TRAFFIC STUDY FOR *FRAȚII GOLEŞTI STREET* AREA IN CÂMPULUNG MUSCEL, IN THE PERSPECTIVE OF BUILDING A *KAUFLAND* SUPERMARKET

Alexandru BOROIU[1], Sorin ILIE[1], Adina CEAPRAZ[2]
[1]University of Pitești, România, [2] Colegiul Tehnic Câmpulung Muscel, România,
alexandru.boroiu@upit.ro, sorin.ilie@upit.ro

Abstract: *The paper shows the need for traffic study in the area of Frații Goleşti Street in Câmpulung Muscel view to the completion of a supermarket, carrying out research to identify and estimate its current and future traffic, so that, based on the obtained results, there were advanced the most suitable proposals for planning the street network and reglementation of the road traffic in the area. The viability of proposed solutions is demonstrated by the implementation of this project as proposed, allowing increased accessibility in the area and, consequently, its transformation into a modern location, of economic and social interest.*

Keywords: road traffic, street network, road planning, road circulation reglementation

1. GENERAL DATA. THE NEED OF THE TRAFFIC STUDY

One of the largest and most expansive retail companies in Europe, *Kaufland*, has set the objective of opening on the *Frații Goleşti Street* in Câmpulung Muscel a supermarket with the same name. The supermarket will occupy an area of 16500 m^2, of which 5500 m^2 only for the building. Also, a parking area of over 250 places will be arranged for clients, and by the opening of this store, it will be created 200 jobs. All investment will exceed 8 million euro and will bring a new competitive element in the market, offering for residents in Câmpulung Muscel an attractive alternative to shopping. The research presented in this paper were made after local administration of Câmpulung Muscel request, who wants to find a lasting solution for the reglementation of road circulation in the *Frații Goleşti Street* area, in accordance with the current regulations and legislation. The traffic study is a key element of the project to build a *Kaufland* supermarket in the city of Câmpulung Muscel, by its results depending on the sizing of the traffic capacity of road sector, the road system design, as well as the impact it could have the built of the supermarket for the *Frații Goleşti Street* area, in the present and in perspective – for a time horizon of 15 years.

2. THE EVALUATION OF CURRENT ROAD TRAFFIC

2.1. THE ORGANIZATION OF ROAD CIRCULATION IN THE AREA SUBJECTED TO STUDY

After analyzing the current road circulation in the area subject to study, it was found the following (figure 1):

- In the proposed location for *Kaufland* supermarket, the road circulation is carried on the *Frații Goleşti Street* in one-way (and further to the intersection with *Tudor Vladimirescu Street*), although the road has a large width of 7 meters.

- In the area of the proposed location, on the two streets that connect the main road artery *Negru Vodă Street* and *Frații Goleşti Street*, the road circulation is also organized on a one-way: *Gheorghe Lazăr Street* (on the sense from *Frații Goleşti Street* to *Negru Vodă Street*) and *1 Mai Street* (on the sense from *Negru Vodă Street* to *Frații Goleşti Street*), which is justified by the reduced width of these streets and that the area is residential and is located near a school;

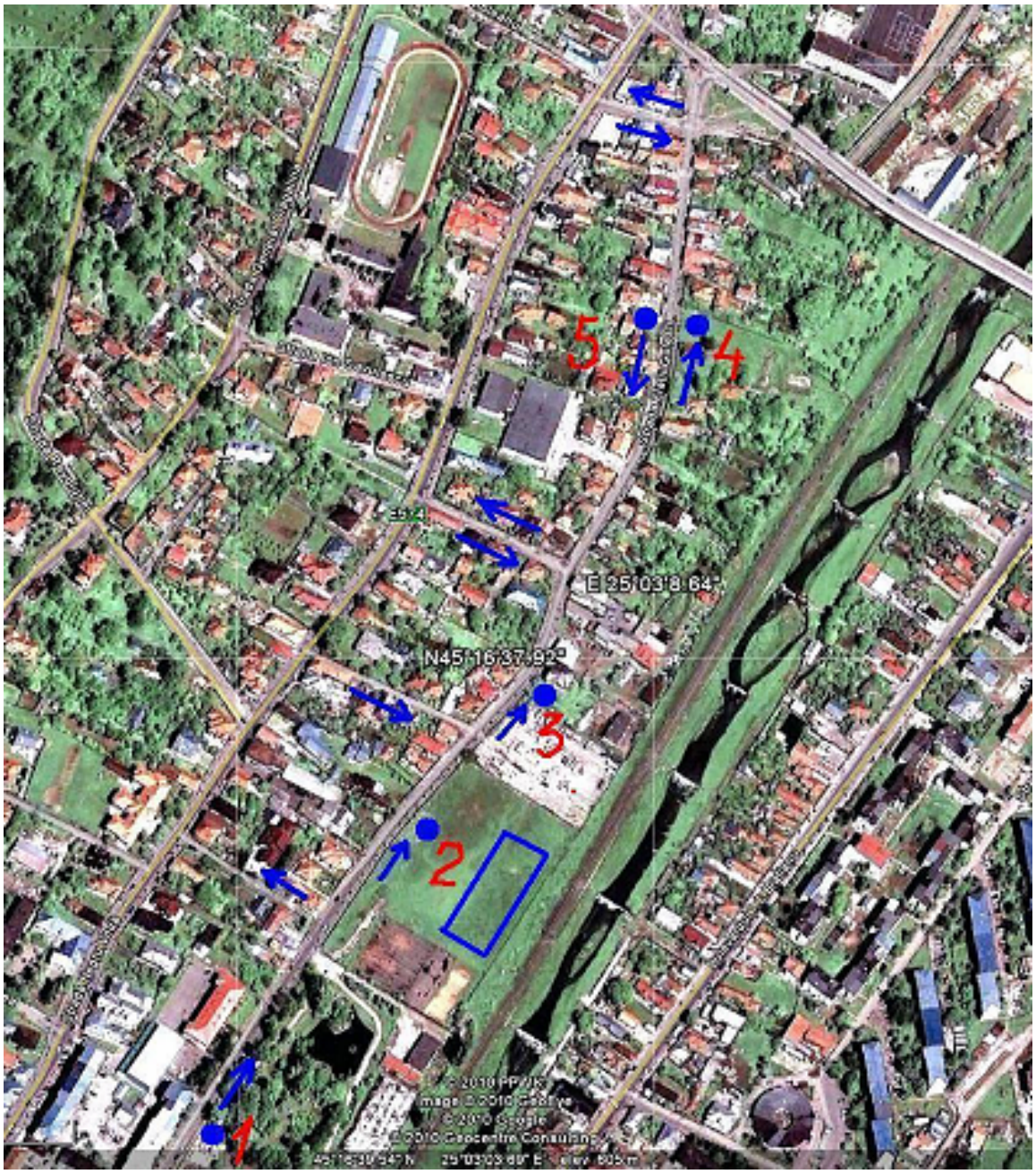

Fig. 1. The current reglementation of road circulation on the *Frații Goleşti Street* area and the points for collecting the traffic data.

- From the intersection with *Tudor Vladimirescu Street* towards *Podul Schei Street* (intersection located at about 200 meters from the proposed location for the supermarket *Kaufland*), the road circulation takes place in both senses;

- On the other linking streets with *Frații Goleşti Street* (*Nicu Leonard Street* – in the South and *Tudor Vladimirescu* and *Locotenent Oncică* streets – in the North), the road circulation runs on both ways;

- The heavy traffic vehicles can reach to the proposed location only from the South, following the route: *Ion Mihalache Boulevard* (so-called the ring road) – the bridge on the *Târgului River* – *Frații Goleşti Street*, with great difficulties to turn right into *Frații Goleşti Street* and to move in front of the school at the beginning / ending the courses; from the north, the access to the ring road over the *Schei Bridge* and then on the *Frații Goleşti Street* would be easier, but the road circulation on both senses is allowed only up to about 30 meters from *Kaufland*'s location (figure 2).

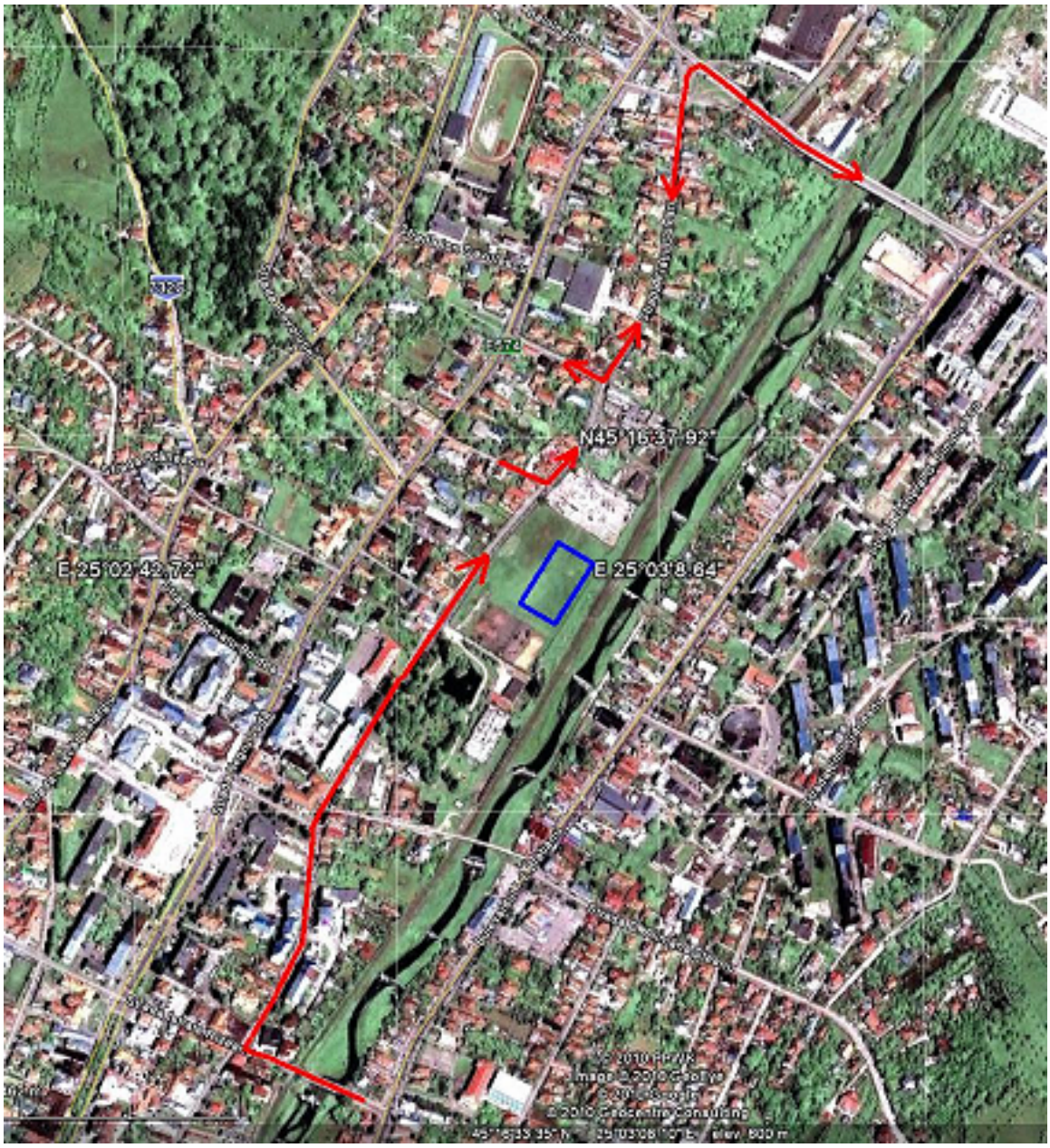

Fig. 2. The analysis of possibilities of trucks access to the supermarket.

2.2. SETTING UP THE TRAFFIC STUDY

The data collection about the road traffic has been realized in the following observation posts on the *Fraţii Goleşti Street* (figure 1):

A. *Northward*

• Post 1 – next to *Kretzulescu Park* (between *Nicu Leonard* and *Gheorghe Lazăr* streets), for the single existing circulation sense;

• Post 2 – next to the proposed location for the supermarket *Kaufland* (between *Gheorghe Lazăr* and *1 Mai* streets), for the single existing circulation sense;

• Post 3 – next to the weekly fair location (between *1 Mai* and *Tudor Vladimirescu* streets), for the single existing circulation sense;

• Post 4 – next to *Lupu Service* location (between *Tudor Vladimirescu* and *Locotenent Oncică* streets), for the northward circulation sense;

B. *Southward*

• Post 5 – next to *Lupu Service* location (between *Tudor Vladimirescu* and *Locotenent Oncică* streets), for the southward circulation sense;

A standard form was used for data collection, with an observation time of 0.5 hours and those periods of observation were the ones presented in Table 1.

Table 1

Observation posts	*Day*	*Horary intervals*
1, 2, 3, 4	Thursday, 12.01.2009	6.30 – 9.00 12.00 – 13.30 15.00 – 20.00
4, 5	Friday, 13.01.2009	10.00 – 11.00
4, 5	Monday, 16.01.2009	01.00 – 01.30

The time periods in which the data were collected were chosen so as to be caught the traffic flows at the times when the traffic is most intense (in the morning and at the noon, when children are brought to school by the parents with personal cars; in the afternoon and in the evening, when the program for employees ends), but also at the time of day when the activities are reduced (during the day – before lunch) or when the normal activities stop (during the night).

2.3. THE DETERMINATION OF TRAFFIC FLOWS

The data was recorded by traffic operators (high school transport profile students from Câmpulung Muscel, within the hours of practical applications, under the guidance of the specialist teacher) on the standard forms for collecting traffic data.

To determinate the road traffic intensity it is neccesary the equivalence of different categories of vehicles in passenger car units. For this purpose, there are applied the provisions of the standard STAS 7348/86 *"The equivalence of vehicles to determine the traffic capacity"*.

The relation for the equivalence of vehicles in passenger car units, when the roads (including the streets) have declivities of less or equal to 2% (which is the case of the street network under study), is:

$$N = \sum_{i=1}^{n} N_i \cdot C_i \qquad (1)$$

where:

• N is the traffic intensity expressed in passenger car units, in time unit (0.5 hours, in the current study);

• N_i is the number of vehicles of category i, in unit time (0.5 hours in the current study);

• C_i is the equivalence coefficient for category i of vehicles.

The values of the equivalence coefficients for the vehicles from traffic flows identified by collecting the data are shown in Table 2.

Table 2

Vehicle category	*The equivalence coefficient*
Bicycles	0.5
Cars with or without trailer	1.0
Commercial vehicles, vans below 3.5 tonnes	1.2
Trucks, buses over 3.5 tonnes	3.5

By equalizing the values in these tables with these equivalence coefficients and adding the obtained values , according to the computing relationship:

$$N = 0.5 \cdot N_b + 1.0 \cdot N_a + 2.0 \cdot N_{am} + 4.0 \cdot N_{AM} \quad [\text{standard vehicles} / 0.5\,\text{hours}] \qquad (2)$$

there are obtained the values for the traffic intensity [passenger car units / 0.5 hours] in the time periods in which the traffic data were collected.

The notations in the formula represent:

- N_b – the traffic intensity of bicycles [bicycles / 0.5 hours];
- N_a – the traffic intensity of cars [cars / 0.5 hours];
- N_{am} – the traffic intensity of vehicles with total mass below 3.5 tonnes [vehicles / 0.5 hours];
- N_{AM} – the traffic intensity of vehicles with total mass over 3.5 tonnes [vehicles / 0.5 hours].

So, it results, for the five observation posts, the values shown in the Table 3.

Table 3.

Horary interval	*The traffic intensity [passenger car units / 0.5 hours]*				
	Observation post 1	*Observation post 2*	*Observation post 3*	*Observation post 4*	*Observation post 5*
6.30 – 7.00	15	15	15	19.7	
7.00 – 7.30	37.2	37.2	39.2	40.8	
7.30 – 8.00	93.8	99.3	92.7	105.6	
8.00 – 8.30	54.2	51.8	70.6	87.4	
8.30 – 9.00	36	39.5	38.6	43.6	
10.00 – 10.30				56.3	**46.4**
10.30 – 11.00				54.1	44.6
12.00 – 12.30	112.2	105.2	149.5	132.3	
12.30 – 13.00	**123.2**	**117.1**	**183**	**169.6**	
13.00 – 13.30	122.4	95.7	137.4	147.5	
15.00 – 15.30	30.4	30.4	54.7	83.9	
15.30 – 16.00	123.4	110	17	20.6	
16.00 – 16.30	108.2	71.7	86.5	129.9	
16.30 – 17.00	92.2	86	48.2	86.6	
17.00 – 17.30	95	93.5	106.1	111.9	
17.30 – 18.00	102	100	121.5	108.5	
18.00 – 18.30	77.5	64.3	65.2	73.2	
18.30 – 19.00	45.2	39.2	53.2	69.2	
19.00 – 19.30	30.4	30.4	35.4		
19.30 – 20.00	32.4	32.4	30.4		
01.00 – 01.30				3	1

It will be retained the maximum values (highlighted in bold) for each of the five observation posts, in order to assess the capacity reserve of the road network in the area which is subject of the study:

- Observation post 1: 123.2 [passenger car units / 0.5 hours];
- Observation post 2: 117.1 [passenger car units / 0.5 hours];
- Observation post 3: 183 [passenger car units / 0.5 hours];
- Observation post: 169.6 [passenger car units / 0.5 hours];
- Observation post: 46.4 [passenger car units / 0.5 hours].

It is noticed that during the night the road traffic intensity is practically zero, the explanation being that on *Frații Goleşti Street* move only residents; it is not a transit artery.

Given that the traffic measurements were not made for the entire period of the day, but only at times when it was considered that its would be surprised the densest flows, its can be adopted for calculating the street network load the following values, obtained by rounding to the higher values of the obtained data:

• 200 passenger car units / 0.5 hours, for one-way circulation section (where the observation posts 1, 2 and 3 were located) and for northward sense of moving in the area with two-way circulation (where it was located the observation post 4);

• 100 passenger car units / 0.5 hours, for southward sense of moving in the area with two-way circulation (where it was located the observation post 5);

It is necessary that the traffic intensities to be converted into a measure unit more favorable for further study – standard vehicles / hour, thus obtaining the hourly road traffic intensities with the relationship:

$$I[\text{standars vehicles / hour}] = \frac{N_t[\text{passenger car units / 0.5 hours}]}{0.5} \quad (3)$$

Thus, the hourly traffic intensities values retained for the calculation on *Fraţii Goleşti Street* will be:

• 400 passenger car units / hour, for one-way circulation section and for northward sense of moving in the area with two-way circulation;

• 200 passenger car units / hour, for southward sense of moving in the area with two-way circulation.

3. THE EVALUATION OF CIRCULATION CAPACITY RESERVE OF THE STREET NETWORK

In accordance with standard STAS 10144/50-088 *"The calculation of streets circulation capacity"*, it is computed the circulation capacity of the *Fraţii Goleşti Street*, based on its technical characteristics:

- street width: 7 meters;
- the number of circulation senses:
  - one (one-way circulation) for observation posts 1, 2 and 3;
  - two (two-way circulation) for observation posts 4 and 5.
- the number of circulation lanes on each sense:
  - two for observation posts 1, 2 and 3;
  - one for observation posts 4 and 5.

Thus, the calculation will be done for the two sections of *Fraţii Goleşti Street* (with one-way circulation, respectively with circulation in both senses).

Considering an average speed of traffic on the two sections of the *Fraţii Goleşti Street* of 36 km/h (10 m/s), the dynamic gauge of the passenger car units, which must include (together with the average length of 5 m) also the safety stopping space by braking if necessary, will be:

$$L_d = 5 + V \cdot t_r + \frac{V^2}{2 \cdot d_f} = 5 + 10 \cdot 0.2 + \frac{10^2}{2 \cdot 5} = 17 \text{ m} \quad (4)$$

where d_f is the average braking deceleration, the adopted value being 5 m/s^2.

The circulation capacity on one circulation lane will be:

$$C_b = \frac{10^3 \cdot V[\text{km / h}]}{L_d} = \frac{10^3 \cdot 36}{17} = 2120 \text{ [passenger car units]} \quad (5)$$

It can be considered in calculating a value even smaller, rounded, of 2000 passenger car units. This way, it results the maximum degree of capacity utilization of the *Fraţii Goleşti Street*, at the current moment:

A. For the section with one-way circulation, where it is considered that both circulation senses are available (circulation capacity utilization requires that it not be allowed vehicles standing or parking on the road):

$$\%C = \frac{I_h}{C} = \frac{I_h}{2 \cdot C_b} = \frac{400}{2 \cdot 2000} = 10\% \quad (6)$$

B. For the section with two-way circulation, on northward sense of circulation:

$$\%C = \frac{I_h}{C} = \frac{I_h}{C_b} = \frac{400}{2000} = 20\% \quad (7)$$

C. For the section with two-way circulation, on southward sense of circulation:

$$\%C = \frac{I_h}{C} = \frac{I_h}{C_b} = \frac{200}{2000} = 10\% \quad (8)$$

It results that in the current traffic conditions, during peak periods of the road traffic, there is a circulation capacity reserve of the *Frații Goleşti Street* (as well as for the adjacent streets with one circulation lane in double sense – *Gheorghe Lazăr Street* and *1 May Street*) of 80%. This finding allows the development of the study for the situation in which, by building a *Kaufland* supermarket in the area, it provides that road traffic will increase. The circulation capacity reserve is substantial, which justifies the study also for the situation in which it will be considered the time evolution of the socio-economic factors in the area for the next 15 years, so the conclusions have a long lasting character.

4. THE ESTIMATION OF TRAFFIC FLOWS GENERATED BY GIVING IN-USE THE *KAUFLAND* SUPERMARKET. PROPOSALS FOR ROAD CIRCULATION ORGANIZING

By giving in-use the *Kaufland* supermarket, traffic flows will increase, given the emergence in traffic of two categories of users:

1 – The supermarket employees, who'll come to work with personal cars or on foot or by public transport. It can be considered that 200 employees will come with their personal cars, 100 for the first shift and 100 for the second one, so at the times of input / output in / out shifts, the traffic in each direction will add up to 100 cars of employees;

2 – The buyers, who will come over the day, and at peak hours it will not be more private cars than parking spaces available for shoppers, meaning that 300 buyers who are stationed in the driveway about an hour, so the road traffic intensity will increase up with 300 cars at peak hours.

It follows that the maximum intensity of road traffic on the *Frații Goleşti Street*, in the case in which it still can be reached on a one-way circulation sense (from South), can have the value:

$$I = 400 + 100 + 300 = 800 \ \ [\text{passenger car units} / \text{hour}] \quad (9)$$

This value is well below the maximum capacity of the streets in the area (4000 passenger car units / hour on the one-way section of *Frații Goleşti Street* and 2000 passenger car units / hour on the section with two-way circulation of *Frații Goleşti Street* and on adjacent streets with one circulation lane in double sense – *Gheorghe Lazar Street* and *1 Mai Street*), allowing the study to forecast traffic for a sufficient time horizon – 15 years.

5. THE ESTIMATION OF THE FUTURE TRAFFIC FLOWS IN THE STUDIED AREA AND THE ANALYSIS OF THE STREET NETWORK CAPACITY IN RELATION WITH THE ESTIMATED ROAD TRAFFIC

Considering the most optimistic scenario of socio-economic development of Câmpulung Muscel city and its population (which is currently declining, according to statistics, given the continuing downturn in the economy in the period after 1990: 44125 inhabitants at the census in 1992 compared with 38209

inhabitants in 2002) and estimating that the motorization index cannot grow by more than 50% over the next 15 years (the dynamic of new car acquisition will not reach the pace of recent years, also because it was already near saturation level), we can say that the intensity of traffic flows cannot increase by more than 50%, so it can reach about 1200 passenger car units / hour and will be far below the value of 2000 passenger car units / hour in the studied area (this is the road network capacity for access to location *Kaufland*, calculated as the minimum between the arrivals on 2 + 1 circulation lanes and the departures on a single circulation lane, i.e. between 4000 + 2000 and 2000 passenger car units). Thus, it can be said that giving in-use of a new *Kaufland* supermarket will not follow in the next 15 years to increase the intensity of road traffic over the street network capacity in the area of *Fraţii Goleşti Street*. In addition, by making minimum arrangements for the street network in the area, in the framework of an optimum reglementation of the road circulation, it will ensure at any time the use of the street network at the entire road circulation capacity.

6. ARRANGEMENT PROPOSALS FOR THE STREET NETWORK AND FOR THE REGLEMENTATION OF ROAD CIRCULATION IN THE STUDIED AREA

Analyzing the street network in the area where it is proposed to built the *Kaufland* supermarket, it is found that there is a section of about 200 meters on the *Fraţii Goleşti Street* (between *Kaufland* location and intersection with *Tudor Vladimirescu Street*) on which the vehicles cannot circulate on the North – South sense (figure 1).

As a result, there are access problems for customers with personal cars and also for trucks that will make supplies of goods, as follows:

a) the client access (as well as the employees access) with the private cars can be made in the present only from South, on *Fraţii Goleşti Street*, the road flow being derived upstream from two road flows: the one from the South of the *Fraţii Goleşti Street* and the one from the *Nicu Leonard Street* (beside the *House of Culture*, having the origin in *Negru Vodă Street*);

b) the access for supplying trucks can only be achieved from the South, following the route: *Ion Mihalache Boulevard* (so-called the ring road) – the bridge on the *Târgului River – Fraţii Goleşti Street*, with difficulties to enter by turning right into *Fraţii Goleşti Street* and at the displacement in front of the school at the beginning / ending the courses (moreover, this access route is very long).

It is noticed that the access from the North to the proposed location cannot be done because that road section of about 200 meters where the road circulation goes on one-way, although the street width is from one end to another large enough, of 7 meters.

Summarizing, there are two major drawbacks in the current situation for the road access in the area:

1 – the access of all vehicles to the location can be made on the *Fraţii Goleşti Street*, only in a single sense, from South to North;

2 – the trucks access requires a long and difficult route.

Moreover, the access of all vehicles is made in front of the school and *Kretzulescu Park*, representing an additional risk factor for road traffic participants in the area. Therefore, to overcome these problems it should be searching for solutions for road arrangement and for the reglementation of road circulation.

Given that it is desired the changes in the reglementation of road circulation and road arrangement to be minimal, analyzing the estimated traffic flow and the geometric characteristics of the existing road infrastructure, we propose the following:

1 – next to the proposed location for *Kaufland*, in its North side, to fit a roundabout intersection, eccentric to the axis of *Fraţii Goleşti Street* (to be arranged partially on the ground of *Kaufland* location), and on the section of *Fraţii Goleşti Street*, between the intersection with *Vladimirescu Tudor Street* and this roundabout intersection, to change from one-way circulation to road circulation in both senses (figure 3), thus realizing the access from *Schei Bridge* to *Kaufland* supermarket, including for trucks that will supply the commodities;

2 – the access from this intersection into the roundabout to the South of *Fraţii Goleşti Street* to be restricted by the corresponding indicator, and the arrangement to be done considering this ban of access – with a direction change to right for the two circulation lanes from the section with one-way of the *Fraţii Goleşti Street* and the implementation of a buffer-island in the left side (figure 3);

3 – given the very short distance between the intersection *"Fraţii Goleşti Street – 1 Mai Street"*, the cars access from *1 Mai Street* into *Fraţii Goleşti Street* will be done with "Mandatory Right" sign, these will cover the intersection in roundabout, wherefrom can enter in the *Kaufland* parking or turn around for moving to North on the *Fraţii Goleşti Street*;

4 – the square between *Podul Schei Street* and *Locotenent Oncica Street* to be transformed into a roundabout intersection, thus allowing easy entry and exit and in safe conditions to / from the *Fraţii Goleşti Street*.

Fig. 3. The road arrangement proposal and the reglementation of road circulation in supermarket area.

The reglementation of the road circulation in the area is achieved by appropriate regulatory signs (figure 3). In this way will be solved all the problems highlighted above and will be preserved the environmental conditions and road safety on the section of the *Fraţii Goleşti Street* next to the school and *Kretzulescu Park*.

7. CONCLUSIONS

The viability of the proposed solutions based on the research made is demonstrated by the fact that the project was put into operation and all proposals from this study had been carried out without any changes.

This way, the *Fraţii Goleşti Street* area became not only a space of commercial interest, but also a modern one, in which the accessibility has greatly increased through adequate arranging of the street network and by the sustainable reglementation of road circulation.

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