BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
Publicat de
Universitatea Tehnică „Gheorghe Asachi” din Iaşi
Tomul LIX (LXIII), Fasc. 3, 2013
Secţia
CONSTRUCŢII. ARHITECTURĂ

ASSURANCE OF ROAD NETWORKS ROBUSTNESS IN CASE OF UNEXPECTED EVENTS

BY

ALEXANDRU COZAR*, RADU ANDREI and NICOLAE ŢĂRANU

"Gheorghe Asachi" Technical University of Iaşi
Faculty of Civil Engineering and Building Services

Received: May 8, 2013
Accepted for publication: May 24, 2013

Abstract. Based on the information regarding the traffic data recorded during the 2010 census and the Origin/Destination surveys , conducted on the entire national road network of Iaşi County, several traffic simulations have been performed. These scenaria can be used to observe the most important routes of the county and possibly to develop a plan for prioritization of future investments

Assuming the occurrence of hazards on the Iaşi county road network, namely the colaps of the bridge on DN 28 from km 6 + 957, due to floods, a traffic scenario/simulation has been developed and the necessary measures for ensuring network robustness by adopting sustainable road pavements have been established.

In this respect, by conducting of a significant construction cases, a series of assumptions regarding the redistribution of traffic values on various road sections of the road network of Iaşi county have been made , and appropriate verifications, in terms of traffic capacity and strength of pavements have been performed .

Finally, a series of alternative routes, equiped with new robust pavements, capable to bear the higher traffic loads arising from redistribution has been established.

Key words: alternative routes; traffic capacity; robustness; robust pavement structures; robust road network; sustainable pavements.

*Corresponding author: *e-mail*: cozaralexandru@yahoo.com

1. Introduction

National road network related to the Iaşi Department of National Roads, has a length of 366.371 km. Network density is 6.2 km/km and 0.5 km/1,000 inhabitants, a density which tends to national average. The network also includes a number of 59 bridges, out of which only 15 have the technical condition grade I. In Fig. 1 is shown the road network of Iaşi County.

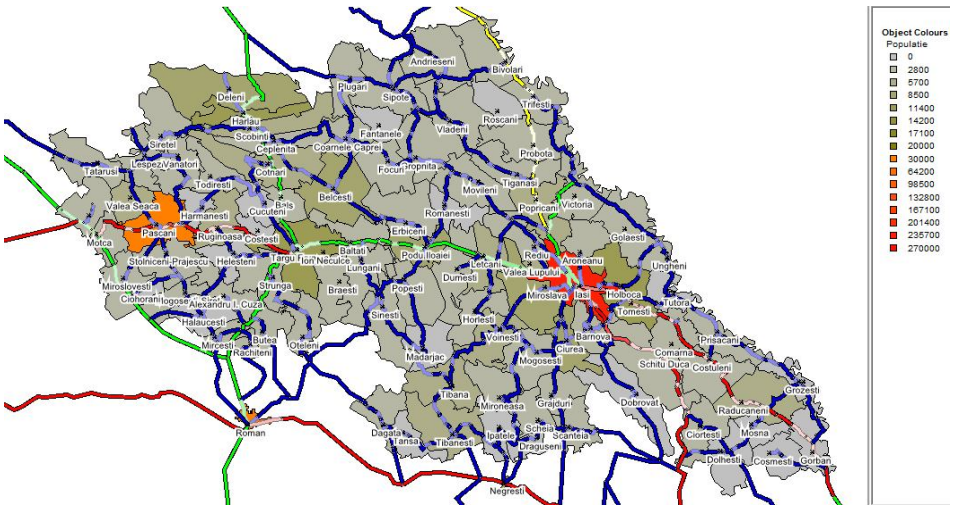

Fig. 1 – The road network and the population of Iaşi County.

Romania county roads are extremely important, having the obligation to ensure the access to the smaller settlements. They are generally used only when there is no other access route to a landmark, because of poor technical condition of them. Also a very important role which they may have is to provide spare capacity. In moments of bottlenecks of national roads, occurred due to various reasons (natural disasters, rehabilitation of roads, traffic accidents, sports events and so on) county roads have to provide alternative traffic clearance.

Realizing a traffic scenario by shutting down the bridge on DN 28, km 6+957, traffic will be redistributed to different alternative routes. There will be considered only a number of three alternative ways being just an assumption on how traffic will be distributed. This scenario is created, having as starting point a precedent, namely the collapse of Mărăcineni Bridge on DN 2, from Buzău County.

A similar situation occurred in 2002, due to the rehabilitation of the bridge, when all the traffic was rerouted on DN 2 (Moţca) - DN 28A (Târgu Frumos) – DN 28 (Iaşi). However, it can not be considered that the situation

was similar with the scenario developed in this case, primarily because of the significantly lower amounts of traffic recorded in 2000 and the fact that the route was chosen as the only acceptable alternative route in terms of poor driving conditions.

Meanwhile, things have changed, both with respect to traffic counts, as well as the technical condition of the road that can be used as alternative routes.

In order to study in detail and to be able to make realistic estimations of the distribution of the traffic excess as a result of shutting down the bridge at km 6+957, were requested Origin/Destination (OD) surveys results, which were submitted by the Company of Motorways and National Roads in Romania, Centre for Road Technical Studies and Informatics, CESTRIN. Using these Origin/Destination surveys, there were obtained a series of traffic data through which it will be possible to carry out the proposed scenario and then to make conclusions about the robustness of the road network in terms of traffic capacity.

2. Case Study

For the hypothesis of shutting down the bridge on DN 28, km 6+957 were considered three alternatives. There are more solutions to avoid this section of road, but only three were treated, considering that these are the most important and most likely to be chosen by road users:

a) For traffic that is carried on DN 2 (Roman) – DN 28 (Târgu Frumos) – DN 28B (Hârlău, Botoşani) and return, was chosen as an alternative way the route *DN 2 (Roman) – DN 2 (Moţca) – DN 28A (Târgu Frumos)*. Extra distance traveled is about 45 km.

b) For traffic that is carried on DN 2 (Roman) – DN 28 (Târgu-Frumos) – DN 28 (Podu-Iloaiei) and return, was chosen as an alternative way the route *DJ 207A (Roman) – DJ 282D (Popeşti) – DN 28 (Podu Iloaiei)*. The distance traveled lower by about 6 km.

c) For the traffic that is carried on DN 2 (Roman) – DN 28 (Târgu-Frumos) – DN 28 (Iaşi) and return, was chosen as an alternative way the route *DN 15D (Roman) – DJ 248 (Rebricea) – DJ 248 (Iaşi)*. Extra distance traveled is about 17 km.

Two calculating variants have been developed, the first one being treated below.

a) The situation in which the traffic which has the OD the cities of Paşcani or Hârlău (all the nearby locations were considered, passing through or continuing their journey) will be deviated on *DN 2 (Roman) - DN 2 (Moţca) - DN 28A (Târgu Frumos)*.

b) The traffic which has the OD the cities of Podu Iloaiei or Târgu Frumos (all the nearby locations were considered, passing through or continuing

their journey) will be deviated on *DJ 207A (Roman) – DJ 282D (Popeşti) - DN 28 (Podu Iloaiei)*.

c) 50% of the traffic which has the OD the city of Iaşi (including all the nearby locations) will be deviated on *DJ 207A (Roman) - DJ 282D (Popeşti) – DN 28 (Podu Iloaiei)*.

d) 50% of the traffic which has the OD the city of Iaşi (including all the nearby locations) will be deviated on *DN 15D (Roman) – DJ 248 (Rebricea) - DJ 248 (Iaşi)*.

The road section of DJ 207A (Roman) – DJ 282D (Popeşti) – DN 28 (Podu Iloaiei) will be treated in terms of traffic capacity for the situation that it should take over the traffic amount that has OD the cities of Podu Iloaiei and Târgu Frumos adding the 50% of the traffic which has OD the city of Iaşi. With no information regarding traffic distribution has been considered normative recommendation to adopt a rate of 60/40. For the same reason, lack of information on the percentage of prohibited overrun areas, were adopted minimum, namely 40% for road traversing the hilly areas and 20% for those in the lowlands.

2.1. Traffic Data

Table 1 presents the actual traffic data and the results of traffic data redistribution due to the collapse of the bridge at km 6+957.

Table 1
Traffic Data Reviewed / Cumulative

DJ	AADT (veh. 24 h)										
	1	2	3	4	5	6	7	8	9	10	MZA
207A	111	174	35	64	75	82	17	16	121	13	929
	135	*1,981*	*106*	*393*	*181*	*118*	*333*	*104*	*127*	*44*	*3,743*
	51	273	47	39	42	26	12	5	48	13	842
	75	*2,080*	*118*	*368*	*148*	*62*	*328*	*93*	*54*	*44*	*3,656*
282D	43	342	22	60	18	12	9	12	11	12	627
	67	*2,149*	*93*	*389*	*124*	*48*	*325*	*100*	*17*	*43*	*3,441*

2.2. Calculation of Traffic Capacity

Table 2 presents the calculations made to determine the levels of service for the three road sections, calculation made for the actual traffic data.

The road was divided into sections based on technical class qualifier, roads that are passing through localities are considered technical class III and those outside the localities are considered technical class II. The road between km 0+000 and km 29+595, namely the section located in Neamț county, was considered technical class I and traffic data were considered to be the same as

those on section between km 29+595 and km 38+400, due to lack of information on traffic data belonging Neamț County.

Table 2
Calculation of the Level of Service – Real Values

DJ	Relief	AADT Traffic 2010 vehicles		AADT Traffic 2010 PCU	Design peak hour flow, Q_C (Q_{C1}+Q_{C2})	Technical class qualifier	Free speed V_L	Level of service	
								1	2
DJ 207A	Hill	Real values	929	2,631	299(179+120)	II	98.8	A	A
						III	44.1	B	B
						II	96.1	A	A
			842	1,990	226(136+90)	II	98.1	A	A
						III	54.8	A	A
						II	98.1	A	A
DJ 282D			627	1,090	124(74+50)	III	44.1	A	A
						II	98.6	A	A
						III	44.1	A	A
						II	99.2	A	A
						III	44.1	A	A

Table 3
Calculation of the Level of Service – Cumulative Values

DJ	Relief	AADT Traffic 2010 vehicles		AADT Traffic 2010 PCU	Design peak hour flow, Q_C (Q_{C1}+Q_{C2})	Technical class qualifier	Free speed V_L	Level of service	
								1	2
DJ 207A	Hill	Real values	3,743	7,845	891(535+356)	II	98.8	B	B
						III	44.1	D	D
						II	96.1	B	B
			3,656	7,204	819(491+328)	II	98.1	B	A
						III	54.8	C	C
						II	98.1	B	A
DJ 282D			3,441	6,304	716(430+286)	III	44.1	C	C
						II	98.6	B	A
						III	44.1	C	C
						II	99.2	B	A
						III	44.1	C	C

From the Table 3 it can be noticed that the level of service changes in almost all cases, reaching even to the D level. What is worth mentioning is that these two road sections are not rehabilitated and the probability that this percentage of 50% from the traffic which has OD the city of Iaşi, to choose this option, is relatively small. However, in order to make this road section a viable one it can be treated as one of great importance, and may be included, with immediate priority, on a future investment list of Iaşi County Council. Of course, this investment will be done properly, respecting the values resulting

from the calculations, both in terms of traffic capacity and the load-bearing capacity.

DJ 207A is a section that would be affected (especially the one between km 0+000…km 38+400), in terms of traffic capacity, following the prepared scenario, It can be developed a series of recommendations to improve traffic capacity and levels of service.

Actual calculation was performed according to the Public Service Management Iaşi County roads database, namely the actual road geometry:

a) Carriage ways = 6.00 m (2 lanes × 3.00 m).

b) Shoulders = 1.50 m (2 × 0.75 m).

In order to remain at reasonable calculation values, which should not exceed the level of service C, less costly measures are proposed, such as:

a) The first measure would be that at the time of road rehabilitation, road profile should be one with a carriageway of 7.00 m (2 lanes × 3.50 m) and two shoulders with minimum width of 0.75 m each. This would result in reducing the coefficient of adjustment for lane width and shoulders, V_{BA}.

b)The second measure would be to increase speed limit across localities from 50 km/h to 70 km/h, at least during the remediation for the problem that led to overload the section in question.

By adopting these two steps, less expensive in terms of investment, it can be seen from Table 4, that the level of service of areas across cities is improved to reach the level C. It should also be borne in mind that, such a case, creates a situation of imbalance, which is highly unlikely to return to normal. Once road users are aware of the good quality of this alternative route, few will return to the old route.

Table 4

Calculation of the Level of Service – Improved Values

DJ	Relief	AADT Traffic 2010 vehicles		AADT Traffic 2010 PCU	Design peak hour flow, Q_C (Q_{C1}+Q_{C2})	Technical class qualifier	Free speed V_L	Level of service	
								1	2
DJ 207A	Hill	Real values	3,743	7,845	891(535+356)	II	98.8	*B*	*B*
						III	44.1	*C*	*C*
						II	96.1	*B*	*B*
			3,656	7,204	819(491+328)	II	98.1	*B*	*A*
						III	54.8	*B*	*B*
						II	98.1	*B*	*A*
DJ 282D			3,441	6,304	716(430+286)	III	44.1	*B*	*B*
						II	98.6	*B*	*A*
						III	44.1	*B*	*B*
						II	99.2	*B*	*A*
						III	44.1	*B*	*B*

This case seems to be the most eloquent, both in terms of traffic capacity and bearing capacity due to large differences between amounts of traffic. Being lower technical class roads, it is normal that the traffic, under normal conditions is far below the values recorded on national roads. For this reason the proposed route can be considered to be of major importance and can be included on a list of immediate investment. Therefore it is necesarry to be taken seriously, because a possible investment based on calculations derived from actual traffic data could be compromised in a few months when that the road would be used by the excess of traffic resulting from a situation such as the imagined scenario.

3. Conclusions

In order to be robust, a road network needs preventive investments, which may be unnecessary time. The purpose of creating a robust road network is to determine the most vulnerable points or areas of the network to determine the best alternative routes and to adopt solutions that can cope the requests occured along with extreme events.

In the present case, simple measures (increased lane width from 3.00 m to 3.50 m, keeping shoulders widths at a minimum of 0.75 m while increasing speed limit across localities from 50 km/h to 70 km/h), applied when upgrading roads, can improve, in terms of traffic capacity, the level of service and can solve traffic issues occurred when the road sections are becoming alternative routes due to extreme events.

Acknowledgement. This paper was realized with the support of POSDRU CUANTUMDOC "Doctoral Studies for European Performances in Research and Inovation" ID79407 project funded by the European Social Found and Romanian Government.

REFERENCES

Florea S., *Podul de la Mărăcineni sau Istoria se repetă,* 2005.

* * * *AND 584/2012 - Normativ pentru determinarea traficului de calcul pentru proiectarea drumurilor din punct de vedere al capacităţii portante şi al capacităţii de circulaţie*. Buletin Tehnica Rutier, Anul VIII, nr. *12*/2012.

* * * *PD 189/2012 - Normativ pentru determinarea capacităţii de circulaţie şi a nivelului de serviciu ale drumurilor publice*. Buletin Tehnica Rutier, Anul IX, nr. *1*/2013.

* * * Baza de date a Secţiei de Drumuri Naţionale Iaşi, 2011.

ASIGURAREA ROBUSTEŢII REŢELELOR RUTIERE ÎN SITUAŢIA APARIŢIEI DE EVENIMENTE EXCEPŢIONALE

(Rezumat)

Având la dispoziție datele referitoare la traficul înregistrat la recensământul din anul 2010 şi anchetele de trafic OD (origine–destinație) de pe toată rețeaua de drumuri naționale a județului Iaşi, o serie de simulări de trafic se pot efectua. Aceste scenarii pot fi folosite pentru a observa rutele cele mai importante ale județului şi eventual pentru a realiza un plan privind prioritizarea viitoarelor investiții.

Se va elabora un scenariu/simulare de trafic în ipoteza producerii unor hazarde asupra rețelei rutiere din județul Iaşi şi se vor stabili măsurile necesare pentru asigurarea robusteții rețelei, prin adoptarea unor structuri rutiere durabile şi a unor măsuri pentru păstrarea funcționalității tronsoanelor de drumuri afectate.

Făcând legătura cu un precedent, anume colapsul podului de la Mărăcineni din 2005, se va simula scoaterea totală din funcțiune a podului rutier, de pe DN 28 de la km 6+957, în urma producerii de inundații.În acest sens, se vor efectua o serie de supoziții privind redistribuirea valorilor de trafic pe diferite tronsoane de drumuri din rețeaua de drumuri a județului Iaşi, pentru ca apoi să se facă o serie de propuneri privind adoptarea unor măsuri privind atât structurile rutiere cât şi capacitățile de circulație.

Având rezultatele obținute în urma simulării efectuate, se vor stabili rute alternative principale, unde se vor propune structuri rutiere noi care să suporte încărcările din traficul rezultat în urma redistribuirii.