Housing estates in Central Europe: Similarities and differences of road network patterns

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***Abstract*—The goal of this paper is to compare road network patterns of housing estates in several countries in Central Europe. The common feature of the housing estates that they were built between 1950 and 1990. Road networks were analyzed using ArcGIS software. The database comes from OSM (openstreetmap). The research found that the road networks of the selected housing estates show similarities in central Europe. Based on these housing estates, three eras can be distinguished in terms of the road network. In the 1950s, a traversable road network of the housing estates was not disturbing due to the small number of vehicles, while by the 1970s, the proportion of dead ends increased. The 1980s were also characterized by traversability in the road networks of housing estates, however, due to the design, through traffic avoids housing estates.**

Keywords—road network; pattern; housing estates; GIS

I. Introduction

Several books and papers identified and classified road network patterns. Four basic road network pattern types can be identified according to Stephen Marshall's book [1] as follows:

- Type A, Historic core: typical of the core area of old cities, it is characterized by an irregular design.
- Type B, Gridiron (central, or extension, or citywide): typical of planned extensions or newly founded settlements, it is characterized by a regular design.
- Type C, Anywhere: including individual villages or suburban extensions, perhaps the most general type.
- Type D, Peripheral development: It is usual in suburbs in USA. One of the features is many dead-ends.

Han et al [2] defined grid-like and tree-like network types, with intermediate structures in between. Boeing [3] investigated 27,000 US urban street networks according to a similar classification. Besides theoretical considerations, street network analysis may have practical outcomes. E.g. [4] argues that street-network sprawl results in excess travel and pollution, while [5, 6] associates street network forms with road safety.

In Central Europe, a special type of urban districts was created after World War 2: multi-story housing estates were built in many countries to alleviate housing shortage. These new residential areas were built in both greenfield and brownfield areas. In most cases, a completely new road network pattern was developed.

The aim of this paper is to analyze the road network structure of these developments and to find possible background for differences among areas.

II. Study area

The subject of the research are 25 housing estates in eight Hungarian cities and 12 housing estates in other Central European cities. These housing estates are located in Austria (Linz, Salzburg, Innsbruck), in the Czech Republic (Plzen, Olomouc, Liberec) and in Slovakia (Kosice). Hungarian cities are mainly located in lowlands, with the exception of Pécs and Miskolc, while the foreign cities are dominated by hills. The population of these cities are between 100,000 and 250,000.

III. Database

The geometrical data of the road pattern comes from the OSM (openstreetmap) database [7]. The investigation was made by the ESRI ArcGIS software. The subject of the research is the motorized roads. The original data were processed based on the attribute data and street views. Figures 1 and 2 show the original database and the investigated road pattern in the housing estate in Győr Adyváros.

Fig. 1. Original database of road network in a district

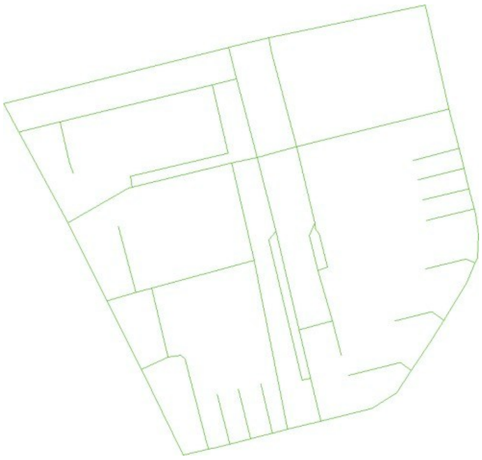

Fig. 2. Investigated (processed) road network in a district

IV. METHOLOGY

The road network patterns of housing estates were investigated based on the connectivity index and the ratio of the dead-ends and junctions [8, 9, 10]. The connectivity index is a parameter of the network traversability. This value is the division of edges and topological points. The topological points are the total number of dead ends and intersections on the network.

In this research the definition of the dead-ends is presented in macro level. This means that the junction (red circle) shown in Figure 3 appears as a dead-end in the road network.

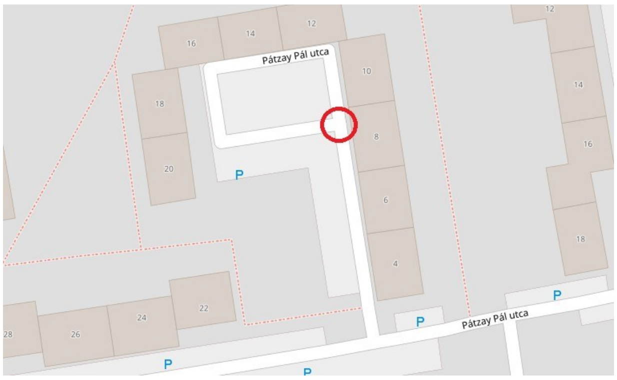

Fig. 3. Node marked with red circle means dead-end in macro level and T junction in micro level [7]

V. RESULTS

A. Ratio of the nodes in the road network

In each examined housing estate, the T junctions dominated in the motorized road networks. The share of the X junctions is significantly less. The ratios of dead ends, T and X junctions for each district are shown in a triangular diagram (Fig. 4). This diagram was made using a Microsoft Excel application [11].

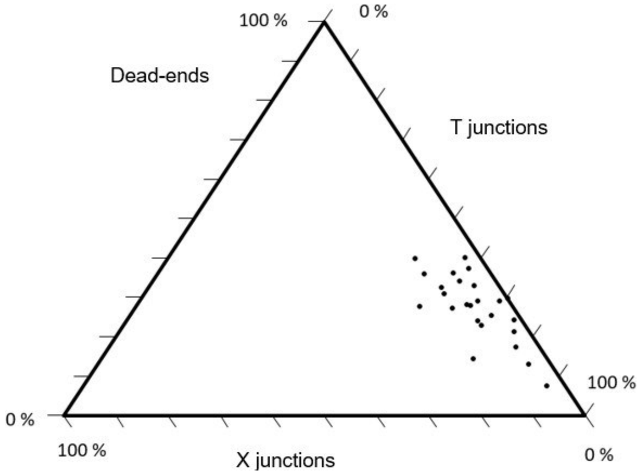

Fig. 4. Types of nodes in housing estates in triangle diagram

Comparing the three types of nodes in pairs in the road network the results show a high correlation between the ratio of the dead-ends and ratio of the T junctions (Figure 5).

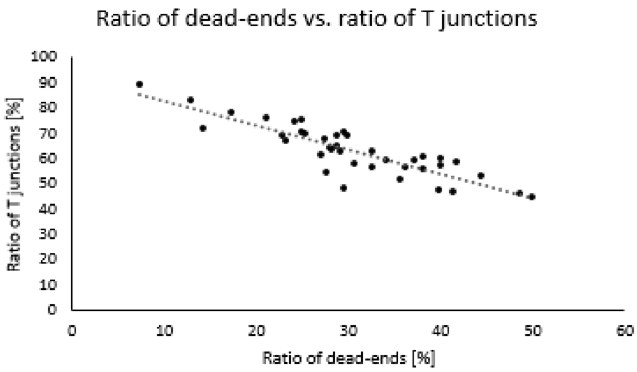

Fig. 5. Ratio of dead-ends vs. ratio of T junctions

In the other cases there are no correlations between the parameters, as shown in Figure 6 and 7. There are some districts where the number of X junctions are zero.

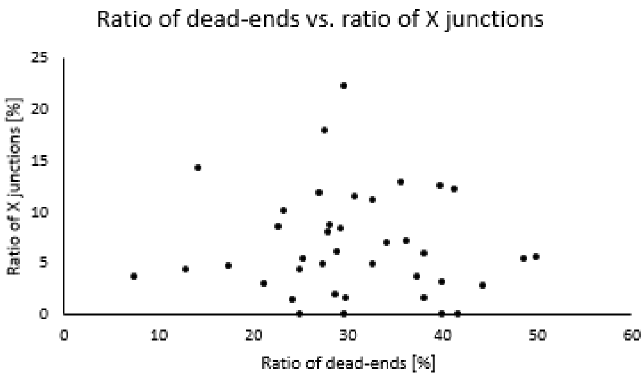

Fig. 6. Ratio of dead-ends vs. ratio of X junctions

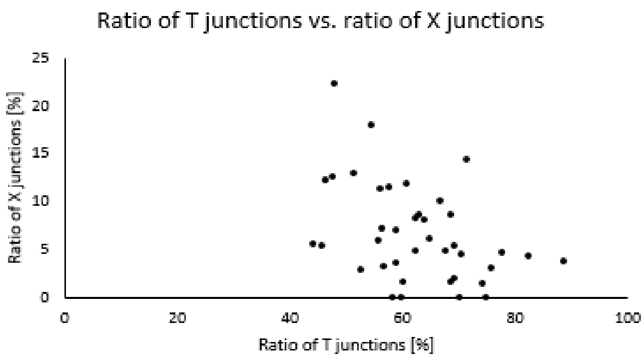

Fig. 7. Ratio of T junctions vs. ratio of X junctions

B. *Road patterns in different decades*

In case of all housing estates, different road network patterns can be observed in different decades. With the parameters mentioned earlier, this difference can be quantified.

The road networks of the 1950s were characterized by network traversability. During this period, the main traffic road often crosses the housing estate, which nowadays appears as a 2x2 lane route within the housing estate (Figure 8).

Fig. 8. Map of Pécs Uránváros [OSM]

Fig. 9. Map of Győr Adyváros [OSM]

In the 1960s and 1970s, the ratio of dead ends in housing estates increased (Fig 9). The traversability of the road network has decreased, and roads have often served as car parks next to buildings. It can be observed in many Hungarian housing estates that garages were located on the ground floor of the buildings, while this was not the case in foreign cities.

The design of the 1980s is similar to the road network of the 1950s. The main difference is that the main traffic roads avoid the housing estates. The next example is Győr Marcalváros2 where the main roads are close to the housing estate. There is an internal road network where is only the local traffic (Figure 10).

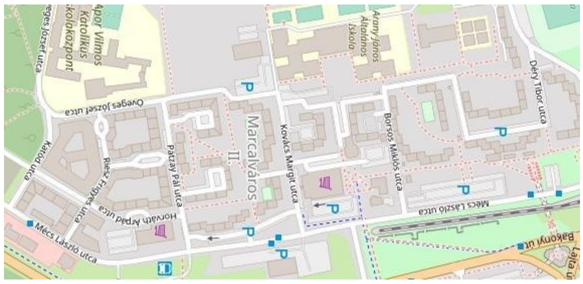

Fig. 10. Map of Győr Marcalváros2 [OSM]

C. *Extreme values in the road network*

The Hungarian districts with the minimum and maximum value of the dead-ends and junctions are shown in Table I.. It is visible that there are large differences in terms of junction type ratios, with 47.6 and 88.9 or 0.0 and 17.9 for T and X junctions. The share of dead ends shows also large differences: 7.4 vs. 40.0 percent.

TABLE I. MINIMUM AND MAXIMUM VALUES IN HUNGARIAN HOUSING ESTATES

City	District	Ratio of dead-ends [%]	Ratio of T junctions [%]	Ratio of X junctions [%]	
Kecskemét	Széchenyiváros2	**7.4**	8.,9	3.7	MIN value
Miskolc	Avas II.	39.8	**47.6**	12.6	
Debrecen	Vénkert	29.6	70.4	**0.0**	
Győr	József Attila	**40.0**	56.9	3.1	MAX value
Kecskemét	Széchenyiváros2	7.4	**88.9**	3.7	
Szeged	Makkosház	27.6	54.5	**17.9**	

Kecskemét Széchenyiváros2 (Hungary) housing estate is listed twice in the table. This housing estate was built in the 1990s and it is situated on the outskirts of the city.

TABLE II. MINIMUM AND MAXIMUM VALUES IN FOREIGN HOUSING ESTATES

City	District	Ratio of dead-ends [%]	Ratio of T junction [%]	Ratio of X junction [%]	
Linz	Heinrich-Kandl Weg	**25.0**	75.0	**0.0**	MIN value
Olomouc	F1 (Nova ulice)	57.1	**38.1**	4.8	
Salzburg	Mülln	40.0	60.0	**0.0**	
Olomouc	F1 (Nova ulice)	**57.1**	38.1	4.8	MAX value
Linz	Heinrich-Kandl Weg	25.0	**75.0**	0.0	
Linz	Ennsfeld	29.6	48.1	**22.2**	

For the foreign districts, the minimum and maximum values of the dead-ends and junctions are shown in Table II. The differences are similarly large differences in terms of junction type ratios, with 38.1 and 75.0 or 0.0 and 22.2 for T and X junctions. The share of dead ends shows also large differences: 25.0 vs. 57.0 percent.

D. *Connectivity index in the road network of the housing estates*

Comparing the changes of the connectivity index of the road network of Hungarian and foreign housing estates built in different decades, it can be seen that in the case of the Hungarian examples, the road network designs of each decade are more separated, as shown in the figures below.

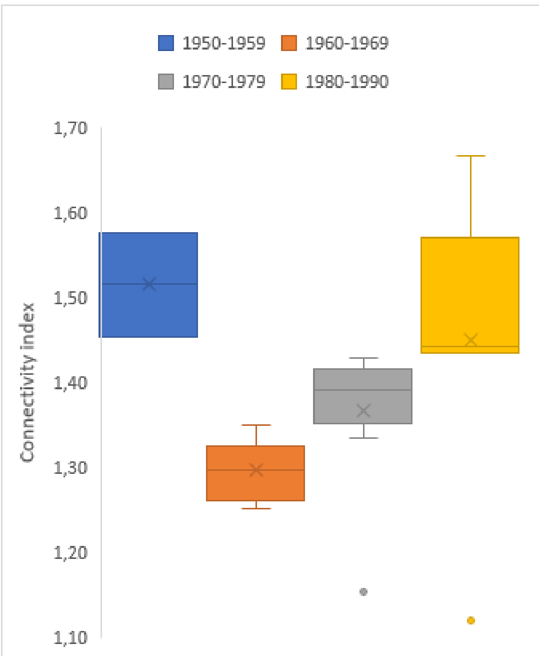

Fig. 11. Change in the connectivity index in the housing estates in Hungary

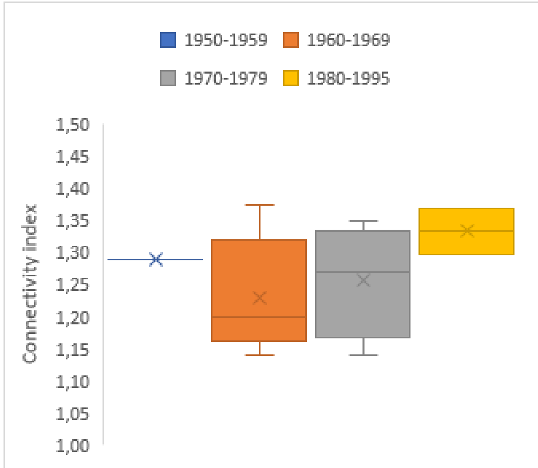

Fig. 12. Change in the connectivity index in the housing estates in neighboring countries

VI. DISCUSSION, CONCLUSIONS

The number of cars in Hungary increased significantly during the decades (Figure 13, [12]). As the number of vehicles increased, so did the traffic volume and the number of parking places, which had an impact on the development of the road network. Due to the negative effects of increasing traffic, designers have tried to reduce the adverse effects of through traffic with new designs for each era.

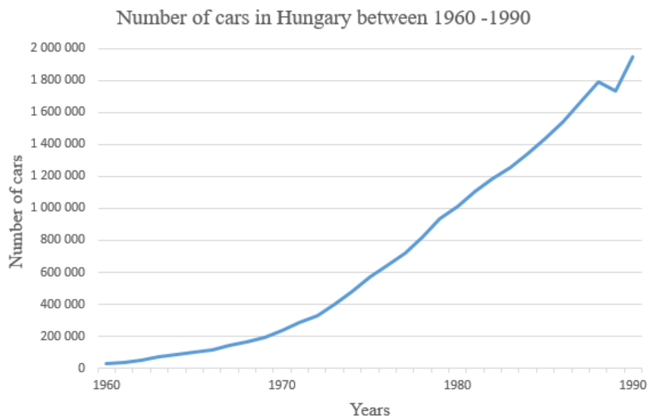

Fig. 13. Number of cars in Hungary between 1960-1990 [HCSO]

The changes of the road pattern over the decades have been similar in the housing estates of Central Europe. The ratio of dead ends in the foreign housing estates is lower than in Hungarian housing estates. In case of motorized roads, in all eras and all countries, the examined housing estates are dominated by T intersections, which are well correlated with the ratio of dead ends.

Remarkable differences were found among different districts in each country. Further research should clarify the reasons behind these differences; how are local conditions and trends in urban planning influencing network forms.

Due to the relatively low number of accidents in these residential areas, no correlation was found between the road network topology and the accident data.

This research revealed that road network patterns are manyfold, and they are changing by decades. Different network patterns may contribute to the cognition processes during driving [13] and they can influence safety. However, there are a lot of questions remained for further research.

One of these challenging open questions is, how urban planners and road designers decide on these network structures, what is their cognitive process, as there are no formal rules or guidelines in any countries, regarding the share of the T or X junctions when designing a new residential (or industrial) area.

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