MEASURES OF PROTECTION AND CONSOLIDATION OF RAILWAY SLOPES DURING OPERATION PERIOD FOR A REHABILITATED RAILWAY LINE STRETCH

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Abstract: *The objective of the present study is that to mitigate the foresee impacts from the railway line rehabilitation works. At the same time the mitigations measures have the aim to environmental rehabilitation, in the operation phase, with the objective to the global environmental rehabilitation of the interested areas of the Banat Plan, Mureş Valley and Deva Depression which intersects with the railway line Curtici-Simeria. According to the capital estimate of mitigations measures to the environmental impact, the investment in the environmental protection of the rehabilitation and upgrade project is primarily defined in about 3% of the total investment. Among the mitigation measures, we mention: slopes stabilization, drainage and erosion control, protection drainage (gabions); bio – engineering techniques; re–vegetation (workers, planting stock, transport of planting material); installation of noise barriers and installations of traffic signs and road bumps. The recommended mitigation measures that should be adopted to avoid or minimize potential adverse impacts consist essentially of prescriptions for the construction period or rather project solutions or technical-realizations with the purpose of foreseeing the possible rising up of impacts in the territory. Therefore it should tried: to contain the impact on the settlement keeping the layout of the project as further as possible from the houses/residential area and, where this wasn't possible, adopting technical solutions; to respect the areas of environmental special interest as the Mureş valley ecosystem and the building nucleus of architectonical interest; to reduce the interruption of the agricultural continuum restoring the accessibility conditions of the local connections network and to maintain the continuity of the water network neither of main level nor of the secondary one. It has been underlined two categories of the project: the one of mitigation measures and the one of optimization of the project on the contents at the outline. The mitigation measures are finalized to pursue the elimination/control of the potential interferences gathered during the environmental analysis that had taken into consideration all the elements involved. The second category of activities carries out a double function: integrate the project infrastructure and the interventions of mitigation defined (for example the one of acoustic barriers) among the operation context. In the definition of these works, the landscape planning covers an extreme important role.*

Key words**:** *railway line, mitigation measures, consolidation system*

INTRODUCTION

The territory of the railway line Curtici-Simeria occupies a depression inter-Carpathian that gently descend in steps from the volcanic peaks of the Călimani (2.100 m a.s.l.) and Gurghiu Mountains to the Middle of the Transylvanian Plain (280 m a.s.l.). This depression is crossed by the valleys of the Mureş and the two Târnava rivers as well as by their tributaries.

The Mureş alluvional meadow, have a particular lithology made up of clays and silty clays, at the upper part, and of sands and then gravels, at the base. This part of Romanian territory is a confluence point between the biogeographic southern (Mediterranean and Balkanic regions) and continental (European and Pannonic regions).

The agricultural lands and the arable areas interest the plane zones (Arad plan and the Mureş valley plan zones) otherwise the important deciduous woods cover the mountains slopes (especially with common oak like *Quercus petrea*, with isolated *Fagus silvatica*, *Fraxinus ornus*, *Acer spp*.). Like in the rest of Romania, human activities historically have modified significantly the landscape. These modifications have reduced the size, the abundance of certain elements of the ecosystem (most notably steppe grassland, wetlands, river courses) and also added new components (especially infrastructural works).

In few case the forest areas, as natural reservation of Bejani Forest and of Deva Castle Hill, in the north part of Deva whit old oak trees and many species resulted from natural cross breeding, the reduction have retained a high level of natural species composition and quality.

In fact less of biodiversity is the main result of the human activity. In particular the intensive agriculture, the industrial development and the urbanization have profoundly affected the biological diversity of the area, both generally and locally. Pollution, alteration of river courses and hydro-technical works, mineral resource extraction and overexploitation of biological resources has been the principles factors involved. In this case, the agriculture maybe also a pollutant factor in some of these areas.

The railway line runs through the vast agricultural land of the Banat, between the Hungarian border and Curtici, then it continues south-eastward up to the important city of Arad where turns eastward to the entrance of the Mureş valley with W-E direction. In the narrow Mureş Corridor are localized more agricultural villages with low density, generally scattered along the main roads or along the small streams runs from the Zarand Mountains.

The eastern stretch of the line, joining Deva at Simeria having a length of about 10 km, runs straight in a flat area site in the central part of Romania, named Podişul Transilvaniei.

MATERIALS AND METHOD

Generally speaking, the transports field has a great impact on the environment, at global scale and on long term, generating serious accidents with casualties, or with loss of vital capacities, important economical damages as well as noise and chemical pollution, sometimes irreversible, substantially modified landscaping and even modifications of human behaviour and of society. The dimension of these phenomena and their characteristics is different depending on the type of the transport systems: terrestrial – surface, underground, aerial and by water. On the other hand, the goods and persons traffic has always been and still is the basis for human society development, allowing trades, global division of the work, trainings and free competition, in a world where the globalization represents an important phenomenon with a great development nowadays.

Strictly referring to terrestrial transports, respectively railway, object of this study, it can be noticed that their impact can be perceived as an adverse impact, especially by the "pure" ecologists, but it must be also observed that they also have a significant positive impact on economy, society development and people at the same time. The adverse impact essentially consists of pollution, and the positive impact consists of the facilitation of the trades ranging from material goods and passengers.

The project will cause a series environmental impact, either during its construction period or operation period. After the completion of the project, the passenger traffic volume will have a great increase, thus bringing about large amount of passengers refuse along the line and at the main stations. The solid wastes are to be properly disposed. The project will not only relieve the tension on railway traffic among cities and the cities outskirts but also promote the social, economic and cultural development along the line and obtain good social environment benefits. The environmental impact during the railway operations period will be permanent. Viewing the environmental impact range and its extent, the major factors are social and

cultural environmental impact, noise and vibration pollution, landscape alteration and the water pollution while other environmental impacts are rather small. In the operation period the main environmental impacts are the noise pollution (the noise pollution includes train running, shunting and loading – unloading operation at stations, locomotive servicing and broadcastings both at stations and yards and other high noise equipment, etc.).

RESULTS AND DISCUSSION

The objective of the present study is that to mitigate the foresee impacts from the railway line rehabilitation works. At the same time the mitigations measures have the aim to environmental rehabilitation, in the operation phase, with the objective to the global environmental rehabilitation of the interested areas of the Banat Plan, Mureş Valley and Deva Depression which intersects with the railway line Curtici-Simeria.

The recommended mitigation measures that should be adopted to avoid or minimize potential adverse impacts consist essentially of prescriptions for the construction period or rather project solutions or technical-realizations with the purpose of foreseeing the possible rising up of impacts in the territory. Therefore it should tried: to contain the impact on the settlement keeping the layout of the project as further as possible from the houses/residential area and, where this wasn't possible, adopting technical solutions; to respect the areas of environmental special interest as the Mureş valley ecosystem and the building nucleus of architectonical interest; to reduce the interruption of the agricultural continuum restoring the accessibility conditions of the local connections network and to maintain the continuity of the water network neither of main level nor of the secondary one.

With reference to what was before developed concerning the analysis of the interferences derived from the work during the operative phase, follows the description of the mitigation measures foreseen. The environmental components, the parameters involved and the related effects are summarized in Table 1.

Table 1

Environmental components involved in the mitigation measures during the operation period

Environmental component	Environmental parameter	Effect
Water environment	Water network	Crossing of the main and secondary hydro network
	Areas of overflowing	Crossing of the areas influenced by periodical overflowing.
	hydro geological vulnerability	Crossing of areas with high vulnerability
Noise-Vibration Environment	Acoustic limits	Receptors in which it is possible to see the overcoming of the acoustic limits
Landscape	Historical-cultural heritage	Historical-monumental heritages present in the area of 200 m close the route.
	Landscape unit	Crossing of agricultural scenery with high landscape importance.
		Crossing of the main and secondary hydro structures.

The problems of the alteration of the continuity of the superficial and underground water network belong to the aspects taken into consideration during the projecting of the works. The project should guarantee the maintenance of the superficial water network continuity either the principal or the secondary one trough the adoption of the appropriate works. In particular, near the main watercourses it is estimated the realization of bridges.

The analysis of the work status before the rehabilitation works underlines some aspects, interested by the layout project, influenced by periodical overflowing. In these aspects the stretches in the surveys should be dimensioned without interfering with the superficial discharge characteristics. Besides the presence of the culverts that guarantees the maintenance of the superficial water network to permits the avoiding the effect of dams in compare to the superficial discharge.

The analysis carried out for the definition of the hydrogeological vulnerability areas directly affected by the project layout underlined the problem of protection from a possible contamination connected with the infiltration of contaminated waters in the water tables under conditions of high level of vulnerability. The separation will be provided using a canalization network properly sized and their content will determine the realization of appropriate catchment's areas, waterproof at the bottom, that will allowed to perform the pre-treatment of the fluids, before being give back to the superficial hydro network. In Curtici station a new building for the disinfecting station for freight and passenger cars is provided, having appropriate hydraulic and sewerage installations. The hydraulic installations are the following: water supplying installations for preparing disaffection solutions and pump installations for the solutions to the disaffection places. Sewerage of waters that is provided from the disinfections platform should take into consideration the ecological norms. Thus the used waters treatment is provided before being discharged into the outlet.

The estimated analysis of the infrastructural railway insertion, has underlined the necessity of providing mitigation measures along the railway in order to minimize acoustic environmental impact. The leading criteria will be to maximum protection likely to be achieved by using plane dimensional anti – noise screening in high sensitive areas (school, hospital, etc.) and in the high populated residential areas and to take the noise level lower or equal to 50dB(A) in all residential areas.

The acoustic protection measures suggested could be divided into two categories:

- Sound absorbent barriers in which, in function with the distance and of the quality of neither the receptors involved nor the intervention context.
- Insertion, when is possible, of arbores/shrubbery screens functioning as a filter for the acoustic contaminations; these green screens provide also a function of integration of the infrastructure in the landscape. Forestation may be made along the line in a planned way if possible, especially at the newly constructed railway and it may be set up with evergreen arbores, shrubs and lawns combining together.

Our analysis defines three critical noise zones in Deva town and a extended urban critical area in Arad town.

The new infrastructure will be also achieved according to a technology that will also include the anti vibration treatment and insulation. The approaches to solve the problems are to use shock absorption pads beneath tracks in relevant sections or lay log welded rails of 60 kg/m in order to alleviate the interferences of the train operation to the urban residents.

The realization of variant alignment of the infrastructure could cause an alteration of the continuity of the agricultural soils with a consequent possible alteration of the soils use conditions from the farmers. The continuity in the managing of the soils, especially in regard to the operating of the agricultural machineries, it is kept realizing flyover and underpasses that allow the continuity of the farm road network.

The specific reference to the farm structure present in the organization of the mitigation or compensation activities will allow the use of residual areas of the agricultural funds, directly interfered with the railway route, avoiding the creation of marginal areas for the agricultural activity and the segmentation and an extreme alteration of environmental ecosystems existing along the crossed territory (watercourses system of the reclamation, the

system of fences between the fields and along the road infrastructures).

The particularly morphology of the interested area shows a specific visual sensibility at the presence of the railway. In particular, with reference to what we explain next, the interventions estimated are focused to realize hiding elements of the railway route trough:

- The realization of embankments at the outline of the railway platform. The solution suggested allow to modify the original project solution, constituted by the survey type, cutting with the adoption of reinforced land to the side close to the railway platform; on the external side it is created tract slope of moderate grade, that goes to connect the land around. Along the segment of slope, arboreal and shrubbery species will be planted, in order to give either a hiding function or an ecological route.
- The creation of green screens along the railway fence; the interventions will be calibrated following the type of railway project and will be shrubbery and arboreal/ shrubbery areas.

This type of measures could be foresees both along the new alignment layout and the actual rehabilitate railway line when cross the flat area of the Mureş Valley.

At the same time the presence of cultural heritage sites located in the high and open visual field, define some areas having a direct visual contact with the railway line. The closeness of the historical-monumental heritages to the railway route suggests the creation of mitigation measures finalized to improve the insertion of the infrastructural line.

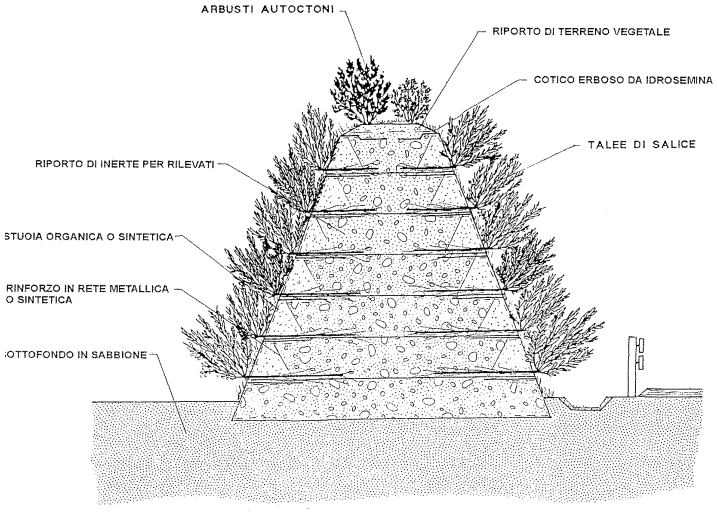

Figure 1: Green noise barrier

The planning of an ensemble of environmental-landscape insertions to be connected with the realization of a railway project, it is considered as a fundamental phase to proceed to the re-qualification of the environmental-landscape characteristics in the context in which there is estimation of intervention and of improvement of the peculiar elements. The environmental arrangements are based on the individuation of restoration works that allow the recovery of the areas touched by the realization of the project and the improvement of the elements crated by it. The purpose is to recreate the continuity of the existing signs and views in the realization of the work and to confer a landscape value to the project elements.

In landscape and environmental designing a role of primary importance may be carry out by the naturalistic engineering interventions and planning. Bioengineering is a technical

technique that project with vegetation and particular materials (for example geotextile, biomat, wire mesh, stones, wood, straw, etc.) to solve the erosion and washout phenomenon.

The main goals of bioengineering interventions are: techno-functional (consolidation against washout and erosion), naturalistic (the project has to design not only the green but also the reconstruction of the para-natural ecosystem throws the utilization of autochthon species), landscape and economic (the structures that natural engineering designs are economical competitive and alternative with respect to the traditional one. The bioengineering interventions are implemented in the following categories: covering or washout (sowing, sowing mattress and mat), stabilizer (shrubs planting, tales, fascines, herbs, etc.) consolidation (live palisade, live grating, gabionade, green mattress, etc.), particular (anti-rock fall, wind-break works etc.) Bioengineering is divided into three different branches of intervention, summarized in: realization of bio-type and para-natural eco-system, realization of consolidation against washout and erosion and intervention on the local fauna, with regard to guarantee the habitat continuity.

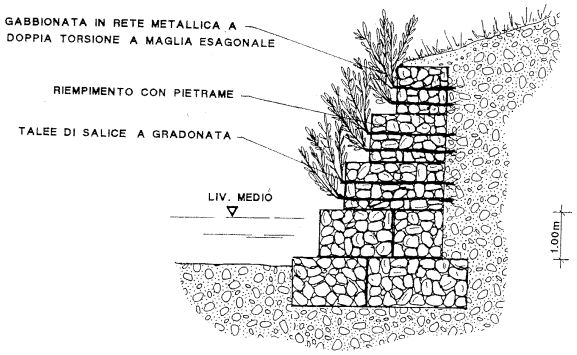

Figure 2: Rock gabion

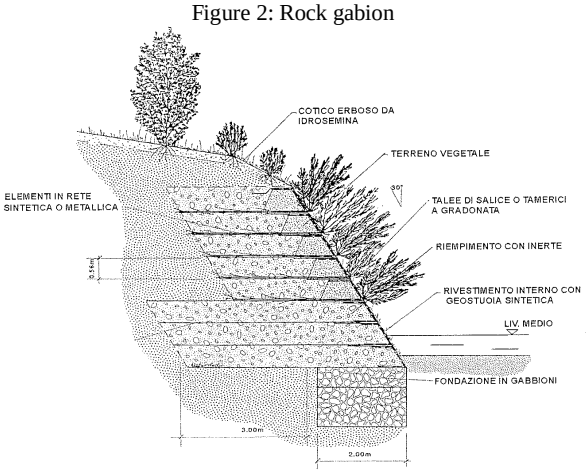

Figure 3: Consolidation system

Green interventions beyond the railway fence have the primary goal to mitigate the environmental interferences by constituting a screen that disguise the railway line. The green interventions alongside the railway body depend on the embankment height. These interventions are:

- in the embankments under 2 m height, this ambit will be faced by the simple grassing or by the realization of shrubs constituted exclusively by shrubby elements;
- in the embankments with middle height (2-5 m), the shrubs and the meadows with bushes and arborous elements will be planted in irregular strips and variable size. These typologies of greening present a dynamic process more developed with respect to the simple mead owing with the local vegetation.

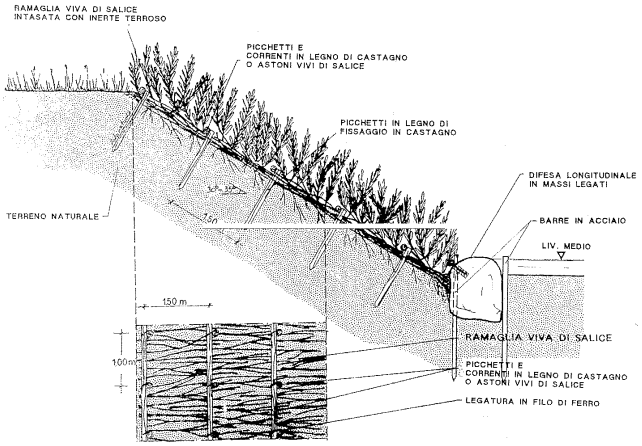

Figure 4: Re-vegetation system

These interventions will be designed in the more sensitive landscape-environmental areas (for ex. proximity with historical elements, rivers crossing). Green interventions develop as well as the aesthetic function, an important naturalistic function like ecological corridor and they represent basic elements that may integrate in the future in a wilder and more elaborate net.

CONCLUSIONS

According to the capital estimate of mitigations measures to the environmental impact, the investment in the environmental protection of the rehabilitation and upgrade project is primarily defined in about 3% of the total investment. Among the mitigation measures, we mention: slopes stabilization, drainage and erosion control, protection drainage (gabions); bio-engineering techniques; re-vegetation (workers, planting stock, transport of planting material); installation of noise barriers and installations of traffic signs and road bumps.

In the process of the design, construction, construction supervision and others should pay much attention to the environmental protection and make perfect and detailed plans to put mitigation measures by the report into practice. The environmental protection facility construction must be carried out simultaneously with the rehabilitation project, as well as their design and operation.

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