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TRAFFIC MODELLING FOR THE FINANCIAL/MARKET ANALYSIS OF THE KRIŽIŠĆE - ŽUTA LOKVA MOTORWAY

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Abstract

The modelling of traffic flows, as needed for the financial/market feasibility analysis of the Križišće-Žuta Lokva Motorway, is described in the paper. Civil-engineering / technical solution alternatives, serving as a basis for creating the road network in accordance with traffic needs, are defined. The analysis and long-term forecast of traffic demand in the area under study is made and, consequently, traffic flows on the existing road network, and on the planned civil-engineering / technical alternative, are investigated. The traffic demand on the road network in the Croatian littoral area, i.e. on national roads D8, D40, D23, D501, D3 and D42, and on the existing sections of the motorways A1 and A6, is analyzed with the purpose of establishing a comprehensive data base for the transport system. The development of traffic supply in the corridor of the motorway A7, and in its contact areas, is also taken into account in the determination of the physical scope of investigations. Regular traffic count data are used in the assessment of traffic demand in the future motorway A7 corridor. Time periods from 1993 to 2008 are included in the time series. The planned traffic supply model is based on the differentiation between two investment situations in the time period under study: network without investment and network with investment. The allocation of the total travel forecast to the network model with investment is made for each year in which the form of network is changed: 2008, 2015, 2020 and 2049, and also for five-year time intervals involving change in annual traffic growth rates. Based on the progress of staged construction of the motorway, the defined traffic demand is related to 3 models of traffic supply predicted within the corridor network. Graphical projection results are presented as a direct product of SW VISUM 10.3 software through total AADT projections. The traffic demand modelling is made for each individual year of the planning period, and is presented in five toll categories.

Keywords: traffic, traffic demand modelling, toll collection

1 Introduction

The traffic demand on the road network in littoral Croatia, i.e. on national roads D8, D40, D23, D501, D3 and D42, and on the existing sections of motorways A1 and A6, is analyzed with the purpose of establishing a comprehensive data base for the transport system under study. The development of transport supply in the motorway A7 corridor and in its boundary area is taken into consideration in determining the physical scope of investigations.
Regular traffic count data were used in the traffic demand assessment for the future motorway A7 corridor.

1.1 Principal results obtained by the O-D analysis

Principal properties of traffic operated on the existing roads and motorways A1 and A6 are described via AADT (average annual daily traffic) and ASDT (average summer daily traffic). The AADT and ASDT data were obtained by analysis of data from automatic traffic counters located at appropriate localities within the corridor under study. The following traffic data were obtained for 2008:

Locality 2917 - Kostrena,	AADT	8909,	ASDT	12844	veh/day,
Locality 2918 - Križišće,	AADT	5631,	ASDT	11218	veh/day,
Locality 2923 - Crikvenica,	AADT	8286,	ASDT	15026	veh/day,
Locality 2928 - Novi Vinodolski,	AADT	6163,	ASDT	13908	veh/day,
Locality 2929 - Senj - North,	AADT	5142,	ASDT	12018	veh/day,
Locality 4101 - Senj,	AADT	3969,	ASDT	8096	veh/day,
Locality 4201 - Brinje,	AADT	1553,	ASDT	1234	veh/day,
Locality 4214 - Brinje jug,	AADT	12161,	ASDT	28561	veh/day,
Locality 4215 - Žuta Lokva South,	AADT	11292,	ASDT	27094	veh/day,
Locality 2915 - Vrata West,	AADT	13137,	ASDT	20256	veh/day.

It can be concluded that the most trafficked localities are A1 and A6 with the AADT of 13137 veh/day and 12161veh/day, respectively. The AADT registered at the localities of Kostrena and Crikvenica is around 8500veh/day, while the AADT for Novi Vinodolski and Senj-North is roughly 5000 and 6000veh/day, respectively.

Figure 1 Position of automatic traffic count sites

2 Traffic analysis

2.1 Planned traffic supply models

The planned traffic supply model is based on differentiation between two investment situations in the time period under study:

- network without investment (existing network, network development level until the time of analysis),
- network with investment (new sections are added to the existing network; new sections require additional investment).

The network with investment dynamically changes in keeping with the dates scheduled for opening to traffic of individual motorway sections. The total travel forecast is allocated to the model of network with investment for every year in which the change in the shape of network

is made/envisaged: 2008, 2015, 2020, and 2049, and for five-year time intervals in which there is a change in annual traffic increase rate. Models of the planned traffic supply on the road network, as developed in the scope of this study, are axed around the future motorway in the corridor A7, and this in accordance with the planned staged construction of the motorway:

- M0 road network supply model for 2008,
- M1 road network supply model for 2016 and 2020,
- M1 model of the fully realized network (situation in 2049) with motorway in the full length.

For each link of the graph defined for the existing road network, we have defined, based on appropriate methodological assumptions, the attributes that describe their traffic supply, necessary and sufficient for establishment of a balanced demand and supply relationship in the network at the level of an average day in the year:

- length l (km, m),
- average free-flow speed AHS (km/h),
- daily capacity Cd (veh/day), and
- function describing relationship between the operating speed (AOS) and flow (v/c), based on the SW software.

2.2 Traffic demand forecast

The traffic demand forecast was developed as follows:

1 using the method involving uniform factor for the zonal increase generation and traffic attraction,
2 by factors of growth gained from rates of expected increase in traffic, in all with variable increase rates in five-year intervals from 2008 to 2049,
3 Factors of growth are applied, using the mentioned simple method, to travel time matrices.
4 The starting matrices for the forecast are the cube matrices of O-D travels, obtained by calibration for 2008 as the base year, with basic zonal or spatial dimensions of [100x100].
5 The starting matrices contain trips per vehicle categories, and the third dimension is provided by three basic vehicle categories: passenger cars, buses and trucks.
6 Based on calibration of defined data, three basic vehicle categories can be disaggregated and expanded to six subcategories. Vehicles for passenger transport can be passenger cars or vans, while trucks can be classified according to the number of axles in three categories.
7 The basic forecast is made according to three basic vehicle categories and dimensions of its unitary matrix bases are [100x100x3] x 4 time sections.

3 Traffic flow forecast: balanced state of the planned traffic supply and demand

The volume and structure of expected future traffic flows on the relevant motorway A7 network with investment were estimated:

1 in several time sections from 2008 to 2049, and they are presented here for three representative time sections: 2008, 2016, 2020 and 2049.
2 According to progress of the staged motorway construction, a defined traffic demand is related to 3 models of planned traffic supply within the corridor network:
   - M0 road network supply model for 2008,
   - M1 road network supply model for 2016 and 2020,
   - M1 model of the fully realized network (situation in 2049) with motorway in the full length.
3 The following balanced relationships are presented: M0•2008, M1•2016, M1•2020 and M1•2049.

4 For clarity reasons, simulation results are presented separately by sectors:
   · relevant network Mo: Section: Križišće - Novi Vinodolski, Novi Vinodolski - Senj, Senj - Žuta Lokva,
   · relevant network M1: Section: Križišće - Novi Vinodolski, Novi Vinodolski - Senj, Senj - Žuta Lokva.
5 Graphical projection results are presented as a direct SW VISUM 10.3 product, through total AADT images.
6 Traffic flow properties per section are presented in figures relating to Motorway A7 sections.

As the simulation was conducted on a wider network - network that defines the scope of the O-D travel matrices - which covers not only the territory of Croatia, but also that of the surrounding countries, simulated flows also contain a part of traffic diverted from other roadways as a result of motorway construction; e.g. from Italy, Slovenia and Bosnia & Herzegovina. Traffic forecast results for network without investment and network with investment are presented in the following figures.

Figure 2 AADT on relevant network without investment Mo▪2008

Figure 3 AADT on relevant network with investment M1▪2016

Figure 4 AADT on relevant network with investment M1▪2020

Figure 5 AADT on relevant network with investment M1▪2049

4 Revenue generated by toll collection

(1) Traffic flows along the toll route of the motorway A7 result from the establishment of balance in the corridor network between the demand and supply, where toll is also added to direct travel costs. That is why the balance between the motorway supply and traffic demand is modelled by simulation in, globally, two steps: (i) first, by establishment of free balance in which the supply gives the user only the options of direct vehicle travelling costs, and passengers between the origin and destination of travel, and (ii) after that, by establishment of a conditional balance which adds the toll collection cost to the direct travelling costs. This is valid for both supply models used in the study. As toll collection is a restrictive element of the supply, it leads in the second step to the analysis of diversion of traffic from sections under study, and to the definition of final market-based balance relationships within the network and the toll route.

(2) One form of traffic supply development is tested - existence of motorway in full profile from the start of use of a section, for both supply models that are used in the study.

(3) Unit rates used in toll collection (i) by vehicle categories, and (ii) by sections for which flows are formed, have been generated in accordance with the following premises:
(i) Five vehicle categories are included in the toll collection system and all of them are used within the period covered by this study:
- Motorcycles
- Nk(1) for vehicles with two axles, up to 2m in height,
- Nk(2) for vehicles with 3 axles, up to 2m in height,
- Nk(3) for vehicles with 2 and 3 axles, more than 2m in height, and for vehicles with 3 axles up to 2m in height,
- Nk(4) for vehicles with more than 3 axles, more than 2m in height.

(ii) The relationship between prices of individual toll categories is constant and amounts to (for the period from 1 January 2009):
- Motorcycles : Nk(1) : Nk(2) : Nk(3) : Nk(4) = 0.6: 1 : 1.5 : 2.275 : 3.3, or,
- 0,033 : 0,055 : 0,0825 : 0,125 : 0,1815 €/km

(4) Traffic flows on facilities under study are assessed and finally defined as the flows of motorcycles, flows of four toll paying vehicle categories [Nk(1)-(4)] and flows of one non-paying category [Nk(9)]. They are the agglomerate of several realistic vehicle types and are hence dependent on changes in the intensity of travel of individual vehicle types during the year. Consequently, their average annual daily traffic (AADT) has a reference forecast value for the analysis, while an average monthly daily traffic (AMDT) has a commercial/revenue assessment value for the analysis.

4.1 Toll revenues on motorways

(1) Calculation of toll is generally based on five determinants for every toll facility, and the same is also true for the roadway which includes motorway A7:
(i) Estimation of an average monthly daily traffic (AMDT) on sections, by individual toll categories.
(ii) Unit toll rates per individual sections and
(iii) length of toll sections.
(iv) Calculation of net toll revenues,
(v) based on constant unit rates (u).

(2) In case of a cash-flow analysis, a conservative scenario with reduced toll revenues can be considered in addition to the above mentioned toll revenues.

(3) The resulting projections of total annual toll revenues generated at each section, and at all sections, are analyzed for the traffic supply development model, and for the optimistic traffic demand development scenario.

(4) The model forecasts toll revenues for the use of the motorway A7.

5 Conclusion

The modelling of traffic flows, as needed for the financial/market feasibility analysis of the Križišće-Žuta Lokva Motorway, is described. Civil-engineering / technical solution alternatives, serving as a basis for creating the road network in accordance with traffic needs, are defined. The analysis and long-term forecast of traffic demand in the area under study is made and, consequently, traffic flows on the existing road network, and on the planned civil-engineering / technical alternative, are investigated. The traffic demand on the road network in the Croatian littoral area, i.e. on national roads D8, D40, D23, D501, D3 and D42, and on the existing sections of the motorways A1 and A6, is analyzed with the purpose of establishing a comprehensive data base for the transport system. The development of traffic supply in the corridor of the motorway A7, and in its contact areas, is also taken into account in the determination of the physical scope of investigations. Regular traffic count data are used in the assessment of traffic demand in the future motorway A7 corridor. Time periods from 1993 to 2008 are included in the time series. The planned traffic supply model is based on the differentiation between two investment situations in the time period under study: network without investment and network with investment. The allocation of the total travel forecast to the network model with investment is made for each year in which the form of network is changed: 2008, 2015, 2020 and 2049, and also for five-year time intervals involving change in annual traffic growth rates. Based on the progress of staged construction of the motorway, the defined traffic demand is related to 3 models of traffic supply predicted within the corridor network. Graphical projection results are presented as a direct product of SW VISUM 10.3 software through total AADT projections. The traffic demand modelling is made for each individual year of the planning period, and is presented in five toll categories.

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