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British Standard

Buildings and structures for agriculture

Part 22. Code of practice for design,
construction and loading

Conception des bâtiments et structures agricoles

Partie 22. Code de bonne pratique pour la conception, la construction et la mise en charge

Konstruktive Gestaltung von landwirtschaftlichen Gebäuden und Bauwerken

Teil 22. Richtlinie für Planung, Ausführung und Belastung

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Foreword

This Part of BS 5502 has been prepared under the direction of the Farm and Horticultural Buildings Standards Committee and is a revision of BS 5502 : Section 1.2 : 1980, which is withdrawn.

While BS 5502 is being revised and added to, the opportunity is being taken to restructure it into the following broad subject areas:

- Part 0 Introduction
- Parts 10 to 19 Reference information and legislation
- Parts 20 to 39 General design
- Parts 40 to 59 Livestock buildings
- Parts 60 to 79 Crop buildings
- Parts 80 to 99 Ancillary buildings

More specifically, the general design group will comprise:

- Part 20 General principles
- Part 21 Materials (revision of Sections 1.1 and 3.2)
- Part 22 Design, construction and loading (revision of Section 1.2)
- Part 23 Fire protection (revision of Section 1.3)
- Part 24 Energy management (revision of Section 1.4)
- Part 25 Services and facilities (revision of Sections 1.5 and 2.5)
- Part 30 Pollution control (new)
- Part 31 Infestation control (revision of Sections 1.7 and 3.10)

The object of introducing the new structure is to allow subject areas to be broadly characterized, and related subject matter, whether in the form of recommendations, guidance or supporting data, to be rationalized and brought together. It will also allow sufficient flexibility to allow the standard to be expanded and developed in a logical way in the future. Parts 20 to 39 relating to general design will follow broadly the existing structure of BS 5502 : Sections 1.0 to 1.7.

The design and construction of, and the loadings for, agricultural buildings and structures carried out in accordance with this code of practice require reference to be made to the relevant material codes of practice, some recommendations of which have been modified by this Part of BS 5502 for classified agricultural buildings and structures. This Part of BS 5502 also contains special considerations peculiar to agricultural buildings and structures that should be taken into account during their design and construction.

It has been assumed in the drafting of this British Standard that the execution of its provisions is entrusted to appropriately qualified and experienced people, for whose guidance it has been prepared.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

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Code of practice

1 Scope

This Part of BS 5502 gives recommendations on the design and construction of, and the loading for, agricultural buildings and structures.

NOTE 1. The titles of the publications referred to in this standard are listed on page 25.

NOTE 2. The numbers in square brackets in the text of this standard refer to the numbered references in appendix A.

2 Definitions and symbols

2.1 Definitions

For the purposes of this Part of BS 5502, the definitions given in BS 449, BS 5268, BS 5628, BS 5950, BS 6100 and BS 8110 apply together with the following.

zone of effect. The area around a retaining structure extending a distance not less than 1.5 times the structure's height (h) above or the depth (d) below ground, whichever is greater, beyond the retaining structure's real or projected ground perimeter.

2.2 Symbols

For the purposes of this Part of BS 5502, the following symbols apply:

b_c	Breadth of compression face of concrete beam (T and inverted L purlins and sheeting rails) measured mid-way between restraints (see BS 8110 : Part 1).
b_t	Breadth of tension face of concrete beam (T and inverted L purlins and sheeting rails) measured mid-way between restraints (see BS 8110 : Part 1).
d	Depth below ground for zone of effect.
d_a	Depth below ground for zone of effect for structure's alternative face.
E1, E2, E3, E4	Classification of exposure situations in accordance with BS 5628 : Part 2.
GL	Ground level.
h	Height above ground for zone of effect.
h_a	Height above ground for zone of effect for structure's alternative face.
H_s	Point load applied horizontally at the surface of a single slat from livestock (in kN).
h_t	Change of level at valley on multispan for snow load calculation.
l_e	Effective length of section (see BS 449 : Part 2 and BS 5950 : Part 1).
l_l	Lower roof span of multispan for snow load calculation.
l_p	Span of purlin, centre to centre of support (in mm).

l_s	Effective span of multi-slat unit.
l_u	Upper roof span of multispan for snow load calculation.
l_v	Width of lower roof affected by increased snow load on multispan.
n	Number of slats in a multi-slat unit.
N	Return period for loading (in years).
P_B	Characteristic load from bedding (including allowance for livestock) acting horizontal to the wall (in kN/m^2).
P_G	Concentrated tractor loads on walls for grass silage (part load) (in kN).
P_L	Vertical load on floors from livestock applied on any square with a 300 mm side (in kN).
P_s	Vertical load from livestock applied on a single slat (in kN/m).
P_v	Vertical load on floors from vehicles applied on any square with a 300 mm side (in kN).
r	Least radius of gyration of a section.
S_A	Additional characteristic load from snow lying on the ground with a probability level of 0.63 and a return period of 5 years, for every 100 m of altitude above mean sea level (in kN/m^2).
S_G	Total characteristic load from snow lying on the ground at the design altitude with a probability level of 0.63 and a return period of 5 years (in kN/m^2).
$S_{G(N)}$	Total characteristic load from snow lying on the ground at the design altitude with a probability level of 0.63 and a return period of N years (in kN/m^2).
$S_{K(N)}$	Total characteristic load from snow on roof at the design altitude with a probability level of 0.63 and a return period of N years (in kN/m^2).
S_L	Characteristic load from snow lying on the ground with a probability level of 0.63 and a return period of 5 years reduced to mean sea level (in kN/m^2).
SC2, 3, 4, 6	Strength class of timber as given in BS 5268 : Part 2.
T_G	Triangular shaped horizontal load on walls from grass silage (part load) (in kN/m^2).
v_c	Design concrete shear stress as given in BS 8110 : Part 1.
V_s	Design wind speed as given in CP 3 : Chapter V : Part 2 (in m/s).
W_G	Uniformly horizontal load from grass silage (part load) (in kN/m^2).
W_L	Uniformly distributed vertical load over gross floor area from livestock (in kN/m^2).
W_p	Design load on purlins derived from the dead load plus imposed load (including services but excluding wind) taken as acting normal to the roof slope (in kN).

*In preparation.

W_s	Vertical load on the gross floor area to be used in the design of slat supports (in kN/m^2).
W_v	Uniformly distributed vertical load over the gross floor area from vehicles (in kN/m^2).
Y_s	Specified minimum yield strength of steel as given in BS 5950 : Part 1.
z	Depth below rolled surface of grass silage or the compacted surface of bedding (in m).
γ_c	Classification factor for agricultural buildings and structures.
γ_f	Partial safety factor for load as given in BS 5628 : Part 2, BS 5950 : Part 1 and BS 8110 : Part 1.
μ	Conversion factor for snow on ground $S_{G(N)}$ to snow on roof $S_{K(N)}$.
ω	Conversion factor for return periods for snow loads based on 5 year return as unity.

3 Preparation of site

3.1 The site of any building should be effectively cleared of turf and other vegetable matter.

3.2 If any drains are severed during the excavations in connection with the building, its drains or services, effective steps should be taken to secure the continued passage of the below ground water through or around the site and to deal with any surface water which may run on to the site.

4 Durability

4.1 Durability life may be different from design life. Where required, guidance should be sought on durability life of materials.

NOTE. This information may normally be obtained from the manufacturer or supplier.

4.2 Unless otherwise stated, the structural components and the external envelope should, with reasonable maintenance, remain efficient for the design life.

5 Foundations

5.1 For the design and construction of foundations of a building, reference should be made to BS 8110 : Part 1 and BS 8004.

Attention should be paid to the possibility of attack by sulphates or any other deleterious matter which may be present in the soil.

5.2 The foundations of a building should:

- (a) safely sustain and transmit to the ground the worst combination of dead load, imposed load and wind load so that it does not cause any settlement or other movement which would impair the stability of, or cause damage to, the building or any adjoining building or works;
- (b) be taken down to such a depth, or be so constructed, as to safeguard the building against damage by swelling, shrinkage or freezing of the subsoil;
- (c) be designed to resist overturning moments or sliding forces, especially where lateral imposed loads, induced by the storage of agricultural or other products against walls, are transferred to the foundations.

6 Works below ground

6.1 Ducts, tanks, hoppers and other works below ground should be so designed and built as to resist external ground pressures including, if relevant, the pressure due to the presence of ground water, nearby foundations and other loadings.

Where liquids are to be retained in such ducts, tanks, etc., they should be so constructed as to prevent any contamination by the escape of such liquids into the subsoil and the entry of ground water into the duct, tank or other receptacle.

Where tanks are constructed in ground which has a high water table, adequate means of preventing flotation should be provided.

6.2 Covers to ducts, tanks, pits and similar constructions should be provided as necessary. They should be constructed to withstand all loads from livestock, stored materials, the transporting of materials over them, and all vehicles used in the building or its environs, or be provided with suitable barriers to prevent such access.

6.3 The construction of any duct, tank, receptacle or other underground works should be capable of resisting any attack by sulphates, acids (such as are produced by the fermentation of silage), manure, washings, and any other deleterious matter present in the stored material or in the subsoil.

7 Structure above foundations

The structure of a building above the foundations should safely sustain and transmit to the foundations or base the combined loads without such deflection or deformation as would impair the stability of the whole or any part of the building, or any other building.

NOTE. For above ground storage in reservoirs, lagoons and tanks, the Reservoirs Act 1975 applies [4]. All structures in excess of 25 000 m³ capacity above the lowest adjoining natural ground level are required to be designed and the construction supervised by a panel engineer. Lists of panel engineers are held by the Department of the Environment and by the Scottish Development Department.

8 Protection of floors

8.1 Where floors of buildings in contact with the ground are used for the storage of grain, seeds, concentrated feed stuffs, fertilizer or for the housing of livestock on insulated floors, they should be so constructed as to prevent the passage of moisture from the ground to the upper surface of the floor or the underside of the insulation.

8.2 Moisture barriers are not normally required for floors for crop production; livestock on a bedding of straw, wood shavings or other absorbent materials; storage of fodder crops and farm wastes; the housing of implements. Notwithstanding the above, attention is drawn to the need to prevent the passage of slurries and wastes, especially silage effluent, to ground water. In addition, it should be considered that buildings may be used in the future for alternative uses.

8.3 Hardcore laid and compacted under any floor should contain no water-soluble sulphates or other deleterious matter in such quantities that it may cause damage to any part of the floor.

8.4 Concrete floors subject to attack by organic acids (see BS 5502 : Section 3.2 for chemical composition of waste products) should be designed and constructed to resist very severe exposure conditions as given in table 3.2 of BS 8110 : Part 1 : 1985 (see also 14.5.4 and 14.5.5). Such floors should be well compacted, cured and, where necessary, be provided with a surface coating.

8.5 Where suspended timber floors are constructed, damp-proof courses should be provided to prevent moisture from the ground adversely affecting the timber or other materials in the floor.

8.6 In class 1 and class 2 buildings (see clause 12) where a timber floor is constructed as a suspended floor, other than above a pit or cellar for the storage of dung, the ground surface should be suitably sealed. The space between such a seal and any timber should be not less than 125 mm and such space should be clear of debris and have adequate through ventilation.

8.7 Where a suspended floor constructed from timber is placed over a cellar or pit specially designed for the storage of dung, reference should be made to BS 5502 : Section 3.2 for the appropriate protective treatment against decay.

9 Protection of walls, piers and columns

9.1 Any wall, pier, or column of a building should be so designed as not to transmit moisture from the ground and,

in the case of external walls, piers or columns, moisture due to rain or snow to any other material which is liable to be adversely effected by it.

9.2 If, for reasons such as hygiene, the walls are regularly subjected to the application of water, or where the products stored therein would cause the walls to be damp, an additional protective surface treatment should be applied over the affected area.

10 Protection of roofs

10.1 Except as stated in 10.2, the roof of any building should be weatherproof and so constructed that it will not transmit moisture due to rain or snow to any part of the structure or its contents which would be adversely affected by such moisture.

10.2 The recommendation in 10.1 does not apply to those buildings where, because of internal environmental requirements, it is necessary to provide openings in the roof for the entry of fresh air or the exhaust of foul air. Where air from such vents may cause corrosion of the surrounding materials, precautions should be taken to protect them.

11 Balustrades and safety rails

Balustrades and/or safety rails should be provided for any workplace or walkway which is situated more than 1.5 m above floor or ground level. They should comply with BS 6180 as modified by 13.12 (see also BS 5502 : Section 1.6).

12 Design classification

12.1 Every farm building and structure should be designed in accordance with one of the four classes given in table 1. All drawings and written reference should include information on the class upon which the design is based.

12.2 Buildings and structures are designated according to the density of human occupancy and the location of the building and to the return period of loadings (design life) on all structural members (including purlins and sheeting rails). The design life does not necessarily relate to the durability of materials of construction (see 4.1).

12.3 For retaining structures or buildings containing a retaining element, the density of occupancy applies within the structure's zone of effect (see 2.1 and figure 1).

12.4 It is necessary, when determining the design classification of a building, for it to satisfy both the occupancy and distance recommendations stated for the class.

12.5 Care should be taken when siting buildings and structures to ensure that the classification of existing buildings and structures is not infringed.

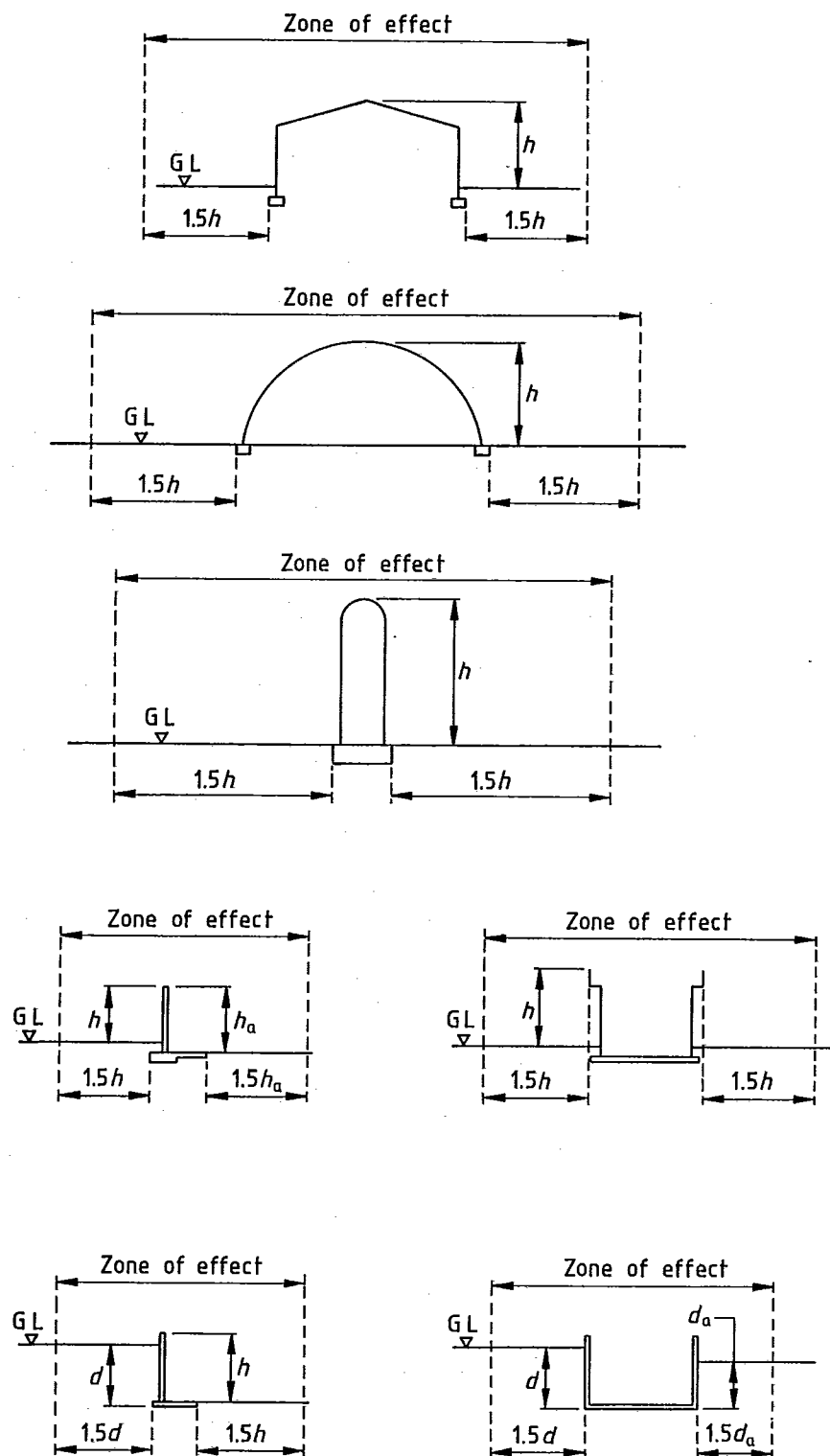


Figure 1. Examples of zone of effect for retaining structures

Table 1. Design classifications

Class (see note 1)	Maximum normal human occupancy within a building or its zone of effect where applicable (person h/year) (see note 2)	Minimum allowable distance to a classified highway or human habitation (see note 3)	Minimum design life
1	Unrestricted	m Unrestricted	years 50
2	Not exceeding 6 h/day at a maximum density of 2 persons/50 m ² (4380/50 m ²)	Either 10 or zone of effect if greater than 10	20
3	Not exceeding 2 h/day at a maximum density of 1 person/50 m ² (730/50 m ²)	Either 20 or zone of effect if greater than 20	10
4	Not exceeding 1 h/day at a maximum density of 1 person/50 m ² (365/50 m ²)	Either 30 or zone of effect if greater than 30	2
NOTE 1. The risk of building collapse is greater in buildings of larger classification number. NOTE 2. If it is known that the occupancy may for short periods (less than 70 days) be of higher density or a larger number of hours per day, then the cumulative effect over a year of all occupancy within a 50 m² area, should be aggregated. If the cumulative effect exceeds the person hours per year figure then the next higher classification should be used. NOTE 3. Distance from a structure to a classified highway or human habitation means the distance to the edge of highway (including footway) or nearest point of human habitation.			

13 Loadings

13.1 General

13.1.1 Loads. This clause covers loads particular to agriculture, other than those covered in BS 6399 : Part 1 or those derived from BS 648 or other relevant British Standards.

13.1.2 Characteristic loads. A characteristic value of load should be evaluated from a mean load together with a factored standard deviation from that mean value. For example, the wind loads given in CP 3 : Chapter V : Part 2 are true characteristic loads since they are statistically based, as are the characteristic loads for snow given in 13.6. Not all the values herein have been obtained from statistical studies, but they are based upon figures used by engineering designers for many years, and the values given may be considered as characteristic values for the purposes of limit state calculations and working stress design.

13.1.3 Dead and imposed loads. Dead and imposed loads should be taken as the loads as defined in, and calculated in accordance with, BS 6399, except as given in 13.4 to 13.12.

13.1.4 Loads from stored materials. Loads and pressures exerted by certain agricultural products should be assessed by special formulae to take account of their physical characteristics, method of storage and dynamic effects.

In assessing loads, consideration should be given to the available height, the method of storage and the physical

properties of the material being stored. In the case of materials such as silage, compaction loads should also be considered.

Where there is the possibility of exceeding the design parameters (such as available height being greater than design height) suitable notices stating the design limitations should be clearly displayed.

The characteristic values of the densities, angle of repose and shearing resistance of stored materials given in table 7 are for the material as stored. No account has been taken of any variation of moisture content or chemical composition during the time that the material is in storage, and it is assumed that (unless stated) no mechanical or other means of consolidation are applied during or following the deposition of the material.

Where the properties of a material may be affected by absorption, loss of moisture, or unusual packing, this should be considered in the design.

13.2 Impact loads

Due consideration should be given to impact loads from machinery and animals especially in regard to walls used as loading blocks and barriers used to retain animals.

NOTE. Loading blocks are defined as walls which machinery such as fore-end loaders may drive against when filling the bucket.

13.3 Dynamic loads

Where loads arising from machinery (moving or static), runways and other plant producing dynamic loads are supported by, or transferred to the framework, allowance should be made for such dynamic effects.

13.4 Wind loads

13.4.1 General. Wind loads should be taken as the wind loads defined in, and calculated in accordance with CP 3 : Chapter V : Part 2 with the exception of canopy roof structures.

13.4.2 Wind loading on canopy roof structures

NOTE. The 1984 edition of BRE Digest 284 should not be used. Table 13 of CP 3 : Chapter V : Part 2 : 1972 (including amendments) is not applicable to these recommendations.

13.4.2.1 Canopy roof structures should be designed in accordance with Building Research Establishment Digest 284, 1986 [1] which is compatible with CP 3 : Chapter V : Part 2 : 1972. Wind loads arising from all possible blockage configurations, including empty, should be considered.

13.4.2.2 Wind loads on gable-end fascias should be calculated using (a) a net pressure coefficient value of +1.2 (i.e. pressure acting into the building) for the windward gable of an empty canopy under a longitudinal wind, and (b) a net pressure coefficient of -1.6 (i.e. pressure acting out of the building) for either gable of a canopy fully-blocked to the downwind eaves under a wind normal to the open face.

13.5 Imposed roof loads other than wind loads

13.5.1 General. For roofs with no access provided (other than that necessary for cleaning and repair) the imposed load should be derived from either:

- (a) a snow load as given and calculated in accordance with 13.6; or
- (b) a snow load as given in table 2, provided that the altitude of the site is less than 100 m.

Table 2. Generalized snow loads (altitude less than 100 m)	
Class	Load
	kN/m ²
1	0.67
2	0.53
3	0.42
4	0.19

In addition to (a) and (b), service loads should be added where appropriate.

13.5.2 Service loads. The necessity of allowing an extra load to cater for services and/or contingencies, particularly when the total load (dead plus imposed) is low, should be considered and such extra load should be based upon the anticipated normal use of the building.

13.5.3 Roof coverings other than glazing. Any part of a roof covering should be capable of withstanding a point load of 0.9 kN concentrated on a square with a 125 mm side.

13.6 Snow loads

13.6.1 General. A method is given in 13.6.2 to 13.6.6 for calculating the roof loading from snow.

NOTE. Snow loads both on the ground and on roofs are generalized and exceptional local effects cannot be ignored. Local shelter from wind may increase the load and uneven warmth or insulation may cause unbalanced loading conditions. Mountainous areas may have local configurations which funnel the snow, resulting in increased loading. Where additional information is required, the nearest meteorological office or local informed sources should be consulted.

Snow loads derived from 13.6 may be lower than those loads given in table 2. These lower loads should be used with caution and only after due consideration of all the factors outlined in 13.6.

13.6.2 Calculation of snow load

13.6.2.1 Summary of the steps in the calculation

- (a) Obtain values for S_L (13.6.2.2) and S_A (13.6.2.3) and hence S_G (13.6.2.4).
- (b) Adjust for return period to obtain $S_{G(N)}$ (13.6.2.5). The design life should be taken as the return period.
- (c) Convert $S_{G(N)}$ to $S_{K(N)}$ (13.6.2.6) dependent upon:
 - (1) whether a primary or secondary member is being considered;
 - (2) the roof pitch;
 - (3) the roof profile.

13.6.2.2 Evaluating S_L . Values of S_L are shown on the map (figure 2) as isopleths drawn at 0.05 intervals from zero to 0.20 and at 0.10 intervals above 0.20. Interpolation is allowed, but in some areas this is difficult. In these cases the higher value should be used.

13.6.2.3 Evaluating S_A . Values of S_A for every 100 m of altitude above mean sea level are shown on the map (figure 2) on a scale running south to north with a value of 0.06 at the south coast of England and a value of 0.09 at the north of Scotland.

A line drawn at right angles to the scale will give a value for all sites falling on the line except for an area covering the Welsh coast and parts of the coast of south west England where a value of 0.06 applies.