foundations of the catenary structures that limited the installation of the modular system at certain points.
4. Different types of noise, as explained above.

Therefore, the efficacy of the low noise barrier installed in Ermua could be reduced due to discrepancies with respect to its optimal requirements, such as greater distance to the source and linear discontinuities in the arrangement of the modules, creating gaps with direct acoustic transmission.

Low Noise Barrier System effectiveness was assessed in an area where the negative consequences of these limitations were small. It is a section without gaps for a longer length.

3 Description of the solution

The solution consists of installing, in a real railway environment such as Ermua Station a modular system of Low Noise Barriers for railway environments (1.2 m high and 2 m long each module) developed by Tecnalia Research & Innovation & BECSA, and currently owned by the company ACUSTRAIN, based on a concrete structure, with acoustic absorption provided by the geometric design of the front panel and additional absorbent material.

The design of the system is aimed at reducing the noise generated by rail traffic in the vicinity of the track, focusing on protecting the noise source located at the railhead.

The Low Noise Barriers design complies with the railway requirements set for any element positioned close to the track. It can be placed close to the source to optimize its acoustic efficiency.

The system does not require additional foundations or works that would require the use of drilling machines on the track, as the system is secured by means of its own design. Therefore, installation costs are optimized.

Installation of the Low Noise Barrier System can be done at night without affecting rail traffic. This requires the prior creation of a smooth gravel and ballast surface as a support base. Later, the modules are moved to the track and installed with their corresponding system to anchor them to each other or to a nearby wall, if necessary. A very simple specific installation procedure has been developed.

Figure 5 – Image of the Acustrain™ Low Noise Barrier installed at Ermua.

The acoustic impact of the installation work is limited since no drilling or track machinery is required. Therefore, annoyance caused to neighbors is reduced to the maximum.

After analyzing the existing conditions and limitations at the site, Tecnalia proposed a project that consists (as presented in figure 5) of:

- A lateral Low Noise Barrier System in the direction of Eibar, 170 m long, from the train station (pk300 to pk470).
- A lateral Low Noise Barrier System in the direction of Ermua, 40 m long, before arriving to the station.
- A double/single central Low Noise Barrier System between tracks, 40 m / 60 m long, close to the station.

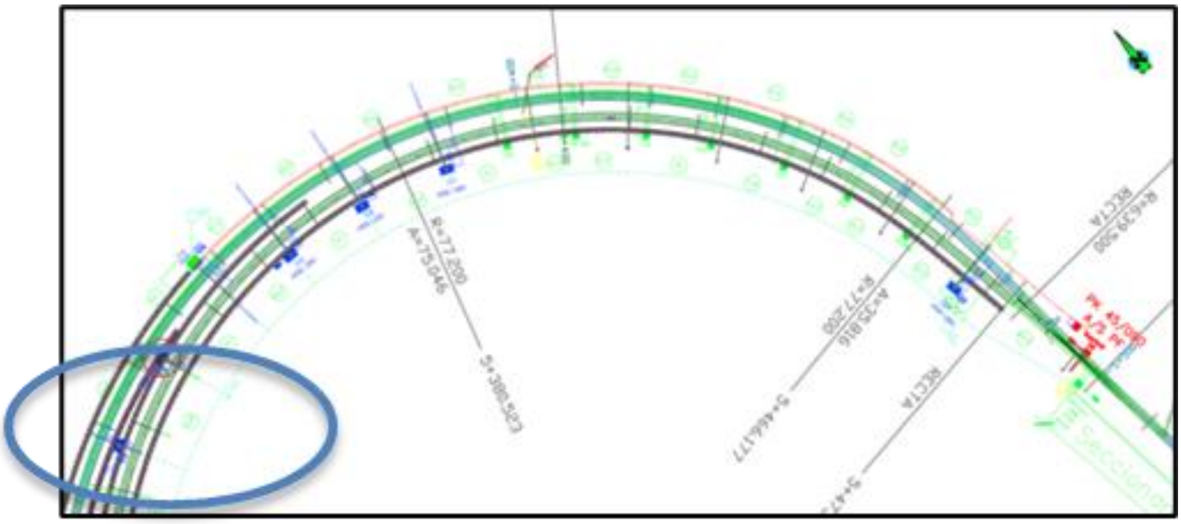

Figure 6 – Project layout (in black Low Noise Barrier System)

Low Noise Barrier System effectiveness was assessed where the system is located on both tracks and between them (section marked in Figure 5).

4 Methodology of evaluation

The correct performance and effectiveness of the installed Low Noise Barrier System has been verified through measurement campaigns, under controlled conditions at different heights and distances. For this, two measurement campaigns have been carried out, before and after its installation, to obtain the Insertion Loss level associated with the barrier. Measurement settings were defined to comply, as far as possible, with the technical specification of CEN/TS 16272-7 Railway applications - Track - Noise barriers and related devices acting on airborne sound propagation - Test method for determining the acoustic performance - Part : Extrinsic characteristics -) in situ values of insertion loss.[3]

The section selected to assess the effectiveness of the Low Noise Barrier System is an optimal solution, where the Barrier is installed in four positions: two lateral positions, on both sides of the tracks and two central position, between the tracks (Figure 6).

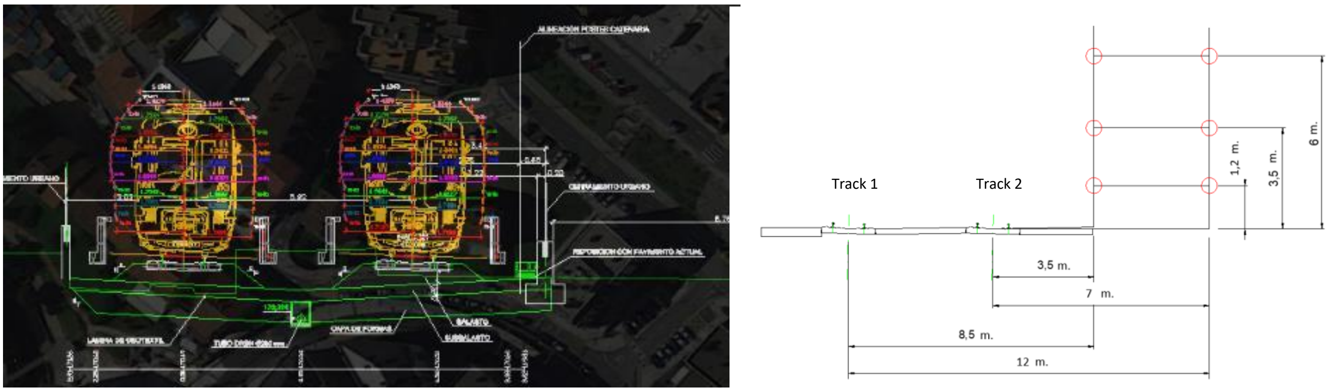

Figure 7 – Description of Low Noise Barrier System at the test section, and Measurement setting

Measurement setting consists on an array of microphones at three heights and two distances from track, in each section/ point (Figure 6) [4].

Measurements were made simultaneously at two distances (3.5 m and 7 m from the nearest track) and at three heights (1.2 m, at 3.5 and 6 m from the railhead). Due to the presence of buildings, the standard distance of 7,5 m was moved to 7 m.

A minimum of 10 pass-bys were measured for each type of train.

Each pass-by is characterized by the LpAeq,tp level. The integration time is longer than that set in the standard to facilitate the analysis of the squeal noise and to ensure it does not contribute to the pass-by level. Therefore, the integration time used lasts from the pass of the first to last boggies, plus the time required for the level to drop by 10 dB.

The repeatability of the conditions of the two campaigns was considered by analyzing the noise levels measured in a reference position in both campaigns. This reference measurement position is not affected by the installation of the Low Noise Barrier System, and the comparison of its data between the two campaigns avoids the effect of possible changes in speeds and/or track conditions. At this reference point, noise levels were measured for the same pass-bys that were measured on the array microphones for the test section in both campaigns.

Referred to the contribution of the squealing noise, to try to have similar conditions, the irrigation system installed in the area was working in both campaigns. However, given that the second campaign was carried out in a warmer season, the noise levels measured in the second campaign are somewhat higher, so additional analysis was necessary to exclude these differences from the Insertion Loss.

5 Results

As said before in the selected test section, the arrangement of the Low Noise Barrier System barrier is close to being the optimal: with practically no discontinuities.

The measured pass-bys are arrivals to the station by the nearby track (towards Ermua) with similar conditions. Considering the pass-bys without the contribution of squealing noise in the measurements with and without Low Noise Barrier System, for the same type of train (900 series passages on track 2), the improvement achieved is greater than 11 dB, with all the attenuations being above 9 dB. Reductions in noise levels appear in all bands of the spectrum.

The improvement occurs at all measurement points in the microphone array, and the Low Noise Barrier System performs as expected from the simulations performed in the design phase and measurements carried out in the prototype phase.

This effectiveness is what could be considered as the closest to the real effect provided by the correctly installed Low Noise Barrier System.

Figure 8– Noise levels with and without Low Noise Barrier System

6 Conclusions

As a summary of the evaluation of the effectiveness of the Low Noise Barrier System, and considering that some contribution of squealing noise in the second campaign could be reducing the acoustic effect, it could be concluded that:

- When the installation of the Low Noise Barrier System can be carried out in accordance with the requirements established to optimize its efficiency, it is estimated that the insertion loss, measured with respect to LAeq, tp (vehicle passage level), is greater than 11 dB.
- In general, the Low Noise Barrier System can be located in the position closest to the track to optimize its acoustic efficiency, since it complies with railway legislation required for elements that are positioned close to the track.
- The procedure to install the Low Noise Barrier System can be performed at night without affecting traffic. It only requires the prior creation of a smooth gravel and ballast surface as a support base, the position of the modules on the trackside and the installation of each module with their corresponding anchors between them or shoring some of them to the wall, if necessary.
- In addition, the acoustic impact of the installation is reduced, since only track machinery is required, without the need for drilling.
- The installation costs are optimal, since it does not require additional foundations, as it is anchored by means of its own solution.

Acknowledgements

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