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PRELIMINARY STUDIES CONCERNING THE EVALUATION OF ROAD NETWORK ROBUSTNESS FOR IAŞI NATIONAL ROADS DEPARTMENT

BY

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Abstract. Structural robustness in road field is a new concept, very little addressed in specialized literature, both in Romania and abroad.

Natural and weather phenomena that occur more frequently are more destructive than ever, endanger normal activities and can wreck road networks, causing significant damages (Grecu, 2005). These phenomena can be diverse: earthquakes, volcanic eruptions, tsunami, landslides, storms, floods, droughts, fire or avalanches. Our country is also affected by natural disasters, the return to normality after such phenomena being very expensive.

Communication networks are very important for the recovery process of the affected areas, the help for possible victims with food or medical supplies depending on the networks operation.

The Romanian national road network faces the same type of problems (Snelder, 2010). A vulnerable road network makes vulnerable the area, the people, the institutions, the tourism and the economy. Thus, the main aspect this article refers to is maintaining the road functional.

The major flaws of Iaşi national road department are the natural disasters which can occur in this area of the country, namely earthquakes, landslides and floods.

Key words: natural hazards; road structure; robustness; vulnerability.

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1. Introduction

The Romanian road network, like many other road networks around the world, faces congested traffic, especially at certain times of the day. This aspect should be solved by addressing the problem from the other perspective, namely the road network robustness. The traffic problems are caused particularly by the drivers' inadequate behavior, by the poor maintenance of the road network, by the traffic growth and the inability of the road network to handle the influx of users. Yet, all the above aspects can be foreseen and maybe prevented.

However, when it comes to actions that man cannot anticipate, the problem aggravates. Natural and weather phenomena which occur more frequently, stronger and destructive than ever, endanger normal activities and can ruin road networks, causing material and even human damages. These phenomena can be diverse: earthquakes, volcanic eruptions, tsunami, landslides, storms, floods, droughts, fire or avalanches. Globally, in the past 35 years, the number of major disasters has increased steadily, with a clear acceleration in the late '80s, with repeated extreme events, both natural and technological. Romania is also affected by all kind of natural disasters, the return to normality after such phenomena being very expensive. For the loss life point of view, statistics show that over the past three decades, disasters worldwide have caused the death of over 8 million people, disease and suffering for more than 1 billion people, losses and material damages of hundreds of billions dollars. On average, each year disasters are the cause for 25,000 deaths and around 3 billion dollars economic damage. These statistics show how dangerous these phenomena are and urge us to handle them with extreme seriousness, in order to reduce to a minimum the loss of life in particular, and also material losses.

Communication networks (Minwei, 2008) are very important for the recovery process of the affected areas, the help for possible victims with food or medical supplies depending on the networks operation.

The Romanian national road network faces the same type of problems. Additionally to the natural disasters, our national road network is not a very well established network and also not one that fully copes with the existing traffic. As we all know, a vulnerable road network makes vulnerable the area, the people, the institutions, the tourism and the economy. Thus, the main aspect this paper refers to is maintaining the road functional.

The road network of Iași's National Roads Department is subject to study in terms of robustness. Its major flaws are the natural disasters which can occur in this area of the country, namely earthquakes, landslides and floods. It will be studied in terms of improving road structures and earthworks in order to create robust road networks.

2. Hazards and Risk Factors in Romania

Lately, our country had an intense activity from the natural disaster point of view, here referring especially to landslides and floods. Rainfall may be considered the major cause of these extreme events. Climate changes, a phenomenon that is happening globally, also favours the generation of hazards, increasing the uncertainty of their intensity and frequency, and also increasing the insecurity to appear new types of extreme phenomena such as tornadoes or desertification.

From the seismic point of view it is well known that Romania is located in a vulnerable area, thus road networks are also vulnerable to this type of calamity.

These natural phenomena have a detrimental effect on the population and the environment and urge us to handle them with extreme seriousness, in order to avoid damage.

For all hazards that may occur in Romania, the road network will be studied only in terms of the three most frequently found natural disasters.

2.1. Seismic Hazards

In Romania have been identified (Grecu, 2005) many epicenter areas, but along the years, earthquakes have been all over the country. Still, one can clearly see the areas with the highest risk: Vrancea region, Făgăraş-Câmpulung area, Banat area, Dobrogea, the Black Sea continental shelf and Crişana region. Earthquakes from neighboring countries such as Ukraine, Serbia, Bulgaria, Greece, Macedonia and even some violent ones from Turkey are also felt in Romania.

Approximately 500 earthquakes occur annually in Romania (Grecu, 2005), most of them of low intensity, affecting about 50% of the country.

Iaşi city and county are included in Vrancea seismic zone.

Road networks can be affected in various ways by the earthquakes action, as at large magnitudes they become impassable, their restoration being extremely expensive in terms of material and execution time.

2.2. Landslide Hazards

Geological condition represents the main cause of landslides, but they are also connected to floods and heavy rains phenomena and, last but not least, to human impact (excavation, slope overload, etc.).

Frequent landslides occur on versants with moderate slopes (10°…30°), consisting of rocks with high shale, intensely fractured and altered.

The most affected areas in Romania are located in the Carpathian foothills, especially in the Curvature area, Moldavia Plateau, Transylvania

Depression, the Getic Plateau, and even in the mountain area (in Eastern Carpathians).

Lungu *et al*. (2009) say that "most of Romania's counties are rated as medium to large areas vulnerable to landslides when it comes to large-scale investment projects on the road infrastructure rehabilitation".

This phenomenon can be seen in Iaşi too, as the county's relief is hilly and plateau, but also due to the presence of clay and shale rocks, to rainfall that generates a high moisture content at certain times of the year, and finally due to uncontrolled human interventions.

The whole county is vulnerable to landslides (Moraru, 2008), but one can distinguish ten areas that affect about 52 localities (the riskiest are Aroneanu, Belceşti, Bârnova, Brăeşti, Costuleni, Cotnari, Deleni, Dolheşti, Mironeasa, Hârlau, Popeşti, Scobinți, Sineşti, Târgu-Frumos, Răducăneni, Țibana, Vlădiceni and Iaşi).

Therefore, road networks, and virtually any communications network are affected by the landslides.

2.3. Hydrological Hazards

Floods are natural hazards caused by water overflow on large areas, and have a direct negative influence on people's lives, society and the environment, causing damage and sometimes even loss of life. Floods, like other types of disasters, are caused by extreme natural phenomena (long-term rainfall, rapid melting of snow, blocking of water by the glaciers) and also due to human activities (accidental flooding).

In our country, as known data (Grecu, 2005), there are nearly 1,000 locations and over 1.5 million ha of land that can be flooded: Someş, Mureş, Tisa, Criş, Danube, Argeş, Vedea, Bega, Teleorman, Ialomița, Timiş, Jiu, Olt, Buzau, Prut and others.

Iaşi County was also affected by floods, which produced significant damage and affected the road network, given the fact that this national road network is built mostly along the main rivers in the county. Rivers that produce damage by increasing flow are Prut and Siret rivers, the latter flooding even Paşcani City numerous times.

Therefore, all these extreme natural phenomena that produce very high damage, require increased attention in order to prevent and limit their effects. In terms of road networks it is mandatory to know the way they act upon road structures, in order to suggest new types of structures studied for areas classified as vulnerable to weather

3. **Current Status of Iaşi National Road**

National road network for Iaşi National Roads Department (D.R.D.P. Iaşi, 2009-2010), has a length of 366.371 km. From this length, the asphalt surface is 360 km, the rest of 6.371 km being of cement concrete. The length of roads in Iaşi County is about 14% of the total length of the Iaşi D.R.D.P. Network density is 6.2 km/km^2 and 0.5 km/1000 people, a density that tends to Romania's average.

Recently (Florescu & Tăutu, 2010), rehabilitation works have taken place especially on routes that are classified as European, namely DN28 Roman-Iaşi, DN24 Iaşi-Sculeni, these interventions not only increasing bearing capacity, but also improving geometric elements in the longitudinal and transverse directions.

In Table 1, are presented the lengths of the national roads from Iaşi County.

Table 1

National Roads in Iaşi Roads Department Administration

D.N.	Sector between localities	Length, [km]	Kilometric position
2	Moţca-Cristeşti-Drăguşeni	7,671	375+541-383+200
24	Codăieşti-Schitu Duca-Iaşi-Vânători-Sculeni	68,310	151+850-219+594
24C	Vânători-Bivolari-Bădărăi	43,766	0+000-43+850
28	Săbăoani-Tg. Frumos-Iaşi-Răducăneni-Albiţa	142,219	0+000-141+410
28A	Tg. Frumos-Paşcani-Moţca	37,852	0+000-37+661
28B	Tg. Frumos-Hârlău-Frumuşica	39,490	0+000-39+000

4. Identification of Road Sections which are Vulnerable to Natural Hazards

Iaşi County is placed in one of the most exposed regions in the country. First of all, earthquakes can affect all transportation infrastructure and more. Due to the relatively high seismic activity, to the type of the soils and to deforestation many landslides occur, the most affected by this type of hazard being the communication networks. Because it is placed on the area of Prut and Siret rivers basin, Iaşi County is extremely vulnerable on hydrological hazards, road network being very exposed.

The national road network from Iaşi National Road Department carries the biggest part of the existing traffic in the county and is also the most important comunication network used for goods and people transportation. Therefore, maintaining its functionality in best conditions represents the main objective. The county road network could take some of the existing traffic but due to its deplorable technical state of repair is not able, at present time, to support extra users in critical moments and not only. Regarding the way people choose to travel, the users behaviour is normal, as they decide to travel on road instead of using the railway network due to better existent conditions. Therefore, the importance of road network is easy to understand, this resulting in the need to develop robust road structures in order to avoid roadblocks, traffic jams, delays, natural disasters damages and also in the need to maintain network functionality.

The principle of road network robustness can be rendered on the county road networks also, which is a very important network and which, if modernized and upgraded to optimal usage parametres, could solve many of present traffic problems. Usually, the shortes distances between localities are found on county roads. Thus, on the conditions mentioned above, these routes are able to take over the light traffic, avoiding the congestion and overload of national roads.

Therefore, in present conditions, it is necessary to create risk maps of vulnerable areas located on Iaşi county national road network.

Considering the fact that the entire Iaşi County is on uniform threat of seismic action, there will be punctually established the areas vulnerable to floods and landslides.

a) The national road DN2 that crosses Iaşi County can be considered one without major risk to produce natural disasters.

b) Along the national road DN24 there are many vulnerable areas to be considered: the areas of Coropceni and Satu Nou villages, Cârlig village, Cotu Morii locality were, over time, affected by landslides and are considered areas with major risk of reactivation. Currently, the road section that crosses Poieni forest and that comes down the forest is considered an area with high risk for landslides, and although some portions have been consolidated, this area remains vulnerable on these phenomena.

As for floods, the kilometric position between 214+000 and 219+594 has a major risk of floods because it is found near the Prut main river bed.

Maintaining the functionality of this road is extremely important because it remains the main route to southern counties and to the eastern border of the country.

c) Another problematic route in Iaşi County from the road structure point of view is DN24C. Its issues must be solved in order to prevent and diminish the effects of natural disasters that may occur on certain points of the route. The problems start from the kilometrical position 0+000, where there was

an area with landslides, which led to route change of the initial road. For the same reason, there was built a bypassing of about 3 km in Popricani locality. Important sectors from DN24C's route need to be rehabilitated in order to stabilize slopes and road bed.

Also, this road has a major risk of flooding, as it is near the main riverbed of the two most important rivers in the county: Prut and Jijia.

Although it is not the most important road from Iaşi County, its problems should not be neglected and execution of special works on vulnerable areas are imperative.

d) The main access road in the city of Iaşi is the national road DN28. Although it was recently rehabilitated and modernized, although it has an increased traffic capacity, comparing to the other roads, there are many areas with risk regarding the stability of the road bed. In localities like Osoi, Tomeşti, Strunga and near Drănceni locality there are some slope stability issues that affect the road. In Gorban locality we find a high risk of producing floods; the area being situated near the Prut river bed. Another flooding risk area is near Drănceni locality, where the road has a cement concrete covering. As it is the most important route to the western side of the country, the most utilized road to Bucharest and also the route to the eastern borders, in terms of road structure robustness, it must be treated as such.

Table 2

Areas in Iaşi County National Road Network with Major Risk in Producing Hazards

No crt	DN	Km pos. Iaşi district	Vulnerable areas		Risk type
			Km pos.	Locality	
1	2	375+541... 383+200	375+541...379+367	–	Road accidents
2	24	151+850... 21+594	158+990...160+010	Coropceni	Landslide
			175+000	Pădurea Poieni	Landslide
			189+000	Iaşi	Landslide
			217+000...219+594	Sculeni	Floods Prut
3	24C	0+000... 43+850	6+300,7+100,9+500	Popricani	Landslide, Road accidents
			25+787...28+384	Trifeşti	Floods Prut
			34+045...36+900	Bivolari	Floods Prut
4	28	0+000... 141+410	18+520...18+650	Strunga	Landslide, Road accidents
			19+990...20+100	Strunga	Landslide, Road accidents
			24+651...67+667	Tg. Frumos-Iaşi	Road accidents
			87+045	Tomeşti	Landslide
			91+100	Osoi	Landslide
			127+031+131+165	Gorban	Floods Prut
5	28A	0+000... 37+661	16+900	Harmăneştii Noi	Landslide, Road accidents
			22+900	Paşcani	Floods Siret

6	28B	0+000... 39+000	32+000...32+300	–	Landslide

e) National road DN28A is the main route to reach Paşcani town, and the touristic area in the northern country. We find a landslide near kilometer position 17+000, that threats the travelers' security. A major problem is the flooding that occurs increasingly more often in the city Paşcani. In that area, Siret river is a constant threat for the road and for the two bridges that cross him (road and railway), because it frequently gets out of his river bed, producing a lot of damages on that part of the town. Thus, it is essential to find and choose solutions that can reduce the level of vulnerability of the area, in terms of avoiding damages produced by floods and landslides.

f) The main connection between the cities of Iaşi and Botoşani is represented by the national road DN28B. Because this section of road has never been affected by floods, the biggest hazards remain the landslides. In order to maintain the operating conditions of the road it is required to use the robust road structures in vulnerable areas.

The valuable areas from Iaşi Countz national roads network are presented in Table 2.

Fig. 1 represents a map with the vulnerable areas from Iaşi County national roads network.

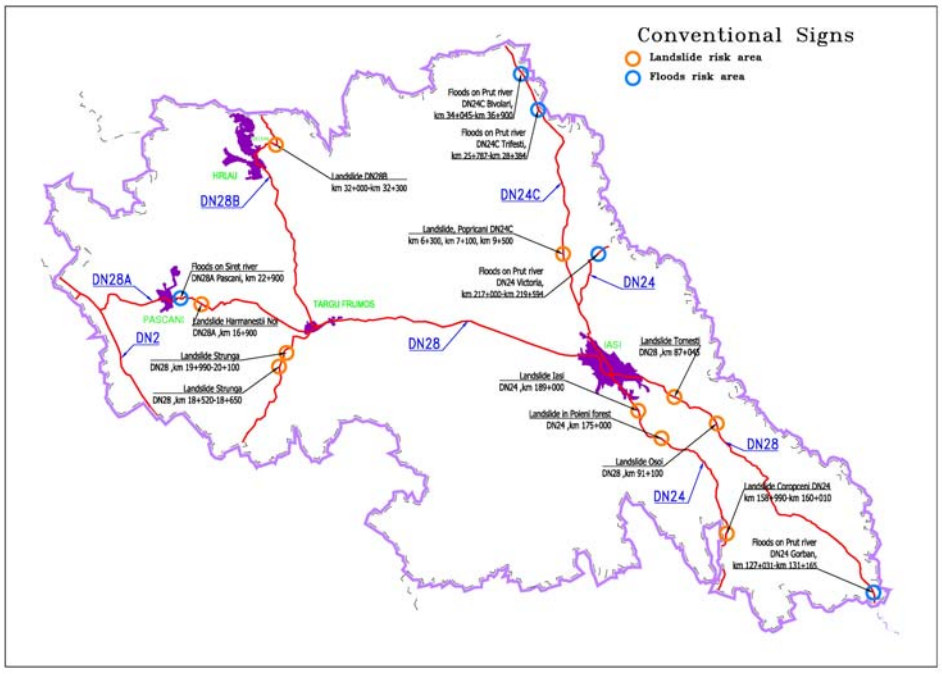

Fig. 1 – Map of Iaşi County road areas vulnerable to natural disasters.

5. Conclusions

In the event of a collapse in one of the areas determined as vulnerable it would occur bigger travel times and detours would be necesary. As Iaşi County has shortages at this chapter, the cost of the travel would increase together with the travelers discomfort. On the other hand, the costs for a total rehabilitation for the affected sections are certainly much higher than the costs for several improvements of the existing situations.

By using robust road structures one wants to avoid extreme situations and also to maintain the functionality of the road in unexpected situations caused by natural hazards. A robust road network can be created in the vulnerable areas by implementing robust road structures, together with new solutions to protect the body road from nature's devastating actions.

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STUDII PRELIMINARE PRIVIND STABILIREA ROBUSTEŢII REŢELEI RUTIERE AFERENTE SECŢIEI DE DRUMURI NAŢIONALE IAŞI

(Rezumat)

Robustețea structurală în domeniul rutier este un concept nou, foarte puțin abordat în lucrările de cercetare, atât în România cât şi în străinătate.

Fenomenele naturale şi meteorologice ce au loc din ce în ce mai des şi sunt mai puternice şi mai distructive ca oricând, periclitează activitățile normale şi pot distruge rețelele rutiere, aducând astfel pagube însemnate. Aceste fenomene pot fi diverse, în toată lumea existând asemenea probleme: cutremure, erupții vulcanice, tsunami, alunecări de teren, furtuni, inundații, secete, incendii, avalanşe. Dezastre naturale lovesc şi țara noastră, revenirea la normalitate după asemenea fenomene fiind una foarte costisitoare.

Rețelele de comunicații sunt foarte importante în procesul de refacere a zonelor afectate, de menținerea funcționalității acestora depinzând ajutorarea victimelor cu alimente, medicamente şi tot ce este necesar pentru supraviețuire.

Cu aceleaşi probleme se confruntă şi rețeaua de drumuri naționale a României. O rețea de drumuri vulnerabilă, face zona, oamenii, instituțiile, turismul, economia deservită vulnerabile. Păstrarea funcționalității drumului este, deci, principalul factor asupra căruia trebuie insistat.

Vulnerabilitățile cele mai mari ale rețelei rutiere aferente secției de Drumuri Naționale Iaşi, sunt dezastrele naturale ce pot avea loc în această zonă a țării, şi anume cutremurele, alunecările de teren şi inundațiile.