Bioengineering materials and techniques

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Abstract. Along this article it will deal with a subject that tends to be strengthened in our country, it is used in the recovery of unstable soils with erosion problems and strong signs of wear and loss of value. It is the subject of bioengineering its techniques and materials used. Bioengineering, also called Biological Engineering, is a discipline used in environmental regeneration interventions, using living materials (plants, trunks, seeds) alone or in combination with other inert materials of construction. Bioengineering allows the fulfillment of technical, ecological, socioeconomic and landscape objectives in the recovery of land with problems of erosion, instability, steep or moderate slopes, hillsides, basins or urban environments. Finally, the relationship between bioengineering and landscape has been strengthened, due to the magnificent results that its combination presents in the recovery not only of the soil, but also of the contribution to the quality of the landscape and its sustainability.

1. Introduction

Colombia has 11 of the 12 soil orders existing in the world, these are diverse and very fragile [1]. Due to this vulnerability, Colombian soils are exposed to several important degradation processes, including erosion, loss of organic matter, salinization, compaction, soil sealing, pollution and desertification. [1], affecting not only the chemical composition of the soils, but presenting serious and unpleasant physical and biological affections on the functionality, productivity and quality of the altered landscapes [2]. This concern is assumed from the design of landscapes, since revegetating a surface would be non-sense and insufficient when the soil is seriously affected. In these cases, it is necessary to address the underlying problem, which presents the soil, through bioengineering, in order to restore the landscape in a sustainable manner. (Bioengineering and Landscape) [3]. This article is aimed at highlighting some strength found in the relationship Bioengineering and Landscape, taking into account its application in real problems, carried out in studies and academic interventions by students of Architecture, of the optional courses in the Landscape line. Research that has been part of the academic, research and teaching for more than a year in the Faculty of Architecture and Engineering of the Colegio Mayor de Antioquia University Institution.

2. Bioengineering

Biological engineering in Spanish, comes from the German “Ingenieur-Biologie”, also called bioengineering or landscape engineering. The term engineering refers to the use of technical and scientific data for constructive stabilization purposes in the control of erosion, and the biological term refers to the functions performed by living organisms, mainly plants (grasses, rushes, herbs, shrubs, trees). It is considered convenient that the live material to be used in a bioengineered intervention is
made using plants of native species, stakes and seeds, and takes advantage of their biotechnical characteristics, using them alone or combined with other inert materials of construction in the reconstruction of ecosystems and the increase in biodiversity [4].

The bioengineering has as main purpose, from the interventions, to fulfill with technical aims, ecological, socioeconomic and landscaping, based in a philosophy to “think as a whole to act locally” [4]. Of equal way, is precise to recognize that inside the branches of the biological engineering, the previous described process, does part of the engineering of processes, in the design of bioprocess to optimize the operation of structures and constructions with organic elements.

2.1 Antecedents of bioengineering
In antiquity and in the middle ages, when stone and wood were the raw material for constructions their empirical techniques were used, where experience and traditions marked the rhythm, bioengineering was already used, although It will bear this name. In the Europe of alpine landscapes, already at the end of the 13th century, Austria and Switzerland carried out works with reference to bioengineering as a discipline, mainly in the stabilization of riverbanks and soils with erosion problems. Later, the heyday of concrete and new construction techniques and materials in the early twentieth century, opaque and relegated the applications of bioengineering to rural areas and lost with this, prominence and strength. It was the economic crisis of the 30s of the twentieth century, where Western Europe returns to resume the use of bioengineering for its low cost and easy procurement of raw materials [5]. The proliferation of applications and the numerous investigative registers on the use and the applications of the bioengineering, allowed that it was included in the cultural and social canons like a discipline that promoted the environmental care, the good use of the natural resources and the restoration of the chemical conditions, physical and biological of the soil.

2.2 Uses of bioengineering
Bioengineering has been proved to be very useful in the treatment of unstable soils or problems of erosion, problems located in water basins, hillsides in urban or rural environments. The use of live material makes the interventions with bioengineering, dynamic constructions, since the gradual growth of the plants already installed in the intervention, cause with time and their development, a strengthening of the structure, protecting the installation to a greater degree and increasing its structural properties in great average, situation that does not occur with conventional constructions of static type. The landscape bioengineering is commonly used in the rehabilitation of humid environments, coastal zones, fluvial fields and reservoirs [6], intervention in areas of mountain mainly in the stabilization of slopes, in the construction of forest tracks and in the regeneration of the tracks of ski. Also, it is used in the recovery of public works: such as highways, pipelines and iron ways. In general, it is used in any environment that it was necessary to recover or regenerate the normal conditions of the soil.

2.3 Bioengineering, landscape and sustainability
Currently the world faces the challenge of climate change, natural phenomena become more intense, frequent and unpredictable, because they make accelerated changes in the territory and with it the loss of the visual quality of the landscape and environmental imbalance. As a teacher and landscape designer, I question myself more and more, the role that the professional future Architect has before the balance of the environment. For this reason, I took advantage of the possibility of including in the curriculum of the Architecture program, optional courses in the landscape line, where it is possible, based on the training function of the university, inculcate good actions, create awareness in the future professional architects, and provide the development of tools to carry out designs and interventions with bioengineering, where the landscape nowadays acquires value category, and is considered as a resource that must be conserved.
3. Techniques, materials and vegetation

To adequately establish the relationship between bioengineering and landscape, the aesthetic look and function of the landscape must be overcome to deepen its use, a feature that is easily allowed with bioengineering since the opportunity offered by deep soil treatment as one of the elements of the landscape and not only its visibility and external perception.

Facing a space with serious signs of degradation, with problems resulting from the inclination of the soil, environmental, anthropic wear and effects caused by natural phenomena, imposes an interdisciplinary task and multidisciplinary actions, since there are many aspects that are involved and that must be taken into account when designing the restoration or recovery of the landscape value of a sector. For this it is necessary to use appropriate techniques and tend to specific cases in the treatment of soil problems, there, bioengineering provides a series of techniques that are coupled very well to the achievement of good landscape quality [7].

Bioengineering techniques have technical, ecological, landscape and socio-economic principles that can be used in this relationship, they are:

- **a) Technical principles:** design and application of living and/or dynamic structures that allow the stabilization of the soil through the root or root system in the control of surface erosion, as well as the consolidation of soils with high or moderate slopes.

- **b) Ecological Principles:** making use of native vegetation combined with other plants appropriate for the case, in this case, this allows the evolution of plant associations more stable, resistant and more proliferative.

- **c) Landscaping Principles:** This allows and/or opens possibilities directed to allow the integration with the works of landscape, diminishing its visual impact and contributing to the sustainability of the landscape.

- **d) Socio-economic principles:** making use of local natural materials, construction and energy costs are reduced, a good use of natural resources is promoted, and employment sources of qualified hands are generated in the use and application of techniques [8].

Bioengineering techniques can be described mainly in three groups: coating techniques, stabilization techniques and mixed techniques. Generally, the use of these techniques is accompanied by specific materials and vegetation, therefore, we will be combining these three themes in the following exhibition.

Coating techniques, as the name implies, are focused on providing support to the land, achieved in various ways, such as hydro-seeding, the use of geotextile beds or meshes and the planting of appropriate vegetation on the geotextile mantle, and the laying of mats of branches. This technique is widely used when the problem of the soil is not very serious, when the detachments or drag of the substrate are smaller and more controllable. Generally, the coating is used in soils with moderate slopes, banks or riverbanks and with a preventive and finishing purpose. The vegetation used goes from the branches of *matarratón*, guava, willow, lemongrass and poplar to arm the mats of branches [8]. For the hydro-seeding and on the geotextile mantle, you can plant fodder peanuts, tradescantia zebrina, tradescantia purpurea, which, in addition to providing a good appearance to the surface, provide grip and stability due to its extensive and deep roots. The organic meshes have a flat structure, are made of natural materials, are biodegradable, serve to support the slope until the vegetation has taken root.

On the other hand, the stabilization techniques allow a deeper treatment of the soil and it is carried out with the-staking, the wicker braiding and the live fascines. The cuttings are very used in the stabilization of riverbanks when the material drag is considerable and consists in introducing a series of small cuttings or cuttings of vegetative species such as willow and poplar into the ground as a sowing. [9]. The cuttings in a short time have re-vegetation on the surface acting as a brake to the passage of the waters of the river and avoiding or diminishing the drag of the substrate since the stakes temporarily consolidate the structure until the cuttings and vegetation are implanted. This technique not only allows the correction in the function of the bank, but it also provides a natural visibility when the riparian forest in the riparian zone of great ecological gain recovers.
The wicker braiding on Figure 1. It arises from the design of a living and dynamic structure from the intertwining of branches capable of re-vegetation, supported by stakes driven into the ground. This technique, like the previous ones, allows, in a short term, to have shrublands that greatly improve the landscape quality. The one called live strips or “fajinas” are clusters or set of branches tied in bunch of cylindrical shape for greater resistance and pressure of the erosion. The branches are held in the ground by means of stakes driven into the ground and have the peculiarity of being branches of easy sprouting, which makes re-vegetation in a short time striking [10].

![Figure 1. Wicker braid made with stakes nailed to the ground that allow interlaced branches interspersed. Model made by students.](image1)

![Figure 2. Acquila lattice, special structure for terrains that require longitudinal and transverse reinforcements. Model made by students.](image2)

Finally, the mixed Technicians realized with the combination of vegetal component and other inert materials like rocks, wooden trunks treaties, nails of steel, wire or cabuya. Like mixed techniques use the entramados wooden and the gabions alive [11]. The wooden frameworks come to be very useful in the treatment of soils with serious and advanced problems of erosion and instability, for which the designed structures turn out to be much stronger, functioning as well as the engineering retaining walls. The most well-known and used wood frameworks, for their versatility and easy coupling to the problems are the Krainer walls. The Krainer walls or wooden frameworks of trunks can have in different positions of the wooden trunks, resulting like this diverse frameworks according to the strength or push that it has to exert in the holding of the terrain, they can be Acquila frameworks, Figure 2, Rome framework, Figure 3, Latin framework, Figure 4 and Loricata framework, Figure 5, [12].

![Figure 3. Lattice Rome. Structure that contains the terrain providing a slight slope. Made by students.](image3)

![Figure 4. Lattice Latin, reinforces, contains and ties the ground avoiding its detachment. Model made by students.](image4)

The frameworks are combined with branches and plants cuttings of fast re-vegetation, grasses and herbaceous species of the region. The plant material that accompanies the bioengineering works must go through a specialized selection in the erosion control and their criteria can vary from the root system, the contribution of organic matter, the maximum height or bearing, the morphology, the...
climatic demands, edaphic and hydric, periodicity of maintenance, aggressiveness and dominance, even to anthropic uses (food, medicinal, artisanal, industrial, ornamental) [13]. Ground cover plants, crawling type, carpet coverings with fibrous and filamentous root systems are the most recommended, as well as herbaceous, medium and high stubble. The morphology of the foliage, density and texture also play a protective and stabilizing function of the structure constructive, since what is sought to use reborn plants in a short time, so that their development and growth of root system and foliage, provide strength, support and great mooring of the structure, which at the end of its useful cycle it will biodegrade, leaving the plants with the function of structure [14].

4. Exercises of bioengineering from the academy
With the group of students in the optional course III in the landscape line, in the Faculty of Architecture and Engineering of the University College of Antioquia, has been venturing into the implementation of some bioengineering techniques in the landscape treatment of land with moderate slopes. Situation that has allowed investigating materials, vegetation and different ways of accommodating and/or coupling the design of dynamic structures to the ground, through academic exercises. The methodology, it means, planning and organization of activities carried out in the exercises In-Situ look for not to move away a lot of the process of design forced that it is still in architecture.

We contemplate the forced step of visiting the place Figure 6, for inspection and landscape survey, where the provisional scope and the possibilities offered by the land for its treatment are defined, from this preliminary analysis the preliminary diagnosis arises, with which a planning and organization of the style and approach is carried out of the treatment, Figure 7. A necessary and followed step is to review the skills and strengths of the members of the team for the distribution of tasks in the field, which allows us to have more success in the scope and content of the work in their In-Situ work. A work program is drafted that includes the survey, diagnosis, preparation of the land, Figure 8, exhibition of the characteristics in the preparation of the material, Figure 9, the technique or techniques to be implemented is properly studied, Figure 10, detail of the materials, equipment and tools to be used, Figure 11, the appropriate mixture is calculated for the substrate and the filling material, Figure 12, selection of the vegetation and designs where the color, the textures and the combination of ornamental plants is present, Figure 13, a budget is presented as approximate possible by collecting recycled material, a schedule of activities, which details the intervention phases and finally an evaluation and delivery of the work, Figure 14.
5. Conclusions

Undoubtedly bioengineering offers the possibility of treating soil with different problems related to the degradation of them. Addressing bioengineering priority to the design of landscapes allowing not only to attack the underlying problem almost always located on the ground, but to provide a much more accurate, relevant and lasting improvement, this has as a consequence and it is that the resulting landscape contains more attributes of sustainability. From the academic point of view, to include in the teaching of landscape the different possibilities that soil bioengineering offers, is crucial to prepare future generations of architects in the development of inter and transdisciplinary skills related to landscape elements. The climate and other external appearances that influence negative or positively the elements of the landscape, surpassing the aesthetic perception of the same and relegating with this its target use, wanting to go further when covering the functional field, useful and productive of the natural values, patrimonial, cultural and identity contained in the landscape.
Acknowledgements
The students of the optional course on the landscape line, express their gratitude to the Colegio Mayor de Antioquia University Institution and to the owners of the "La Gloria" Farm in Copacabana-Antioquia, for the establishment of the Cooperation Framework agreement which allows, the realization of contextualized practices and the transfer and social appropriation of knowledge.

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