Traffic loads on road bridges

European development of EN 1991 – Eurocode 1 – Part 2

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EN 1991 – Eurocode – Part 2 – Traffic loads on bridges

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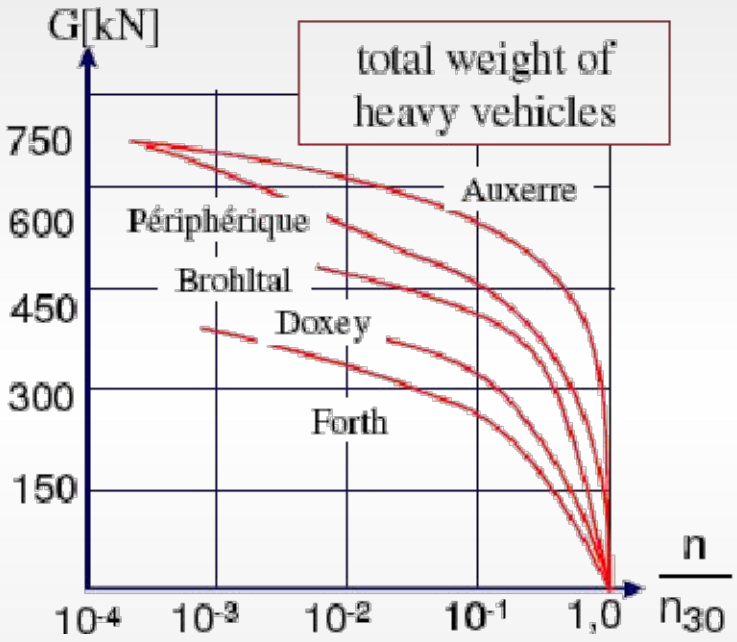
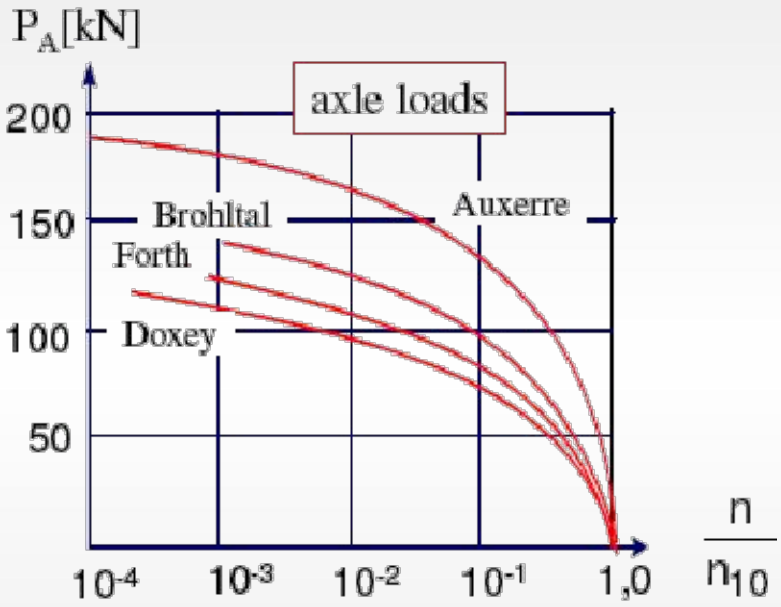
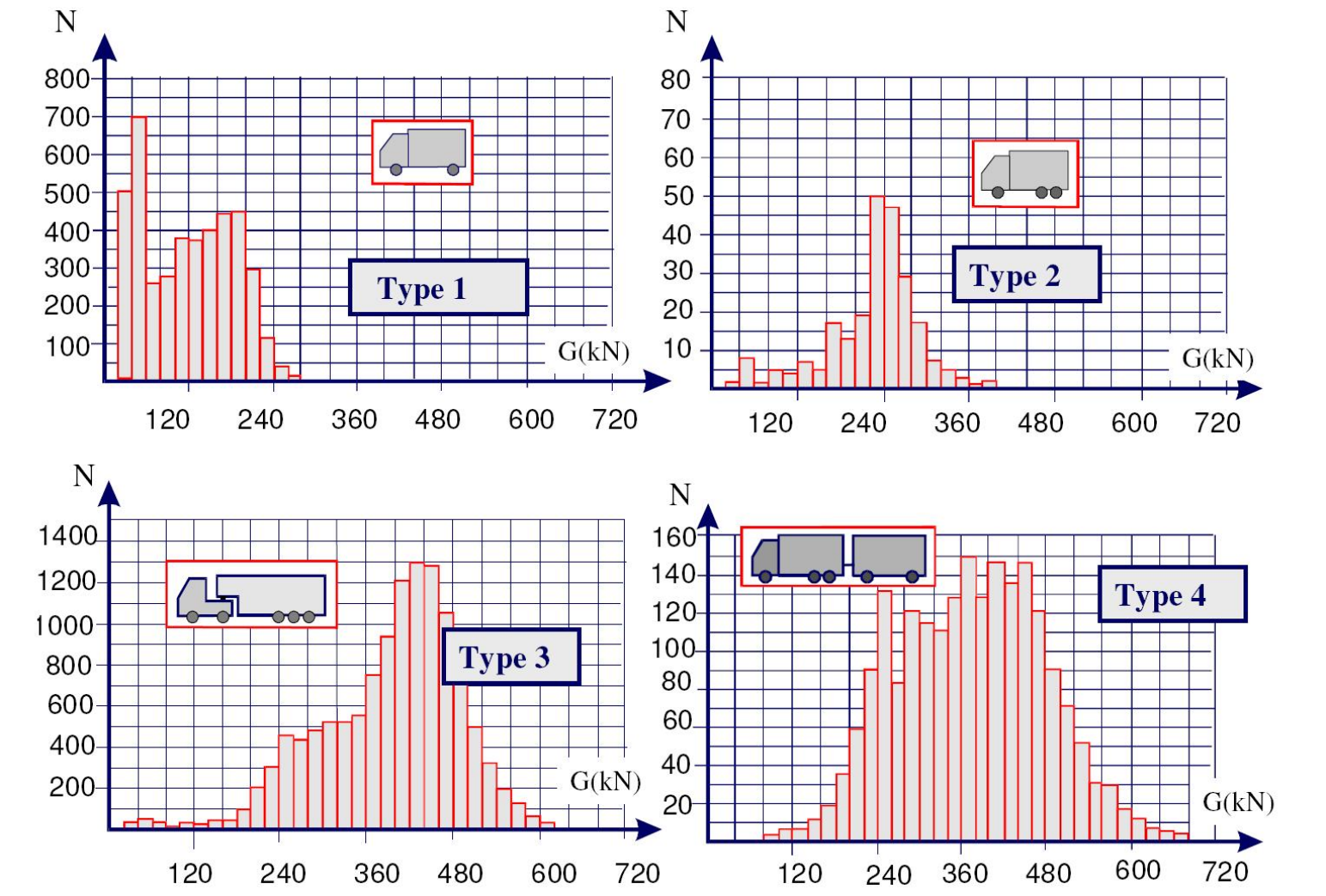
Statistical distributions of vehicle weights at different locations

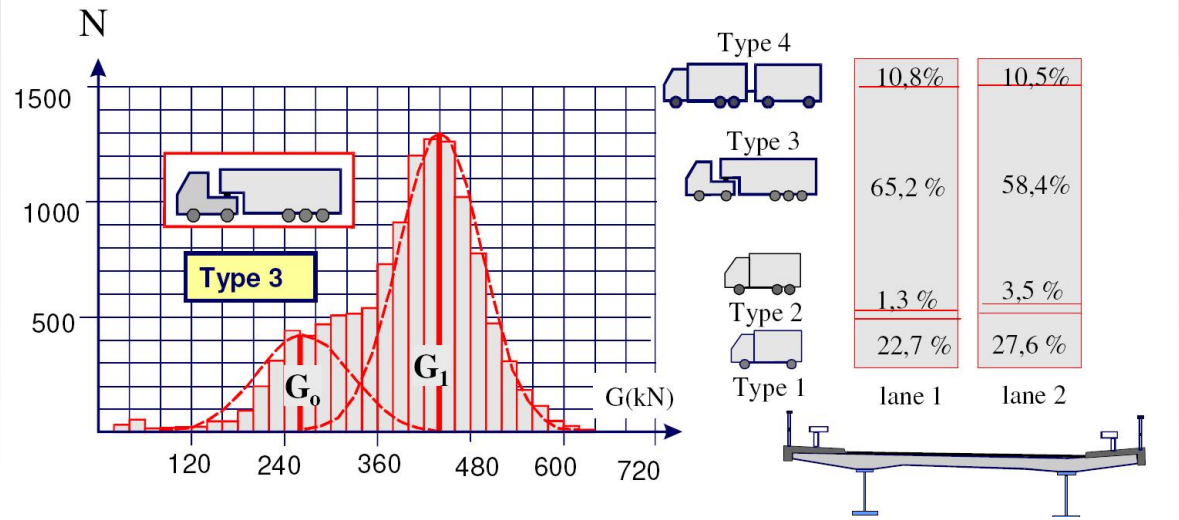




Density distributions of total vehicle weights for various types of vehicles (Auxerre)

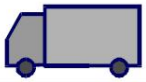
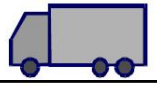


Statistical modelling of light and heavy vehicles on various lanes

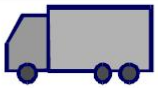
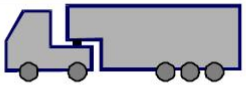


		mean value μ of the total vehicle weight kN		standard deviation σ kN		relative frequency %	
		Lane 1	Lane 2	Lane 1	Lane 2	Lane 1	Lane 2
Type 1	G_o	74	64	35	33	13,3	17,2
	G_1	183	195	28	34	9,4	10,4
Type 2	G_o	123	107	46	45	0,3	1,3
	G_1	251	257	38	43	1,0	2,2
Type 3	G_o	265	220	60	78	17,1	28,0
	G_1	440	463	54	79	48,1	30,4
Type 4	G_o	254	196	45	69	3,6	4,1
	G_1	429	443	68	78	7,2	6,4

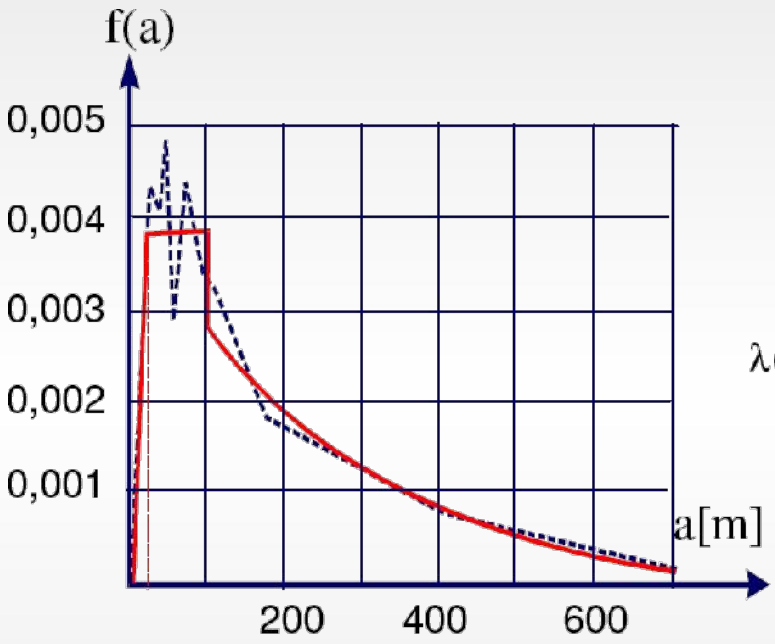
Distribution of axle loads from total vehicle loads

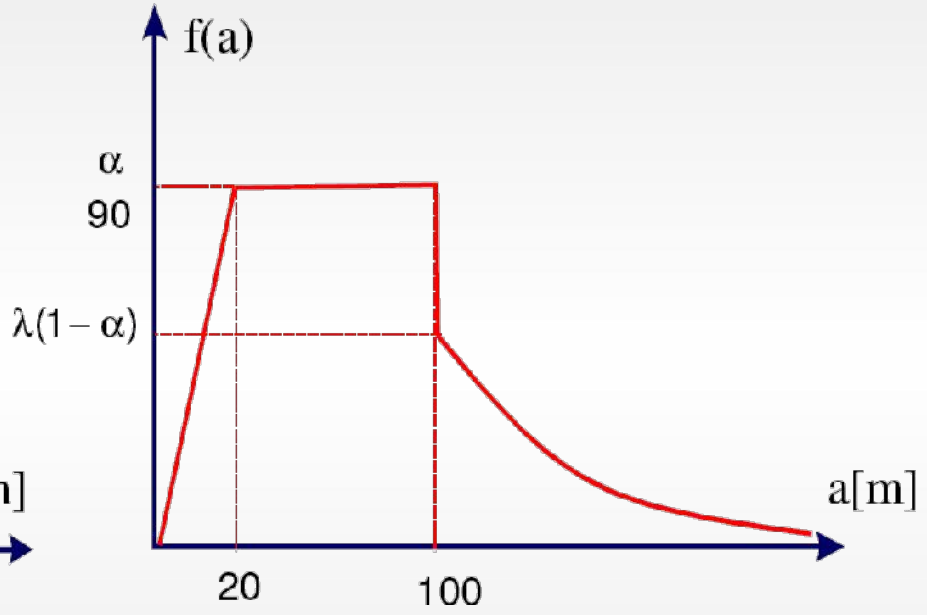
Type of vehicle		Axle 1		Axle 2		Axle 3		Axle 4		Axle 5	
		m	σ	m	σ	m	σ	m	σ	m	σ
Type 1 	G_o	50,0	8,0	50,0	8,0						
	G_l	35,0	7,0	65,0	7,0						
Type 2 	G_o	40,5	8,4	36,2	8,8	23,7	7,3				
	G_l	29,4	5,7	42,8	4,2	27,8	5,3				
Type 3 	G_o	30,6	5,8	27,5	4,4	16,2	3,6	13,6	3,1	12,1	3,1
	G_l	17,1	2,4	26,9	4,4	19,9	3,0	19,0	2,8	16,7	3,8
Type 4 	G_o	31,7	5,7	31,3	5,8	13,4	4,1	13,7	3,5	9,9	3,3
	G_l	18,5	4,1	29,1	4,2	18,9	3,6	18,3	3,4	15,2	4,3

Distribution of distances of axles of vehicles

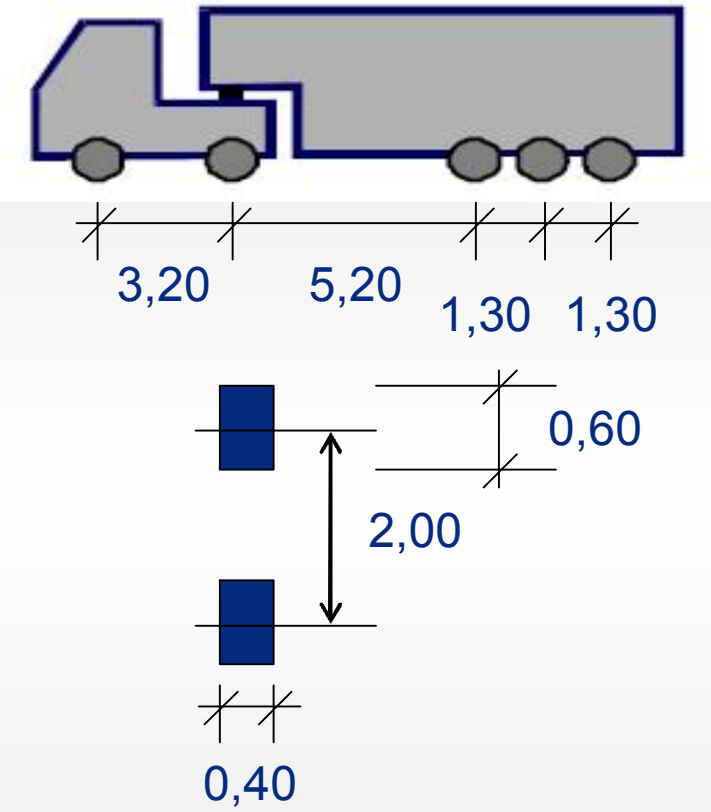
Type of vehicle	Axle 1-2		Axle 2-3		Axle 3-4		Axle 4-5	
	m	σ	m	σ	m	σ	m	σ
Type 1 	3,71	1,1						
Type 2 	3,78	0,71	1,25	0,03				
Type 3 	3,30	0,26	4,71	0,78	1,22	0,13	1,23	0,14
Type 4 	4,27	0,40	4,12	0,31	4,00	0,42	1,25	0,03

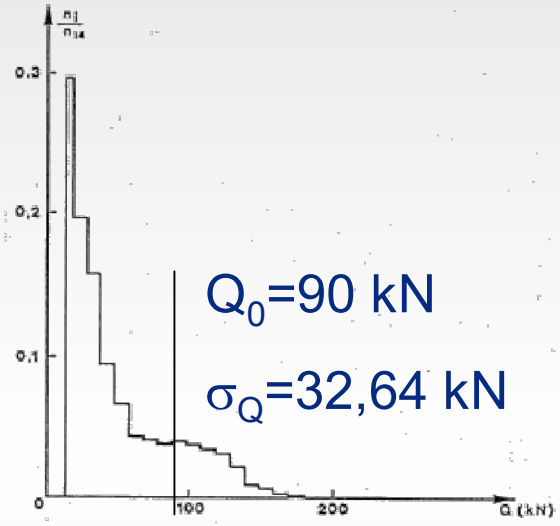
Density distribution for the spacing between vehicles





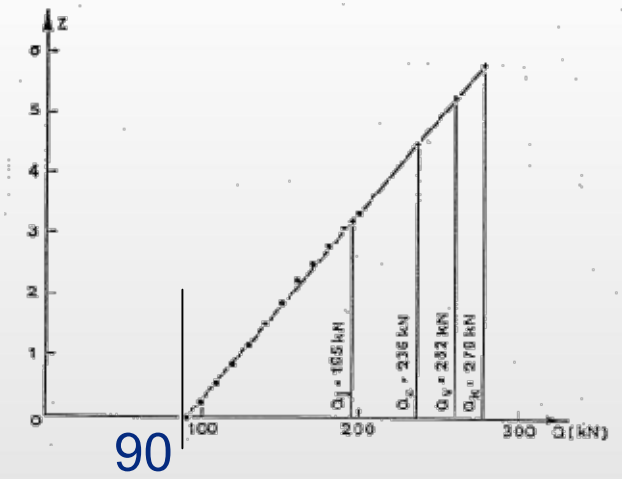
Statistical distribution of single axle loads





Q_0=90 kN

σ_Q=32,64 kN



Daily extreme	195 kN	
annual extreme	236 kN	
1000 years extreme	279 kN	(characteristic value)

Characteristic values of axle loads and vehicle loads from various European data

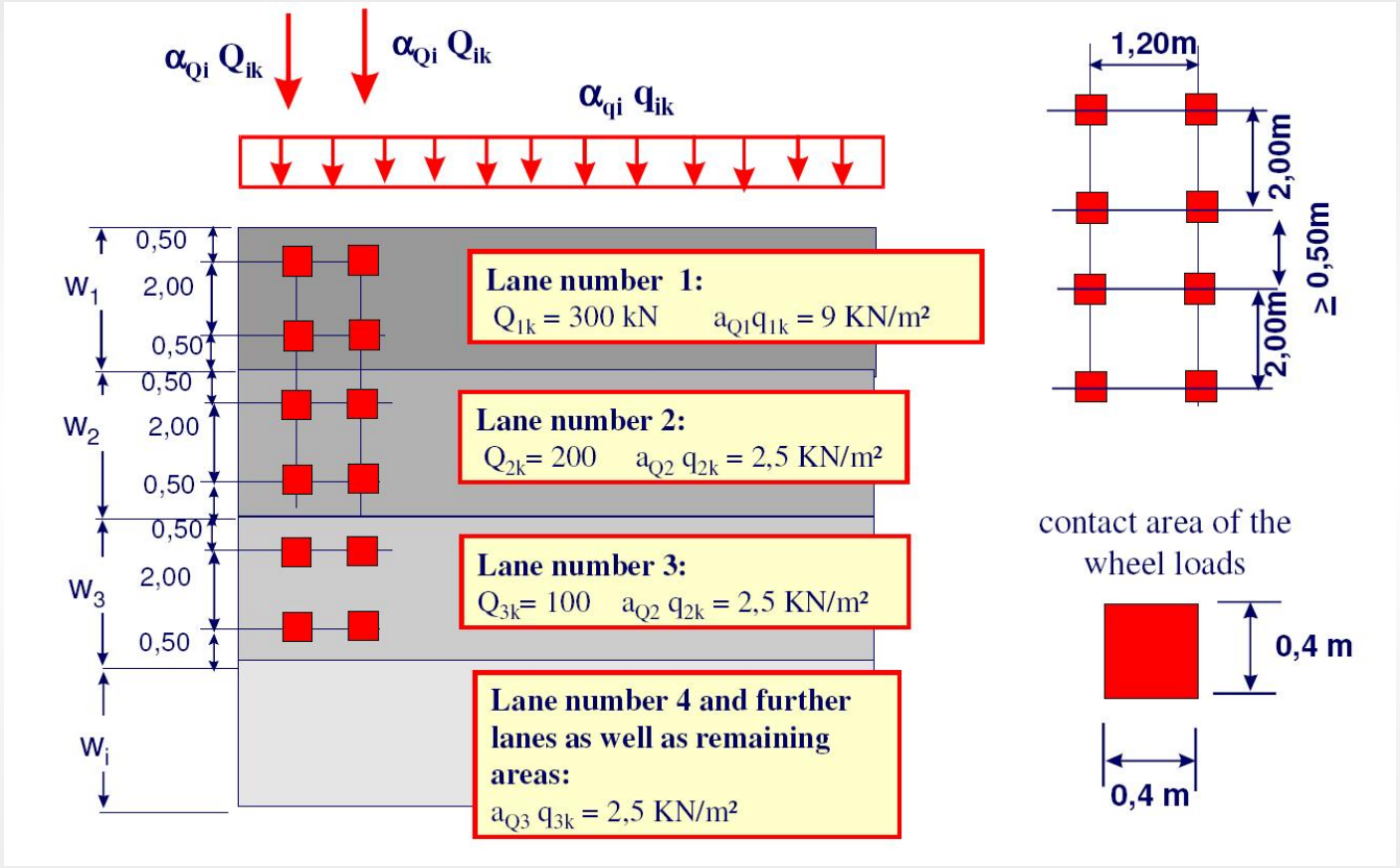
country	location	year	number n_1 of lorries per day	weight of one axle kN	tandem axles kN	tridem axles kN	gross weight of vehicle kN
Germany	Brohltal	1984	4793	211	357	434	853
Belgium	Chamonix	1987	1204	192	355	480	724
France	Auxerre	1986	2630	245	397	527	811
France	Angers	1987	1272	192	340	456	670
France	Lyon	1987	1232	267	450	475	930

Load model LM1 with axle loads and uniformly distributed loads

900 kN

500 kN

300 kN



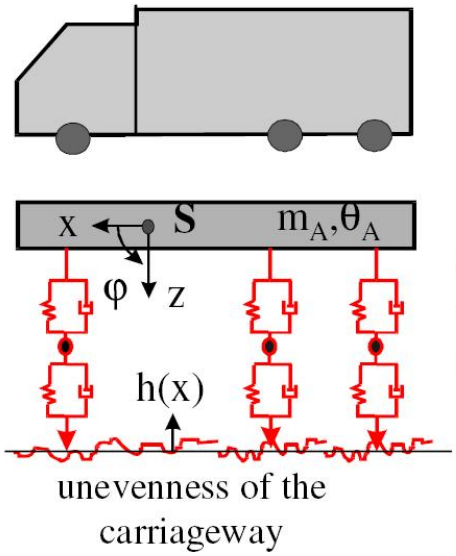
Visualisation of load pattern

“characteristic” vehicle Q_k = 880 kN

I'Q_1 = 120 kN I'Q_2 = 250 kN I'Q_3 = 170 kN.
a = 3,2 à 4,0 m. b = 4,0 à 6,4 m. c = 1,1 à 2,2 m.
I' est le coefficient dynamique inclus dans les mesures.

Dynamic modelling of vehicles and road surface

Modelling of the vehicles



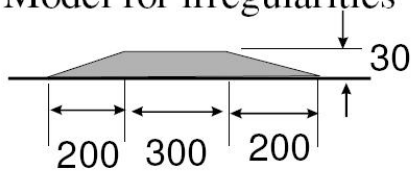
spring and damper of the vehicle body

mass of the axle

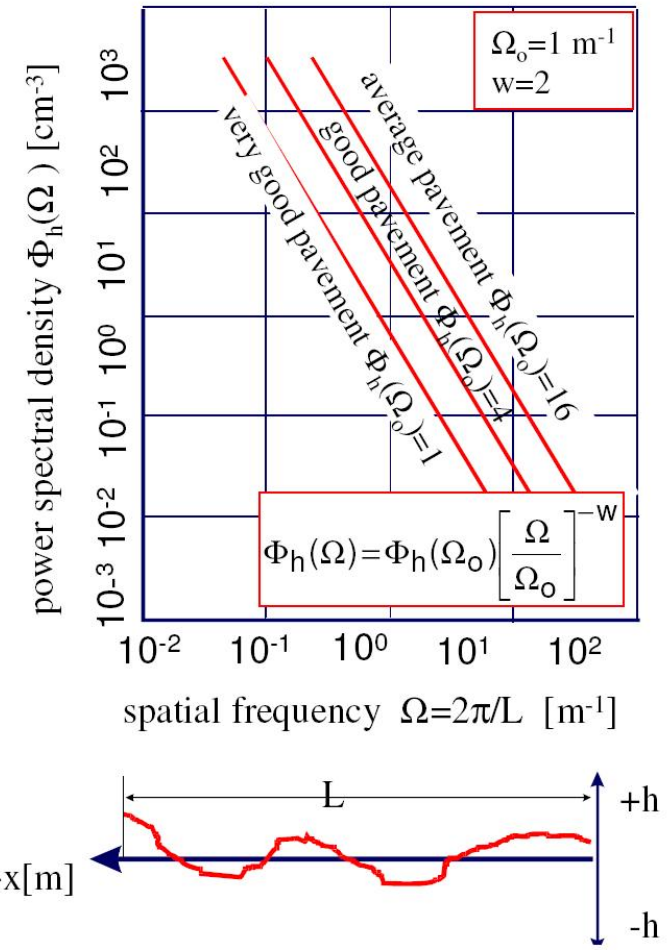
spring and damper of the tyre

unevenness of the carriageway

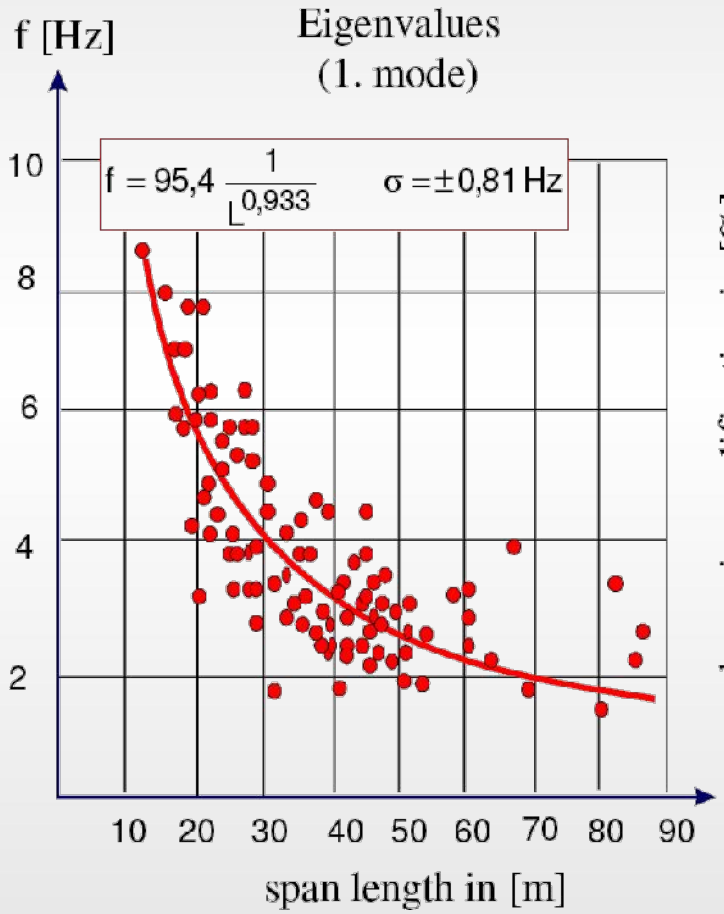
Model for irregularities

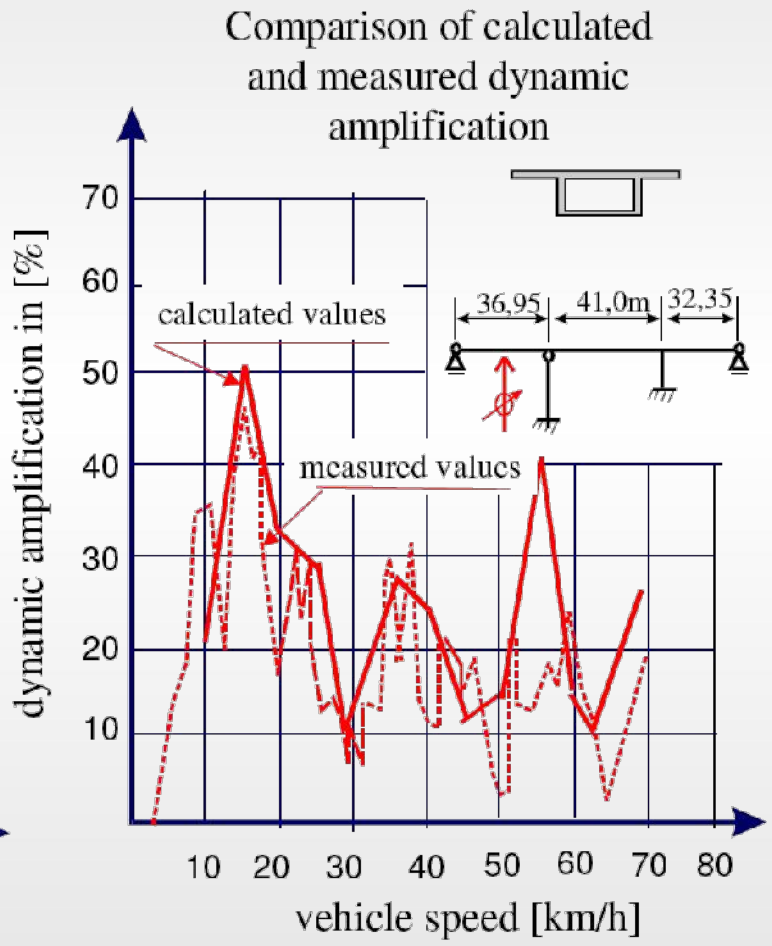


PSD- spectras acc. to ISO-TC 108

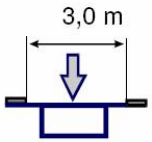
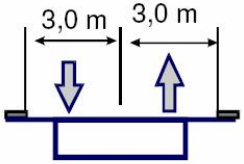
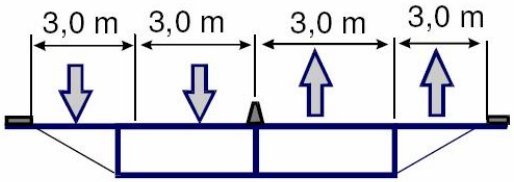


Dynamic modelling of bridges and calibration of the multi-step programme to recorded data

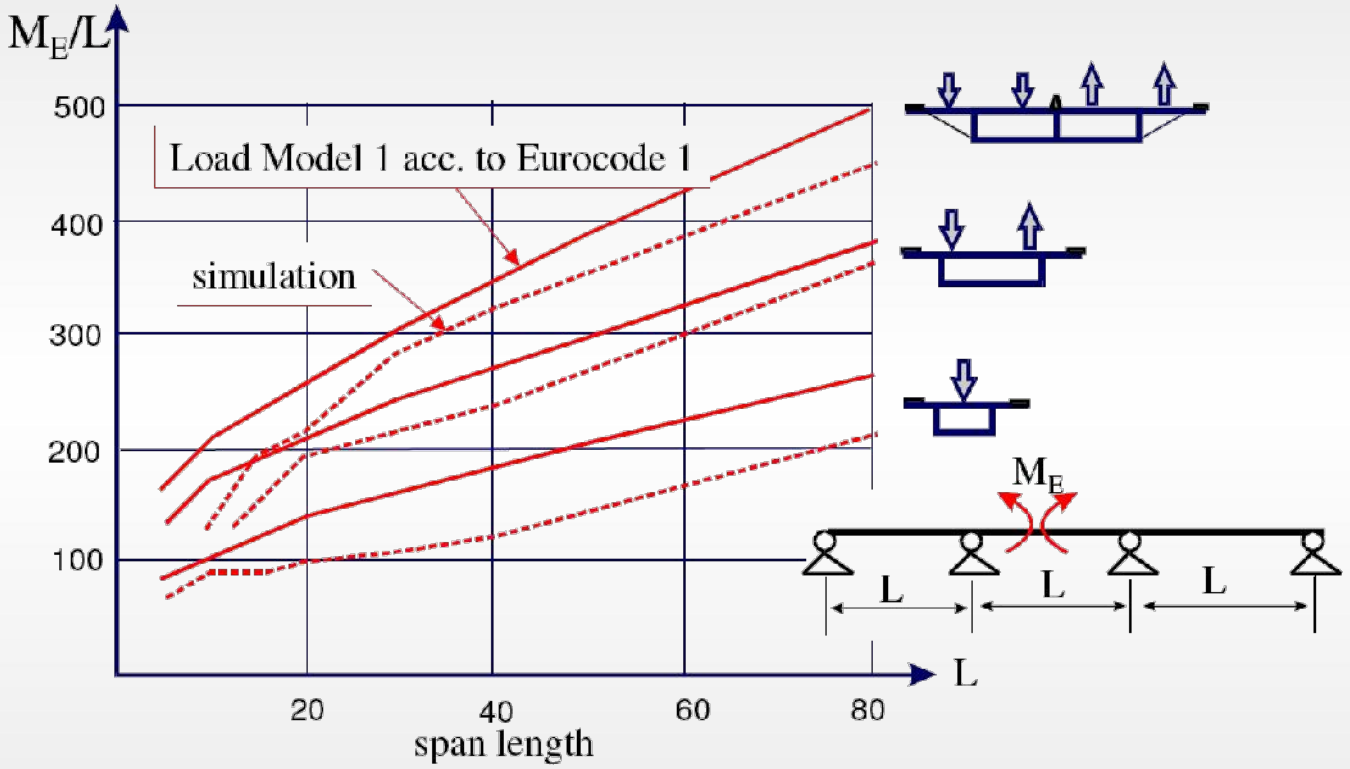




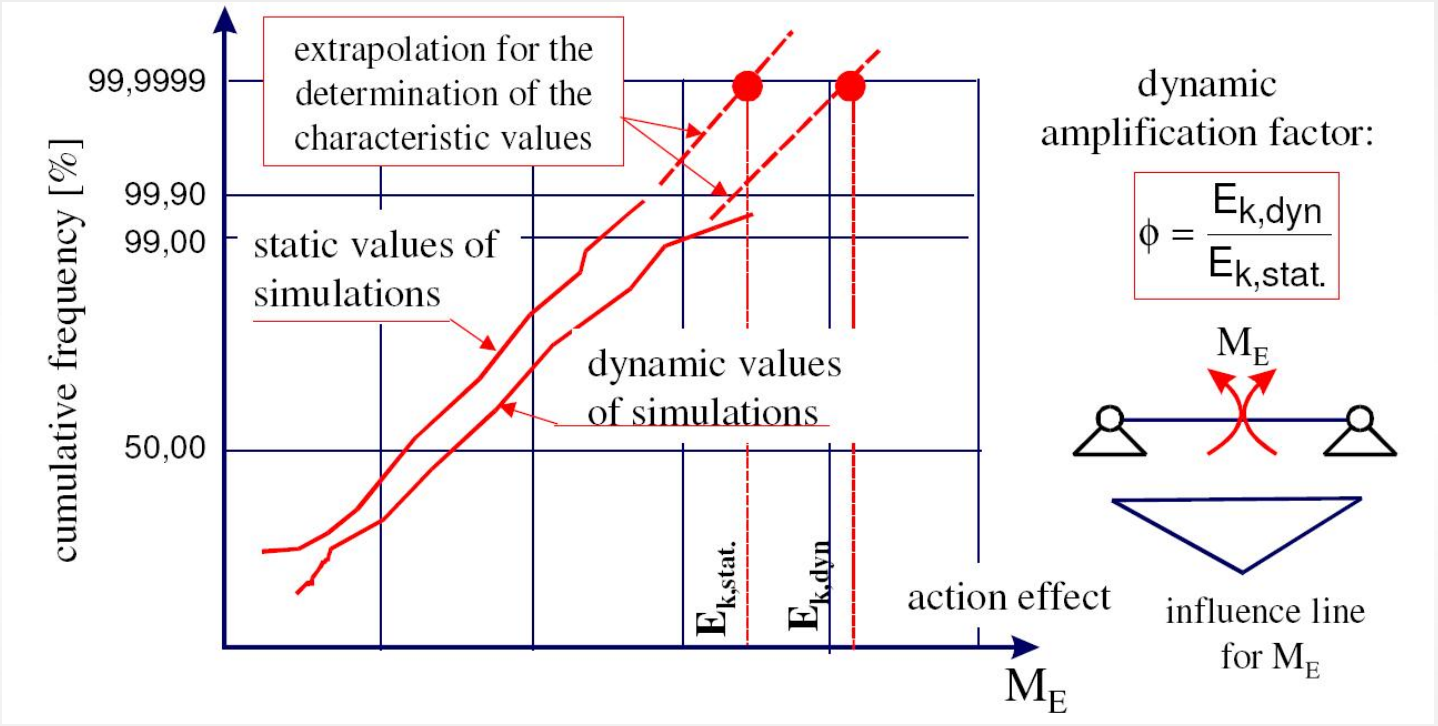
Scenarios for numerical simulations

number of lanes	type of cross section	traffic types of the different lanes
1		Type 1
2		Lane 1: Type 1 Lane 2: Type 2
4		Lane 1: Type 1 Lane 2: Type 3 Lane 3:Type 3 Lane 4: Type 2

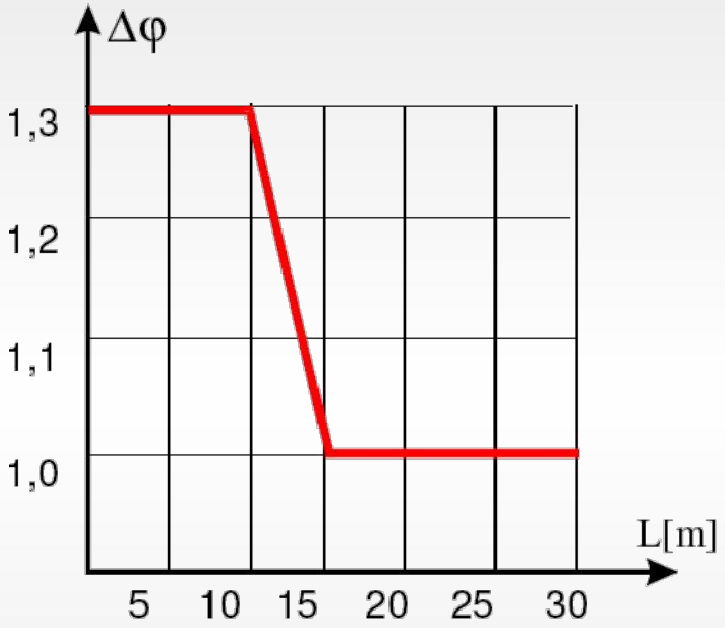
Results of numerical simulation of characteristic values M_E and effects of LM1

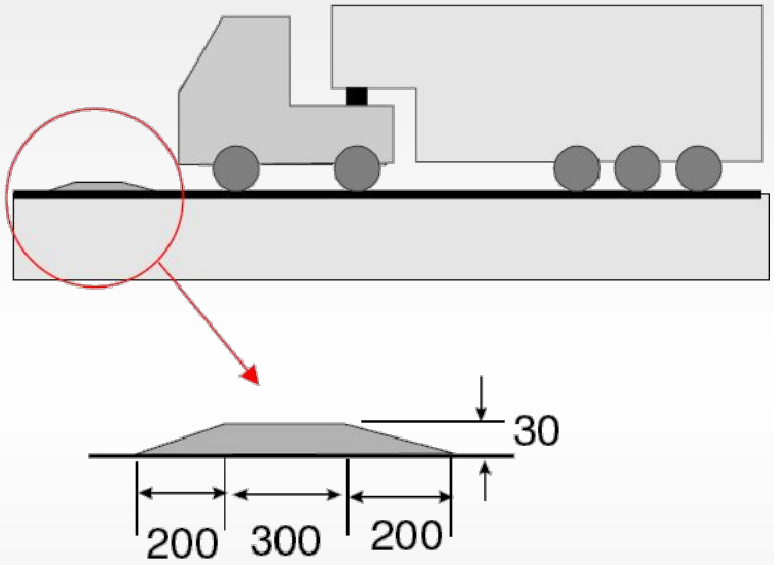


Side effect of simulation: definition of dynamic impact factor



LM 2: 300 kN · 1,3 = 400 kN



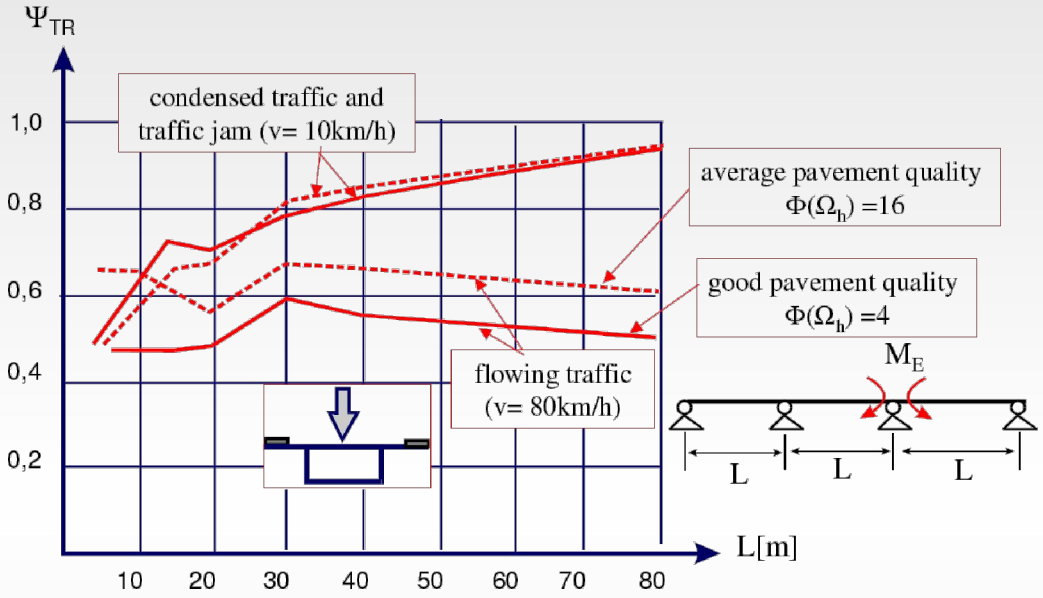


Model for irregularities

Definition of combination factors

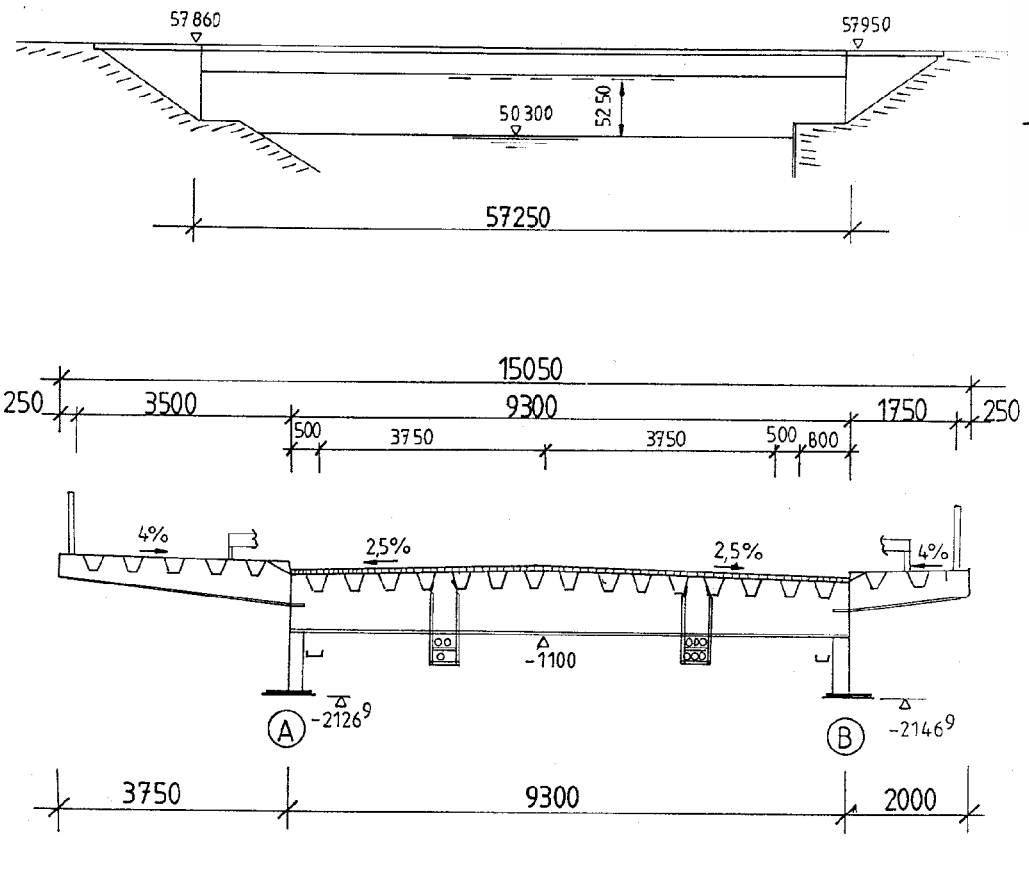
Design situation	Return period T_R	Fractile of the distribution of action effects in %
infrequent	1 year	99,997
frequent	1 week	99,891
quasi - permanent	1 day	99,240

“Frequent“ value ψ_1 in EN 1990 – A2

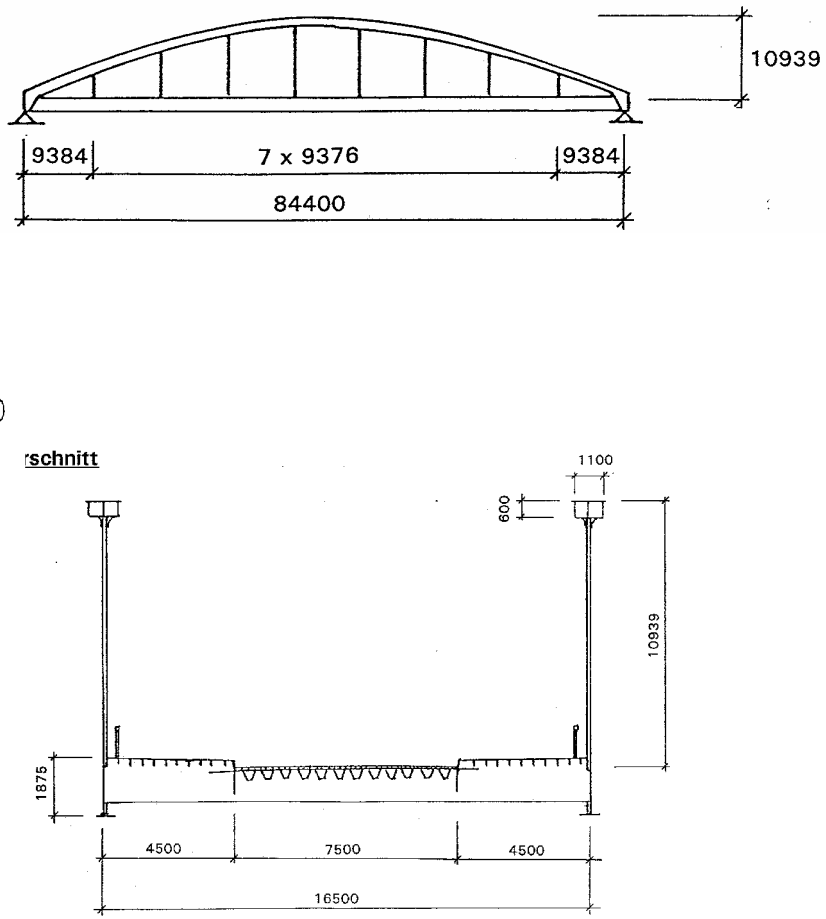


Load Model 1			Load Model 2
	Tandem system	Uniform distributed loads	Single axle
Infrequent design situations	0,8	0,8	0,8
Frequent design situations	0,75	0,4	0,75
Quasi permanent design situations	0	0	0

Reference-bridges for β-analysis

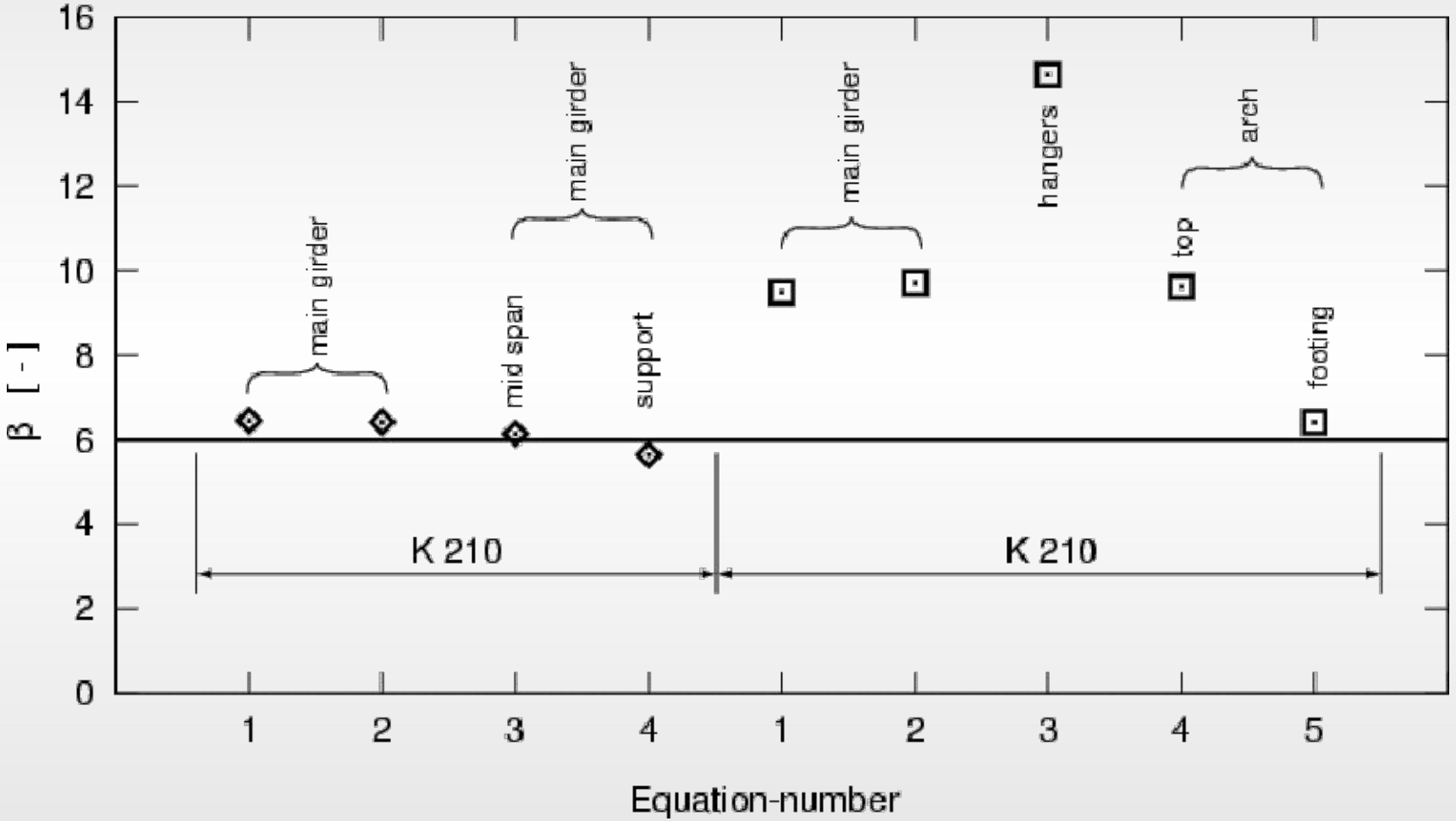


K 210

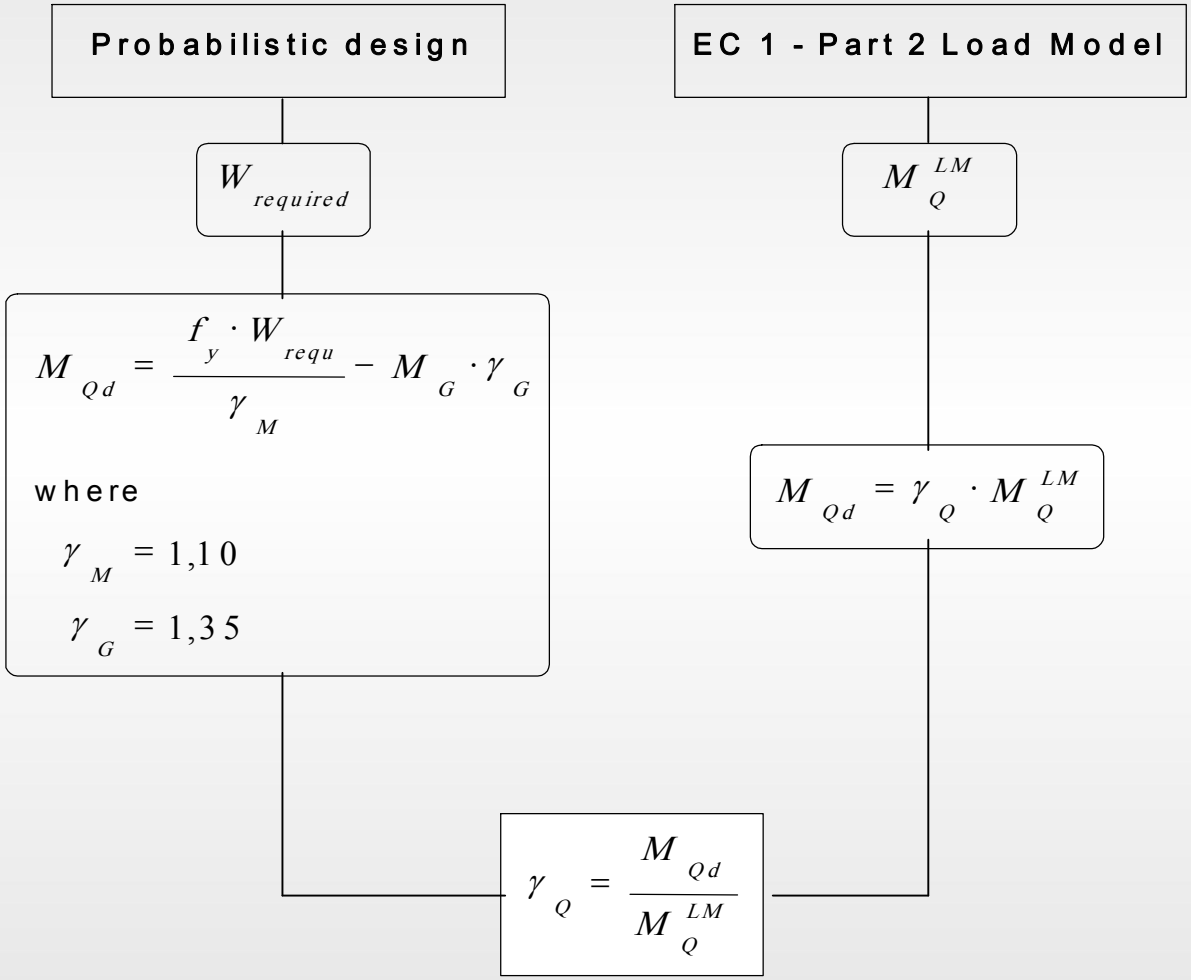


K 138

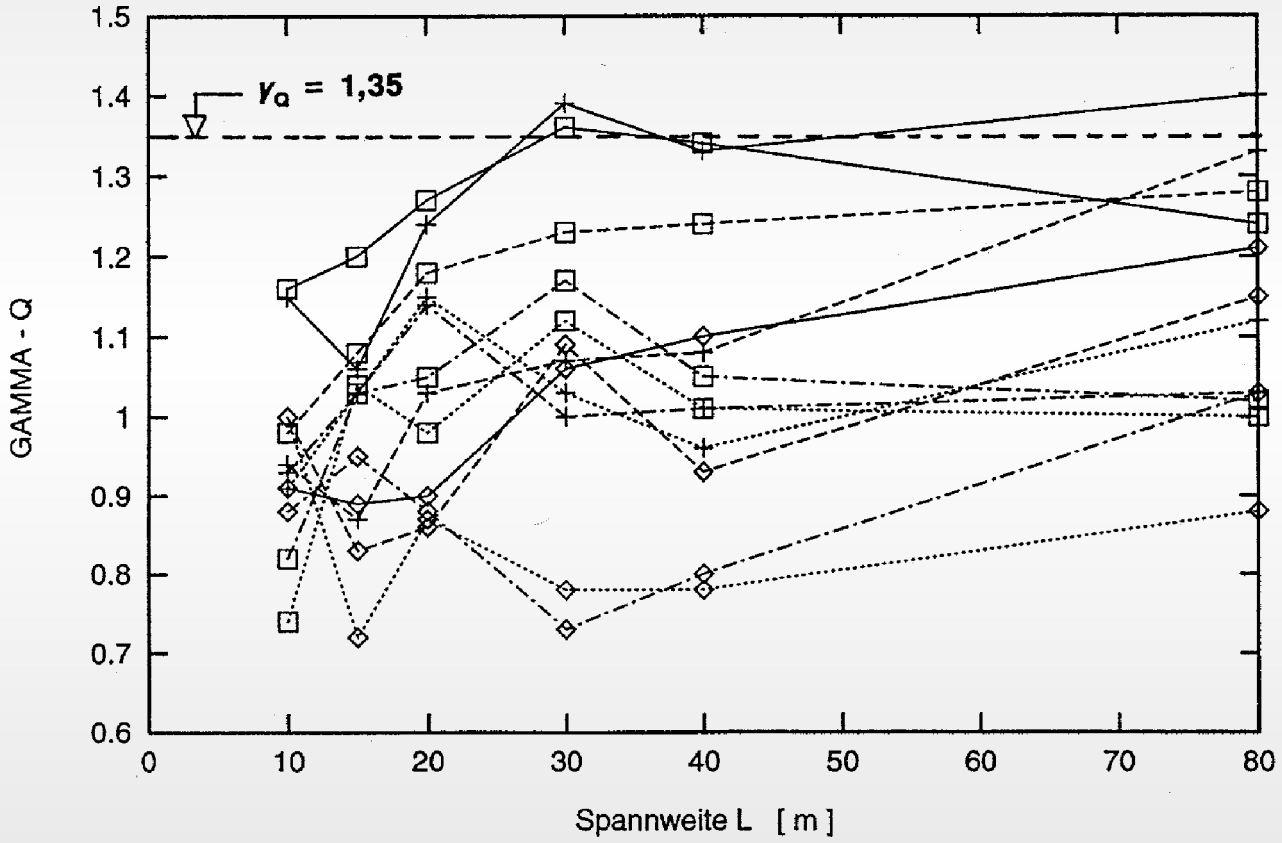
β-values determined for „Auxerre“-traffic



Procedure of determine γ_Q



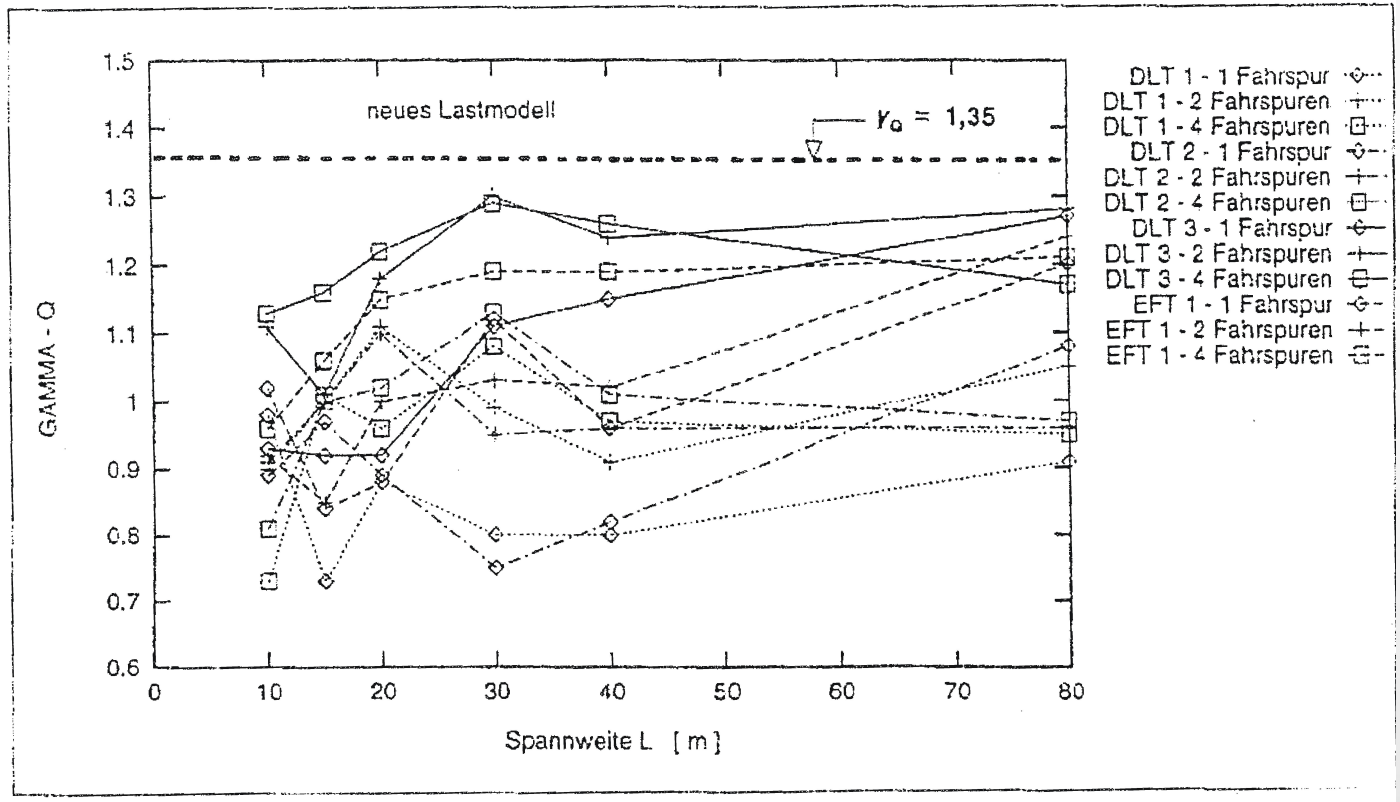
γ_Q-values resulting for the recommended values α_{Q1}= 1 and α_{qi}= 1



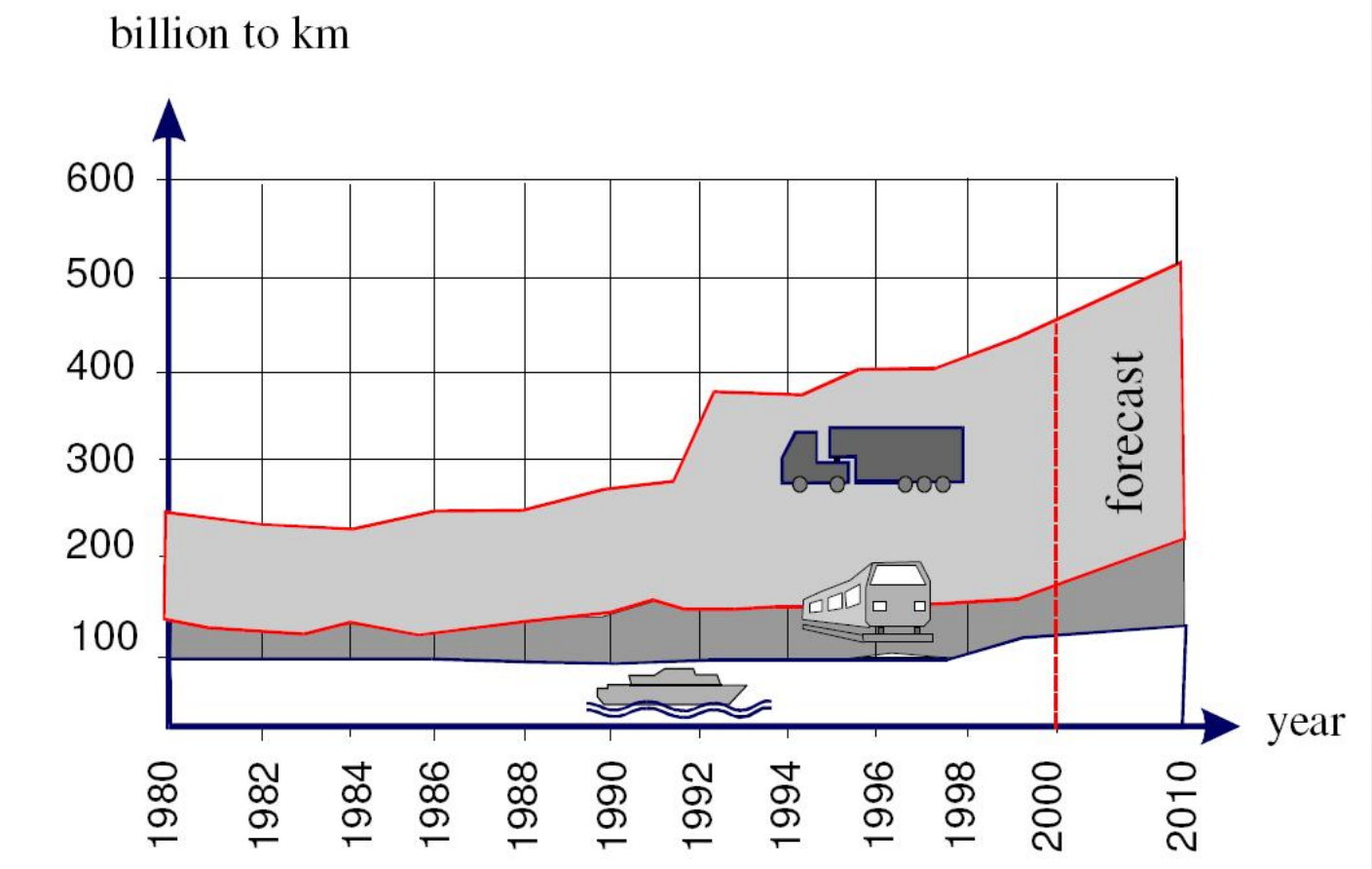
γ_Q-values for modifications of α_{qi}

Q_1 = 9 kN/m² → 8 kN/m²

Q_2 = 2,5 kN/m² → 5 kN/m²

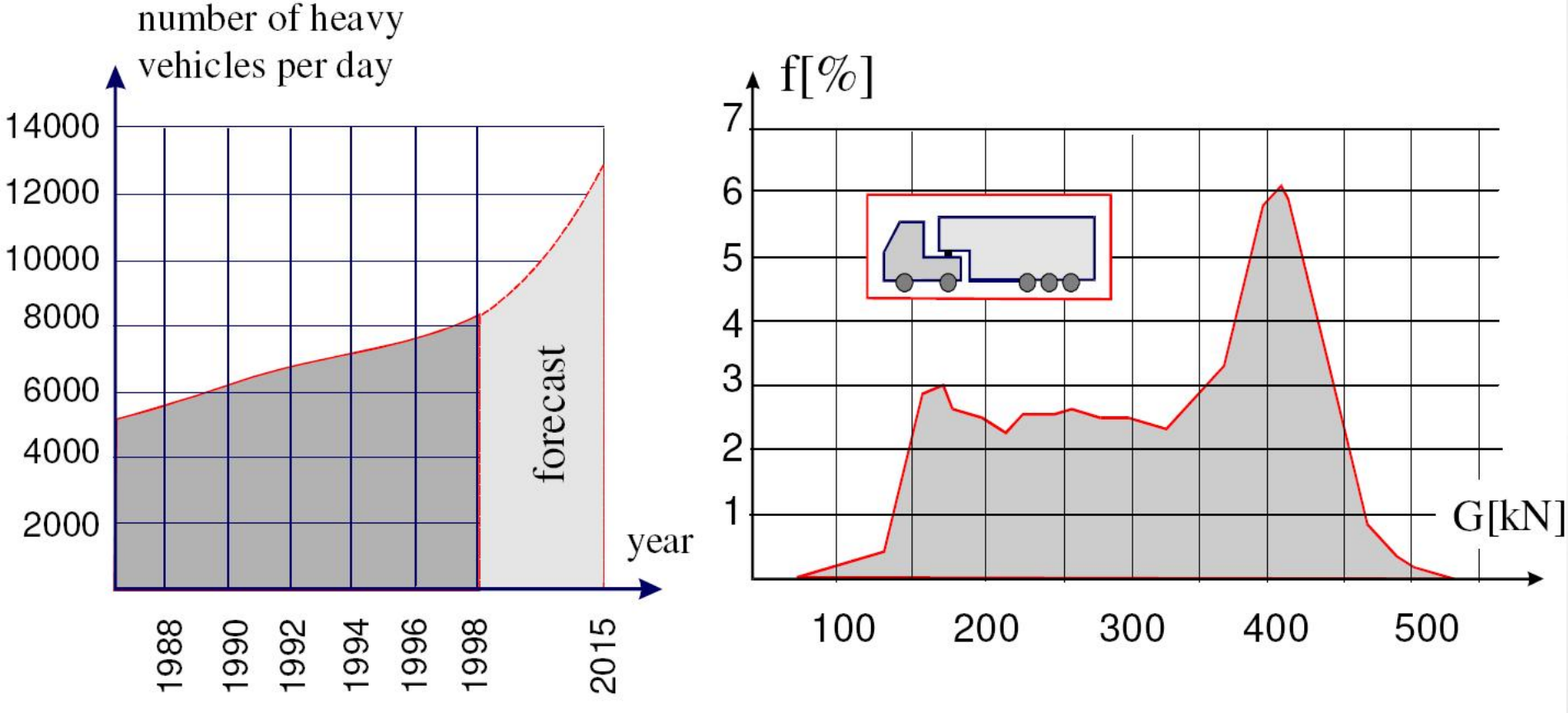


Development of freight volume



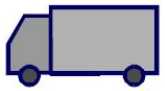
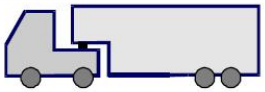
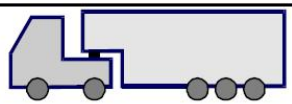
Development of freight volume

Prognosis for number of heavy vehicles and loading rate

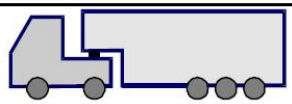


Traffic jam on a highway

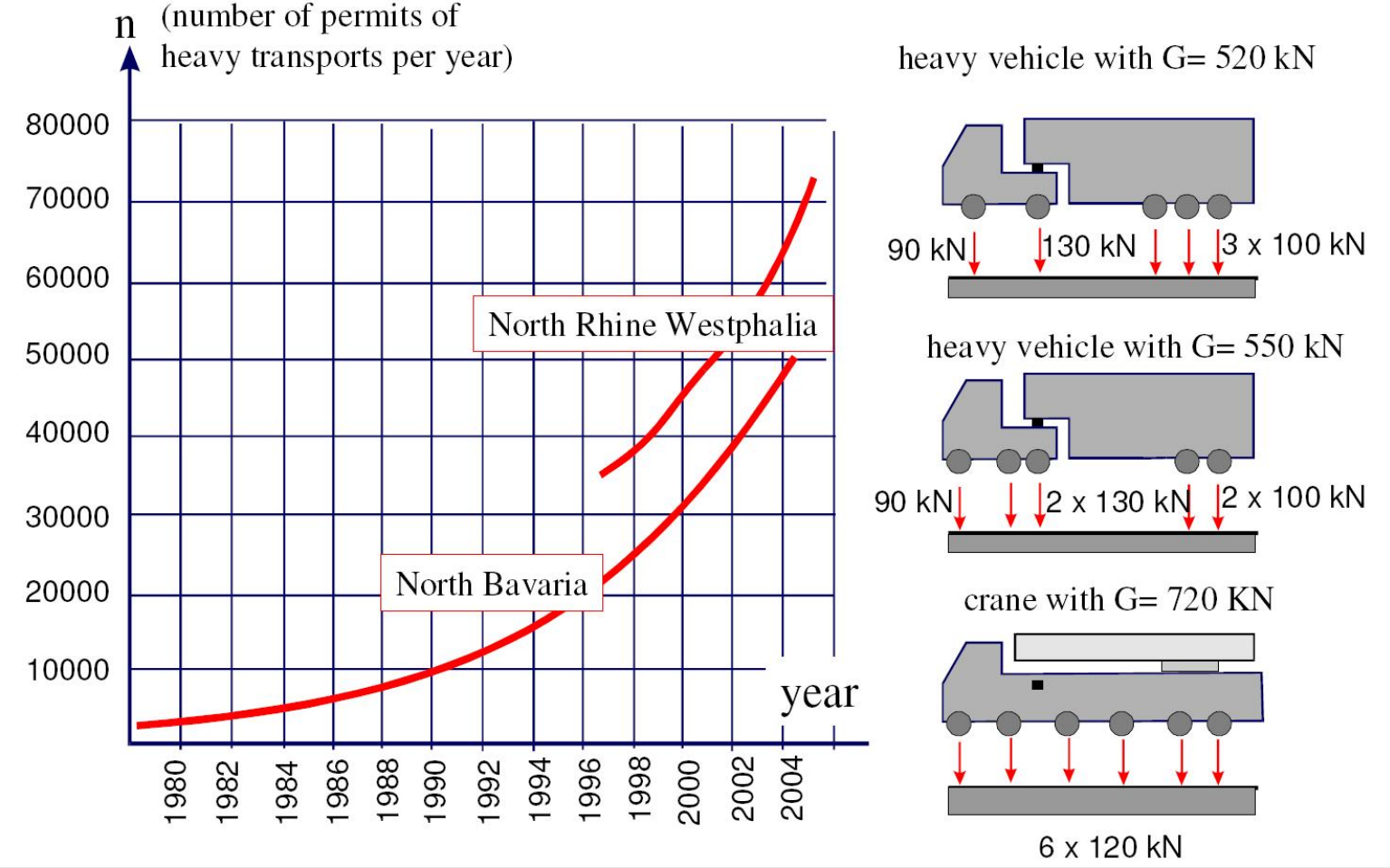
Recorded data at Brohltal (2004) and comparison with data from Auxerre

type of vehicle		mean value μ of the total vehicle weight kN	standard deviation σ kN	relative frequency %
Type 1 	G_o	59,6	14,6	5
	G_l	91,7	44,0	6
Type 2 	G_o	190,3	23,2	1
	G_l	208,4	73,9	4
Type 3 	G_o	276,8	59,5	12
	G_l	414,5	32,5	5
Type 4 	G_o	156,7	18,8	3
	G_l	211,4	52,8	5
Type 5 	G_o	259,6	92	37
	G_l	405,3	24,8	22

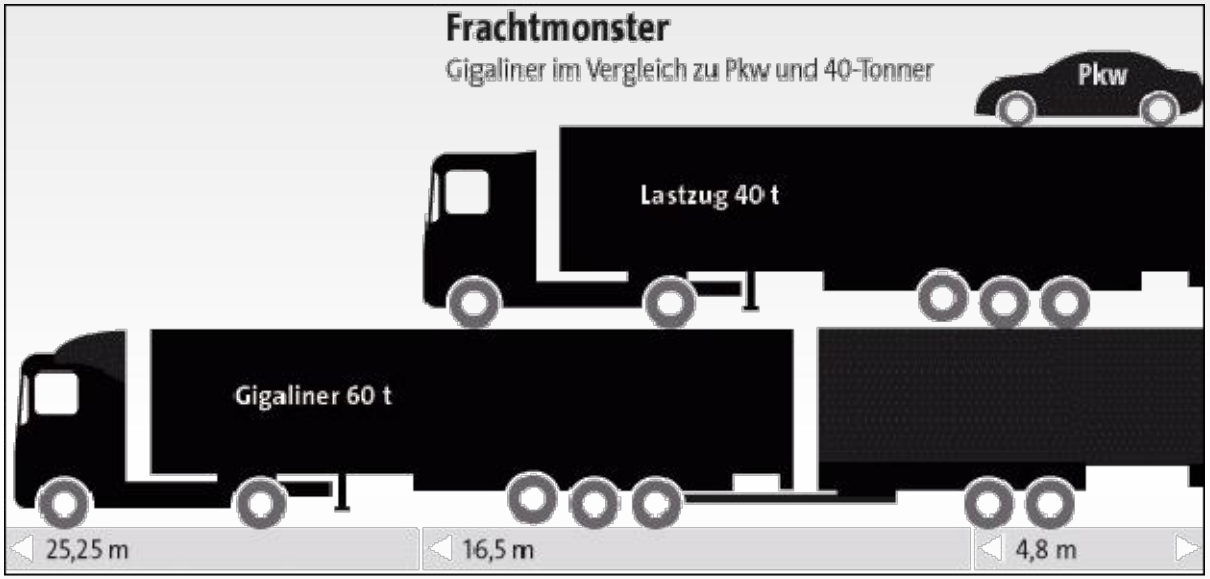
Statistical parameters of the traffic records of Auxerre (1986)

Type 5 	G_o	265	60	28,0
	G_l	440	54	30,4

Development of exceptional heavy traffic with special permissions



Giga-liners in comparison with heavy articulated vehicle



Größenvergleich: Gigaliner, 40-Tonner und Pkw
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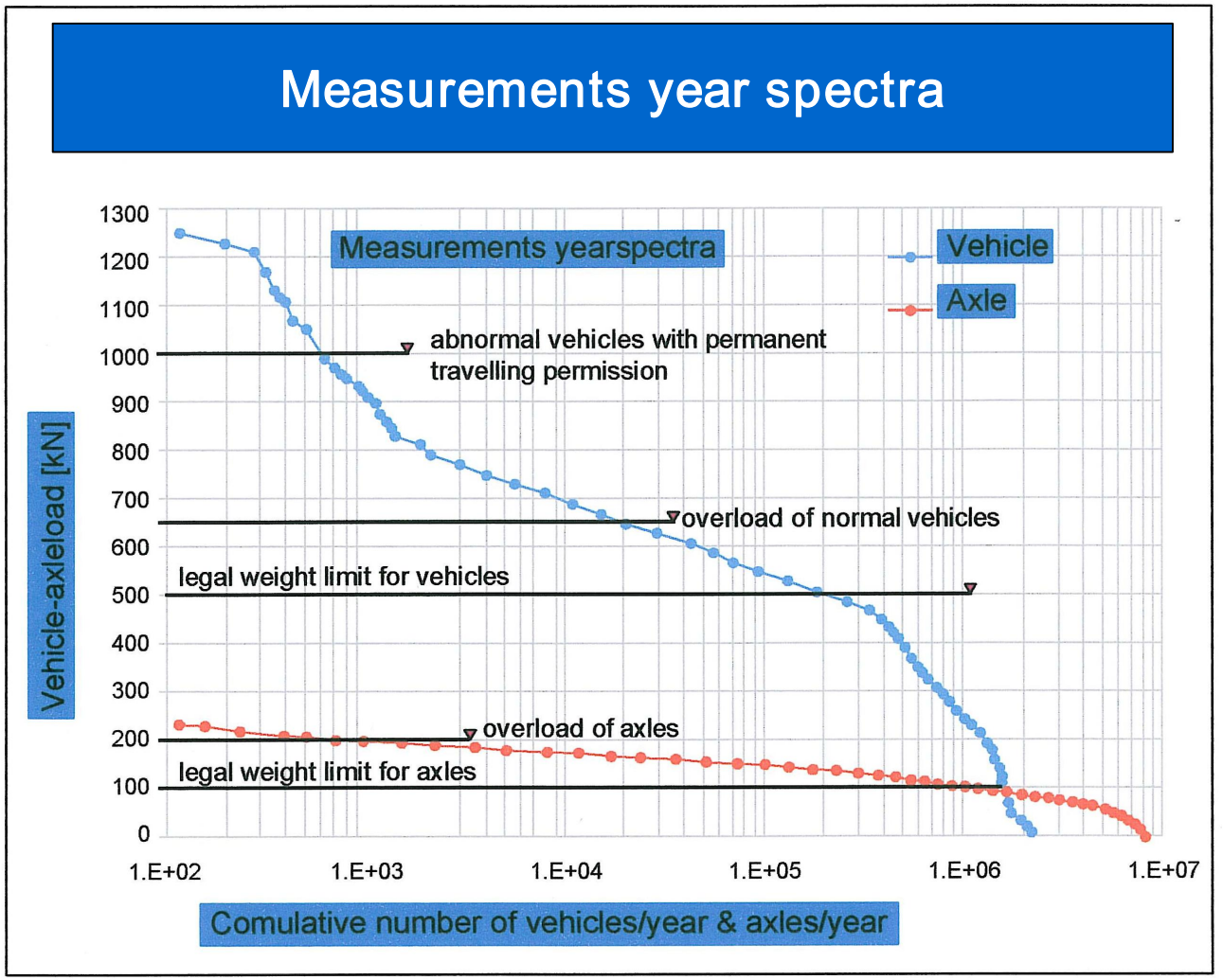
Tests with Giga-liners

Axle loads and vehicle loads recorded in the Netherlands



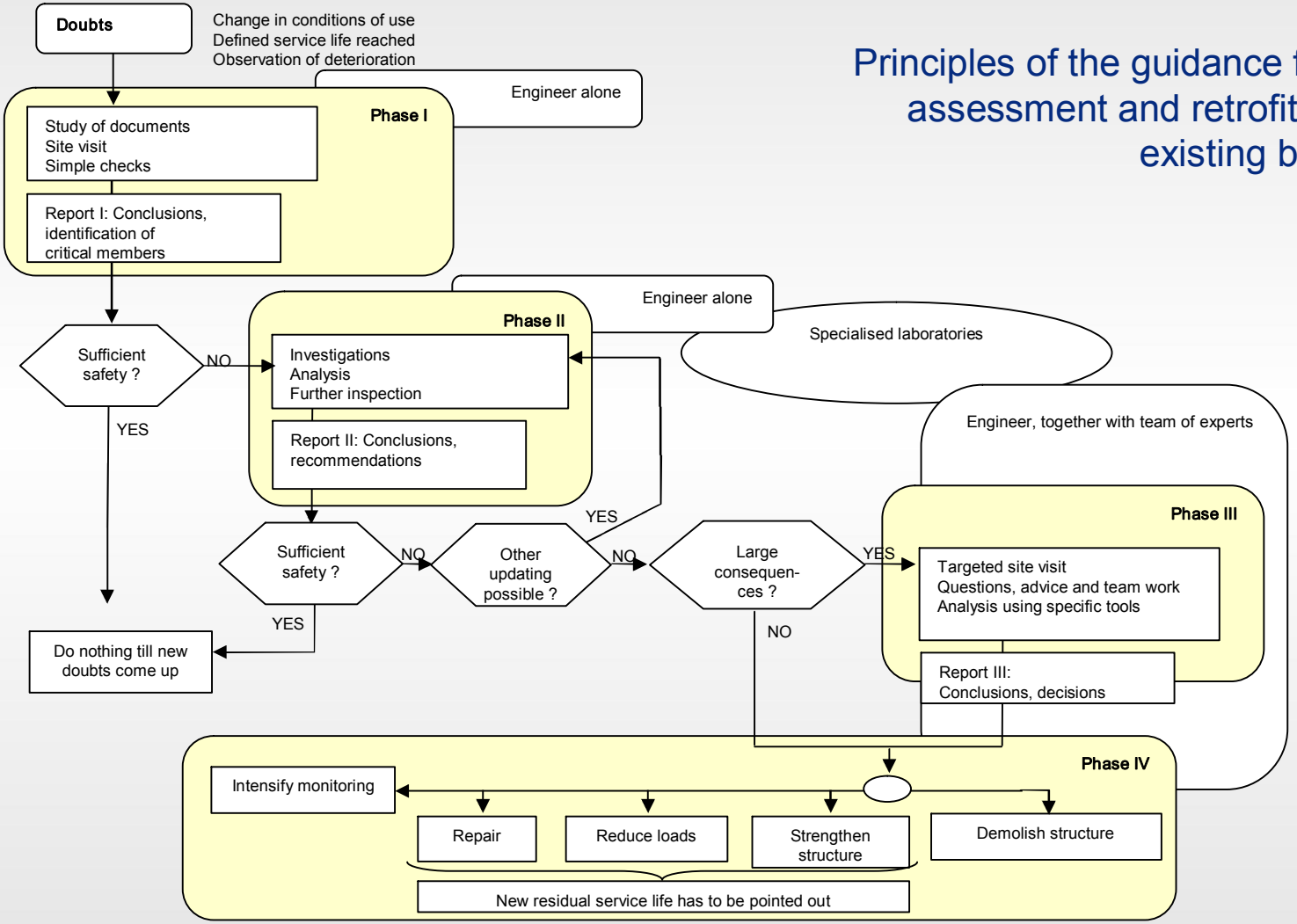
Models of special vehicles for road bridges in EN 1991 – Part 2 – Annex A

Table A1: Classes of special vehicles

Total weight	Composition	Notation
600 kN	4 axle-lines of 150 kN	600/150
900 kN	6 axle-lines of 150 kN	900/150
1200 kN	8 axle-lines of 150 kN or 6 axle-lines of 200 kN	1200/150 1200/200
1500 kN	10 axle-lines of 150 kN or 7 axle-lines of 200 kN + 1 axle line of 100 kN	1500/150 1500/200
1800 kN	12 axle-lines of 150 kN or 9 axle-lines of 200 kN	1800/150 1800/200
2400 kN	12 axle-lines of 200 kN or 10 axle-lines of 240 kN or 6 axle-lines of 200 kN (spacing 12m) + 6 axle lines of 200 kN	2400/200 2400/240 2400/200/200
3000 kN	15 axle-lines of 200 kN or 12 axle-lines of 240 kN + 1 axle line of 120 kN or 8 axle-lines of 200 kN (spacing 12m) + 7 axle lines of 200 kN	3000/200 3000/240 3000/200/200
3600 kN	18 axle-lines of 200 kN or 15 axle-lines of 240 kN or 9 axle-lines of 200 kN (spacing 12m) + 9 axle lines of 200 kN	3600/200 3600/240 3600/200/200

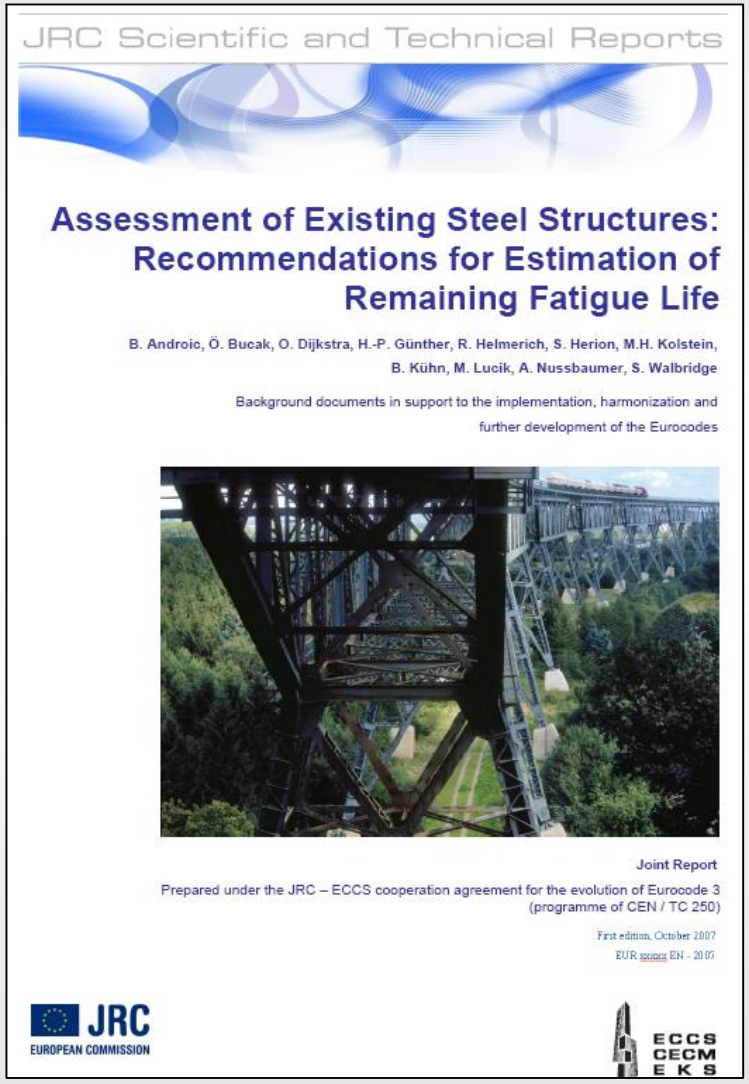
FP6-Project: Sustainable Bridges

Flow chart for assessment

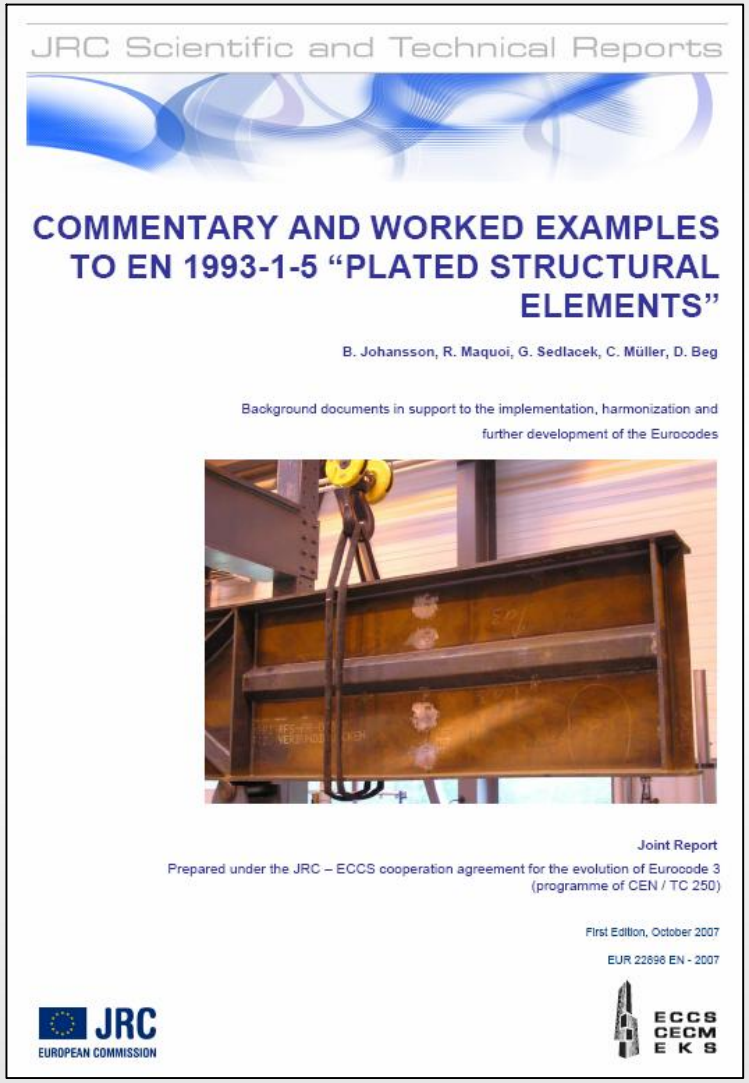


Principles of the guidance for the assessment and retrofitting of existing bridges

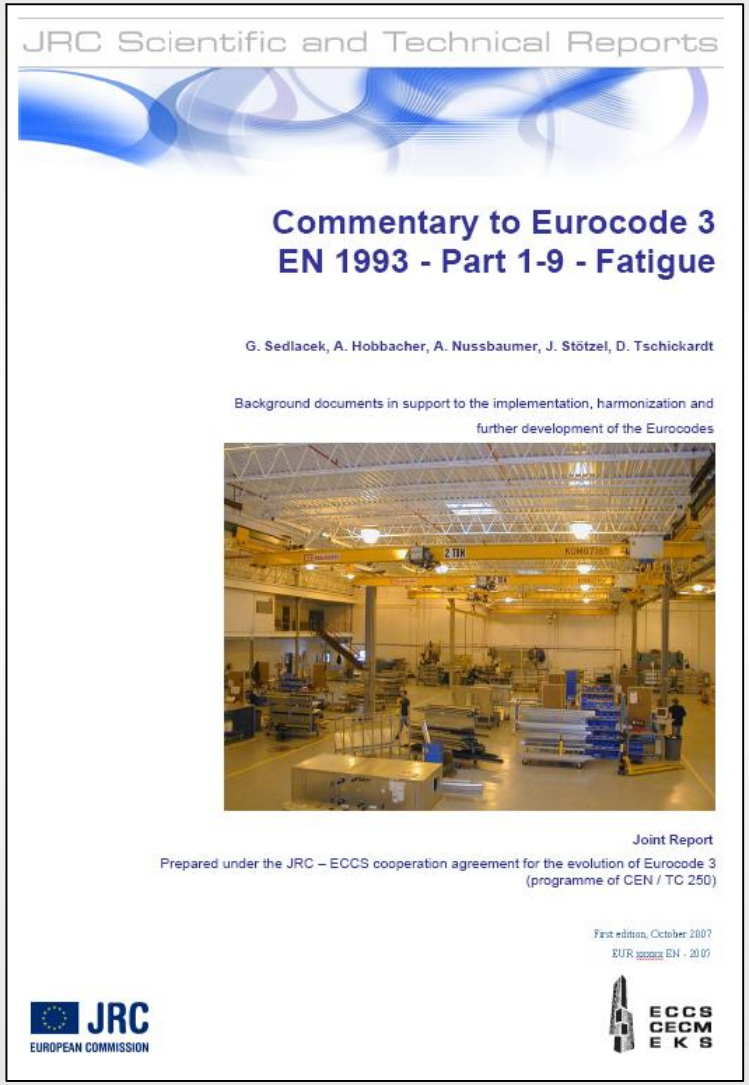
JRC-ECCS-Report: Assessment of existing steel structures



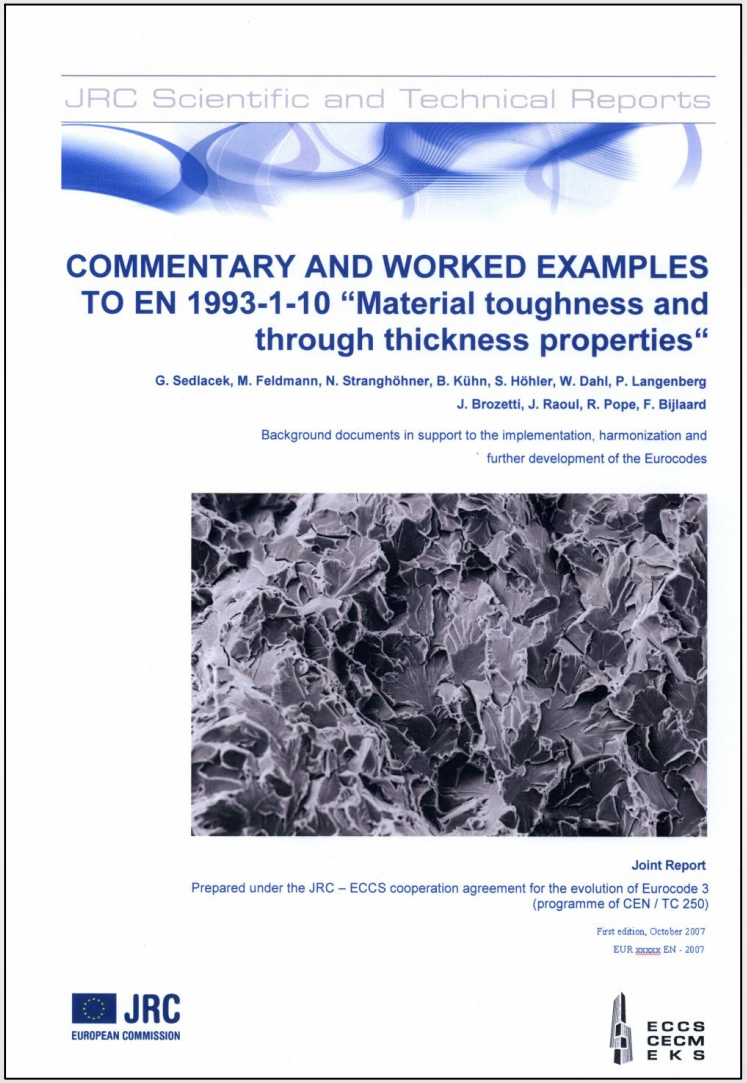
JRC-ECCS-Report: Plate buckling



JRC-ECCS-Report: Fatigue



JRC-ECCS-Report: Material toughness and through thickness properties



JRC Scientific and Technical Reports

COMMENTARY AND WORKED EXAMPLES TO EN 1993-1-10 "Material toughness and through thickness properties"

G. Sedlacek, M. Feldmann, N. Stranghöhner, B. Kühn, S. Höhler, W. Dahl, P. Langenberg
J. Brozetti, J. Raoul, R. Pope, F. Bijlaard

Background documents in support to the implementation, harmonization and further development of the Eurocodes

Joint Report

Prepared under the JRC – ECCS cooperation agreement for the evolution of Eurocode 3 (programme of CEN / TC 250)

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