EBCS- 1 Part 1-1

Ethiopian Building Code Standard – Based on European Norme

Actions on structures – Part 1-1:
General actions - Densities, self-weight, imposed loads for buildings

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Ministry of Urban Development, Housing and Construction.

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NATIONAL FOREWORD

The Proclamation to define the powers and duties of The Executive organs of The Federal Democratic Republic of Ethiopia Proclamation No 691/ 2010 and Ethiopian Building Proclamation No 624/2009 empowers the Ministry of Urban Development, Housing and Construction to prepare the Country's Building Code, issue Standards for design and construction works, and follow up and supervise the implementation of same.

This Ethiopian Standard is the official English language version of "BASIS OF STRUCTURAL DESIGN - **EBCS EN 1991-1-1:2014**". It supersedes part of "BASIS OF DESIGN AND ACTIONS ON STRUCTURES - EBCS-1 1995" which is withdrawn. With an eye on the latest technological advancements and trends worldwide and with the aim of bringing the Ethiopian Construction Standard at par with the present state-of-the-art, this edition has brought a major shift in terms of contents and comprehensiveness. Ethiopia is a signatory member of CEN/CENELEC to adopt European Standards in a similar fashion as the Members and Affiliates of CEN/CENELEC in which Ethiopia is bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving the basic framework of European Standard the status of a national standard without any alteration. The major benefits to be gained in applying these standards are the harmonization of professional practice and the ensuring of appropriate level of workmanship, level of safety and quality of construction work.

EBCS EN 1991-1-1:2014 is prepared based on EN 1991-1-1 by a Technical Committee "BASIS OF DESIGN AND ACTIONS ON STRUCTURES" the secretariat of which is held by Addis Ababa University. The document is intended to be used in conjunction with EBCS EN 1991:2014 to EBCS EN 1998:2014 for the structural design of buildings and civil engineering works, including geotechnical aspects, structural fire design, situations involving earthquakes, execution and temporary structures. The normative part of this Ethiopian Building Code Standard is chosen based on the local needs and construction practice. The range and possible choice are given in the normative text, and a Note will qualify it as a Nationally Determined Parameter (NDP) specific for the Ethiopian Construction industry. The NDPs can be a specific value for a factor, a specific level or class, a particular method or a particular application rule. In the current version of the Ethiopian Building Codes, the NDPs are mostly taken from the recommendations provided by the European Standards. To particularly determine the appropriate values, levels, methods and application conforming to our local conditions extensive and continuous research shall be conducted. In line with such rigorous approach, the NDPs will be published in a National Annex which will be incorporated by amendment into this Ethiopian Standard in due course, after public consultation has taken place for a grace period of one year. As this standard is technical document which, by their very nature, require periodic updating, revised edition will be issued by the Ministry from time to time as appropriate.

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This document does not purport to include all the necessary provisions of a contract. Users are responsible for their correct application.

Compliance with this Ethiopian Building Code Standard does not of itself confer immunity from legal obligations.

The Ministry of Urban Development Housing and Construction as mandated acknowledges this document as a national resource tool and reference document which comprises a

front cover, an inside front cover, a title page, National foreword, Table of Contents, pages 1 to 34 and a back cover. This Ethiopian Construction Standard, having been prepared under the direction of the Ethiopian Building Proclamation No 624/2009, was published under the authority of the Ministry of Urban Development, Housing and Construction on 01 December 2014.

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SECTION 1 GENERAL

1.1 Scope

(1) EBCS EN 1991-1-1:2014 gives design guidance and actions for the structural design of buildings and civil engineering works including some geotechnical aspects for the following subjects:

- Densities of construction materials and stored materials;
- Self-weight of construction works;
- Imposed loads for buildings.

(2) Section 4 and Annex A give nominal values for densities of specific building materials, and for additional stored materials. In addition for specific materials the angle of repose is provided.

(3) Section 5 provides methods for the assessment of the characteristic values of self-weight of construction works.

(4) Section 6 gives characteristic values of imposed loads for floors and roofs according to category of use in the following areas in buildings:

- residential, social, commercial and administration areas;
- garage and vehicle traffic areas;
- areas for storage and industrial activities;
- roofs;
- helicopter landing areas.

(5) The loads on traffic areas given in Section 6 refer to vehicles up to a gross vehicle weight of 160 kN. The design for traffic areas for heavy vehicles of more than 160 kN gross weight needs to be agreed with the relevant authority. Further information may be obtained from EBCS EN 1991-2.

(6) For barriers or walls having the function of barriers, horizontal forces are given in Section 6. Annex B gives additional guidance for vehicle barriers in car parks.

Note: Forces due to vehicle impact are specified in EBCS EN 1991-1-7 and EBCS EN 1991-2.

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1.2 Normative References

This Ethiopian Standard incorporates by dated or undated reference provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to, or revisions of, any of these publications apply to this Ethiopian Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

ISO 3898	Basis of design of structures - Notations. General symbols
ISO 2394	General principles on reliability for structures

ISO 8930	General principles on reliability for structures. List of equivalent terms
EBCS EN 1990:2014	EBCS 0: Basis of Structural Design
EBCS EN 1991-1-7:2014	EBCS 1: Actions on Structures: Part 1-7: Accidental actions from impact and explosions
EBCS EN 1991-3:2014	EBCS 1: Actions on Structures: Part 3: Actions induced by cranes and machinery

Note 1: The following Ethiopian Standards which are published or in preparation are cited in normative clauses :

Note 2: The following Ethiopian Standards which are published or in preparation are cited in NOTES to normative clauses :

EBCS EN 1991-1-4:2014: Actions on structures: Part 1-4: Wind actions

EBCS EN 1991-1-6:2014: Actions on structures: Part 1-6: Actions during execution

1.3 Distinction between Principles and Application Rules

(1) Depending on the character of the individual clauses, distinction is made in this Part between Principles and Application Rules.

(2) The Principles comprise: -general statements and definitions for which there is no alternative, as well as -requirements and analytical models for which no alternative is permitted unless specifically stated.

(3) The Principles are identified by the letter P following the paragraph number.

(4) The Application Rules are generally recognised rules which comply with the Principles and satisfy their requirements.

(5) It is permissible to use alternative design rules different from the Application Rules given in EBCS EN 1991-1-1:2014 for works, provided that it is shown that the alternative rules accord with the relevant Principles and are at least equivalent with regard to the structural safety, serviceability and durability which would be expected when using the Ethiopian Building Code Standards.

Note: If an alternative design rule is substituted for an Application Rule, the resulting design cannot be claimed to be wholly in accordance with EBCS EN 1991-1-1:2014 although the design will remain in accordance with the Principles of EBCS EN 1991-1-1:2014. When EBCS EN 1991-1-1:2014 is used in respect of a property listed in an Annex Z of a product standard or an ES ETAG.

(6) In this Part the Application Rules are identified by a number in brackets, e.g. as this clause.

1.4 Terms and definitions

For the purposes of this Ethiopian standard, the terms and definitions given in ISO 2394, ISO 3898, ISO 8930 and the following apply. Additionally for the purposes of this standard a basic list of terms and definitions is provided in EBCS EN 1990:2014, 1.5.

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1.4.1 **bulk weight density**
the bulk weight density is the overall weight per unit volume of a material, including a normal distribution of micro-voids, voids and pores

Note: In everyday usage this term is frequently abbreviated to “density” (which is strictly mass per unit volume).

1.4.2 **angle of repose**
the angle of repose is the angle which the natural slope of the sides of a heaped pile of loose material makes to the horizontal

1.4.3 **gross weight of vehicle**
the gross weight of a vehicle includes the self-weight of the vehicle together with the maximum weight of the goods it is permitted to carry

1.4.4 **structural elements**
structural elements comprise the primary structural frame and supporting structures.

1.4.5 **non structural elements**
non structural elements are those that include completion and finishing elements connected with the structure, including non-structural parapets. They also include services and machinery fixed permanently to, or within, the structure

1.4.6 **partitions**
non load bearing walls

1.4.7 **movable partitions**
movable partitions are those which can be moved on the floor, be added or removed or re-built at another place

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1.5 Symbols

(1) For the purposes of this standard, the following symbols apply.

Note: The notation used is based on ISO 3898: 1997.

(2) A basic list of symbols is provided in EBCS EN 1990:2014 clause 1.6 and the additional notations below are specific to this part of EBCS EN 1991:2014.

Latin upper case letters

A loaded area

A_0 basic area

Q_k characteristic value of a variable concentrated load

Latin lower case letters

g_k weight per unit area, or weight per unit length

n number of storeys

q_k characteristic value of a uniformly distributed load, or line load

Lower case Greek letters

α_A reduction factor

α_n reduction factor

γ bulk weight density

φ dynamic magnification factor

Ψ_0 factor for combination value of a variable action, see table A.1.1 of EBCS EN 1990:2014

ϕ angle of repose (degrees)

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SECTION 2 CLASSIFICATION OF ACTIONS

2.1 Self-weight

(1) The self-weight of construction works should be classified as a permanent fixed action, see EBCS EN 1990:2014, 1.5.3 and 4.1.1.

(2) Where this self-weight can vary in time, it should be taken into account by the upper and lower characteristic values (see EBCS EN 1990:2014, 4.1.2). However, in some cases where it is free (e.g. for movable partitions, see 6.3.1.2(8)), it should be treated as an additional imposed load.

Note: This applies in particular when the "permanent" actions may be favourable.

(3)P The loads due to ballast shall be considered as permanent actions and possible redistributions of ballast shall be taken into account in the design, see 5.2.2 (1) and (2).

(4)P The earth loads on roofs and terraces shall be considered as permanent actions.

(5) With regard to 2.1(3)P, the design should consider variations in moisture content and variation in depth, that may be caused by uncontrolled accumulation during the design life of the structure.

Note: For detailed information on earth pressures see EBCS EN 1997.

2.2 Imposed loads

(1)P Imposed loads shall be classified as variable free actions, unless otherwise specified in this standard, see EBCS EN 1990:2014, 1.5.3 and 4.1.1.

(2) When considering the accidental design situation where impact from vehicles or accidental loads from machines may be relevant, these loads should be taken from EBCS EN 1991-1-7:2014.

(3) Imposed loads should be taken into account as quasi-static actions (see EBCS EN 1990:2014, 1.5.3.13). The load models may include dynamic effects if there is no risk of resonance or other significant dynamic response of the structure, see EBCS EN 1992 to EBCS EN 1998. If resonance effects from syncronised rythmical movement of people or dancing or jumping may be expected, the load model should be determined for special dynamic analysis.

Note: The procedure to be used may be given in the National annex.

(4) When considering forklifts and helicopters, the additional loadings due to masses and inertial forces caused by fluctuating effects should be considered. These effects are taken into account by a dynamic magnification factor φ which is applied to the static load values, as shown in expression (6.3).

(5)P Actions which cause significant acceleration of the structure or structural members shall be classified as dynamic actions and shall be considered using a dynamic analysis.

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SECTION 3 DESIGN SITUATIONS

3.1 General

(1)P The relevant permanent and imposed loads shall be determined for each design situation identified in accordance with EBCS EN 1990:2014, 3.2.

3.2 Permanent loads

(1) The total self-weight of structural and non-structural members should be taken into account in combinations of actions as a single action.

Note: See EBCS EN 1990:2014 Table A1.2 (B) Note 3.

(2) For areas where it is intended to remove or add structural or non-structural elements, the critical load cases should be taken into account in the design.

(3) The self-weight of new coatings and/or distribution conduits that are intended to be added after execution should be taken into account in design situations (see 5.2).

(4)P The water level shall be taken into account for the relevant design situations.

Note: See EBCS EN 1997.

(5) The source and moisture content of bulk materials should be considered in design situations of buildings used for storage purposes.

Note: The values for the densities provided in Annex A are for materials in the dry state.

3.3 Imposed loads

3.3.1 General

(1)P For areas which are intended to be subjected to different categories of loadings the design shall consider the most critical load case.

(2)P In design situations when imposed loads act simultaneously with other variable actions (e.g actions induced by wind, cranes or machinery), the total imposed loads considered in the load case shall be considered as a single action.

(3) Where the number of load variations or the effects of vibrations may cause fatigue, a fatigue load model should be established.

(4) For structures susceptible to vibrations, dynamic models of imposed loads should be considered where relevant. The design procedure is given in EBCS EN 1990:2014 clause 5.1.3.

3.3.2 Additional provisions for buildings

(1) On roofs, imposed loads, and wind actions should not be applied together simultaneously.

(2)P When the imposed load is considered as an accompanying action, in accordance with EBCS EN 1990:2014, only one of the two factors ' (EBCS EN 1990:2014, Table A1.1) and a_n (6.3.1.2 (11)) shall be applied.

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(3) For dynamic loads caused by machinery see EBCS EN 1991-3:2014.

(4) The imposed loads to be considered for serviceability limit state verifications should be specified in accordance with the service conditions and the requirements concerning the performance of the structure.

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SECTION 4 DENSITIES OF CONSTRUCTION AND STORED MATERIALS

4.1 General

(1) Characteristic values of densities of construction and stored materials should be specified. Mean values should be used as characteristic values. See however 4.1(2) and 4.1(3).

Note: Annex A gives mean values for densities and angles of repose for stored materials. When a range is given it is assumed that the mean value will be highly dependent on the source of the material and may be selected considering each individual project.

(2)For materials (*e.g.* new and innovative materials) which are not covered by the Tables in Annex A, the characteristic value of the density should be determined in accordance with EBCS EN 1990:2014 clause 4.1.2 and agreed for each individual project.

(3) Where materials are used with a significant scatter of densities e.g. due to their source, water content etc, the characteristic value of these densities should be assessed in accordance with EBCS EN 1990:2014 clause 4.1.2.

(4) If a reliable direct assessment of the densities is carried out, then these values may be used.

Note: EBCS EN 1990:2014 Annex D may be used.

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SECTION 5 SELF-WEIGHT OF CONSTRUCTION WORKS

5.1 Representation of actions

(1) The self-weight of the construction works should in most cases, be represented by a single characteristic value and be calculated on the basis of the nominal dimensions and the characteristic values of the densities.

(2) The self weight of the construction works includes the structure and non-structural elements including fixed services as well as the weight of earth and ballast.

(3) Non-structural elements include:

- roofing ;
- surfacing and coverings ;
- partitions and linings ;
- hand rails, safety barriers, parapets and kerbs ;
- wall cladding ;
- suspended ceilings;
- thermal insulation ;
- fixed services (see 5.1.(4)).

Note: For information on fixed machinery see EBCS EN 1991-3:2014. For other industrial equipment (e.g. safes) the manufacturer should be consulted.

(4) Fixed services include :

- equipments for lifts and moving stairways ;
- heating, ventilating and air conditioning equipment ;
- electrical equipment ; -pipes without their contents ;
- cable trunking and conduits.

(5)P Loads due to movable partitions shall be treated as imposed loads, see 5.2.2(2)P and 6.3.1.2(8).

5.2 Characteristic values of self-weight

5.2.1 General

(1)P The determination of the characteristic values of self-weight, and of the dimensions and densities shall be in accordance with EBCS EN 1990:2014, 4.1.2.

(2) Nominal dimensions should be those as shown on the drawings.

5.2.2 Additional provisions for buildings

(1) For manufactured elements such as flooring systems, facades and ceilings, lifts and equipment for buildings, data may be provided by the manufacturer.

(2)P For determining the effect of the self-weight due to movable partitions, an equivalent uniformly distributed load shall be used and added to the imposed load, see 6.3.1.2 (8).

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SECTION 6 IMPOSED LOADS ON BUILDINGS

6.1 Representation of actions

(1) Imposed loads on buildings are those arising from occupancy. Values given in this Section, include:

- normal use by persons;
- furniture and moveable objects (e.g. moveable partitions, storage, the contents of containers);
- vehicles;
- anticipating rare events, such as concentrations of persons or of furniture, or the moving or stacking of objects which may occur during reorganization or redecoration.

(2) The imposed loads specified in this part are modelled by uniformly distributed loads, line loads or concentrated loads or combinations of these loads.

(3) For the determination of the imposed loads, floor and roof areas in buildings should be sub-divided into categories according to their use.

(4) Heavy equipment (e.g. in communal kitchens, radiology rooms, boiler rooms etc) are not included in the loads given in this Section. Loads for heavy equipment should be agreed between the client and/or the relevant Authority.

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6.2 Load arrangements

6.2.1 Floors, beams and roofs

(1)P For the design of a floor structure within one storey or a roof, the imposed load shall be taken into account as a free action applied at the most unfavourable part of the influence area of the action effects considered.

(2) Where the loads on other storeys are relevant, they may be assumed to be distributed uniformly (fixed actions).

(3)P To ensure a minimum local resistance of the floor structure a separate verification shall be performed with a concentrated load that, unless stated otherwise, shall not be combined with the uniformly distributed loads or other variable actions.

(4) Imposed loads from a single category may be reduced according to the areas supported by the appropriate member, by a reduction factor a_A according to 6.3.1.2(10).

6.2.2 Columns and walls

(1) For the design of columns or walls, loaded from several storeys, the total imposed loads on the floor of each storey should be assumed to be distributed uniformly.

(2) Where imposed loads from several storeys act on columns and walls, the total imposed loads may be reduced by a factor a_n according to 6.3.1.2(11) and 3.3.1(2)P.

6.3 Characteristic values of Imposed Loads

6.3.1 Residential, social, commercial and administration areas

6.3.1.1 Categories

(1)P Areas in residential, social, commercial and administration buildings shall be divided into categories according to their specific uses shown in Table 6.1.

(2)P Independent of this classification of areas, dynamic effects shall be considered where it is anticipated that the occupancy will cause significant dynamic effects (see 2.2(3) and (5)P).

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Table 6.1 - Categories of use

Category	Specific Use	Example
A	Areas for domestic and residential activities	Rooms in residential buildings and houses; bedrooms and wards in hospitals; bedrooms in hotels and hostels kitchens and toilets.
B	Office areas	
C	Areas where people may congregate (with the exception of areas defined under category A, B, and D[1)])	**C1**: Areas with tables, etc. e.g. areas in schools, cafés, restaurants, dining halls, reading rooms, receptions. **C2**: Areas with fixed seats, e.g. areas in churches, theatres or cinemas, conference rooms, lecture halls, assembly halls, waiting rooms, railway waiting rooms. **C3:** Areas without obstacles for moving people, e.g. areas in museums, exhibition rooms, etc. and access areas in public and administration buildings, hotels, hospitals, railway station forecourts. **C4**: Areas with possible physical activities, e.g. dance halls, gymnastic rooms, stages. **C5**: Areas susceptible to large crowds, e.g. in buildings for public events like concert halls, sports halls including stands, terraces and access areas and railway platforms.
D	Shopping areas	**D1:** Areas in general retail shops **D2**: Areas in department stores

[1)] Attention is drawn to 6.3.1.1(2), in particular for C4 and C5. See EBCS EN 1990 when dynamic effects need to be considered. For Category E, see Table 6.3

NOTE 1 Depending on their anticipated uses, areas likely to be categorised as C2, C3, C4 may be categorised as C5 by decision of the client and/or National annex.

NOTE 2 The National annex may provide sub categories to A, B, C1 to C5, D1 and D2

NOTE 3 See 6.3.2 for storage or industrial activity

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6.3.1.2 Values of actions

(1)P The categories of loaded areas, as specified in Table 6.1, shall be designed by using characteristic values q_k (uniformly distributed load) and Q_k (concentrated load).

Note: Values for q_k and Q_k are given in Table 6.2 below. Where a range is given in this table, the value may be set by the National annex. The recommended values, intended for separate application, are underlined. q_k is intended for determination of general effects and Q_k for local effects. The National annex may define different conditions of use of this Table.

Table 6.2 - Imposed loads on floors, balconies and stairs in buildings

Categories of loaded areas	q_k [kN/m^2]	Q_k [kN]
Category A		
- Floors	1.5 to 2.0	2.0 to 3.0
- Stairs	2.0 to 4.0	2.0 to 4.0
- Balconies	2.5 to 4.0	2.0 to 3.0
Category B	2.0 to 3.0	1.5 to 4.5
Category C		
- C1	2.0 to 3.0	3.0 to 4.0
- C2	3.0 to 4.0	2.5 to 7.0 (4.0)
- C3	3.0 to 5.0	4.0 to 7.0
- C4	4.5 to 5.0	3.5 to 7.0
- C5	5.0 to 7.5	3.5 to 4.5
Category D		
- D1	4.0 to 5.0	3.5 to 7.0 (4.0)
- D2	4.0 to 5.0	3.5 to 7.0

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(2) Where necessary q_k and Q_k should be increased in the design (e.g. for stairs and balconies depending on the occupancy and on dimensions).

(3) For local verifications a concentrated load Q_k acting alone should be taken into account.

(4) For concentrated loads from storage racks or from lifting equipment, Q_k should be determined for the individual case, see 6.3.2.

(5)P The concentrated load shall be considered to act at any point on the floor, balcony or stairs over an area with a shape which is appropriate to the use and form of the floor.

Note: The shape may normally be assumed as a square with a width of 50 mm. See also 6.3.4.2(4)

(6)P The vertical loads on floors due to traffic of forklifts shall be taken into account according to 6.3.2.3.

(7)P Where floors are subjected to multiple use, they shall be designed for the most unfavourable category of loading which produces the highest effects of actions (e.g. forces or deflection) in the member under consideration.

(8) Provided that a floor allows a lateral distribution of loads, the self-weight of movable partitions may be taken into account by a uniformly distributed load q_k which should be added to the imposed loads of floors obtained from Table 6.2. This defined uniformly distributed load is dependent on the self-weight of the partitions as follows:

- for movable partitions with a self-weight : 1.0 kN/m wall length: qk =0,5 kN/m2;

- for movable partitions with a self-weight : 2.0 kN/m wall length: qk =0.8 kN/m2;
- for movable partitions with a self-weight : 3.0 kN/m wall length: qk =1.2 kN/m2.

(9) Heavier partitions should be considered in the design taking account of:

- the locations and directions of the partitions;
- the structural form of the floors.

(10) In accordance with 6.2.1(4) a reduction factor α_A may be applied to the q_k values for imposed loads in Tables 6.2, and 6.10 for floors, and accessible roofs, Category I (See Table 6.9).

Note 1: The recommended value for the reduction factor α_A for categories A to E is determined as follows :

$$\alpha_A = \frac{5}{7}\Psi_0 + \frac{A_0}{A} \le 1.0 \qquad (6.1)$$

with the restriction for categories C and D: $\alpha_A \ge 0{,}6$

where:

Ψ_0 is the factor according to EBCS EN 1990:2014 Annex A1 Table A1.1

$A_0 = 10.0\text{m}^2$

A is the loaded area

Note 2: The National Annex may give an alternative method.

(11) In accordance with 6.2.2(2) and provided that the area is classified according to table 6.1 into the categories A to D, for columns and walls the total imposed loads from several storeys may be multiplied by the reduction factor α_n .

Note 1: The recommended values for α_n are given below.

$$\alpha_n = \frac{2 + (n-2)\Psi_0}{n} \qquad (6.2)$$

where:

n is the number of storeys (> 2) above the loaded structural elements from the same category.

Ψ_0 is in accordance with EBCS EN 1990:2014, Annex A1, Table A1.1.

Note 1: The National annex may give an alternative method.

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6.3.2 **Areas for storage and industrial activities**

6.3.2.1 Categories

(1)P Areas for storage and industrial activities shall be divided into the two categories according to Table 6.3.

Table 6.3 -Categories of storage and industrial use

Category	Specific use	Example
E1	Areas susceptible to accumulation of goods, including access areas	Areas for storage use including storage of books and other documents.
E2	Industrial use	

6.3.2.2 Values for Actions

(1)P The loaded areas, categorized as specified in Table 6.3, shall be designed by using characteristic values q_k (uniformly distributed load) and Q_k (concentrated load).

Note: Recommended values for q_k and Q_k are given in Table 6.4 below. The values may be changed if necessary according to the usage (see Table 6.3 and Annex A) for the particular project or by the National annex. q_k is intended for determination of general effects and Q_k for local effects. The National annex may define different conditions of use of Table 6.4.

Table 6.4 - Imposed loads on floors due to storage

Categories of loaded areas	q_k [kN/m^2]	Q_k [kN]
Category E1	7.5	7.0

(2)P The characteristic value of the imposed load shall be the maximum value taking account of the dynamic effects if appropriate. The loading arrangement shall be defined so that it produces the most unfavourable conditions allowed in use.

Note: For transient design situations due to installation and reinstallation of machines, production units etc. guidance is given in EBCS EN 1991-1-6:2014.

(3) The characteristic values of vertical loads in storage areas should be derived by taking into account the density and the upper design values for stacking heights. When stored material exerts horizontal forces on walls etc., the horizontal force should be determined in accordance with EBCS EN 1991-4:2014.

Note: See Annex A for densities.

(4) Any effects of filling and emptying should be taken into account.

(5) Loads for storage areas for books and other documents should be determined from the loaded area and the height of the book cases using the appropriate values for density.

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(6) Loads in industrial areas should be assessed considering the intended use and the equipment which is to be installed. Where equipment such as cranes, moving machinery etc, are to be installed the effects on the structure should be determined in accordance with EBCS EN 1991-3:2014.

(7) Actions due to forklifts and transport vehicles should be considered as concentrated loads acting together with the appropriate imposed distributed loads given in Tables 6.2, 6.4. and 6.8.

6.3.2.3 Actions induced by forklifts

(1) Forklifts should be classified in 6 classes FL 1 to FL 6 depending on net weight, dimensions and hoisting loads, see Table 6.5.

Table 6.5 - Dimensions of forklift according to classes FL

Class of Forklift	Net weight [kN]	Hoisting load [kN]	Width of axle *a* [m]	Overall width *b* [m]	Overall length *l* [m]
FL 1	21	10	0.85	1.00	2.60
FL 2	31	15	0.95	1.10	3.00
FL 3	44	25	1.00	1.20	3.30
FL 4	60	40	1.20	1.40	4.00
FL 5	90	60	1.50	1.90	4.60
FL 6	110	80	1.80	2.30	5.10

(2) The static vertical axle load Q_k of a forklift depends on the forklift classes FL1 to FL6 and should be obtained from Table 6.6.

Table 6.6 - Axle loads of forklifts

Class of forklifts	Axle load Q_k [kN]
FL 1	26
FL 2	40
FL 3	63
FL 4	90
FL 5	140
FL 6	170

(3) The static vertical axle load Q_k should be increased by the dynamic factor φ using expression (6.3).

$$Q_{k,dyn} = \varphi Q_k \qquad (6.3)$$

Where:

$Q_{k,dyn}$ is the dynamic characteristic value of the action

φ is the dynamic magnification factor

Q_k is the static characteristic value of the action

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(4) The dynamic factor c for forklifts takes into account the inertial effects caused by acceleration and deceleration of the hoisting load and should be taken as:

φ = 1.40 for pneumatic tyres,

φ = 2.00 for solid tyres.

(5) For forklifts having a net weight greater than 110 kN the loads should be defined by a more accurate analysis.

(6) The vertical axle load Q_k and $Q_{k\ ndyn}$ of a forklift should be arranged according to Figure 6.1.

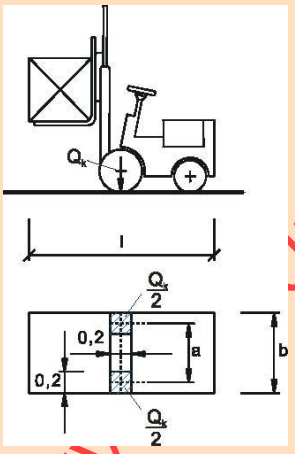

Figure 6.1 - Dimensions of forklifts

(7) Horizontal loads due to acceleration or deceleration of forklifts may be taken as 30 % of the vertical axle loads Q_k.

Note: Dynamic factors need not be applied.

6.3.2.4 Actions induced by transport vehicles

(1) The actions from transport vehicles that move on floors freely or guided by rails should be determined by a pattern of wheel loads.

(2) The static values of the vertical wheel loads should be given in terms of permanent weights and pay loads. Their spectra should be used to define combination factors and fatigue loads.

(3) The vertical and horizontal wheel loads should be determined for the specific case.

(4) The load arrangement including the dimensions relevant for the design should be determined for the specific case.

Note: Appropriate load models from EBCS EN 1991-2:2014 may be used where relevant.

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6.3.2.5 Actions induced by special devices for maintenance

(1) Special devices for maintenance should be modelled as loads from transportation vehicles, see 6.3.2.4.

(2) The load arrangements including the dimensions relevant for the design should be determined for the specific case.

6.3.3 Garages and vehicle traffic areas (excluding bridges)

6.3.3.1 Categories

(1)P Traffic and parking areas in buildings shall be divided into two categories according to their accessibility for vehicles as shown in Table 6.7.

Table 6.7 - Traffic and parking areas in buildings

Categories of traffic areas	Specific Use	Examples
F	Traffic and parking areas for light vehicles (≤ 30 kN gross vehicle weight and ≤ 8 seats not including driver)	garages; parking areas, parking halls
G	Traffic and parking areas for medium vehicles (>30 kN, ≤ 160 kN gross vehicle weight, on 2 axles)	access routes; delivery zones; zones accessible to fire engines (≤160 kN gross vehicle weight)
Note 1: Access to areas designed to category F should be limited by physical means built into the structure. **Note 2:** Areas designed to categories F and G should be posted with the appropriate warning signs.		

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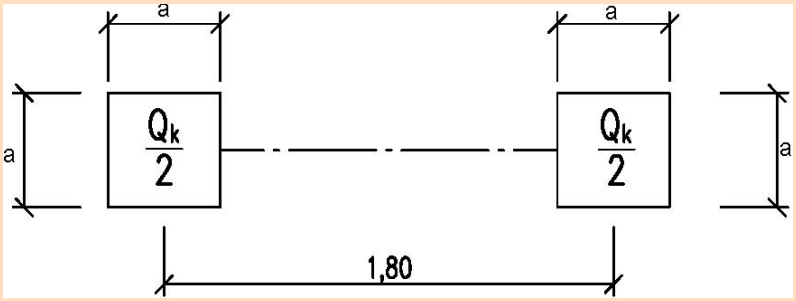
6.3.3.2 Values of actions

(1) The load model which should be used is a single axle with a load Q_k with dimensions according to Figure 6.2 and a uniformly distributed load q_k. The characteristic values for q_k and Q_k are given in Table 6.8.

Note: q_k is intended for determination of general effects and Q_k for local effects. The National annex may define different conditions of use of this Table.



Note: For category F (see Table 6.8) the width of the square surface is 100 mm and for category G see Table 6.8) the width of a square surface is 200 mm.

Figure 6.2 - Dimensions of axle load

Categories of traffic areas	q_k [kN/m2]	Q_k [kN]
Category F Gross vehicle weight: ≤ 30 kN	q_k	Q_k
Category G 30 kN < gross vehicle weight ≤ 160 kN	5.0	Q_k
Note 1: For category F. q_k may be selected within the range 1.5 to 2.5 kN/m^2 and Q_k may be selected within the range 10 to 20 kN. **Note 2:** For category G, Q_k may be selected within the range 40 to 90 kN. **Note 3:** Where a range of values are given in Notes 1 & 2, the value may be set by the National annex. The recommended values are underlined.		

Table 6.8 - Imposed loads on garages and vehicle traffic areas

(2) The axle load should be applied on two square surfaces with a 100 mm side for category F and a 200 mm side for Category G in the possible positions which will produce the most adverse effects of the action.

6.3.4 **Roofs**

6.3.4.1 Categories

(1)P Roofs shall be categorised according to their accessibility into three categories as shown in Table 6.9.

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Table 6.9 - Categorization of roofs

Categories of loaded area	Specific Use
H	Roofs not accessible except for normal maintenance and repair.
I	Roofs accessible with occupancy according to categories A to D
K	Roofs accessible for special services, such as helicopter landing areas

(2) Imposed loads for roofs of category H should be those given in Table 6.10. Imposed loads for roofs of category I are given in Tables 6.2, 6.4 and 6.8 according to the specific use.

(3) The loads for roofs of category K which provide areas for helicopter landing areas should be for the helicopter classes HC, see Table 6.11.

6.3.4.2 Values of actions

(1) For roofs of category H the minimum characteristic values Q_k and q_k that should be used are given in Table 6.10. They are related to the projected area of the roof under consideration.

Table 6.10 - Imposed loads on roofs of category H

Roof	q_k [kN/m^2]	Q_k [kN]
Category H	**qk**	**Qk**
Note 1: For category H q_k may be selected within the range 0.00 kN/m^2 to 1.0 kN/m^2 and Q_k may be selected within the range 0.9 kN to 1.5 kN. Where a range is given the values may be set by the National Annex. The recommended values are: q_k = 0.4 kN/m^2 , Q_k = 1.0kN **Note 2:** q_k may be varied by the National Annex dependent upon the roof slope. **Note 3:** q_k may be assumed to act on an area A which may be set by the National Annex. The recommended value for A is 10 m^2, within the range of zero to the whole area of the roof. **Note 4:** See also 3.3.2 (1)		

(2) The minimum values given in Table 6.10 do not take into account uncontrolled accumulations of construction materials that may occur during maintenance.

Note : See also EN 1991-1-6: Actions during execution.

(3)P For roofs separate verifications shall be performed for the concentrated load Q_k and the uniformly distributed load q_k, acting independently.

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(4) Roofs, other than those with roof sheeting, should be designed to resist 1.5 kN on an area based on a 50 mm sided square. Roof elements with a profiled or discontinuously laid surface, should be designed so that the concentrated load Q_k acts over the effective area provided by load spreading arrangements.

(5) For roofs of category K the actions from helicopters on landing areas should be determined in accordance with Table 6.11, and using the dynamic factors given in 6.3.4.2 (6) and expression 6.3

Table 6.11 - Imposed loads on roofs of category K for helicopters

Class of helicopter	Take-off load Q of helicopter	Take-off load Q_k	Dimension of the loaded area (m x m)
HC1 HC2	$Q \leq 20$ kN 20 kN< $Q \leq 60$ kN	Q_k = 20 kN Qk = 60 kN	0.2 x 0.2 0.3 x 0.3

(6) The dynamic factor φ to be applied to the take off load Q_k to take account of impact effects may be taken as c = 1.40.

(7) Access ladders and walkways should be assumed to be loaded according to Table 6.10 for a roof slope < 20°. For walkways which are part of a designated escape route, q_k should be according to Table 6.2. For walkways for service a minimum characteristic value Q_k of 1.5 kN should be taken.

(8) The following loads should be used for the design of frames and coverings of access hatches (other than glazing), the supports of ceilings and similar structures:

a) without access: no imposed load;

b) with access: 0.25 kN/m^2 distributed over the whole area or the area supported, and the concentrated load of 0.9 kN so placed as to produce maximum stresses in the affected member.

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6.4 Horizontal loads on parapets and partition walls acting as barriers

(1) The characteristic values of the line load q_k acting at the height of the partition wall or parapets but not higher than 1.20 m should be taken from Table 6.12.

Table 6.12 - Horizontal loads on partition walls and parapets

Loaded areas	q_k [kN/m]
Category A	q_k
Category B and C1	q_k
Categories C2 –to C4 and D	q_k
Category C5	q_k
Category E	q_k
Category F	See Annex B
Category G	See Annex B

Note 1: For categories A, B and C1, q_k may be selected within the range 0.2 to 1.0 (0.5).

Note 2: For categories C2 to C4 and D q_k may be selected within the range 0.8 kN/m –to 1.0 kN/m.

Note 3: For category C5 q_k may be selected within the range 3.0 kN/m to 5.0 kN/m.

Note 4: For category E q_k may be selected within the range 0.8 kN/m to 2.0 kN/m. For areas of category E the horizontal loads depend on the occupancy. Therefore the value of qk is defined as a minimum value and should be checked for the specific occupancy.

Note 5: Where a range of values is given in Notes 1, 2, 3 and 4, the value may be set by the National Annex. The recommended value is underlined.

Note 6: The National Annex may prescribe additional point loads Qk and/or hard or soft body impact specifications for analytical or experimental verification.

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(2) For areas susceptible to significant overcrowding associated with public events e.g. for sports stadia, stands, stages, assembly halls or conference rooms, the line load should be taken according to category C5.

ANNEX A
(INFORMATIVE)
TABLES FOR NOMINAL DENSITY OF CONSTRUCTION MATERIALS, AND NOMINAL DENSITY AND ANGLES OF REPOSE FOR STORED MATERIALS

Table A.1 - Construction materials-concrete and mortar

Materials	Density γ [kN/m^3]
concrete (see ES EN 206)	
lightweight density class LC 1.0	9.0 to 10.0 [1)2)]
density class LC 1.2	10.0 to 12.0 [1)2)]
density class LC 1.4	12.0 to 14.0 [1)2)]
density class LC 1.6	14.0 to 16.0 [1)2)]
density class LC 1.8	16.0 to 18.0 [1)2)]
density class LC 2.0	18.0 to 20.0 [1)2)]
normal weight	24.0 [1)2)]
heavy weight	>1)2)
mortar	
cement mortar	19.0 to 23.0
gypsum mortar	12.0 to 18.0
lime-cement mortar	18.0 to 20.0
lime mortar	12.0 to 18.0

[1)] Increase by 1kN/m^3 for normal percentage of reinforcing and pre-stressing steel

[2)] Increase by 1kN/m^3 for unhardened concrete

Note: See Section 4

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Table A.2 - Construction materials-masonry

Materials	Density γ [kN/m^3]
masonry units	
clay masonry units	see EBCS EN 771-1
calcium silicate masonry units	see EBCS EN 771-2
aggregate concrete masonry units	see EBCS EN 771-3
autoclaved aerated masonry units	see EBCS EN 771-4
manufactured stone masonry units	see EBCS EN 771-5
glass blocks, hollow	see EBCS EN 1051
terra cotta	21.0
natural stones, see EBCS EN 771-6	
granite, syenite, porphyry	27.0 to 30.0
basalt, diorite, gabbro	27.0 to 31.0
tachylyte	26.0
basaltic lava	24.0
gray wacke, sandstone	21.0 to 27.0
dense limestone	20.0 to 29.0
other limestone	20.0
volcanic tuff	20.0
gneiss	30.0
slate	28.0

Note: See Section 4.

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Table A.3 - Construction materials-wood

Products	Density γ [kN/m^3]
wood (see ES EN 338 for timber strength classes)	
timber strength class C14	3.5
timber strength class C16	3.7
timber strength class C18	3.8
timber strength class C 22	4.1
timber strength class C24	4.2
timber strength class C27	4.5
timber strength class C30	4.6
timber strength class C35	4.8
timber strength class C 40	5.0
timber strength class D 30	6.4
timber strength class D 35	6.7
timber strength class D 40	7.0
timber strength class D 50	7.8
timber strength class D 60	8.4
timber strength class D 70	10.8
glued laminated timber (see ES EN 1194 for Timber strength classes)	
homogenous glulam GL24h	3.7
homogenous glulam GL28h	4.0
homogenous glulam GL32h	4.2
homogenous glulam GL36h	4.4
combined glulam GL24c	3.5
plywood	
softwood plywood	5.0
birch plywood	7.0
laminboard and blockboard	4.5
particle boards	
chipboard	7.0 to 8.0
cement-bonded particle board	12.0
flake board, oriented strand board, wafer board	7.0
fibre building board	
hardboard, standard and tempered	10.0
medium density fibreboard	8.0
softboard	4.0

Note: See Section 4.

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Table A.4 - Construction materials-metals

Materials	Density γ [kN/m^3]
metals	
aluminium	27.0
brass	83.0 to 85.0
bronze	83.0 to 85.0
copper	87.0 to 89.0
iron, cast	71.0 to 72.5
iron, wrought	76.0
lead	112.0 to 114.0
steel	77.0 to 78.5
zinc	71.0 to 72.0

Table A.5 - Construction materials-other materials

Materials	Density γ [kN/m^3]
other materials	
glass, broken	22.0
glass, in sheets	25.0
plastics	
acrylic sheet	12.0
polystyrene, expanded, granules	0.3
foam glass	1.4
slate	28.0

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Table A.6 -Stored materials -building and construction

Materials	Density γ [kN/m3]	Angle of repose ϕ [°]
aggregates (see EBCS EN 206)		
lightweight	9.0 to 20.0 [1)]	30
normal	20.0 to 30.0	30
heavyweight	> 30.0	30
gravel and sand, bulked	15.0 to 20.0	35
sand blast furnace slag	14.0 to 19.0	30
lumps	17.0	40
granules	12.0	30
crushed foamed	9.0	35
brick sand, crushed brick, broken bricks	15.0	35
vermiculite		
exfoliated, aggregate for concrete	1.0	-
crude	6.0 to 9.0	-
bentonite		
loose	8.0	40
shaken down	11.0	-
cement		
in bulk	16.0	28
in bag	15.0	-
fly ash	10.0 to 14.0	25
glass, in sheets	25.0	-
gypsum, ground	15.0	25
lignite filter ash	15.0	20
lime	13.0	25
limestone, powder	13.0	25 to 27
magnesite, ground	12.0	-
plastics,		
polyethylene, polystyrol granulated	6.4	30
polyvinylchloride, powder	5.9	40
polyester resin	11.8	-
glue resins	13.0	-
water, fresh	10.0	

[1)] see table A.1 for density classes of lightweight concrete

Note: See Section 4.

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Table A.7 -Stored products -agricultural

Products	Density γ [kN/m^3]	Angle of repose ϕ [°]
farmyard		
manure (minimum 60 % solids)	7.8	-
manure (with dry straw)	9.3	45
dry chicken manure	6.9	45
slurry (maximum 20 % solids)	10.8	-
fertiliser, artificial		
NPK, granulated	8.0 to 12.0	25
basic slag, crushed	13.7	35
phosphates, granulated	10.0 to 16.0	30
potassium sulphate	12.0 to 16.0	28
urea	7.0 to 8.0	24
fodder, green, loosely stacked	3.5 to 4.5	-
grain whole (≤ 14 % moisture content unless indicated otherwise)		
general	7.8	30
barley	7.0	30
brewer´s grain (wet)	8.8	-
herbage seeds	3.4	30
maize in bulk	7.4	30
maize in bags	5.0	-
oats	5.0	30
oilseed rape	6.4	25
rye	7.0	30
wheat in bulk	7.8	30
wheat in bags	7.5	-
grass cubes	7.8	40
hay		
(baled)	1.0 to 3.0	-
(rolled bales)	6.0 to 7.0	-
hides and skins	8.0 to 9.0	-
hops	1.0 to 2.0	25
malt	4.0 to 6.0	20
meal		
ground	7.0	45
cubes	7.0	40
peat		
dry, loose, shaken down	1.0	35
dry, compressed in bales	5.0	-
wet	9.5	-
silage	5.0 to 10.0	--
straw		
in bulk (dry)	0.7	-
baled	1.5	-
tobacco in bales	3.5 to 5.0	-
wool		
in bulk	3.0	-
baled	7.0 to 13.0	-

Note: See Section 4.

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Table A.8 - Stored products - foodstuffs

Products	Density γ [kN/m^3]	Angle of repose ϕ [°]
eggs, in stands	4.0 to 5.0	-
flour		
bulk	6.0	25
bagged	5.0	-
fruit		
apples	8.3	30
- loose	6.5	-
- boxed	7.8	-
cherries	5.9	-
pears	2.0	-
raspberries, in trays	1.2	-
strawberries, in trays tomatoes	6.8	-
sugar		
loose, piled	7.5 to 10.0	35
dense and bagged	16.0	
vegetables, green		
cabbages	4.0	-
lettuce	5.0	-
vegetables, legumes		
beans	8.1	35
- general	7.4	30
- soya peas	7.8	-
vegetables, root		
general	8.8	-
beet root	7.4	40
carrots	7.8	35
onions	7	35
turnips	7	35
potatoes		
in bulk	7.6	35
in boxes	4.4	-
sugar beet,		
dried and chopped	2.9	35
raw	7.6	-
wet shreds	10.0	-

Note: See Section 4.

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Table A.9 - Stored products - liquids

Products	Density γ [kN/m^3]
beverages	
beer	10.0
milk	10.0
water, fresh	10.0
wine	10.0
natural oils	
castor oil	9.3
glycerol (glycerine)	12.3
linseed oil	9.2
olive oil	8.8
organic liquids and acids	
alcohol	7.8
ether	7.4
hydrochloric acid (40 % by weight)	11.8
methylated spirit	7.8
nitric acid (91 % by weight)	14.7
sulphuric acid (30 % by weight)	13.7
sulphuric acid (87 % by weight)	17.7
turpentine, white spirit	8.3
hydrocarbons	
aniline	9.8
benzene (benzol)	8.8
coal tar	10.8 to 12.8
creosote	10.8
naphtha	7.8
paraffin (kerosene)	8.3
benzine (benzoline)	6.9
oil, crude (petroleum)	9.8 to 12.8
diesel	8.3
fuel	7.8 to 9.8
heavy	12.3
lubricating	8.8
petrol (gasolene, gasoline) liquid gas	7.4
butane	5.7
propane	5.0
other liquids	
mercury	133
red lead paint	59
white lead, in oil	38
sludge, over 50 % by volume water	10.8

Note: See Section 4.

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Table A.10 - Stored products - solid fuels

Products	Density γ [kN/m^3]	Angle of repose ϕ [°]
charcoal		
air-filled	4	-
air-free	15	-
coal		
block briquettes, tipped	8	35
block briquettes, stacked	13	-
egg briquettes	8.3	30
coal, raw from pit	10	35
coal in washing pools	12	-
coal dust	7	25
coke	4.0 to 6.5	35 to 45
middlings in the quarry	12.3	35
waste washing tips in colliery	13.7	35
all other kinds of coal	8.3	30 to 35
firewood	5.4	45
lignite/brown coal		
briquettes, tipped	7.8	30
briquettes, stacked	12.8	-
damp	9.8	30 to 40
dry	7.8	35
dust	4.9	25 to 40
low-temperature coke	9.8	40
peat		
black, dried, firmly packed	6 to 9	-
black, dried, loosely tipped	3 to 6	45

Note: See Section 4.

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Table A.11 - Stored products - industrial and general

Products	Density γ [kN/m^3]	Angle of repose ϕ [°]
books and documents		
books and documents,	6.0	-
densely stored	8.5	--
filing racks and cabinets	6.0	-
garments and rags, bundled	11.0	-
ice, lumps	8.5	-
leather, piled	10.0	-
paper		
in rolls	15.0	-
piled	11.0	-
rubber	10.0 to 17.0	-
rock salt	22.0	45
salt	12.0	40
sawdust		
dry, bagged	3.0	-
dry, loose	2.5	45
wet, loose	5.0	45
tar, bitumen	14.0	-

Note: See Section 4.

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ANNEX B
(INFORMATIVE)
VEHICLE BARRIERS AND PARAPETS FOR CAR PARKS

B(1) Barriers and parapets in car parking areas should be designed to resist the horizontal loads given in B(2).

B(2) The horizontal characteristic force *F* (in kN), normal to and uniformly distributed over any length of 1.5 m of a barrier for a car park, required to withstand the impact of a vehicle is given by:

$$F = \frac{0.5mv^2}{(\delta_b + \delta_c)}$$

Where :

m is the gross mass of the vehicle in (kg)

v is the velocity of the vehicle (in m/s) normal to the barrier

δ_c is the deformations of the vehicle (in mm)

δ_b is the deformations of the barrier (in mm)

B(3) Where the car park has been designed on the basis that the gross mass of the vehicles using it will not exceed 2500 kg the following values are used to determine the force F:

m = 1500 kg

v = 4.5 m/s

δ_c = 100 mm unless better evidence is available.

For a rigid barrier, for which δ_b may be given as zero, the characteristic force *F* appropriate to vehicles up to 2500 kg gross mass is taken as 150 kN.

B(4) Where the car park has been designed for vehicles whose gross mass exceeds 2500 kg the following values are used to determine the characteristic force *F*.

m = the actual mass of the vehicle for which the car park is designed (in kg)

v = 4.5 m/s

δ_c = 100 mm unless better evidence is available

B(5) The force determined as in B (3) or B (4) may be considered to act at bumper height. In the case of car parks intended for vehicles whose gross mass does not exceed 2500 kg this height may be taken as 375 mm above the floor level.

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B(6) Barriers to access ramps of car parks have to withstand one half of the force determined in B (3) or B (4) acting at a height of 610 mm above the ramp.

B(7) Opposite the ends of straight ramps intended for downward travel which exceed 20 m in length the barrier has to withstand twice the force determined in B (3) acting at a height of 610 mm above the ramp.

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