# EFFECTS OF TRAFFIC LOADS ON ROAD BRIDGES – PRELIMINARY STUDIES FOR THE RE-ASSESSMENT OF THE TRAFFIC LOAD MODEL FOR EUROCODE 1, PART 3



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#### Abstract

WIM has developed greatly in the last ten years and confidence in the accuracy of recorded data has increased significantly. Traffic data recently obtained from a number of representative European sites are used to re-calibrate the codified main load model of the European bridge loading code, Eurocode 1 Part 3. A wide range of real and virtual bridge forms were chosen for the study. Simulations were performed using free-flowing and jammed traffic. Load effects generated were determined and statistical extrapolations were performed, where appropriate, to determine characteristic values for the load effects. Some of the assumptions used in the derivation of the original loading model were re-assessed.

Keywords: Traffic loads, load effect, bridges, design code, Eurocode, extrapolation.

#### Résumé

Le pesage en marche s'est largement développé lors des 10 dernières années, et la qualité et la précision des mesures ont progressé. Des données de charges récemment collectées sur plusieurs sites représentatifs Européens sont utilisées pour réajuster le modèle de charge général de l'Eurocode 1 Partie 3 (charges du trafic sur les ponts routiers). Un très grand nombre de sollicitations sur des ponts réels ou théoriques est considéré. Les calculs sont réalisés par simulation du passage des trafics, fluides ou encombrés. Des extrapolations sont faites pour déterminer les valeurs caractéristiques d'effets. Certaines hypothèses utilisées lors de l'élaboration du modèle de charge initial sont réanalysées.

Mots-clés: Charges du trafic, sollicitations, ponts, règlement de calcul, Eurocode, extrapolation.

### Zusammenfassung

WIM hat sich in den letzten 10 Jahren stark entwickelt, und die Qualität und die Genauigkeit der Messungen haben sich erheblich erhöht. Verkehrsdaten, die in der letzten Zeit von einer Anzahl europäischer repräsentativer Stellen erhalten wurden, wurden verwendet, um das Lastmodell vom Eurocode 1 Teil 3 (Verkehrslasten auf Strassenbrücken) nachzukalibrieren. Eine sehr grosse Anzahl Beanspruchungen auf realen oder virtuellen Brücken wurde für die Studie gewählt. Simulationen wurden bei fliessendem und gestautem Verkehr durchgeführt. Statistische Extrapolationen wurden durchgeführt, um die charakteristischen Werte für die Beanspruchung festzulegen. Einige Annahmen, die in der Erstellung des ursprünglichen Lastmodells verwendet wurden, wurden neu analysiert.

Schlüsselwörter: Verkehrslasten, Beanspruchungen, Brücken, Rechenvorschriften, Eurocode, Extrapolation.

## 1. Introduction

The draft Eurocode 1, Part 3 (CEN 1994), *Traffic loads on bridges*, currently at ENV stage, defines the traffic load models to be used in the design of road bridges. In the initial calibration of the models, traffic data recorded using Weigh-in-Motion (WIM) data from four European Union countries (Jacob et al., 1989a) was used in parallel with theoretical models (Jacob et al 1989b, Flint and Jacob 1996), to determine target calibration values. After five years as an ENV, EC1 Part3 is currently being prepared for conversion to EN (European Norm) status. To allow for any changes in the European traffic during the last ten years, and in order to reassess, and if necessary update, the target load effect values, it was decided to perform new calculations on a large scale. This study was also intended to address questions which remained open in the preliminary background studies, or were raised in the studies performed by member states when producing their national application documents (NAD's) (O'Brien et al. 1998, Crespo-Minguillón & Casas 1996).

The quality of WIM data has increased greatly in the last ten years due to improved technologies and the development of specifications regulating accuracy levels (COST323, 1997a). Traffic data recently obtained from a number of representative European sites are used, simulated as *free-flowing* and *jammed* traffic, and their load effect on a wide range of real and virtual bridge forms are computed and extrapolated in accordance with established guidelines for traffic flow scenarios (Flint & Jacob 1996, Bruls et al. 1996).

## 2. Traffic data

In the last 10 years, since the background studies for Eurocode 1, Part 3 were developed, some changes in traffic composition and flow could be expected to have occurred within Europe. The newest WIM systems provide a much more accurate picture of the random variables governing traffic flow, i.e., vehicle gross weights, axle loads, spacing, speed, headway etc.. Traffic data recorded on major European motorways and national routes in 1996 and 1997 are used for this initial re-assessment of the Eurocode main load model.

## 2.1 Traffic samples and flow

The traffic used, outlined in table 1, consisted of WIM recordings made in France, on the following motorways and national routes :

- motorways A1 and A2 from Paris to Lille and Brussels,
- motorway A31 at Bulgnéville, between Nancy and Dijon carrying the traffic between Benelux and North-West Germany to South-East France, Italy and Spain,
- motorway A6 at Chalon from Paris to Lyon, carrying the traffic of the A31 and from North-West France and the Paris region to South-East France, Italy and Spain,
- main highway RN10 at Trappes, from Paris to Chartres, Tours and Bordeaux.

For each continuous WIM record, table 1 gives the number of lanes monitored, n, the actual number of lanes at the site, N, the number of measured directions and the total number of recorded trucks. At some sites axle loads were recorded without axle spacings, with only a vehicle classification. In such cases the axle spacings were artificially reconstructed, using the available statistics on the silhouettes by vehicle category.

The total observed mean truck flows (i.e., vehicles with gross weight greater than 35kN) are given in Table 1. 1900 to 5000 lorries per day were recorded on the slow lanes, while on the fast lane, these figures dropped to between 100 and 700 vehicles per day, 4 to 8% of the total heavy vehicle flow. Traffic flow is idealised as a modified Poisson process (Jacob et al, 1989b) to take account of the minimum spacing between two successive vehicles. The distribution of the *headway* distance between heavy vehicles, defined as the distance between successive trucks in the same traffic lane, is thus modelled by a *gamma* type law dependent on the volume of vehicle flow per hour. When the truck flow is greater than 250 vehicles per hour, the distribution of spacing is exponentially decreasing with the 95% fractile value of headway at 30m. Where the vehicle flow drops below 200 vehicles per hour the distribution of meadway, is almost uniform with very high randomness. The mode varies between 10 and 100 m depending upon the volume of vehicle flow per hour, with mean varying from 10 to more than 1000 m and with similar large variation.

Site	Year	Lanes		Measured	Date	Recording	No.	Total flow
		Ν	n	Directions		period (days)	trucks	(trucks/h)
A1	1996	6	4	2	9/9-14/9	6	67482	
A1	1997	6	4	2	27/1-30/1	4	48938	11935
A1	1997	6	4	2	22/10-28/10	7	86455	
A2	1996	4	4	2	9/9-16/9	8	33683	4400
A2	1997	4	4	2	27/1-30/1	4	19149	
A6	1997	6	4	2	20/10-22/10	3	30837	10280
A31	1997	4	4	2	9/10-22/10	14	57106	4080
RN10	1997	4	1	1	17/1-24/1	7	8404	
RN10	1997	4	1	1	19/9-26/9	8	10584	1275
RN10	1997	4	1	1	3/12-10/12	8	10300	(1 lane)

**Table 1** - Traffic data description (N: number of lanes, n: number of lanes monitored)

### 2.2 Vehicle and axle weights

Figure 1 illustrates the gross vehicle weight distribution for the recorded A6 (1997) and A31 (1997) traffic. These are compared with the histogram formed from data recorded on the A6 in 1986. The distributions confirm the bimodal shape found in the past (Jacob et al. 1989a), if



Figure 1 - Gross Weight distribution

the light vans are not considered. The first mode contains the fully loaded small trucks or partially loaded larger trucks while the second involves the fully loaded large trucks.

For many bridge loading problems, it is standard practice to consider the gross weight distribution as a combination of two Normal distributions (Jacob et al., 1989b). The upper tail of the second mode, centred around 410 kN in each case, demonstrates smaller deviation for the new traffic records, perhaps because of an increase in the accuracy of modern WIM systems. The overload rate did not decrease during this period according to the static weight controls, but the maximum legal gross weight increased from 373 to 393 kN (and 432 kN for some types of lorry). The reduced variation decreases the extrapolated maximum single axle load and gross vehicle weight (table 2), and could, therefore, lead to a reduction in the concentrated load of the main load model of the Eurocode 1, Part 3. On the A31, the proportion of fully loaded heavy lorries (second mode) is slightly larger than on the A6 because, at this site, there is less local short distance traffic, involving lighter and smaller lorries.

Examples of axle load distributions are given in Figure 2, considering axles counted individually, tandem axles and tridem axles counted as groups, where a group is defined as a set of successive axles with a spacing of less than 2.0 m (COST323, 1997b).

Reference	Single Axles	Tandem Axles	Tridem Axles	Gross
periods				Weights
1 day	193	300	382	652
1 week	252-205	353-324	442-406	750-693
1 year	273-227	<i>394-</i> 367	476-450	<i>819</i> -768
100 years	295-260	442-410	571-495	925-844

Table 2 - Extrapolated axle loads and gross weights (in kN) (figures in italic are from 1989)



Figure 2 - Axle load distributions on A1 1996: (a) single axles; (b) tandems; (c) tridems

## 3. Determination of the Target Values

The target values represent the characteristic load effects values calculated to a specified probability of exceedence the design life of the structure. The determination of these values requires several choices including:

- Traffic samples
- Traffic scenarios
- Influence lines and surfaces

- Return periods and fractiles for characteristic values
- Extrapolation methods

# 3.1 Traffic Samples

The original study, prior to the writing of the Eurocode, had concentrated on representative mainland European traffic's recorded at sites in France, Germany and Italy. The French traffic recorded at Auxerre (A6) was predominant as one of the most extreme sites in mainland Europe, yielding, in the majority of cases, the largest load effects. In this study, as in the original one, the collected traffic data was considered for individual sites and the results were compared. It was not possible to mix the traffic data as some extrapolation procedures, based on mathematical simulations of traffic, require samples of homogeneous traffic. Extrapolation of the calculated load effects is necessary as the design life of the structure is much greater than the period of recording of the WIM data. The one week for which recording is carried out is short compared to the lifetime of structure. However, during one week a large enough number of trucks, with sufficient cases to effectively describe the loading to which the structure will be subjected during its lifetime is recorded. It is, consequently very important to ensure that the recording period is not chosen randomly in the year. It must be carefully chosen to display the mean statistical characteristics of the yearly traffic. For extrapolation from one week to 1 year to 50 years to 100 years the arbitrary assumption is made that the traffic is stationary. This is reasonable as no models can accurately predict the future growth of traffic or changes in the design of vehicles. These are decisions taken by administrators and legislators and if changes are made then clearly reassessment of the code would be required.

## 3.2 Traffic scenarios

Traffic records only give information on normal traffic. It is clear, however, that the most critical situations for long spans appear when the traffic is disturbed while for short spans (i.e. <40 m) or local load effects the heaviest individual axle (or group) or vehicle load is dominant. Therefore, it has been necessary to combine realistic traffic scenarios (arrangements of vehicle, traffic types) such as free flowing and jammed traffic. It is important for subsequent extrapolation to ensure that the duration of each simulated scenario be retained for comparison with respect to its expected frequency during the lifetime of the bridge. A number of alternate traffic flow scenarios were performed for both free flowing, jammed and mixed traffic, on up to four lanes. For the Trappes data, where only one lane of WIM data was recorded, two bi-directional lanes were simulated. This was done by reversing the direction of the recorded lane, adding a time delay, to ensure randomness, and running the recorded and synthesised records against one another.

## Free flowing traffic simulations

Traffic was modelled, using the recorded vehicle spacings. For two lane bridges, two cases of free traffic were simulated:

- recorded driving lane traffic, 'D', was run in both free flowing lanes, in alternate directions, a typical bridge situation.
- recorded driving lane traffic, 'D', was coupled with passing lane data, 'P'. In such cases where records for two flow directions were present, the heavier combination of driving and passing lane traffic was chosen.

No. of Lanes in Bridge	Lane No. 1	Lane No. 2	Lane No. 3	Lane No. 4
1	D1			
$2^{1}$	D1	D2		
$2^2$	D1	P1		
3	D1	P1	D2	
4	D1	P1	P2	D2

**Table 3 -** Traffic data used in free flowing simulations (index indicates simulation number, D<br/>& P = Driving & Passing lane traffic respectively, 1 & 2 = Direction of flow)

Table 3 details traffic data simulated in each lane for bridges up to a maximum of four lanes. The free flowing simulations were performed using the program CASTOR-LCPC (Eymard and Jacob, 1989) developed at the Laboratoire Central des Ponts et Chausées. Loads effects were calculated, for the traffic samples described in Section 3.1, as the program moved the vehicles along the bridge, lane by lane, preserving the axle loads and spacing as well as the vehicle spacings recorded on site. Level crossing histograms were calculated in real time during the simulations. The histogram is obtained by counting the number of times that the load is recorded exceeding a given value. This is repeated for a complete range of threshold values and the results presented in the form of a histogram. These level crossing histograms are a useful means of extrapolating a load effect to a period longer than the recording period as outlined in Section 3.5. Level crossing histograms were compiled in this way by the CASTOR-LCPC program for all simulations. Probability density functions were fitted to the computed load effect histograms and extrapolated using 'Rice's formula' in a procedure which is well known in the field of time varying processes (Flint and Jacob 1996).

No dynamic magnification was applied to the calculated load effects at this stage. However in free traffic some dynamic factor should be applied to allow for dynamic interaction between the vehicle and the bridge. The factor will slightly increase the free traffic characteristic load effect values. Discussion is ongoing into the appropriate magnitude of the impact factors and further investigations have been proposed.

## Jammed and mixed traffic simulation

Traffic jam scenarios were also simulated using the available WIM data. This was first achieved by reducing the inter-vehicle spacing for all vehicles (between subsequent axles) to a standard 5 m. This was chosen as being representative of typical congested or slow-moving traffic conditions (Prat 1991). These traffic flow scenarios are denoted as:

- 'T' for traffic jams excluding vehicles of gross weight less than 35 kN,
- *'C'* for traffic jams including all vehicles.

In order to account for rare occurrence such as upstream of toll and custom areas or during a truck demonstration where traffic is sorted by type, the possibility of truck convoys need to be simulated. This possibility of convoys was allowed for, in the simulations used to derive the Eurocode load model, by removing vehicles under 35 kN from recorded driving lane traffic data. This, more critical, jammed traffic situation is denoted D<sup>T</sup>. As it can be considered to be an extremely unlikely scenario, extrapolation of the resulting load effects was not considered appropriate.

The generation of multiple lanes of jammed flow or of mixed jammed and free flow is further complicated by the need to maintain temporal consistency between the different lanes of traffic. It is important to ensure that, in simulating different traffic flow in adjacent lanes, that

the mixing procedure does not combine traffic from different time periods within the day. None of the available software which claims to perform random simulation of traffic generated by theoretical models may consistently deal with the problem of maintaining temporal consistency and weight correlation. In the artificial generation of traffic too few flow scenarios and variables are modelled. Even if a large number of variables were modelled, the more subtle unnoticeable correlations may be missed. Herein lies the huge advantage of WIM data.

The mixing process performed is best explained by the following example in which two lanes of jammed flow are constructed for one lane of jammed driving lane traffic excluding cars  $(D^{T})$ , and the other lane composed of jammed driving lane traffic including cars  $(D^{C})$ . For each hour of recorded traffic, the length of the  $D^{T}$  jam will clearly be considerably less than that of the  $D^{C}$  jam. As it is subject to a longer train of traffic, the second lane is deemed to govern and is assigned a notional speed of 5 m/s. A notional speed is then calculated for the first lane that will ensure that the two trains of traffic take the same amount of time to pass the bridge. (This notional speed will be 5 m/s multiplied by the ratio of the lengths of the two trains). For example suppose the length of the jammed vehicle train,  $D^{C}$ , in the second lane is 100 m, whilst the length of the vehicle train in the first lane, composed of only trucks,  $D^{C}$ , is 10 m. Then, with the notional speed in lane 2 equal to 5 m/s, in order to ensure that the two vehicle trains pass in the same time, the speed of the vehicle train in lane 1 must be 0.5 m/s.

The jammed traffic modelled on each lane for bridges of up to four lanes, is outlined in table 4. Jammed traffic simulations were performed using the program CASTOR-LCPC with reconstructed data files. No dynamic amplification of the load is required as the traffic in a jam is either slow-moving or stopped.

**Table 4** - Type of traffic data used in jammed simulations (Index indicates simulation number,  $D^{T}$  = Jammed driving lane traffic with vehicles under 35kN removed,  $D^{C}$  = Jammed driving lane traffic,  $D^{F}$  = Free-flowing driving lane traffic,  $P^{C}$  = Jammed passing lane traffic,  $P^{F}$  = Free-flowing passing lane traffic, 1 & 2 = Direction of flow)

No. of Lanes in Bridge	Lane No. 1	Lane No. 2	Lane No. 3	Lane No. 4
$1^1$ $1^2$	$D1^{T}$			
$2^1$	D1	P1 <sup>C</sup>		
$\frac{1}{2}$	$D1^{T}$	D2 <sup>F</sup>		
23	D1 <sup>C</sup>	D2 <sup>F</sup>	T oF	
$3^{1}$ $3^{2}$	D1 <sup>1</sup> D1 <sup>C</sup>	P1 <sup>C</sup> P1 <sup>C</sup>	D2 <sup>r</sup> D2 <sup>F</sup>	
$\frac{4^1}{4^2}$	$D1^{T}$	P1 <sup>C</sup> P1 <sup>C</sup>	P1 <sup>F</sup> P2 <sup>C</sup>	D2 <sup>F</sup> D2 <sup>C</sup>
$4^{3}$	D1 <sup>C</sup>	P1 <sup>C</sup>	$P2^{F}$	D2 <sup>F</sup>

### **3.3 Influence lines and surfaces**

Numerous influence surfaces (for beams and slabs) were used. The main longitudinal influence lines are indicated in table 5. In the simulations eight span lengths were considered: 10, 20, 30, 50, 75, 100, 150, 200 m. Previous studies have demonstrated the critical influence lines to be I1 & I9 (Prat, 1991). In addition to these theoretical influence lines a number of

real influence lines are also used with corresponding transverse influence lines relevant for fatigue studies.

### 3.4 Return period and fractile

The occurrence of any load or load effect on the bridge may be discretised and described by a stationary time series (X<sub>1</sub>), for i=1,...,n, where the ith lorry has a gross weight X<sub>i</sub> (Flint and Jacob, 1996). Y<sub>N</sub> and Y<sub>T</sub> denote the random maximum load and load effect occurring after N events or during the reference time period T, respectively. The return period of any value x, R<sub>x</sub> is the mean time interval between two exceedences of the value x by the stationary time series X<sub>i</sub>, i=1,...n, or the mean time elapsed before the first exceedence of x. Thus it may be shown that if y<sub>α</sub> is the (1-α) fractile of Y<sub>N</sub>, for N and  $T \rightarrow +\infty$ , the return period is given in Equation (1) as (Jacob 1991):

$$R = R_{y\alpha} \cong \frac{-T}{Ln(1-\alpha)} \cong \frac{T}{\alpha} \quad \text{if} \quad 0 < \alpha << 1 \tag{1}$$

The relationship is independent of the value of  $y_{\alpha}$  and of the common density of all of the random variables X<sub>i</sub>. The characteristic values for extrapolation of the traffic effects were determined such that the probability of exceeding the load effect during the specified design life of T = 100 years was calculated with a 0.9 fractile probability that  $y_{\alpha}$  is exceeded during T. From Equation (1), a return period of R = 1000 years is required.

Influence Line Number	Representation	Description of the Influence Line	
Ю		Total load.	
11, 12		Maximum bending moment of a simply supported and double fixed <sup>1</sup> span, respectively.	
13		Maximum bending moment at the support of the former double fixed beam <sup>1</sup> .	
I7 <sup>2</sup> , I8		Minimum and maximum bending moment at mid-span of the first of two spans of a two span continuous beam.	
19		Continuous support moment of the former two span beam.	
110		Continuous support shear of the former two span beam.	

Table 5 - Influence lines used in simulation

<sup>1</sup> with an inertia strongly varying between mid-span and the ends

<sup>2</sup> the second span only is loaded

## **3.5 Extrapolation method**

Extrapolations of the extreme load effects are performed for free and congested traffic with cars, under the assumption that the load effect behaves as a stationary Gaussian process, X(t). The hypothesis of stationarity is necessary as the extrapolation may not take account of any future changes in traffic patterns which might reasonably be only expected to result from human decision and road and transport management strategies. The assumption of normality is used to derive the theoretical upcrossing distribution which is asymptotically normal for large values, i.e. above a given threshold, (Leadbetter, 1983). The level crossing distribution, given by the Rice's formula is not itself normal but has a normal tail which governs the extrapolation. It is written as:

$$p(x) = \frac{1}{2\pi} \frac{\sigma_x}{\sigma_x} \exp\left(-\frac{\left(x-\bar{x}\right)^2}{2\sigma_x^2}\right) = k \cdot \exp\left(-\frac{\left(x-m\right)^2}{2\sigma^2}\right)$$
(2)

This probability distribution function was fitted to the computed level crossing histogram, computed by CASTOR-LCPC for each case (i.e., traffic sample and influence surface) with the set of distribution parameters k, m and  $\sigma$  optimised to fit the level crossing histogram of the load effect for a traffic record recorded over a time period,  $\tau$ . Then for a reference period, T, and an  $\alpha$ -upper fractile we solve :

$$p(a) = \alpha \cdot \frac{\tau}{T} \tag{3}$$

which gives :

$$a = m \pm \sigma \sqrt{2 \ln\left(\frac{kT}{\alpha \tau}\right)} \qquad (+ \text{ if } a > 0, - \text{ if } a < 0). \tag{4}$$

In the extrapolation of jammed scenarios, a revised estimate of the traffic recording time period,  $\tau$ , is made. The revised value of  $\tau$ , denoted,  $\tau'$ , is the predicted time of passage of the synthesized jammed records:

$$\tau' = \frac{\pi}{\pi} \tau \left( \frac{\overline{v}}{\overline{v}_o} \right) \tag{5}$$

where:

 $\overline{v}$  is the average speed of the synthesised jammed trains given by Equation (6) as:

$$\overline{v} = \frac{1}{\tau} \int_{a}^{\tau} v(t) dt \tag{6}$$

 $\overline{v}_{a}$  is the typical speed of actual traffic jams,

 $\pi$  is the total synthesised jam duration moving at average speed  $\overline{v}$ ,

 $\pi'$  is the actual expected jam duration during recording time period  $\tau$ .

Take, for example, a given site, where one weeks recorded WIM data is used to synthesize one weeks worth of jammed traffic. Suppose from one weeks worth of data, 24 hours of a particular jam scenario are constructed. Where the average jam speed is calculated as 10 m/s. In reality, the site experiences, on average, 2 hours per day (i.e. 14 hours per week) of the simulated jam type conditions with an average speed of 5m/s. Thus, although the traffic recording period was,  $\tau = 1$  week, the revised recording period value to be used for extrapolation, is given by Equation (5) as,  $\tau = 4.3$  weeks.

#### 4. Results and Discussion

The results for two lane free simulations  $2^1$  and  $2^2$ , as outlined in Table 3 are illustrated in Figures 3 and 4 for all recorded traffic. No dynamic magnification or extrapolation of these load effects has been performed. The greatest effect is seen to be induced by the A1 traffic. The increase in effect induced by the A1 1997 (January) compared to A1 1996 records of approximately 6% is explained by the shorter period of traffic data supplied for A1 1997, where no week-end day was included. That proves the importance of using a full week record in such types of study. The differences of the maximum load effects from one traffic to another only occur for span lengths over 20 m, and become significant over 100 m. That is independent of the site, while for longer spans, the accumulation of heavy lorries becomes dominant, which depends on the traffic density.

The effect of the relatively high probability of multiple presence with strong transverse correlation, discussed in Section 2.2, is seen in the results of the free simulations,  $2^1$  and  $2^2$  illustrated in Figure 4.



Figure 3 - Midspan moment for free flowing truck traffic (no extrapolation)



Figure 4 - Midspan moment for free flowing and jammed truck traffic (no extrapolation)



Figure 5 - Extrapolated midspan moment for free flowing traffic for various reference periods

The difference in calculated load effects for the free and jammed simulations is also illustrated in Figure 4. The jammed load effects, as expected, govern for spans greater than approximately 40 m. The effect of the required reference period and, consequently, the return period in the determination of characteristic, infrequent and frequent load effects was of interest in this study. Figure 5 illustrates the effect of changing the reference periods on the extrapolated load effect for the free simulations,  $2^2$ , using A1 1996 traffic. For the 200m span there is a difference of 15% between the 1 week and 1 year return periods. This difference reduces to 5% for 1 to 5 years, and 2% for each of 5-10 years, 10-20 years, 50-100 years and 50-100 years.

### 5. Conclusions

This paper has outlined the preliminary studies performed for the re-assessment of Eurocode 1, Part 3, *Traffic loads on Bridges*. An extensive database of WIM traffic records collected on representative European routes has been used for the study. A significant reduction in the variance of recorded data has been demonstrated, which is expected to compensate for the increase of gross weight legal limits in EU in the last 10 years. A major factor in this reduction is the improvement in the quality and accuracy of WIM systems in the past decade. The extrapolation technique is outlined, which is used in the determination of the characteristic load effects, where the different frequencies of occurrence of the traffic flow scenarios modelled is accounted for. Use of Rice's formula under the assumption of stationarity is detailed. Completion of the re-assessment will require the incorporation of more traffic from other European countries. Further studies into the relevant dynamic factors to be applied to the extreme and extrapolated values for free flowing traffic effects are proposed. The final report on the re-assessment will provide target values for comparison with those calculated in the 1991 study.

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