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RESEARCH ON THE PERFORMANCE OF THE HGVS IN THE MAJOR GREEK ROAD NETWORK USING WIM TECHNOLOGY

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ABSTRACT

The work presented within the framework of this paper concerns the first major research on heavy goods vehicles (HGVs) operating on the national highway network of Greece. Data was collected at seven sites along the two main road axes of the country. A total of about 3.000.000 records at all sites were collected concerning all vehicles classes. Data was collected using permanent Weigh-In-Motion (WIM) technology. In addition to that, comparison measurements were taken from high-speed and low-speed WIM systems. The results will be taken into account when considering enforcement for the overloaded HGVs along the national highway network. In the framework of this research emphasis was given in the development of a comprehensive database concerning the WIM measurements and more specific the dynamic and static characteristics of the HGVs. This database is unique for the Greek highway network and it is a necessary step in order to provide useful information to engineers and support all future actions in the area of pavement design and management.

1. INTRODUCTION

During the last decades a shift in the movement of goods towards the use of Heavy Good Vehicles (HGVs) has been observed. In Greece the total amount of HGVs transported goods for an average working day is about 500.000tns corresponding to about 70.000 trips [1]. According to the results of the National Origin – Destination survey, there is an annual 3% increase in the HGVs traffic during the period 1980-1995. This is accounted to the transport related costs, the requirement of the transport companies, the growing density and quality of the highway network and the trends in the transport industry. This increase of HGVs traffic has raised questions about the potential negative impacts in the Greek highway network, and therefore, revealed the need for a systematic recording of the HGVs characteristics.

A research project was carried out during 1992 concerning the collection and analysis of HGVs data along parts of the national highway network [2]. In 1998 the Ministry of Development, General Secretariat for Research and Technology assigned a research project [3] concerning the determination and assessment of the dynamic characteristics of HGVs and their impact to the national highway network, to the Department of Transportation and Hydraulic Engineering, Faculty of Rural and Surveying Engineering, Aristotle University of Thessaloniki, to the Central Laboratory of Public Works (responsible authority for pavement quality) and to the Egnatia Road S.A. (responsible authority for the construction, operation and maintenance of the Egnatia Road).

The project deals with the recording of the static and dynamic characteristics of HGVs using the Weigh-In-Motion (WIM) technology, with reference to the two main road axes in the country (Patras-Athens-Thessaloniki-Evzonoi -PATHE and Egnatia Road). PATHE connects the southern with the northern part of the country and has a length of 1.050 kilometers. Egnatia Road connects the western with the eastern part of the country and has a length of 680 kilometers (some parts of this highway are under construction). Both highways play a significant role in the freight transport sector of the country and therefore they are important to the traffic of HGVs. The project also deals with the analysis and evaluation of the collected data in order to create a database, in accordance to the guidelines imposed by the European Action COST 323.

Research was made on the characteristics of the overloaded HGVs and on their impact to the highway network. Within the project monitoring of the pavement performance due to the loading from HGVs, forecasts about the traffic loads in the examined road axes were also made. Finally the development of a database for pavement design and management and the support of the decision making process concerning the budget allocation for road construction, operation and maintenance was made together with the design of guidelines for the evaluation of the impact of HGVs on road axes and for the computation of the pavement construction elements.

2. DATA COLLECTION METHODOLOGY

The main criterion for the selection of sites for the survey was that each one must be characterized by significant HGVs traffic. An attempt has been made so that the number and position of these sites will secure the geographical coverage of the examined highways. These sites are presented in Figure 1. It was not possible to have simultaneous counts to all seven sites as it was originally scheduled. Since the number of the available loggers was smaller than the number of the available sensors and loops, the loggers were removed from one site to another according to a predefined program of counts. The counting period started in August 2000 and ended in March 2001. It is divided into four discrete periods as follows: summer period (August 2000), autumn period (September-November 2000), winter period (December 2000 – February 2001), spring period (March-April 2001).

Two WIM systems were installed (one for each of the two highways).Underground cabling was used to connect the sensors with the logger. In four out of seven sites PEEK TRAFFIC Ltd. sensors were used while in the rest two sites the Electronique Controle Mesure (E.C.M.) sensors were used. The layout of the installation consisted of two piezoelectric weight sensors having a length of 3,5 meters, another piezoelectric on scale sensor having a length of 0,5 to 0,8 meters and finally an inductive loop in order to create the necessary magnetic field. A total number of 3.053.116 records (referred to all vehicle classes) were finally collected.

Repeated visits to the sites were necessary in order to transfer data from the logger to a portable personal computer and also to replace the batteries of the system. The frequency of these visits depended on the traffic volumes and on the batteries used. Measurements of the evenness were also made in each site in order to assess the quality of the pavement. These measurements were made for a distance of one kilometer before and after the exact position of the WIM systems. Apart from the field data collection process, an extended survey was conducted in order to collect data on the construction elements of the pavement (e.g., year of construction, type and year of last maintenance etc.), on the available traffic volumes, on the classification of the HGVs, on the maximum allowed axle and gross weight etc.

Traffic volume data was based on the results of the National Transportation Survey which was carried out in 1993 by the Ministry of Environment, Physical Planning and Public Works [4]. Data on HGVs became available from the Ministry of Transport and Communications, division of freight transport.

3. PRESENTATION OF RESULTS

Due to the fact that two WIM systems were used within the framework of the project, there was incompatibility concerning the data obtained from the loggers. Therefore there was an effort in order to perform a common analysis process. The first WIM system (ADR–Peek Traffic) uses the Standard FHWA classification system but with one change (class 14 now refer to auto-calibration vehicles: passenger cars having wheelbase between 2,40 and 2,60 m.). Class 15 is now the default class for vehicles with more than 8 axles. The second WIM system (Hestia Station–ECM) uses a more detailed classification system created by the manufacturer. Data from this second WIM system was converted, by using the distances between axles, in order to be compatible with the ADR–Peek Traffic WIM system. For the purposes of the project the FHWA classes 1, 2 and 14 (subclass of class 2) referred to passenger cars while the rest classes referred to HGVs.

A significant number of false records were identified before the statistical analysis. Filters checking basic parameters of the WIM data were applied to false records. These filters check the status code that the logger gives to each record, the vehicle speed, the wheelbase, the distances between axles and the axles weights. Due to the large amount of data, powerful tools were used in order to design the databases, to allow for computations and to produce statistical results. Data analysis process includes all the analytical information from every site, on every period of counts and on every direction of vehicles.

The identification of the overloaded vehicles was made taking into account the values of the maximum allowed weights for the international transport as defined by the Ministry of Transport and Communications in Greece. The transformation of the axle loads to Equivalent Single Axle Loads (ESALs) of 8.155 tn (18.000 lbr) was made using the respective coefficients of the American Association of State Highway Officials. (A.A.S.H.O.) Two coefficients were defined for the purposes of the analysis in order to express the "aggressiveness" of loads to the pavement. The first coefficient (Vehicle Class Equivalence Coefficient – V.C.E.C.) is defined as the ratio of the total number of equivalent axles per vehicle class over the total number of vehicles of this class (Dept. of Transportation and Hydraylic Engineering et.al. 2001).

The second coefficient (Area Equivalence Coefficient – A.E.C.) is defined as the ratio of the total number of equivalent axles over the total number of the heavy goods vehicles at a certain position or area. Geographic information systems technologies was used in order to produce thematic maps with ESALs and overloaded vehicles.

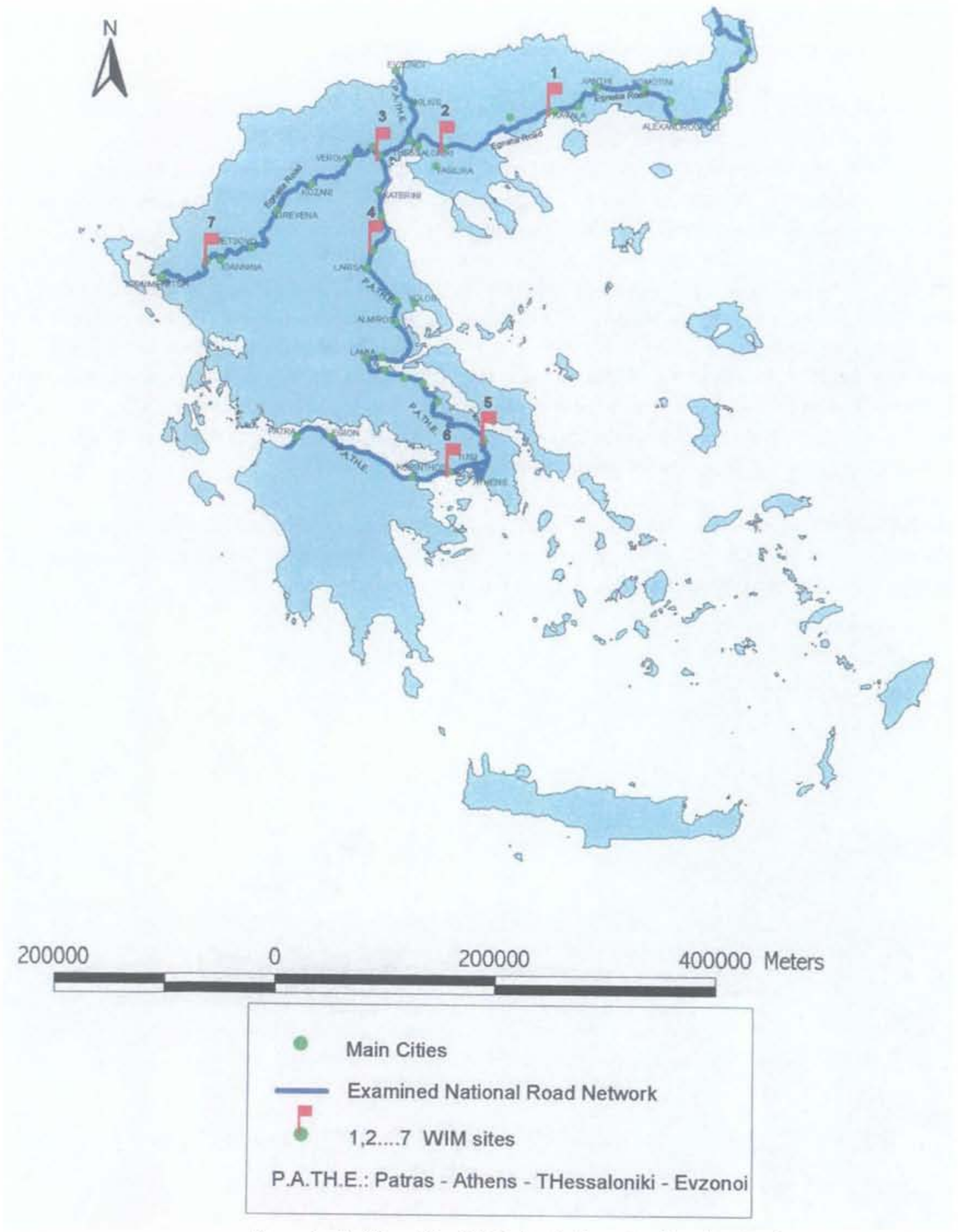

Figure 1 - Position of the WIM sites in the national road network

In the following figures and tables, detailed data concerning HGVs in a specific array (site 3) are presented. The results refer to the direction: Athens to Thessaloniki (PATHE). Results obtained during the period 13[th] September 2000 to 9[th] November 2000 (total number of days where measurements took place is equal to 58).

Figure 2 presents the variation of the cumulative number of the HGV for a period of 24 hours in a specific area (site 3). Figure 3 presents the distribution of the cumulative number of HGV per class in a specific array and for the specific period of 58 days. The majority of HGV belong to class 9 with 5 axles and to class 5 with 2 axles. Figure 4 presents the distribution of the cumulative number of HGV of class 9 with 5 axles. There is a high value concerning HGV with Total Gross of 38-42 tns something which is expected due to the fact that drivers usually utilize the maximum permitted capacity of their vehicles.

The number of overloaded HGV of this specific class is decline as the Total Gross increases, something which again is highly expected.

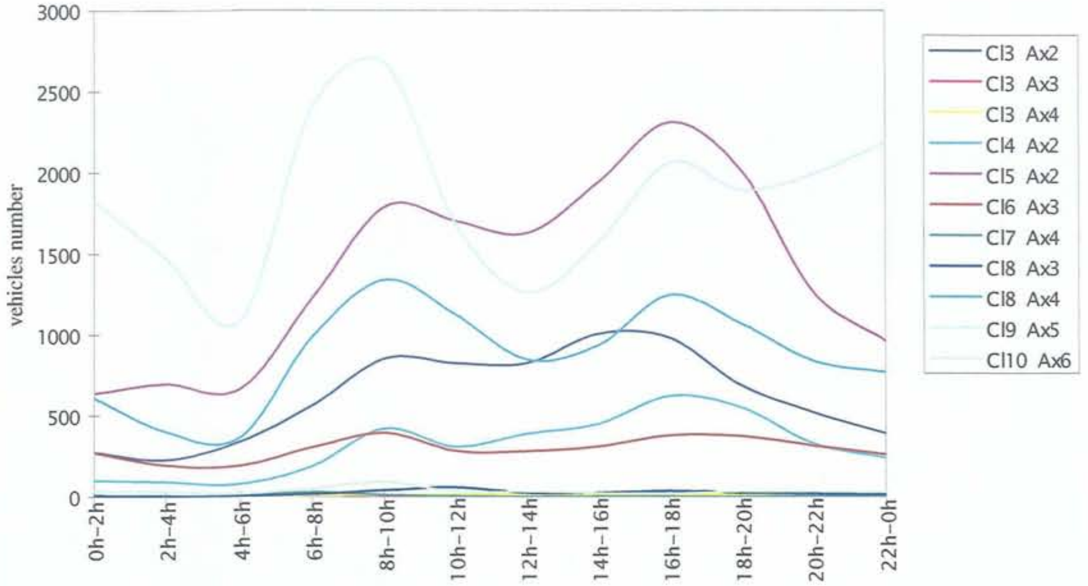

Figure 2 - Variation of the cumulative number of HGV

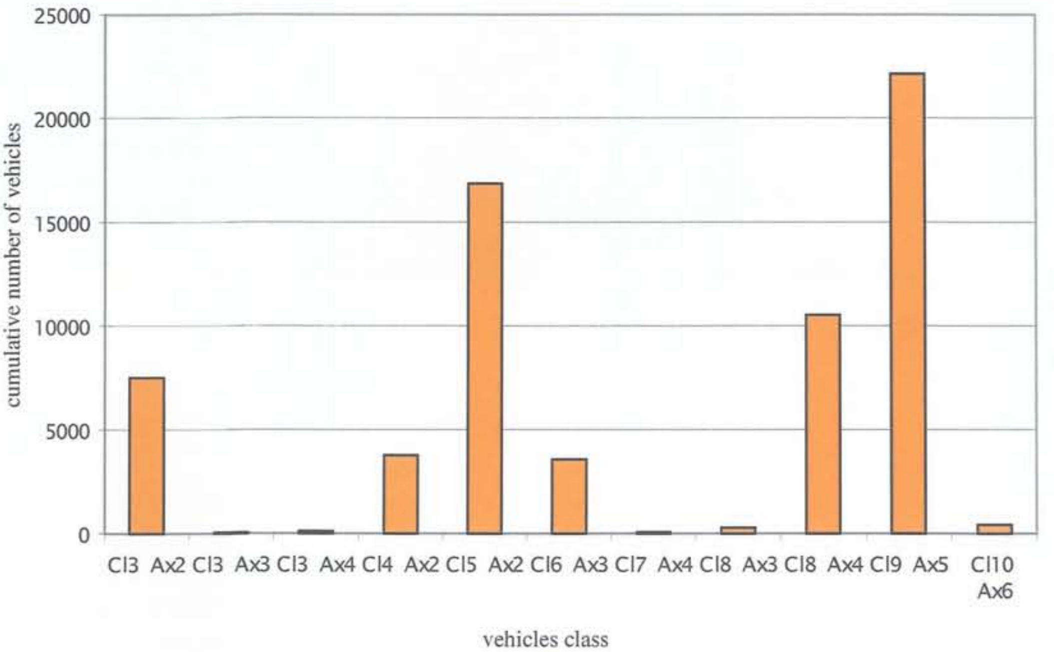

Figure 3 - Distribution of the cumulative number of HGV per class

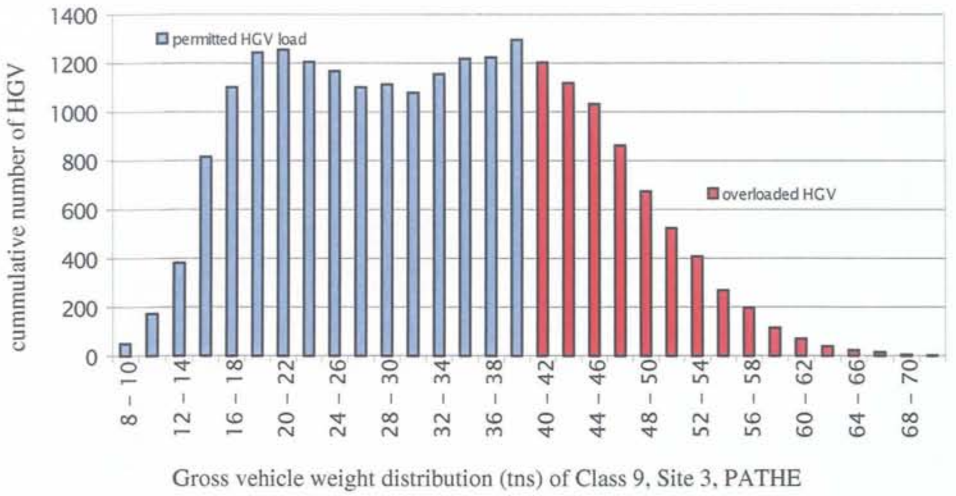

Figure 4 - Total Gross distribution of the cumulative number of HGV (class 9 with 5 axles)

Figure 5 presents the distribution of the cumulative number of ESALs per Total Gross category and per vehicle class. High value refer to 16-18 tns, although no direct comparisons can be made due to different HGV characteristics and limits imposed by the current legislation.

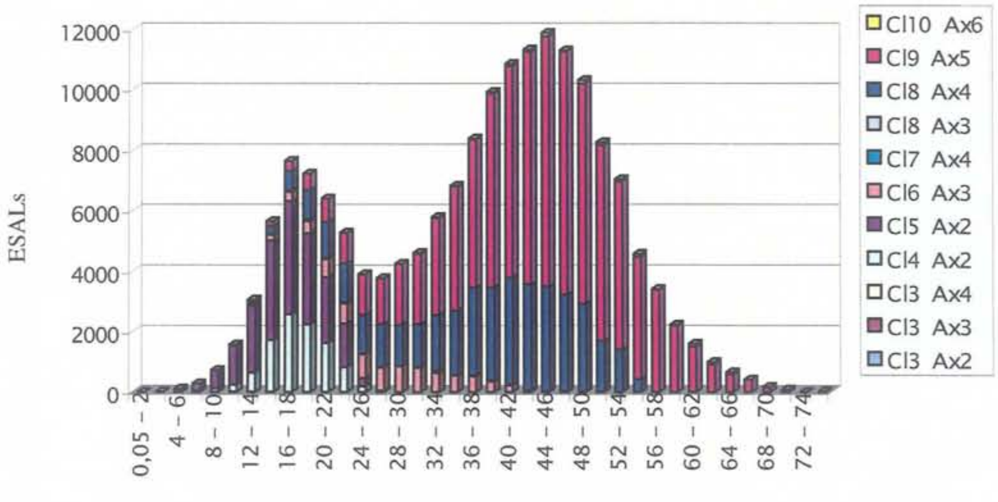

Figure 5 - Distribution of cumulative number of ESALs per total Gross category and per vehicle class

Characteristics of the HGV as recorded by the WIM system are presented in tables 1,2 and 3. More specifically, results concerning minimum, average and maximum values of Total Gross per HGV, values of wheelbase, length of vehicle, speed and finally average and maximum values of axle systems weight are included in these tables. Tables 4 and 5 include data on the distribution of overloaded HGV per class and VCEC and AEC.

In figures 6 and 7 the percentage of overloaded HGVs in each site and the average number of ESALs in each site are presented. Overloaded vehicles in figure 6 refer both to axle weight and gross vehicle weight. The percentages presented in the specific figure are the summation of the above two cases of the overloaded vehicles.

Table 1 - Characteristics of HGV as recorded by the WIM system (per HGV class)

Class	Axles	Vehicles Number	Percent (%)	Wheelbase (m)			Total Length (m)			Speed (km/h)		
				Minimum Value	Maximum Value	Average Value	Minimum Value	Maximum Value	Average Value	Minimum Value	Maximum Value	Average Value
	2	7499	11,5	3,1	3,9	3,5	3,3	10,2	5,6	36	148	90
3	3	42	0,1	5,6	7,9	7,2	6,9	9,8	8,8	47	124	76
	4	124	0,2	7,9	9,5	8,8	8,8	22,0	11,1	66	116	89
4	2	3775	5,8	6,1	7,6	6,3	6,5	18,1	12,2	45	148	98
5	2	16852	25,8	4,0	6,1	4,9	4,3	16,7	8,7	21	162	90
6	3	3562	5,5	2,0	17,6	6,0	5,3	18,6	9,3	30	149	89
7	4	69	0,1	5,0	8,8	6,2	6,2	11,5	8,6	50	106	80
8	3	278	0,4	6,8	12,3	10,3	9,3	16,5	12,9	48	149	90
	4	10539	16,1	5,1	22,4	12,1	5,8	21,9	15,1	34	164	88
9	5	22129	33,9	8,0	25,0	13,2	8,7	21,9	16,4	21	170	87
10	6	434	0,7	8,9	18,3	14,6	12,7	21,8	17,4	54	106	85
	Totals:	65303	100,0									

Table 2 - Average and Maximum values of HGV axle systems weight as recorded by the WIM system

Class	Axles	Total Number of system axles			Average Weight (Kg)			Maximum Weight (Kg)		
		Simple	Double	Triple	Simple	Double	Triple	Simple	Double	Triple
	2	14998	-	-	1797	-	-	4000	-	-
3	3	126	-	-	2074	-	-	5841	-	-
	4	248	124	-	2971	4227	-	5910	13906	-
4	2	7550	-	-	7392	-	-	16366	-	-
5	2	33704	-	-	5096	-	-	16379	-	-
6	3	3599	3536	5	6578	13939	16499	14527	31655	23370
7	4	82	10	58	6822	23780	23157	11293	30578	40357
8	3	834	-	-	5736	-	-	15927	-	-
	4	28309	6919	3	6371	12188	21111	16378	32389	26789
9	5	52011	8872	13630	7175	13209	17220	16376	32212	46800
10	6	734	713	148	6181	12283	16016	15060	30640	37416
Totals:		142195	20174	13844						

Table 3 - Minimum, average and maximum values of Total Gross per HGV class

Class	Axles	G.W. Average (kg)	G.W. Minimum (kg)	G.W. Maximum (kg)
	2	3594	1307	6945
3	3	6221	2184	12114
	4	10170	1775	23171
4	2	14784	5423	27099
5	2	10191	2197	25724
6	3	20507	6162	43605
7	4	31019	9710	48968
8	3	17209	7708	38159
	4	25121	7338	55981
9	5	32765	8441	71939
10	6	36094	12174	74734

Table 4 - Distribution of overloaded HGV per class

Class	Axles	Total Number of vehicles	Over loaded Vehs.	(%)	Overloaded Vehs. (Gross weight)	(%)	Overloaded Vehs. (axle weight)	(%)
	2	7499	0	0,0	0	0,0	0	0,0
3	3	42	0	0,0	0	0,0	0	0,0
	4	124	0	0,0	0	0,0	0	0,0
4	2	3775	860	22,8	756	20,0	104	2,8
5	2	16852	1242	7,4	1025	6,1	217	1,3
6	3	3562	964	27,1	873	24,5	91	2,6
7	4	69	45	65,2	41	59,4	4	5,8
8	3	278	18	6,5	13	4,7	5	1,8
	4	10539	3147	29,9	2960	28,1	187	1,8
9	5	22129	8356	37,8	6551	29,6	1805	8,2
10	6	434	180	41,5	167	38,5	13	3,0
Totals:		65303	14812	22,7	12386	19,0	2426	3,7

Table 5 - Distribution of ESALs per HGV class

Class	Axles	Vehicles Number	ESALs	V.C.E.C.
	2	7499	75	0,01
3	3	42	2	0,05
	4	124	12	0,10
4	2	3775	10233	2,71
5	2	16852	18382	1,09
6	3	3562	7779	2,18
7	4	69	268	3,88
8	3	278	372	1,34
	4	10539	40096	3,80
9	5	22129	92147	4,16
10	6	434	1343	3,09
Totals:		65303	170707	
A.E.C.		2,61		

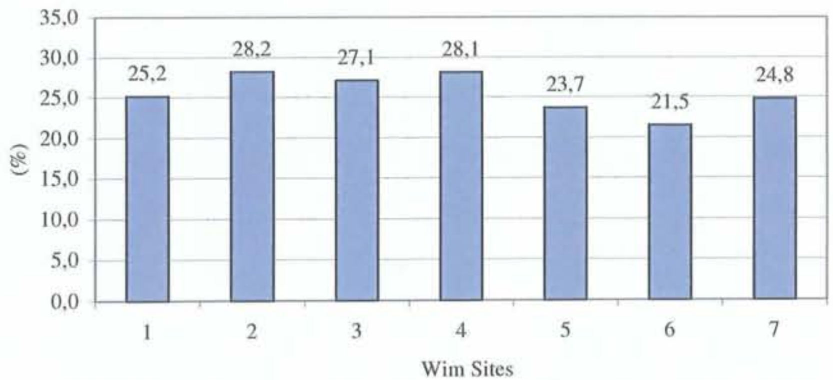

Figure 6 - Percentage (%) of overloaded HGVs in each site

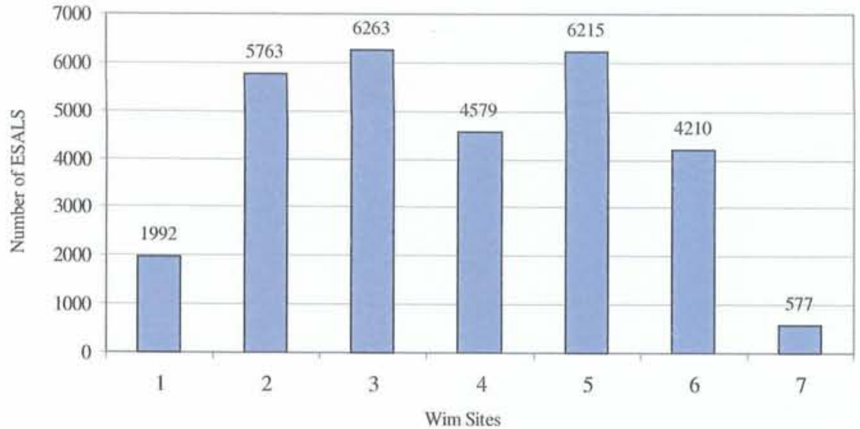

Figure 7 - Average daily number of ESALs in each site

4. CONCLUSIONS

The percentage of the WIM records finally used in the analysis was 65% (the rest concerns the false records). Concerning the traffic composition in the national network, high percentages appear in class 9 with 5 axles in class 8 with 4 axles in class 5 with 2 axles and in class 3 with 2 axles. The rest of the classes appear to have significantly smaller contribution to the traffic composition. The percentage of overloaded vehicles (considering only HGVs) varies between 21,5% and 28,2%. Within the framework of the project only some initial values for V.C.E.C. for specific vehicle classes can be accepted due to the fact that are based on large number of counts. The volume of data collected is considered to be insufficient for a reliable pavement evaluation. In order to do such an evaluation, repeated traffic counts are needed in the seven sites until deteriorations will be identified in the pavement. In this case there will be the opportunity for the development of prediction models in the area of pavement maintenance in the country. Comparison of Greek results to other studies concerning the loading of different class vehicles is not possible due to the small period of measurements. Taking into account the results of the project and the geographical distribution of the sites selected, a number of other sites for the continuation of this work was identified. Concerning the time periods of the measurements, a minimum period of one week every three months (seasonable measurements) is proposed for all permanent stations. Therefore, all range of peak values (taking again into account the experience gained within the project) will be included in a future work.

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