1 INTRODUCTION

Europe and the United States: A Comparison

Geographic, demographic and highway system data for the USA, selected States, and selected European countries are given in Table 1.1, in order of increasing land area. A direct comparison of various European countries and the USA by land area can be made. The land area of these European countries is about 20 percent of the USA and the length of main and national motorways is about 33 percent that of the USA.

. Population and Roadway Density

European countries in general have higher population densities than nearly all USA States. For example, the five countries visited by the Study Tour have an average population density of 312 people per square kilometer compared to the USA average 26.

Europe also has over three times more kilometers of roadway per square kilometer than the USA. The USA has on average 0.7 km of highway per square km (1.1 mi per square mi) of land area, while Europe has on average 2.4 km of highway per square km (3.9 mi per square mi) of land area. Some European countries have much more dense highway networks; Austria, for example, has 7.6 km of highway per square km (12.2 mi per square mi).

These statistics are important in understanding the great concern that many European countries have for noise pollution. However, Table 1.2 shows that several northeastern States (Rhode Island, Connecticut and New Jersey) have densities comparable to those of European countries. The following data give a comparison between selected States and countries in Europe having the same population density.

Table 1.2 Comparisons of population and roadway densities.

Country or State	People per sq km	Km Road per sq km
USA	26	0.7
Austria	544	7.6
Netherlands	349	2.7
New Jersey	380	2.7
Belgium	318	4.4
Rhode Island	314	3.0
W. Germany	249	2.0
Connecticut	247	2.4
France	102	1.5
Pennsylvania	102	1.6
Spain	77	0.6
California	67	0.6

1 km^2 = 0.386 mi^2, 1 km/km^2 = 1.61 mi/mi^2

Table 1.1 Road system statistics comparison of the United States and selected European countries.

	Total Land Land Area (1000 sq km)	Population Density (per sq km)	Road System (thousands km)		Kilometers of Road per Thousand of Population		Kilometers of Road per Square Kilometer of Area		Cars per Thousand of Population	Fatality Rate Deaths per 100 Million veh-km
			Main and National	Secondary and Other	Main and National	Secondary and Other	Built Urban Area	Total Land Area		
Rhode Island	3	314	1.5	7.9	1.6	8.0	16.6	3.0	551	1.4
Delaware	5	122	1.0	7.6	1.6	11.7	16.6	1.6	591	1.6
Connecticut	13	247	4.6	27.1	1.4	8.4	13.0	2.4	762	1.1
Austria	14	544	11.5	95.0	1.5	12.5	na	7.6	na	na
New Jersey	20	380	9.3	45.5	1.2	5.9	11.6	2.7	6%	1.2
Maryland	27	167	6.5	38.5	1.4	8.5	14.6	1.7	599	1.4
Belgium	31	318	14.5	122.4	1.5	12.4	13.0	4.4	350	3.9
Switzerland	41	160	19.8	51.2	3.0	7.7	na	1.7	na	na
Netherlands	42	349	4.4	109.2	0.3	7.4	7.1	2.7	348	1.4
Portugal	92	111	19.1	0.0	1.9	0.0	1.0	0.2	155	6.6
Pennsylvania	117	102	24.7	163.4	2.1	13.7	22.4	1.6	518	1.6
New York	127	140	24.5	153.0	1.4	8.6	24.2	1.4	469	1.6
Florida	152	79	19.3	142.3	1.6	11.8	14.4	1.1	709	1.9
West Germany	249	2%	39.8	453.8	0.7	7.4	9.0	2.0	463	2.3
Wyoming	252	2	7.1	57.4	14.5	117.1	107.7	0.3	575	1.2
NY-NJ-PA	265	141	58.4	361.9	1.6	9.7	20.6	1.6	521	1.5
Italy	301	191	51.3	251.2	0.9	4.4	4.8	1.0	423	2.2
California	411	67	44.0	211.7	1.6	7.7	19.4	0.6	568	1.6
Spain	505	77	20.6	297.5	0.5	7.7	3.0	0.6	263	6.9
France	544	102	34.9	770.0	0.6	13.8	9.2	1.5	394	3.0
United States	9400	26	651.9	5581.4	2.7	22.9	2.6	0.7	561	1.5

Most data 1987. Sources: "Europe in Figures," Eurostat, 1989; World Road Statistics, IRF, 1991. Highway Statistics, 1987, U.S. Statistical Abstract, 1991,1992.

Table 1.3 Roadway mileage comparisons for European countries and US States of comparable population and roadway densities.

Europe	Main Motorways (km)	Comparable State	Main Motorways (km)
Austria	11,500		
Netherlands	4,400	New Jersey	9,300
Belgium	14,500	Rhode Island	1,500
West Germany	39,800	Connecticut	4,600
France	34,900	Pennsylvania	24,700
Spain	20,600	California	44,000

1 km = 0.621 mi

- **Highway Network**

A comparison of the main and national motorways of these same countries with various States is given in Table 1.3. The USA has 651,900 km (404,800 miles) of main motorways. The total of 215,900 km (134,100 miles) for all European countries is 33 percent of the USA's mileage.

- **Climate**

Climatic factors have an effect on concrete pavement performance and it is important to have a general understanding of the climates of Europe vs the USA. In general, the climate is milder in most of the countries visited than in the northern USA.

- **Traffic Statistics**

The cars per thousand of population and fatality rate deaths per 100 million vehicle km travelled are shown for the same countries in Table 1.4. The USA has a significantly larger number of cars per 1000 population, but most European countries (excepting the Netherlands) have far higher fatality rates than the USA.

- **Consequences of Infrastructure Neglect in Eastern Germany**

Travel over thousands of kilometers of European. highways clearly showed that those highways (all types of pavements) are in far better condition than most highways in the USA. The serious deterioration that exists on American highways and streets was virtually never seen in Europe. Pavement rehabilitation is applied much earlier so that the traveling public almost never sees serious deterioration or roughness, let alone serious pavement-related hazards.

Table 1.4 Comparisons of vehicle ownership and fatality rates in European countries and US States.

Europe	Cars/1000 Population	Fatality Rate*	Comparable State	Cars/1000 Population	Fatality Rate*
Netherlands	348	1.4	New Jersey	646	1.2
Belgium	350	3.9	Rhode Island	551	1.4
W. Germany	463	2.3	Connecticut	762	1.1
France	394	3.0	Pennsylvania	518	1.6
Spain	263	6.9	California	568	1.6

* Deaths per 100 million vehicle-km travelled (multiply by 1.61 for deaths per 100 million vehicle-miles.)

The most impressive, never-to-be-forgotten portion of the European Study Tour was the travel and visits in the former East Germany. Driving into the former East Germany presents an immediate dramatic difference in the condition of pavements and other roadside structures from that in the West. The deteriorated condition of many sections of highways was evident immediately upon passing over the former border (with empty guard towers at interchanges) between Munich and Berlin where the entire distance is mostly concrete pavements constructed over 50 years ago.

Simply put, there has been no highway maintenance done in eastern Germany over the past 40 years, which has lead to major deterioration of the highway infrastructure to the point that serious mobility, congestion, and safety problems exist and complete expensive reconstruction is the only feasible solution for most sections.

During meetings in Berlin, government officials described how bad the highway pavements were, especially within towns. They get letters and phone calls every day from many people stating that they cannot carry on their normal work because of impassible streets and highways. Teachers cannot teach, police cannot patrol, etc.!

However, it is most interesting to note that the German government is now placing an enormous emphasis on spurring economic recovery in the east through a massive reconstruction of many deteriorated highways. The Study Tour witnessed many of these projects on the drive from Munich to Berlin and then on the freeway ring around Berlin.

The German government's recognition that highways are vital to this recovery, and their action to rehabilitate the highways in the east as the first step in recovery was very impressive to the Study Tour. The Study Tour was told that in the State of Brandenburg (where Berlin is located), 1.2 billion Deutsche Marks (DM) were available this year, some 300 million DM more than they can spend, apparently because not enough contractors are available!

Europe, a "Window" to Future Transportation Infrastructure Issues

Europe seems to represent a "window" through which some important issues of the future transportation infrastructure in the USA can be observed. Some of these already exist in more densely populated and industrial areas of the USA.

- **More and Heavier Trucks and Axle Weights**

For a number of years, European countries have experienced 8 percent or more annual growth in truck volume on freeways. This rate of growth is expected to accelerate in the future with the coming of the European Community (EC). Heavy truck volumes run 20 to 30 percent of average daily traffic (ADT) on many freeways and daily truck volumes run from 1000 to over 10,000 per day in one direction in the outer lane.

The legal axle weights in several countries are summarized in Table 1 .5. The EC will apparently adopt a uniform 11.5 metric ton (denoted by t) (25,300 pounds) single axle as its legal limit, which will mean an increase for some countries, but other countries already have a higher limit, such as a 13 t (28,600 pounds) single axle and a 21 t (46,300 pounds) tandem axle in some countries, among the highest in the world. Note that these load limits are far higher than those in the USA. Apparently little enforcement of axle weights exists. One weigh-in-motion site showed that 4 percent of axles were even above these "highest in the world" legal limits. Comparison of the axle load distribution from the 1960's to the 1990's shows a major shift to heavier axle weights.

These weights will make Europe's trucking industry very competitive from a transportation cost standpoint.

- **More Trucks with Super-Single Tires and Higher Tire Pressures**

The trucks in many European countries have super-single tires. These tires were rated at 0.86 MPa (125 psi) tire pressure.

- **Environmental Issues**

Use of existing roadbed construction materials is emphasized. Existing concrete pavement is often cracked or crushed and used as a base for a new concrete pavement or recycled as aggregate in new concrete pavement.

Table 1.5 Legal axle load limits in Europe and USA.

Country	Single Axle		Tandem Axle	
	tons	pounds	tons	pounds
Austria	10	22,046	16	35,300
Belgium	13	28,660	n/a	
France	13	28,660	n/a	
Germany	11.5	25,353	19	41,888
Italy	12	26,455	19	41,888
Netherlands	11.5	25,353	n/a	
Portugal	12	26,455	20	44,092
Spain	13	28,660	21	46,297
Switzerland	8.2	18,077	n/a	
USA	9.1	20,000	15.4	34,000

Recycling all materials at the job site (no land filling) is required in some cases.

Noise emission from pavement-tire interaction is very important at this time in Europe. In fact, pavement-tire noise reduction was one of the most talked-about topics on the tour Eliminating splash during rainstorms is considered important for safety.

Maintaining high friction is important because the friction value has been related to wet-weather accidents.

- **Reduction of Congestion Through Fewer Lane Closures**

Longer-lasting pavements require fewer lane closures for repair or reconstruction.

Lower pavement maintenance needs require fewer lane closures.

Rapid construction reduces lane closures.

- **Consideration for Future Traffic Control Needs in Design and Rehabilitation**

One side of a typical divided highway (two lanes plus shoulders) consists of full-width paving thickness that can later be divided into four lanes so that the pavement in the other direction can be closed for reconstruction or rehabilitation, or for emergencies. Note that lanes through construction zones are reduced in width.

- **Emphasis on Level of Service**

The level of service provided by freeway pavements in Europe was observed to be very high. This may be due to a combination of factors including higher investment in the infrastructure (see Figure 1. l), improved designs, more durable materials, and higher construction requirements.

A primary reason for the achievement of quality highways in Europe is a longer original design life and a European mindset for long-term use, not only of highways but also of homes, cars and all other products. Europe is not a disposable-driven economy. Designs include a large safety factor. For example, actual concrete strengths regularly exceed design strengths by a considerable margin, and design strengths used in Europe are considerably higher than ours. USA construction contracts and quality control programs are focused on uniformity and building as closely as possible to specified requirements, whereas their designs and contracts are focused on getting the best, longest-life product possible.

Virtually no concrete durability problems were observed in any country. The comprehensive Swiss quality control (QC) program to achieve durable concrete provides an understanding of how this level of quality is achieved.

Many European concrete pavements built in the 1950's and 1960's have performed extremely well and only recently have some of these pavements required rehabilitation. Other much older concrete pavements exist in Europe, such as the 67-year-old pavement in Brussels, or the East German autobahn concrete pavements which are more than 50 years old (although traffic was not heavy for many years). Even now these pavements do not exhibit any durability problems, though they do show cracking and faulting problems. Many kilometers of concrete pavements built in Portugal between 1935 and 1945 are all still in service. Austria has many jointed concrete pavements that are over 30 years old that have performed very well.

- **Cooperation of Government and Industry in Research**

Europe benefits greatly from close' cooperation between public and private organizations. An ideal example is the French national research study on concrete pavements. These type of relationships are growing in the USA as well. In fact, close cooperation among industry, State, and Federal officials is one of the reasons that this tour took place.

During the European Study Tour, the participants freely discussed many aspects of transportation facilities. The participants felt that this interaction between Federal, State, and industry personnel was extremely valuable and contributed greatly to increased understanding.