

# Elements for the design of acoustic barriers: some cases in Rio de Janeiro city

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**ABSTRACT:** The growth of environmental degradation in the great urban centers has reducing the spaces that offer appropriate levels of environmental comfort for their inhabitants. The landscape planning, one of the main instruments for the improvement of the urban space, besides being poorly explored, often does not integrate all the areas of comfort involved in this issue. The implantation of acoustic barriers along thoroughfares with heavy vehicles circulation is an impressive example. Although its basic function is the sound protection of the spaces located in their surroundings. Other aspects, such as visual obstruction and interference in ventilation should be carefully appraised in order to minimize the impact on the landscape created by such barriers.

The aim of this paper is to present some solutions for the landscape composition of those barriers. The use of design and the vegetation may also transform the acoustic barriers into an interesting element on the urban landscape and contributes to the thermal comfort. This paper is focused in the city of Rio de Janeiro comprehending places where acoustic protection is needed; some examples already built and projects of barriers integrated to the revitalization of the harbor area.

**Keywords:** acoustic barrier; urban space; landscape planning.

## 1. INTRODUCTION

A built space consists of a rearrangement of nature by an individual, in an application of his sphere of influence and his way of being [9] These rearrangements, in urban space, are forms built to comply with constant social needs, which are dynamical, because they change in quality, quantity and spatial situation.

Comfort conditions of these spaces can be modulated by several kinds of determinants, such as: visual sensation of colour, form, movement and polarization of light, tact, smell, hearing, among others, as well as how and by whom the space is perceived [7][10]

In this global context of comfort, acoustic quality obtained by means of barriers cannot be thought of separately, but their necessary functional features must be associated to a visual design which integrates them to the environment in which they are built [1]

The concern with the aesthetical composition of space is a key point in warm and damp regions like Rio de Janeiro, due to the difficulty of protecting the inhabitants of the noise, since the outdoor spaces are used during the whole year and the buildings have constant natural ventilation because of high humidity levels.

## 2. ACOUSTIC BARRIERS

Generically, the expression 'acoustic barrier' includes vertical walls, ground elevation, and partial or total covering of the way, with the purpose of

reducing the noise level in the affected area near the road [2].

In the beginning, the designs of acoustic barriers disconsidered the integration to the urban environment, the result being a merely technical solution with a sound attenuation too small if compared to the aesthetic impact. Only in the last decade did the integration to the urban landscape begin to be considered a relevant factor in an acoustic barrier design [12].

Being large structures, usually as tall as 6 meters, acoustic barriers produce significant change in the view of the road, blocking it and thus creating an uniformly monolithical landscape instead of the urban scenery. They also change the perception of the way by the surrounding community, giving the suggestion of a physical and psychical barrier between that community and other places [1].

A positive visual image to road users and surrounding communities can be combined to the benefits of noise reduction by means of a project which allies the minimum conditions of sound attenuation and aesthetic qualities, producing an attractive and integrated barrier that leads to a new landscape configuration of the urban context in which it is built.

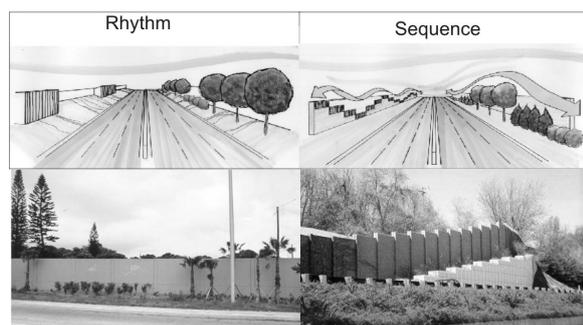
These methods consist of exploring color and transparent materials, elements that compose forms, topography (creating a slope that makes up a natural acoustic barrier), vegetation, or even integrating these factors. Use of vegetation goes beyond its functional aspects, because of its importance to the inhabitants of the city, confirmed by many researches in which vegetation is mentioned by many interviewed subjects in a loving and joyful manner [6]

### 3. AESTHETIC COMPOSITION OF AN ACOUSTIC BARRIER

The aesthetic elaboration of an acoustic barrier begins with the analysis of who will observe it and how, taking into account questions such as distance, movement, line, form, scale, distribution, rhythm, sequence and orientation [8]. Each of these factors must be carefully considered and chosen in order to create a design compatible with its surroundings.

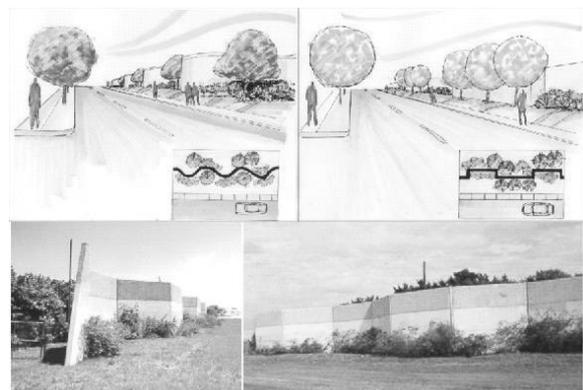
In the composition of a barrier, distribution can yield order and unity, producing a sense of balance [1]. Two basic types of distribution include symmetry and asymmetry. Symmetry is a result of an equal distribution of elements along a central axis, creating a mirror effect, and is considered to be a formal distribution. On the other hand, asymmetry is more informal, not possessing a central axis, and its elements are disposed along the way, compensating one another and thus not creating the double image effect.

Rhythm and sequence establish consistence with a recognized pattern. These repeated patterns create a sensation of acquaintance, comfort and progressiveness. They can be produced by the use of vertical elements as well as vegetation.



**Figure 1:** Repeated patterns establishing rhythm and sequence [1][13]

The body configuration of a vertical barrier can be changed from its horizontal alignment, trying to avoid the continuous line and generating a three-dimensional form, which creates "negative" spaces that can be used for vegetation. Some possibilities of this displacement are shown on Figure 2.



**Figure 2:** Displacement of the barrier body [1][13]

There are several possible textures and patterns for the surface of the barrier, but their composition must be structured according to the speed of the observer, so that it does not become a negative visual element. At high speed, texture is not sharp and patterns cannot be perceived. In that case, simple, dense textures and large patterns should be used, emphasizing their form. On the opposite side of the road, turned to the surrounding community, visual perception takes place at much lower speed, by people walking or driving slowly. There, finer and more complex patterns and textures should be used [8].

### 4. USE OF VEGETATION

Exclusive use of vegetation as an acoustic barrier, without other elements, does not present satisfactory noise reduction levels. A large distance between source and receiver is necessary for vegetation to be an adequate barrier [3], its exclusive use not being viable for small distances.

#### 4.1. Functional aspects and visual composition of vegetation

A typological classification of vegetation is necessary for its good use in a project. Basic classification can be according to size: trees, bushes, palm trees and herbs; according to tolerance to direct sunlight exposure, and according to suitability to climate.

Leaf density, classified as dense, medium and rare, can be important because of its influence in the shadow and in the composed texture. Growth time influences the choice of vegetation, slow-growing plants being avoided for a quicker composition of the landscape. Finally, it can be classified according to the time of the year in which leaves, flowers and fruits appear, as well as according to their color. As leaves are concerned, vegetation is classified as deciduous, which loses its leaves in the autumn, and evergreen, which has leaves all the time.

Because of their great variety, plants can be used to create environments differing not only in form, but also in color and smell. The classification is important to allow the choice of vegetables which are suitable to the climate of the studied region, available space, intended visual composition of form and color, as well as possible variation throughout the year.

#### 4.2. Vegetation and thermal comfort

Beyond its visual interest, vegetation has been studied for its role in thermal comfort. Trees, bushes and lining vegetation, like grass, tend to stabilize temperature and prevent extremes, which is the opposite of manufactured surfaces. Generally speaking, on a sunny day, a grass-covered region can be 5 to 6°C (9 to 11°F) cooler than a region exposed to radiation [4].

Another important factor is reflection of incident light, which occurs in a rate of 10 to 15%, a lower reflection of light and heat, for instance, than in concrete (25 to 35%). Vegetation can also clean the air by capturing dust particles due to the viscosity of

its leaves. These facts can be explained by the high amount of heat needed for surface transpiration and vaporization in leaves, where incident solar energy is effectively dissipated by multiple reflections, absorption, only a small amount of it being lost to the atmosphere [5].

Use of vegetation becomes even more interesting in Brazilian context because of its low cost, its abundant growth in the humid tropical climate, self-reconstitution, low maintenance cost and thermal qualities. Moreover, plants have optimal photosynthesis rates near the Equator, where Brazilian cities like Rio de Janeiro (22°54') are situated.

In these regions with little temperature variation along the year, maintenance and equilibrium of vegetation are easily achieved, since climatic stability ensures the constancy and resistance required to the visual quality of spaces.

## 5. INTEGRATION BETWEEN VEGETATION AND ACOUSTIC BARRIERS

Uses of vegetation as a landscape element can take place beyond the mentioned above, as lining and composition element of the elevated barriers or implanted together with vertical barriers in order to camouflage them. It can also serve to reduce the great extension of the barrier, enhancing vertical or horizontal lines, as well as to attenuate noise and reduce temperature, which is very important in Brazilian climate.

### 5.1. Composition forms

Vegetation composition can follow symmetry, asymmetry, rhythm, sequence and orientation characteristics too, by means of the use of textures, patterns and contrasts generated by the different types, forms and sizes of the vegetables, creating or enhancing focal points of interest, serving as a portrait to views and objects, aesthetically stimulating drivers along the way and producing the sensation of a natural space for the users of its surroundings.

This integration between the vertical barrier and the vegetation depends also on the space availability around the barrier. When space is reduced, creeping plants can be fixed to structures on the barriers, or the barrier can be made a "great flowerbed" (Figure 4).

In viaducts, possibilities are restricted by factors like weight limit and small available area. In that case, one should work with the pagination of the body of the barrier, or use epiphytes, which don't need ground (that increases weight) and can grow on *xaxim* (trunk of certain tree ferns (family *Cyatheaceae*) used in floriculture as plant pots) plates, which are much lighter.

However, large scale use of *xaxim* acoustic barriers is not recommended since its extraction from ferns can become predatory. Nowadays, *xaxim* can be replaced by coconut (*Cocos nucifera* L) fiber, which is advantageous because the fiber comes from the fruit, which regenerates quickly, and because coconut is largely available in Brazil and only 12% of

its fiber is economically explored. Another advantage of its use is the satisfactory acoustic attenuation [11]

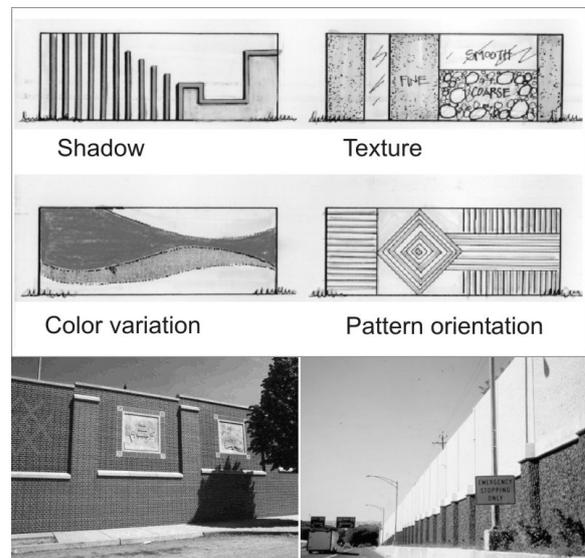


Figure 3: Different forms of composition [1][13]

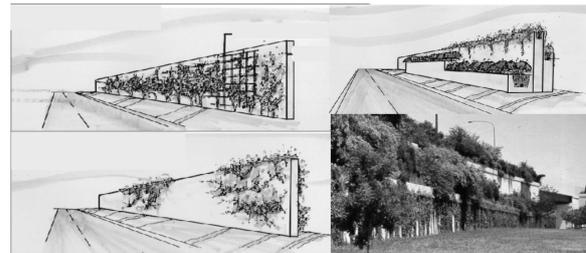


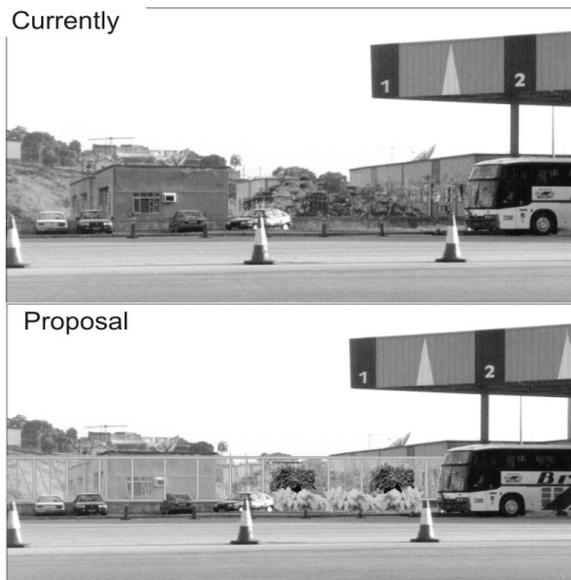
Figure 4: Use of creeping plants and with flowerbeds [1][13]

## 6. CASE STUDY

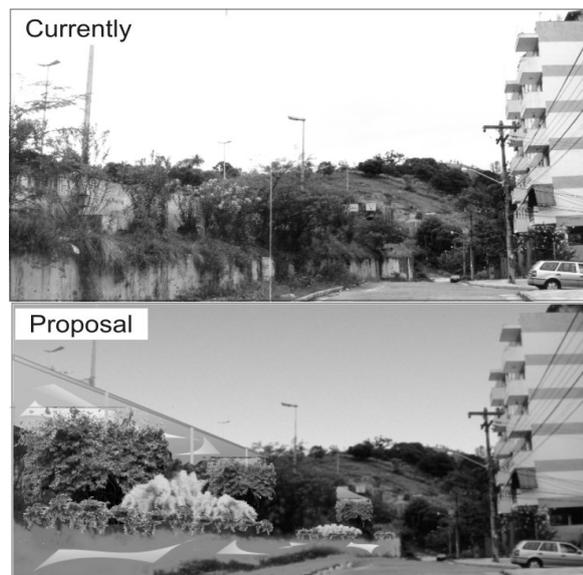
In Brazil, the use of acoustic barriers is not as common as in other countries. In Rio de Janeiro, an example are the vertical barriers installed in "Linha Amarela" (*Yellow Line*), a new 25-kilometer expressway connecting Fundão Island to Barra da Tijuca.

These barriers were implanted in certain parts of the road only, with aesthetic concern in the choice of colors. However, further noise measurements showed the need of barriers in other parts of the road.

For those areas, different barriers were proposed, focusing on their integration to the urban landscape with emphasis on the use of vegetation. These propositions were carried out in Água Santa e Freguesia, and are shown on Figures 5 and 6.



**Figure 5:** Intervention in Água Santa – Pedágio – as seen from the road [14]



**Figure 6:** Intervention in Freguesia – as seen from the surroundings [14]

## 7. CONCLUSION

The city must be erected with art. Concern with aesthetic composition of the urban context should comprise all spaces, regardless of their use and the time of the day, and every element, from the greater building to the smaller object of the urban space. Knowing the composition of the space, and how its elements can be associated to form and color, texture and movement, helps understand space perception and establish guidelines of the quest for global environmental comfort.

Applying these parameters to the design of acoustic barriers in an urban context becomes essential, because the barriers sharply divide space, in a way that a judicious study of aesthetic

composition, acoustic comfort and thermal improvement is fundamental to their integration.

Vegetation presents itself as a practical, cheap and effective solution, because it allies good thermal response that suits the hot climate and easy maintenance, especially when it is evergreen and rustic, not needing specialized workers. It allows interesting volumetric composition due to the great variety of sizes, forms, colors and textures.

Other advantages can be mentioned, such as good approval by population, due to the good integration to the surroundings and the proposal of solutions in which the community can take part, like the implantation of new green areas. It also minimizes vandalism acts like graffiti, because of the reduction of exposed surface. All these factors point to the importance of including vegetation in this and other kinds projects, making its use more and more common in several countries around the world, and hoping to make it present in our future interventions.

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