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Autor: Sedlacek, Gerhard

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EC 1: Imposed Loads on Buildings

EC 1: Charges d'exploitation dans les bâtiments

EC 1: Verkehrslasten im Hochbau

Gerhard SEDLACEK
Prof. Dr.
RWTH Aachen
Aachen, Germany

Gerhard Sedlacek, born in 1939, is Professor for Steel Construction at the RWTH Aachen. He has been convener of the Project Team for the preparation of the chapter «Imposed loads on floors and roofs» in Eurocode 1.

SUMMARY

After recalling the list of contents of Part 2.4 of Eurocode 1 «Imposed Loads on Buildings» the background of the choice of the loading models and the numerical values for loads on roofs and floors is presented. The studies that have been carried out include both probabilistic approaches and comparisons of rules in national codes. They are documented in a Background Document to Part 2.4.

RESUME

Après une présentation du contenu de la partie 2.4 de l'Eurocode 1 «Charges d'exploitation dans les bâtiments», l'article traite des bases et du choix des modèles d'actions ainsi que des valeurs numériques pour les charges sur les toitures et planchers. Les études entreprises concernent aussi bien des approches probabilistes que des comparaisons de normes nationales. Elles sont détaillées dans un document annexe à la partie 2.4.

ZUSAMMENFASSUNG

Nach Darstellung des Inhaltsverzeichnisses des Teiles 2.4 des Eurocode 1 «Verkehrslasten im Hochbau» wird auf den Hintergrund der dort angegebenen Belastungsmodelle und der Zahlenwerte für Lasten auf Decken und Dächern eingegangen. Dabei wird auch auf die Untersuchungen mit probabilistischen Ansätzen und die Vergleiche mit nationalen Normen hingewiesen, die im Hintergrundbericht zu dem Teil 2.4 dokumentiert sind.

1. SCOPE OF THE PART "IMPOSED LOADS ON BUILDINGS"

In the part "Imposed Loads on Buildings" of Eurocode 1 loaded floor and roof areas are divided into four classes according to their use

- areas in dwellings, offices etc.
- garages and vehicles traffic areas
- areas for storage and industrial activities
- roofs.

The standard gives numerical values for the floor and roof loads in buildings including parking and vehicle traffic areas.

For areas for storage and industrial activities only guidance for the determination of numerical values is given.

The list of contents of the part "Imposed Loads on Buildings" can be taken from fig. 1.

Part 2.4 **Imposed loads on Buildings**

2.4.1 General and Principles

2.4.2 Object, Field of Application and Scope

2.4.3 Definitions

2.4.4 Design Situations

2.4.4.1 General
2.4.4.2 Load Cases for Ultimate Limit State Verifications
2.4.4.3 Load Cases for Serviceability Limit State Verifications
2.4.4.4 Fatigue

2.4.5 Areas of Dwellings, Offices, etc.

2.4.5.1 Categories
2.4.5.2 Values of Actions

2.4.6 Garage and Vehicle Traffic Areas

2.4.6.1 Categories
2.4.6.2 Values of Actions

2.4.7 Areas for Storage and Industrial Activities

2.4.8 Roofs

2.4.8.1 Categories
2.4.8.2 Values of Actions

2.4.9 Horizontal Loads on Partition Walls and Barriers due to Persons.

Figure 1: List of Contents of Part 2.4 "Imposed Loads on Buildings" of Eurocode 1

2. BACKGROUND OF THE MODELS AND NUMERICAL VALUES [1]

2.1 Areas of dwellings, offices etc. [1],[2]

For areas of dwellings, offices etc. the imposed loads depend on the type of occupancy, see fig. 2.

The loads may be caused by:

- furniture and moveable objects (e.g. light moveable partitions), loads from commodities the contents of containers.

  These loads are at certain points in time subjected to considerable instantaneous changes in their magnitudes, mainly due to change of occupancy or tenant, change of use etc. Between these instantaneous changes the load varies very slowly with time and the magnitudes of the variations are generally small, see fig. 2a.

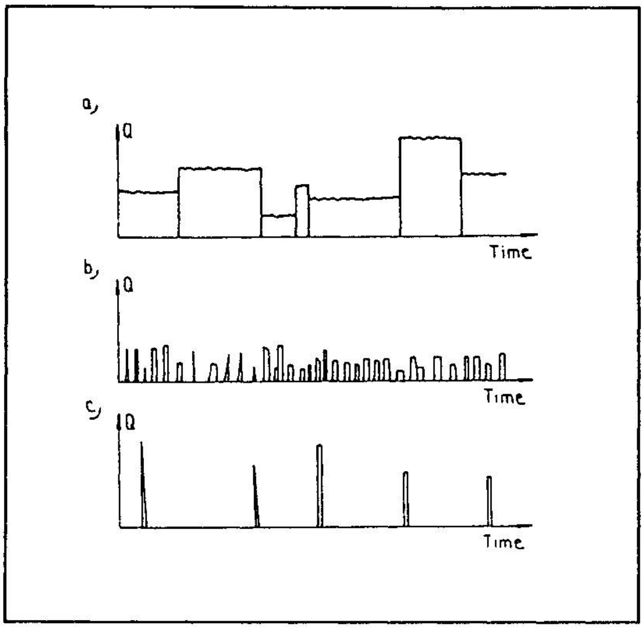

Figure 2: Time variability of the magnitude Q of the load
a) Load caused furniture and heavy equipment
b) Load caused by persons in ordinary load situations
c) Loads in special load situations

- normal use by persons. These loads are often periodical and only present during a relatively small part of the time, e.g. for school rooms only about 1/4 of the day, as illustrated in fig. 2b. The proportion between the load caused by persons and the load caused by furniture depends on the type of locality. E.g. for residential buildings it is small, in theatres and on corridors it is great. In some cases the loads from persons may also cause dynamic effects, e.g. in dancing halls.
- extraordinary use, such as exceptional concentrations of persons or of furniture, or the moving or stacking of commodities which may occur during reorganization or redecoration. These special situations occur during a short or moderate period of time, however sufficiently often during the lifetime of a building to make it necessary to take them into account, fig. 2c.

In an attempt to determine the design values and the characteristic values of imposed loads on a statistical basis the following assumption have been made:

1. In principle for the description of imposed loads it appeared appropriate to consider separately the variation in space and the variation in time.
2. For the variation in space for practical reasons it is normally usual to represent the "per definition" discrete loads by means of an equivalent uniformly distributed load. This uniformly distributed load is dependent on the tributary area, and also on the static system of the component to be designed.

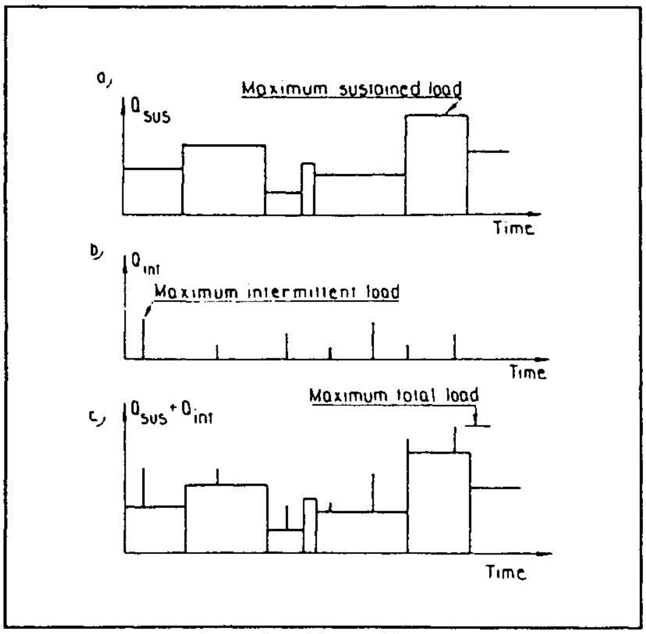

Figure 3: Sustained load (Q_{sus}), intermittent load (Q_{int}) and total load as stochastic process representing the variability

3. The variation in time is taken into account by modelling the load by two components, fig. 3:
   - a quasipermanent (sustained) load, fig. 3a, the magnitude of which represents approximately the time average of the real fluctuating load between the changes of occupancy, including herein also the weight of persons who are normally present. The magnitude of the fluctuations between the changes of occupancy will then be included in the uncertainties of the sustained load.
   - an intermittent load, fig. 3b to represent all kinds of live load not covered by the sustained load, e.g. the loads due to extraordinary use.

The combined sustained and intermittent live load is shown in fig. 3c.

4. To determine the design values a reference period of 50 years and a reliability index β = 3.80 has been adopted and the characteristic values p_K were determined from the design values p_d by

$$p_K = \frac{p_d}{\gamma_Q}$$ where γ_Q = 1.50 was used.

Unfortunately the statistical database for the determination of the characteristic values is rather poor; the numerical load measurements in the literature [4] deal mainly with quasipermanent loads parts in some areas of representative use only, whereas little is known about quasipermanent loads in case of other types of use (e.g. warehouses, archives, libraries, tool sheds) and about short term loads, where estimations are necessary.

Fig. 4 gives some values determined in this way.

Imposed Load	Tributary area [m²]	p_K [kN/m²]	ψ_o	ψ_2
Office building	10	1,90	0,44	0,27
	50	0,95	0,68	0,50
Residental building	10	1,75	0,51	0,23
	50	0,87	0,69	0,32
Commercial building	10	2,10	0,45	0,14
	50	1,00	0,66	0,31
School	10	2,20	0,50	0,23
	50	1,30	0,67	0,37
Hotel	10	2,30	0,54	0,09
	50	0,90	0,72	0,26
Hospital	10	0,80	0,58	0,43
	50	0,55	0,31	0,56

Figure 4: Characteristic values and combination values determined on a statistical basis.

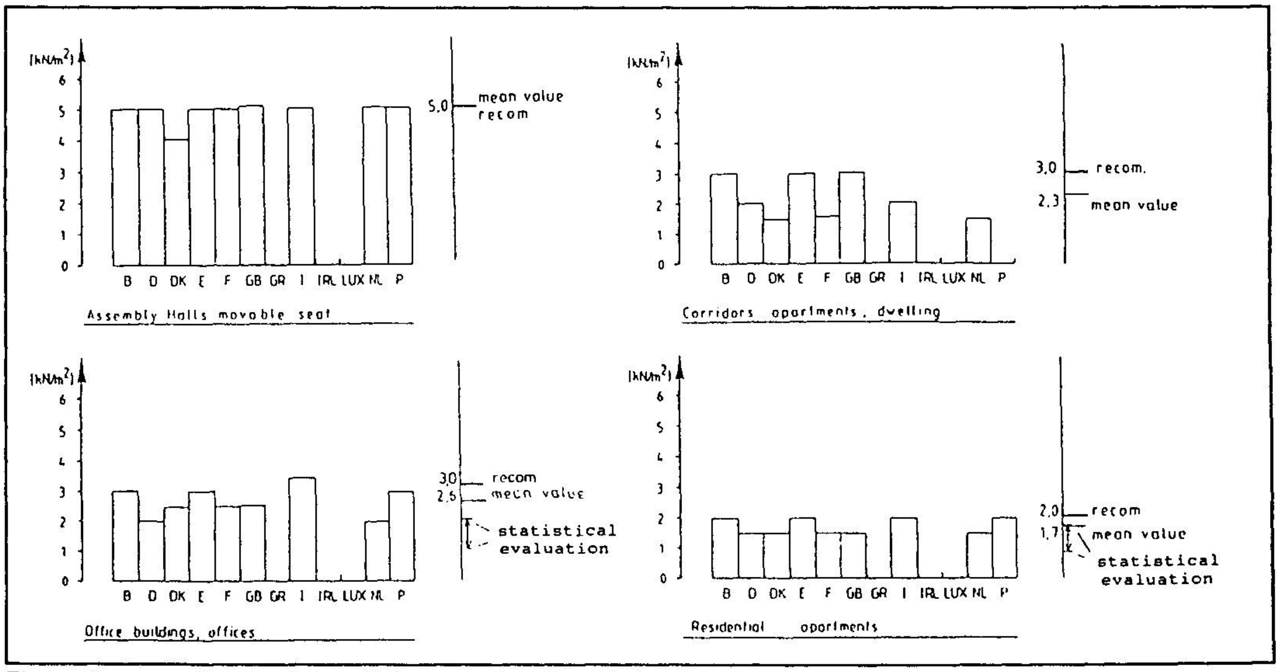

Figure 5: Comparison of European load regulations.

As the justification of all characteristic values on the basis of statistical data could not be reached, a more pragmatic way of deriving the load values was adopted in addition: they are derived from a comparison of the existing European national load regulations.

loaded areas		q_k [kN/m²]	Q_k [kN]	ψ_0	ψ_1	ψ_2
category A (domestic and residential activities)	- general	2,0	2,0	0,7	0,5	0,3
	- stairs	3,0	2,0	0,7	0,5	0,3
	- balconies	4,0	2,0	0,7	0,5	0,3
category B (public buildings, offices, schools, hotels)	- general	3,0	2,0	0,7	0,5	0,3
	- stairs, balconies	4,0	2,0	0,7	0,5	0,3
category C (assembly halls, theatres, restaurants, shopping areas)	- with fixed seats	4,0	7,0	0,7	0,7	0,6
	- other	5,0	7,0	0,7	0,7	0,6
category D (areas in warehouses, department stores)	- general	5,0	7,0	1,0	0,9	0,8

Figure 6: Imposed loads on floors in buildings.

Fig. 5 gives some examples from these comparisons.

Fig. 6 gives the the final proposals for the characteristic values of the uniformly distributed loads q_K and the combination factors ψ_i and for a concentrated load Q_K acting alone in dependance of the category on use of the floor.

2.2 Garage and vehicle traffic areas [1],[3]

In general the quasipermanent imposed load part does not exist in parking garages. Schematic diagrams for the daily fluctuations of the total number of cars in car parks depending on the location may be taken from fig. 7.

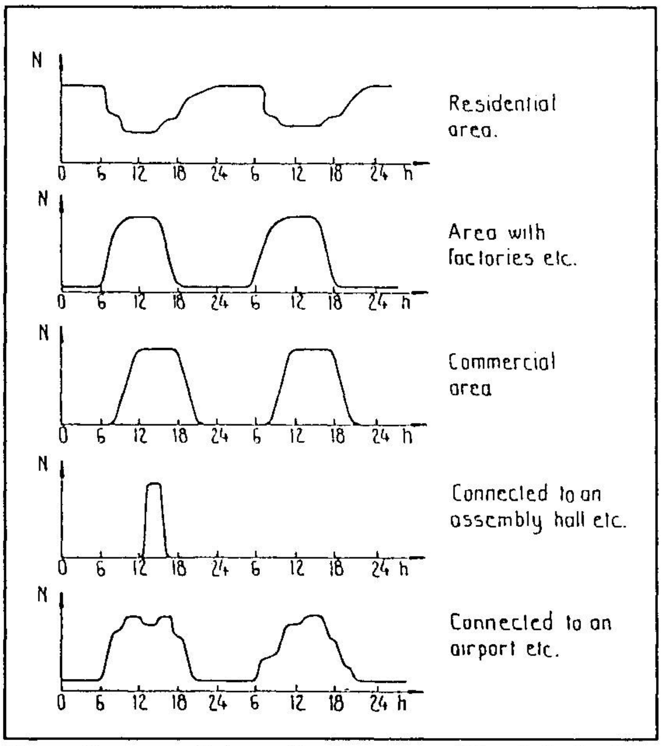

Figure 7: Schematic diagrams of the daily fluctuation of the total number of cars in car parks with different locations.

A propabilistic approach to determine the characteristic values of the uniformly distributed loads on parking areas may be based on the following assumptions:

- the spatial variability between different parking places which all are marked and have the same shape and magnitude in the whole car park is such that there is no correlation between the load values for the individual places and the same statistical data (Gaussian distribution) for the vehicle weights Q_i are valid for all of them.

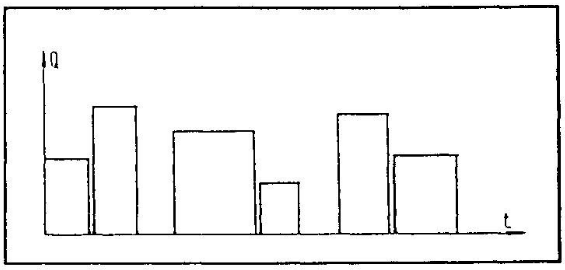

Figure 8: Rectangular wave renewal process

- the temporal characteristics of the loads at the individual parking places are modelled by a rectangular wave renewal load process, see fig. 8, that can be defined by the busy time t_d (hrs per day) when the car park is occupied and the dwell time t_u when a specific parking place is occupied continuously by the same car. The mean number of cars per day is then $\overline{p} = \frac{t_d}{t_u}$.

Design values and characteristic values calculated with these assumptions are given in fig. 9.

Imposed load on traffic areas	Tributary area [m²]	p_K [kN/m²]	ψ_o
parking areas :			
vertical	10 50	4,00 2,11	0,55 0,62
diagonal	10 50	3,55 1,83	0,54 0,60
approach ways	10 50	2,19 0,76	0,84 0,79

Figure 9: Characteristic values and combination values determined on a statistical basis.

traffic areas		q_k [kN/m²]	Q_k [kN]	ψ_0	ψ_1	ψ_2
category E	vehicle weight: ≤ 35 kN	2,0	20	0,7	0,7	0.6
category F	vehicle weight: 35 kN - 160 kN	5,0	85	0,7	0,5	0.3

Figure 10: Imposed loads on garages and vehicle traffic areas.

These values have been used in defining the characteristic values and combination values in Part 2.4 of EC 1, which are given in fig. 10. By the simultaneous action of uniformly distributed and concentrated loads the influence of the tributary area has been taken into account.

2.3 Roofs

roofs	q_k [kN/m²]	Q_k [kN]
category G	0,75	1,5

Figure 11: Imposed load on roofs

Numerical values for uniformly distributed loads and concentrated loads acting independently are given for the roof category, where the roof is not accessible except for maintenance, repair and cleaning, see fig. 11. These values have been derived from a comparison of national codes.

2.4 Horizontal Loads on Partition Walls and Barriers due to Persons.

use of the loaded area	q_k [kN/m]
Category A	0,5
Category B	1,0
Categories C and D	1,5

Figure 12: Horizontal loads on partition walls and barries due to person

For barriers or partition walls having the function of barriers, horizontal forces due to persons are given as shown in fig. 12.

These values are not suitable for the design of railings in sports stadia.

2.5 Influence of the loading area

The influence of the loading area is taken into account in a different way for the loading area within one storey and for loading areas from several storeys.

For loading areas within one storey the influence if any is modelled by the simultaneous action of an area independent uniformly distributed load and a concentrated load.

For loading areas from several storeys (only relevant for areas with category A to D) a reduction factor $\alpha_n = \frac{2 + (n - 2)\,\psi_o}{n}$ is used that is related to the number of storeys (n > 2) and the combination factor ψ_o.

3. REFERENCES

[1] Background document: Chapter 6: Imposed Loads on Floors and Roofs, June 1990

[2] CIB-W81-Report Publication 116: Actions on Structures - Live Loads in Buildings

[3] CIB-W81-Report: Actions on Structures - Loads in Car Parks, Sept. 1991

[4] Sentler, L: Live Load Surveys: A review with discussions, report 78 Lund, Sweden, 1976

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