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Temporary structure - Tents - Safety

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National foreword

This British Standard is the UK implementation of EN 13782:2015. It supersedes BS EN 13782:2005 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee MCE/3/4, Fairground and amusement park machinery and structures - Safety.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Fliegende Bauten - Zelte - Sicherheit

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Foreword

This document (EN 13782:2015) has been prepared by Technical Committee CEN/TC 152 “Fairground and amusement park machinery and structures - Safety”, the secretariat of which is held by UNI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by October 2015, and conflicting national standards shall be withdrawn at the latest by October 2015.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 13782:2005.

The main changes in comparison to EN 13782:2005 are:

a) chapters have been restructured and condensed in form and content;

b) technical additions in reference to the Eurocodes;

c) adjustments of the notations used in the Eurocodes;

d) editorial corrections and changes.

According to the CEN/CENELEC Internal Regulations, the national standards organisations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Introduction

The object of this European Standard is to provide safety requirements for tents. The safety requirements are aimed to safe-guard persons and objects against damage caused by design, manufacturing and operation of these structures.

These guidelines have been drawn up according to past experience and risk analysis.

Existing national rules concerning health and safety of workers remain untouched.

1 Scope

This European Standard specifies safety requirements which need to be observed at design, calculation, manufacture, installation, maintenance, of mobile, temporary installed tents with more than 50 m^2 ground area.

This European Standard applies also to multiple small tents which are normally not covered by this standard and will be installed close together and exceed 50 m^2 in sum.

NOTE Information is given in Annex C on Examination and Approval.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 818 (all parts), *Short link chain for lifting purposes — Safety*

EN 1090 (all parts), *Execution of steel structures and aluminium structures*

EN 1990, *Eurocode - Basis of structural design*

EN 1991-1-1, *Eurocode 1: Actions on structures - Part 1-1: General actions - Densities, self-weight, imposed loads for buildings*

EN 1991-1-3, *Eurocode 1 - Actions on structures - Part 1-3: General actions - Snow loads*

EN 1991-1-4: *Eurocode 1: Actions on structures - Part 1-4: General actions - Wind actions*

EN 1997-1, *Eurocode 7: Geotechnical design - Part 1: General rules*

EN 10204:2004, *Metallic products - Types of inspection documents*

EN 12385-1, *Steel wire ropes — Safety — Part 1: General requirements*

EN 12385-2, *Steel wire ropes — Safety — Part 2: Definitions, designation and classification*

EN 12385-3, *Steel wire ropes — Safety — Part 3: Information for use and maintenance*

EN 12385-4, *Steel wire ropes — Safety — Part 4: Stranded ropes for general lifting applications*

EN 15619, *Rubber or plastic coated fabrics - Safety of temporary structures (tents) - Specification for coated fabrics intended for tents and related structures*

ISO 2602, *Statistical interpretation of test results — Estimation of the mean — Confidence interval*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
tent
mobile, temporary installed structure enclosed with covers (textiles, foils) or partly with rigid elements

Note 1 to entry: It can be built as an enclosed or open building i.e. marquee, tent-hall, booth.

3.1.1
tent with primary load-bearing structure
load bearing structure with enclosing elements

EXAMPLE Structures with primary load bearing structure can be roofs, frameworks, post-and-beam system.

3.1.2
membrane tent
tent with a load bearing pre-stressed textile structure with double curved shape, supported by masts and/or cables

3.1.3
pole tent
tent with centre poles, where guying is used to stabilize the fabric covering

3.2
initial approval
design and calculation review, verification, examinations and tests necessary for tent operation

3.3
modification
any alteration of a tent which results in a departure from the original design specification

3.4
repair
restorations of worn, damaged or decayed parts back to the original design specification

3.5
maintenance
replacement of components which are designed to be replaced at specified intervals

4 General requirements for design, analysis and examination

4.1 Design documents

The design documents shall include information for the verification of the stability, resistance and operating safety, especially a description of the construction and operation, the stability verification and design drawings as well as relevant documents concerning the burning behaviour.

The documents shall include all the possible configurations of the tent.

4.2 Description of construction and operation

The tent in particular its design and utilization and its static system shall be explained in this description.

The description shall include details of the particular features of the tents and of any alternative modes of installation which may exist, also details of the main dimensions, limitations, design particulars and materials.

4.3 Construction drawings

These shall exist for all sub-assemblies and individual components, the fracture or failure of which might endanger, the stability or operating safety of the tent.

The construction drawings shall feature all the dimensions and cross section values required for testing and approval, also details of materials, structural components, fasteners and connectors.

The construction plans shall comprise the following:

— General drawings in plan view, elevation and sections, to one of the following scales, i.e. 1:100, 1:50 or 1:20. If clearness and readability does not suffice other scales shall be used;

— Detail drawings relating to all the structural subassemblies not clearly discernible on the general drawings, also detail plans of connections and of individual items of structural nature that are likely to affect the safety of the tent and of its operation, drawn to a larger scale.

5 Selection of materials

5.1 General

Only materials in respect of which design data are featured in European Standards shall be used for structural components.

Other materials can only be used on condition that proof of their serviceability has been established. The designer shall give special consideration to structural joints which are to be welded and the weldability of the selected metals in accordance with European Standards.

5.2 Selection of covering materials

For rubber and plastic coated fabrics EN 15619 applies. The supplier certification shall be provided.

For other fabric materials and cladding elements of:

— cotton fabrics;

— synthetic fabrics;

— solid covering and sheeting such as sectional metal sheets, wood or plastic panels and multi components elements,

the following requirements shall be regarded:

— fabric materials designated for structural use shall conform to EN standards or, in absence, to agreement by the parties involved;

— it shall be ensured that the material and the connections specified provides sufficient weathertightness, tensile strength to ensure safe and durable performance of the textile cover. The partial safety factors for structural use of fabrics shall be according to 8.6;

— standards for textile, membrane and inflatable structures.

5.3 Joining of covering materials

Joints by sewing, welding and adhesives and zips shall conform to the relevant EN standards or shall be tested for their ultimate tear and shear properties. The ageing and environmental influences shall be taken into account by the application of additional partial safety factors.

Zips shall be tested for their strength to withstand the calculated loads of the structure. Effects of wearing out and influence of UV light on plastic shall be considered.

If suitable structural strength cannot be verified they can only be used in non-safety critical applications.

6 Principles of numerical analysis

6.1 General

If subsequently not determined differently, the verification shall follow the relevant part of the Eurocode and shall comprise:

— limit states analysis (according to theory of 1st or 2nd order);

— stability limit states analysis, i.e. bar buckling plate and shell buckling;

— if required, verification of deformation limit states;

— verification of safety against overturning, sliding and lifting off.

6.2 Verification

The verification shall include the following details, amongst others:

— design loads, taking into account the possible operating conditions or installations alternatives. Special loads imposed during erection should be recognized;

— information concerning material and components;

— main dimensions and cross-section values of all load bearing structural components;

— determination of the most unfavourable stresses and details relating to the strength of the load bearing structural components and of the fasteners;

— if calculations are insufficient to evaluate limit states of assemblies the analysis may be substituted by testing at an independent testing body. There, the testing body shall commit the appropriate number of tests, samples, the testing procedure, the reporting etc., according to the relevant EN standards or in absence of the relevant EN standards by agreement with the parties involved;

— details of deformations (flexure, torsion), in as much as such details affect the serviceability or operating safety of the tent;

— details of those components which require special examination and inspection.

7 Design actions

7.1 General

All the applicable actions shall be taken into account according to EN 1991-1-1, EN 1991-1-3 and EN 1991-1-4.

Adaptations due to the special utilization of tents are stated in the following chapters.

7.2 Permanent actions

For tents a very precise assumption of the permanent actions is possible. As far as variation can occur the values $G_{k,sup}$ and $G_{k,inf}$ shall be taken into account for assessing the applicable structural response. Elsewhere a single characteristic value G_k is sufficient:

— G_k characteristic value of permanent action;

— $G_{k,sup}$ upper characteristic value of permanent action;

— $G_{k,inf}$ lower characteristic value of permanent action.

Included in the above category are the actual dead loads of the load bearing structure, of the accessories and of the technical equipment required for operation also the claddings, decoration and the like. The influence of dry or wet material conditions shall be recognized ($G_{k,sup}$, $G_{k,inf}$).

7.3 Equivalent load

The stability shall be checked with a vertical uniformly distributed equivalent load of q_{el} = 0,1 kN/m^2 on the roof. This load shall not be combined with other load cases, except self-weight.

7.4 Variable actions

7.4.1 Live loads

7.4.1.1 Vertical loads for areas with universal, public access

The following vertical imposed loads shall be applied for:

— Floors, stairways, landings, ramps, entrances, exits and the like in facilities (tents, booths):

q_k = 3,50 kN/m^2

— Raised floors and platforms or if particularly dense crowds are anticipated for the above mentioned category:

q_k = 5,00 kN/m^2

— Stairs, alternatively, an area load in accordance with clauses above, whatever is more unfavourable:

Q_k = 1,00 kN per step

— Seat boards of rows of seats per seat run and for floors between fixed rows of seats, unless higher loads results from the application of area loads (q_k = 3,5 kN/m^2):

q_k = 1,50 kN/m

7.4.1.2 Vertical loads for areas not open for public access

The following vertical imposed loads shall be applied for:

— All floors, platforms, ramps, staircases, catwalks and the like which are walked over by individual persons, whatever is more unfavourable:

q_k = 1,50 kN/m^2

or

Q_k = 1,50 kN individual load

7.4.1.3 Horizontal imposed loads

The following horizontal imposed loads shall be applied for parapets, fences, railings, wall panels etc.

When bounding floors with public access designed for q_k = 3,50 kN/m^2:

— q_k = 0,50 kN/m at hand rail height;

— q_k = 0,10 kN/m at intermediate rail height.

When bounding floors with public access designed for q_k = 5,00 kN/m^2:

— q_k = 1,00 kN/m at hand rail height;

— q_k = 0,15 kN/m at intermediate rail height.

When bounding floors without public access designed for q_k = 1,50 kN/m^2:

— q_k = 0,30 kN/m at hand rail height;

— q_k = 0,10 kN/m at intermediate rail height.

In order to achieve an adequate longitudinal and transverse stiffness in the case of raised floors and platforms in tents, a horizontal load acting at every floor level in the most unfavourable direction in each case simultaneously shall be entered in the calculation in addition to any eventual wind force in accordance with 7.4.2. This horizontal component load shall be taken as 1/20th of the imposed vertical load in accordance with 7.4.1.1 and 7.4.1.2.

7.4.2 Wind loads

7.4.2.1 General

The wind loads shall be based on EN 1991-1-4, assuming that the special nature of the textile covers is taken into account and regarding:

— location;

— duration and period of installation;

— use under supervision of an operator;

— possibilities of protecting and strengthening.

7.4.2.2 Minimum loads

For any other location where the fundamental value of the basic wind velocity $v_{b,0}$ > 28 m/s, calculations shall be provided for the tent verifying the stability and resistance with the local conditions. For the determination of the necessary peak velocity pressure $q_p(z_e)$ EN 1991-1-4 shall apply in conjunction with the requirements of the national annexes. The values obtained may be reduced by the factor 0,7.

For locations where the fundamental value of the basic wind velocity $v_{b,0} \leq 28$ m/s, the wind load per unit may be evaluated applying the following minimum values.

The wind pressure acting on the external surfaces, w_e, should be obtained from the following expression:

$$w_e = q_p(z_e) \cdot c_{pe} \quad (1)$$

where

$q_p(z_e)$ is the peak velocity pressure (as a function of the reference height for the external pressure), in kN/m²;

z_e is the reference height for the external pressure, in m;

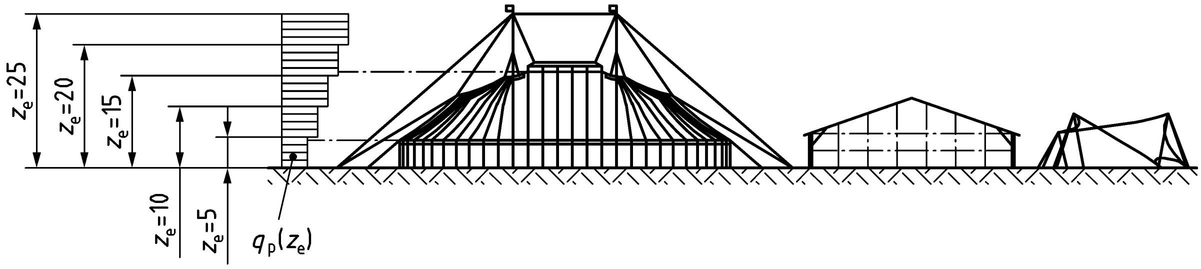
c_{pe} is the pressure coefficient for the external pressure.

Table 1 — Peak velocity pressure $q_p(z_e)$

Reference height z_e m	**Peak velocity pressure** $q_p(z_e)$ kN/m²
$z_e \leq 5$	0,50
$5 < z_e \leq 10$	0,60
$10 < z_e \leq 15$	0,66
$15 < z_e \leq 20$	0,71
$20 < z_e \leq 25$	0,76

Contrary to the pressures specified in Table 1, a reduced peak velocity pressure of $q_p(z_e)$ = 0,30 kN/m² may be applied in the case of tents with a width of 10 m or less and height of 5 m or less.

Dimensions in metres



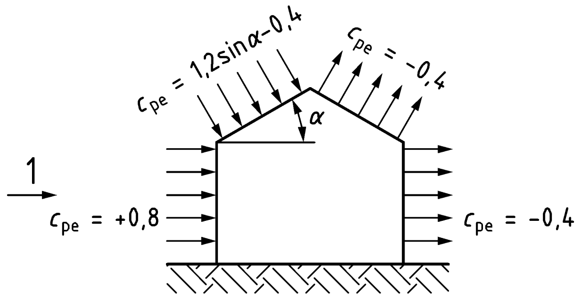
Key

z_e reference height for the external pressure

$q_p(z_e)$ peak velocity pressure (as a function of the reference height for the external pressure)

Figure 1 – Reference height z_e and corresponding peak velocity pressure profile $q_p(z_e)$

In general the pressure coefficients for various structures and structural members shall be taken from EN 1991-1-4. However on the basis of past experience with tents of conventional design, the shape factor for gable roof structures of the type illustrated in Figure 2 may be determined with the aid of the external pressure coefficients, c_{pe}, given there. The internal pressure coefficient, c_{pi}, need not be taken into account for closed structures.



Key

1 direction of wind

α angle of the roof pitch

c_{pe} external pressure coefficient

Figure 2 — External pressure coefficient c_{pe} for closed tents of gable roof shape

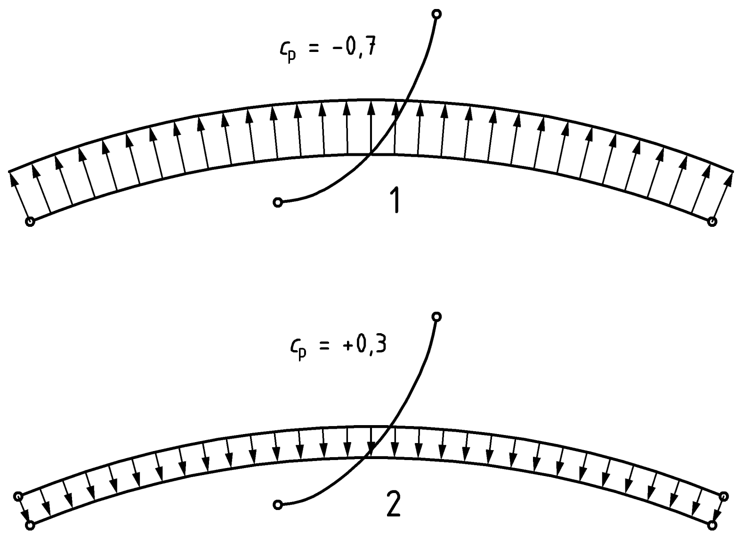
NOTE The pressure coefficients, c_p, for closed tents of round shape are presented in Annex A.

7.4.2.3 Wind on the membrane load bearing structure

The pressure coefficients may be taken according to EN 1991-1-4, or to wind tunnel test.

Wind tunnel testing shall be done by an experienced laboratory in accordance with EN 1990.

Pressure coefficients are presented in Figure 3.



Key

1 wind up

2 wind down

c_p pressure coefficient

Figure 3 — Pressure coefficient c_p

7.4.3 Snow loads

Snow loads shall be applied in accordance with EN 1991-1-3.

Snow loads need not to be taken into account for tents:

— erected in areas, where there is no likelihood of snow or;

— operated at a time of the year, where the likelihood of snow can be discounted or;

— where by design or operating conditions snow settling on the tent is prevented;

— where pre-planned operation action prevents snow from settling on the tent.

This last condition may be achieved by:

— sufficient heating equipment is installed and is ready for use and;

— heating is started prior to snow fall and;

— tent is heated in such a way, that the whole roof cladding has an outside air temperature of more than + 2 °C;

— cladding is made and tensioned in such a way, that ponding of water or any other deformations of the cladding cannot take place.

If a snow height not exceeding 8 cm is ensured by removing snow, a reduced snow load for tents may be applied with q_k = 0,20 kN/m^2 on the overall roof area.

7.4.4 Seismic forces

Seismic forces may generally not be considered because of the flexibility and the light weight of the tent.

7.5 Load combinations

Load combinations shall be applied in accordance with EN 1990.

The design values of the actions may be simplified with the following combinations and partial safety factors:

$$E_\text{d} = \max \begin{Bmatrix} \gamma_\text{G}\, G_\text{k} + \gamma_{\text{Q},1}\, Q_{\text{k},1} \\ \gamma_\text{G}\, G_\text{k} + \sum \gamma_{\text{Q},i}\, Q_{\text{k},i} \\ \gamma_\text{G}\, G_\text{k} + \gamma_{\text{Q,el}}\, Q_{\text{k,el}} \end{Bmatrix} \tag{2}$$

where

E_d	is the design value of effect of actions;
γ_G = 1,35	is the partial safety factor for unfavourable permanent actions;
γ_G = 1,00	is the partial safety factor for favourable permanent actions;
$\gamma_{\text{Q},1}$ = 1,50	is the partial safety factor for only one variable action;
$\gamma_{\text{Q},i}$ = 1,35	is the partial safety factor for more variable actions;
$\gamma_{\text{Q,el}}$ = 1,35	is the partial safety factor for equivalent load;
G_k	is the characteristic value of permanent action;
$Q_{\text{k},1}$	is the characteristic value for only one of the variable actions;
$Q_{\text{k},i}$	is the characteristic value for more variable actions;
$Q_{\text{k,el}}$	is the characteristic value of vertical equivalent load according to 7.3.

8 Verification of stability and equilibrium

8.1 General

The limit states due to all different actions shall be determined separately for the individual actions of Clause 7. The limit states due to the combinations of actions shall be calculated. It shall be verified that the design value of internal forces or moments does not exceed the corresponding design resistance of the respective part and the ultimate or serviceability limit state is not exceeded.

Special consideration shall be given to the limit state verification regarding deformation and stability, as the deformation limit can be a decisive value. Any favourable effect resulting from the 2$^{\text{nd}}$ order theory may be taken into account.

All verifications shall be performed for the most unfavourable loading. In this connection, the permanent, variable and accidental actions shall always be assumed to have the position and magnitude which result in the most unfavourable limit states for the structural and mechanical components to be calculated. For structural and mechanical components and items of equipment which are not permanent fixtures, it shall also be ascertained whether more unfavourable conditions are likely to arise when such items are displaced or removed.

Non-standard formula shall be recorded in writing with the symbols in accordance with European Standards or International Standards. The sources of such formula shall be stated, if this source is accessible to everyone.

In other cases, the derivation of the formula shall be presented to such an extent that their correctness can be verified.

If computer processing for calculation is used, special consideration shall be given to the requirements for the review of computer calculations during the design approval. Clear information concerning the software, formula, units etc. shall be submitted. Input and output shall be completely printed. The correctness of the input assumptions and the output shall be comprehensively reviewed during design approval.

The design value of the resistance, R_d, shall be evaluated in accordance with the following formula:

$$R_d = \frac{R_k}{\gamma_M} \quad (3)$$

where

R_k is the characteristic value of the resistance;

γ_M is the partial safety factor for a material property.

The values stated in the respective European Standard shall be taken into account.

8.2 Verification against overturning, sliding and lifting

8.2.1 General

Safety against overturning, sliding and lifting shall be calculated.

Favourably acting permanent actions shall be taken into account with their lower value only.

If sufficient safety cannot be guaranteed by virtue of the dead load of a structure alone, then further additional steps shall be taken to ensure it, such as counterweights, anchorages and buttresses for example.

As the weight of tents can be determined accurately, the following minimum partial safety factors shall be applied:

Table 2 — Partial safety factor γ against overturning, sliding and lifting

	Loading	γ
1	Favourably acting proportions of the dead load	1,0
2	Unfavourably acting proportions of the dead load	1,1
3	Unfavourably acting wind loads	1,2
4	Unfavourably acting proportions of loads other than the loads listed in items 2 and 3	1,3
NOTE If loads are resolved into components, then these components should be multiplied by the same value of γ.		

8.2.2 Safety against overturning

The safety against overturning shall be calculated from:

$$\sum \gamma M_{Rk,\,stb} \geq \sum \gamma M_{Ek,dst} \tag{4}$$

where

γ are the partial safety factors in accordance with Table 2;

$M_{Rk,stb}$ are the stabilizing moment proportions (characteristic value);

$M_{Ek,dst}$ are the overturning destabilizing moment proportions (characteristic value).

8.2.3 Safety against sliding

The safety against sliding shall be calculated from

$$\mu \cdot \sum \gamma N_k \geq \sum \gamma H_k \tag{5}$$

where

μ is the coefficient of friction in accordance with Table 3;

γ are the partial safety factors in accordance with Table 2;

N_k are the vertical load components (characteristic value);

H_k are the horizontal load components (characteristic value).

The following coefficients of friction may be assumed for the determination of the frictional forces, unless higher values determined by tests are available in individual cases, or unless moisture dictates the adoption of lower values.

Table 3 — Coefficient of friction μ

	Wood	Steel	Concrete
Wood	0,40	0,40	0,60
Steel	0,40	0,10	0,20
Concrete	0,60	0,20	0,50
Clay[a]	0,25	0,20	0,25
Loam[a]	0,40	0,20	0,40
Sand and gravel	0,65	0,20	0,65

a At least of stiff consistency in accordance with EN 1997–1.

It shall be borne in mind that loosening by vibration may occur in the case of supports subjected to vibratory stress.

If stability is not attained by static friction alone then the structure should be anchored in the ground. In such cases the safety against sliding shall be calculated in conjunction with the action of soil anchors. In this context, the coefficient of friction in accordance with Table 3 shall only be entered in the calculation at 70 % of the listed values.

$$\bar{\mu} \cdot \sum \gamma N_{\text{k}} + Z_{\text{h,d}} \geq \sum \gamma H_{\text{k}} \qquad (6)$$

where

$\bar{\mu} = 0{,}7\mu$

$Z_{\text{h,d}}$ is the horizontal design load bearing capacity of rod anchors.

8.2.4 Safety against lifting

The safety against lifting shall be calculated from:

$$\sum \gamma N_{\text{Rk,stb}} \geq \sum \gamma N_{\text{Ek,dst}} \qquad (7)$$

where

$N_{\text{Rk,stb}}$ are the vertical stabilizing load components (characteristic value);

$N_{\text{Ek,dst}}$ are the vertical lifting destabilizing load components (characteristic value).

With anchor ties there is the following relationship:

$$\sum \gamma N_{\text{Rk,stb}} + Z_{\text{v,d}} \geq \sum \gamma N_{\text{Ed,dst}} \qquad (8)$$

where

$Z_{\text{v,d}}$ is the vertical design load bearing capacity of rod anchors.

8.3 Dead load for tent covers

The dead load of dry canvas shall be assumed as being g_{k} = 0,005 kN/m^2 for the calculation of the structures in respect of wind pressure from below which is required for the assessment of the safety against overturning and for the sizing of the anchoring; for all other purposes, it shall be assumed as specified in EN standards or, in absence, in agreement by the parties involved.

8.4 Structures with primary load bearing structure

8.4.1 Ballast mountings for protection against wind suction loads

Where the actions from mountings (furniture in the tents) can be confirmed as permanent actions they may be included in the calculations. For anchor loads etc. see also 9.3.

8.4.2 Wind bracings

The wind bracings arranged in the roof and wall plane shall be capable of absorbing the forces acting on the gables. Two wind bracings may be arranged in consecutive bays in such a way that each is designed to absorb one half of the forces acting on the gable. The intermediate bracings shall be designed for half of the forces acting on the gable. Intermediate bracings shall also be provided for those structures, where gable forces do not occur. Generally a maximum of six bays, not exceeding 30 m, free of bracings may be situated between the bracings. If not, a special calculation shall be carried out.

In braced bay all forces arising in the main frame due to the bracing shall be considered, including the forces required to provide stability. The main frame members (forces for the stabilization of the roof trusses etc.) shall also be taken into account in the sizing of the bracings.

In case of pitch roofs, where in the bracing area deflection forces arise from the angle of the frame girders at the ridge, these forces shall be taken into account.

8.4.3 Cladding forces on the structure due to wind

Wind acting on the flexible claddings generates one-sided traction forces particularly in the end bays. These forces shall be considered at all rim-supports (i.e. ridge, eave purlins, rafters, corner-up-rights).

The value of the traction forces depends on various parameters (i.e. geometry, cut sizes, joints, material properties, climate influences). These forces shall be approximately evaluated by iterative calculation taking into account the stiffness of the material and the tolerances of fabrication.

The membrane forces resulting from wind may be taken as 0,80 kN/m if no exact verification is carried out. This applies to 5 m span, a pressure coefficient c_p = 0,40 and a peak velocity pressure $q_p(z_e)$ = 0,50 kN/m^2. For other spans and wind loads a conversion may be done using a constant ratio:

f / l = constant

where

f is the sag;

l is the span.

The absorption of these membrane forces by all the edge girders (ridge purlins, eaves purlins, roof truss girders and corner posts) shall be checked.

The increased edge suction loads (according to wind load standards for buildings) can be ignored for flexible wall and roof surfaces. As regards rigid roof coverings, the fastening means shall be sized in accordance with EN standards or in absence of the relevant EN standards by agreement with the parties involved in respect of the increased edge suction loads.

8.5 Membrane and pole tent

8.5.1 General

If the shape of the structure allows a calculation in two opposite directions separately, the calculation is allowed to be made by static replacement systems. In any other case a spatial system is to be calculated considering deformations.

In cases where nonlinear deformation can lead to favourable load carrying effects on certain elements, the safety coefficients shall be applied not on the load side but on the material side.

Because a failure of the load bearing membrane may lead to a complete collapse of the entire structure, the suitability of the material and of the jointing and fastening techniques shall be demonstrated by approval or other certificates according to EN standards or in absence of the relevant EN standards by agreement with the parties involved.

8.5.2 Pre-stressing

The structure shall be mechanically pre-stressed in order to stabilize the membrane structure against the external loads which arise, and also in order to prevent any whip, flutter or breakdown.

The actions resulting from the permanent working load of the membrane at the edge of the structure resulting from pre-stressing shall not exceed 5 % of the short duration average tensile strength of the fabric. More may be taken into account with justification by tests.

Actions (pre-stressing, snow load and wind load) shall be combined to take into account the nonlinear behaviour of the structure. The pre-stressing load shall be considered in the load combination with its adequate partial safety factor.

8.5.3 Design and construction details on membrane

The main curvature direction shall correspond with the main direction of the stress. The mesh of calculation model shall be laid in accordance with the main curvature direction. The cutting pattern layout of the membrane shall be laid in accordance with the mesh orientation of the calculation model.

If rope-, belt- or skin-strengthening is foreseen, care shall be taken that no weakening of the base-material occurs (e.g. by amassment of seams, clamps or eyelets).

8.6 Verification of load bearing capacity of technical textiles and their connections

The following formula is valid for material and connections:

$$f_{\mathrm{d}} = \frac{f_{\mathrm{tk}}}{\gamma_{\mathrm{M}}} \qquad (9)$$

where

f_{d} is the design resistance (ultimate limit state);

f_{tk} is the characteristic tensile strength in monoaxial tensile short duration tests at 23 °C;

γ_{M} is the partial safety factor for a material property given in Table 4.

Factors to apply for polyester coated with polyvinylechloride and their welded connections see Table 4.

Characteristic values for materials and connections shall be evaluated by tests.

If tests are not enough to calculate f_{tk} it shall be assumed:

$$f_{\mathrm{tk}} = 0{,}8\, f_{\mathrm{tm}} \qquad (10)$$

where

f_{tm} is the average of tensile strength in tensile short duration test at 23 °C.

Table 4 — Partial safety factor γ_M for material and welded connections HF (PES+PVC)

	Product in conformity with EN 10204:2004, **“Type 2.2”**	**Product in conformity with** EN 10204:2004, **“Type 3.1”**
Material		
permanent load	2,5	2,5
short duration loads[a]	2,5	2,0
in presence of snow[b]	2,5	2,0
Welded connections 1st class		
permanent load	—	7,0
short duration loads	—	3,0
in presence of snow	—	2,5
Welded connections 2nd class		
permanent load	15,0	12,0
short duration loads	6,0	5,0
in presence of snow	6,0	5,0

NOTE For the definition of the classes see B.5.

a “Short duration loads” means load conditions with high temperature.

b “In presence of snow” means load conditions without high temperature.

These values are valid only if tests on the connection give a value more than 70 % of tensile strength of the material both in tests at 23 °C and 70 °C.

When these criteria are not respected and for materials other than PES + PVC more special investigations shall be done regarding the influence of temperature and permanent load.

All tests shall comply with the relevant EN standards or in absence of the relevant EN standards by agreement with the parties involved. At least there shall be 3 tests performed to achieve the standard deviation and the 95 % confidence intervals of the main values according to the procedures given in ISO 2602.

8.7 Safety margin, safeguards

Because a load bearing membrane can be subject to considerable deformations, care shall be taken to ensure that no structural or other parts may hinder the deformation of the membrane if not taken into account in the calculation.

In so far as rigid load bearing components (i.e. masts, supports etc.) are restrained solely by the membrane, the overturning of such components in the event of a one sided removal of the membrane shall be prevented by additional measures, and the necessary degrees of freedom of movement in the operating condition shall remain intact.

For a pole tent with a width greater than 12 m and mast height greater than 7 m, both poles and masts shall be independently guyed to prevent or delay their collapse in the event of total or partial membrane failure unless the design can justify otherwise.

8.8 Post tensioning

Design measures which enable a post-tensioning of the structure to be effected should be incorporated (e.g. turnbuckles, support extensions etc.), for the purpose of compensating the creep of the membrane (material, stitching, fastenings, ropes etc.).

9 Ground anchorages

9.1 General

Uncertain soil conditions make it extremely difficult to assess the load bearing capacities of anchorages accurately. If for the respective soil conditions no verification using the rules of foundation engineering is carried out the following approximation method may be used. Test loadings shall be performed on each site in the case of doubt.

Therefore this clause is restricted to

a) weight anchors, i.e. ballast bodies placed on the surface of the ground or buried, and

b) rod anchors, i.e. metal fitted with eyelets or with an upset head.

Concerning special anchors such as wing anchors, folding anchors, screw anchors and sectional steel anchors for example, the determination of their load bearing capacities loading tests shall be done.

9.2 Load bearing capacity of weight anchors

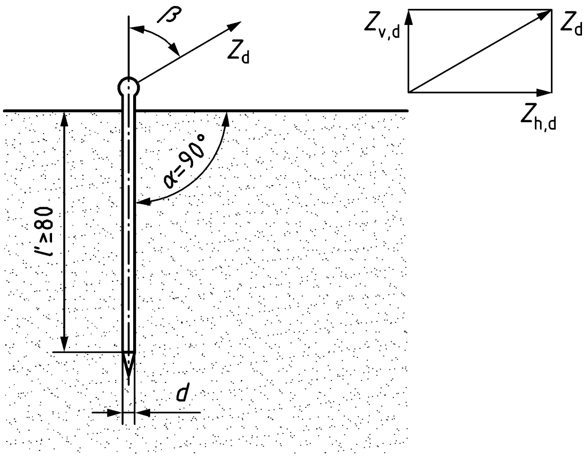
When calculating the load bearing capacity of fully or partially buried anchors, the earth resistance shall only be taken into account on condition that the anchor is capable of performing small displacements and rotations without any danger to the structure and that the foundation soil conditions are sufficiently known.

9.3 Load bearing capacity of rod anchors

The design load bearing capacity of rod anchors, Z_d, with a circular cross section and a minimum depth of penetration of $l' = 80$ cm shall be determined in accordance with the empirical formula given in Table 5.

A rod anchor is presented in Figure 4.

Dimensions in centimetres



Key

Z_d design load bearing capacity of the rod anchor, in N;

$Z_{h,d}$ horizontal design load bearing capacity of the rod anchor, in N;

$Z_{v,d}$ vertical design load bearing capacity of the rod anchor, in N;

d diameter of the rod anchor, in cm;

l' depth of penetration of the rod anchor, in cm;

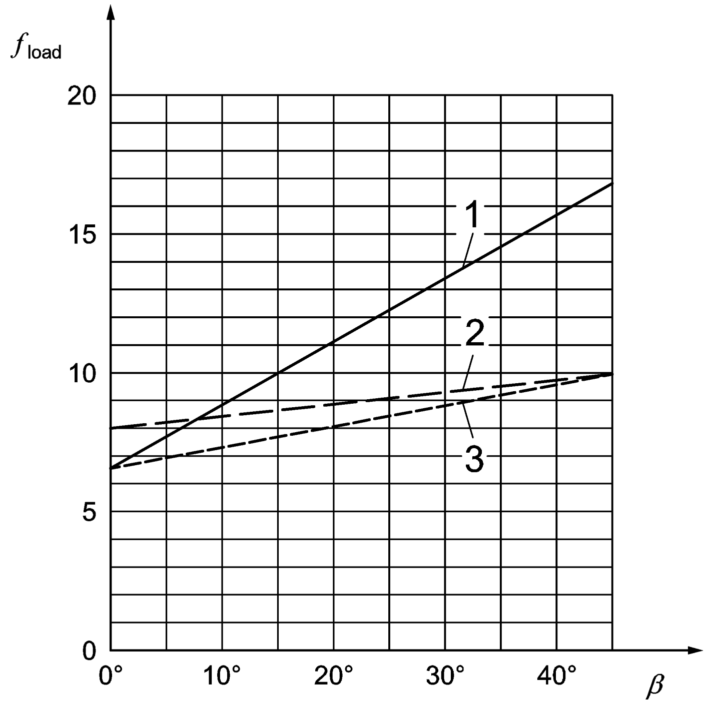
α angle of penetration of the rod anchor;

β angle of acting tensile force to the vertical.

Figure 4 — Rod anchor

Table 5 — Design load bearing capacity of rod anchors Z_d

Angle of acting tensile force to the vertical β	**Design load bearing capacity of rod anchors** Z_d [N]
$\beta = 0°$	$Z_d \mathrel{\hat{=}} f_{load} \cdot dl' = 6{,}5 \cdot dl'$ for stiff cohesive and for dense cohesionless soils
$\beta = 0°$	$Z_d \mathrel{\hat{=}} f_{load} \cdot dl' = 8{,}0 \cdot dl'$ for very stiff cohesive soils
$\beta \geq 45°$	$Z_d \mathrel{\hat{=}} f_{load} \cdot dl' = 10{,}0 \cdot dl'$ for cohesive soils of at least medium to stiff consistency
$\beta \geq 45°$	$Z_d \mathrel{\hat{=}} f_{load} \cdot dl' = 17{,}0 \cdot dl'$ for dense cohesionless soils
$0° < \beta < 45°$	The load bearing capacity for the soil types shall be determined by interpolation (see Figure 5)



Key

1 dense cohesionless soils

2 very stiff cohesive soils

3 stiff cohesive soils

f_{load} factor for determining the load bearing capacity of rod anchors

ß angle of acting tensile force to the vertical

Figure 5 — Factor f_{load} for determining the load bearing capacity of rod anchors

The formulas given in Table 5 are only valid when the rod anchor provides the expected level of grip after it is driven in the ground:

— for β = 0° the friction shall be effective along the entire length of the rod anchor;

— for $\beta \geq$ 45°, the angle of penetration α shall be 90°.

At the angle of penetration of the rod anchor α = 90°, the obliquely loaded anchor will attain its maximum load bearing capacity, as proved by experience.

In order to prevent any bending of anchors subjected to oblique traction, the following minimum diameter, d_{min}, should be kept for simple round steel rod anchors:

$$d_{min} = 0{,}025\ l' + 0{,}5 \tag{11}$$

where

l' is the depth of penetration of the rod anchor, in cm.

The point of application of the force on rod anchors subjected to bending stress shall be situated as close to the ground surface as possible, or beneath it.

The lower end of the rod anchor shall present no increase in section, in order not to decrease the friction at the stem.

9.4 Test loadings on site

A test loading conducted on rod anchor has to consist of at least three tests. A partial safety factor of γ = 1,6 regarding ultimate limit load is to apply for the lowest value of the test loading, Z_u, in order to determine the design load bearing capacity of rod anchors, Z_d, in subsequent calculations.

$$Z_d = \frac{Z_u}{\gamma} \tag{12}$$

where

Z_u is the lowest value of the test loading;

γ = 1,6 is the partial safety factor.

The load bearing capacity determined in this manner shall not result in anchor movement which would result in stresses, deformations or instability inadmissible for the structure.

9.5 Calculation of loading capacities

The resulting load, Z_{res}, acting on the anchoring and the associated angle of acting tensile force to the vertical, β, according to Figure 4 shall be determined by vector addition of the individual load components, taking partial safety factors, γ , in Table 2 into account.

$$Z_{res} = \sum \gamma \cdot Z_k \tag{13}$$

where

Z_k are the characteristic values of the loads;

γ are the partial safety factors according to Table 2.

It has to be proven that:

$$\frac{Z_{res}}{Z_d} \leq 1 \tag{14}$$

where

Z_d is the design load bearing capacity of rod anchors, according 9.3 or 9.4.

9.6 Further requirements

If groups of rod anchor are used, every single rod anchor can only be taken fully into account with its maximum loading when the distance between two rod anchors is at least 5 times the diameter of the rod.

If groups of more than 6 rod anchors are used, the maximum load bearing capacity has to be proven. An earth cone with an angle of 45° beginning on the outmost rod anchor can be taken into account without further proof.

If displacements in excess of 2 cm occur on loaded rod anchors or similar devices, then the load bearing capacity of the anchor will no longer be fully ensured. An increase of the resistance against pull-out failure can be achieved either by means of additional anchors or by driving in wooden wedges. In the case of pure tensile stress in the direction of the axis of the rod anchor, the danger of a complete failure of the anchor arises when very small movements occur.

After the driving in of a rod anchor, the soil on the surface shall be tamped against the anchor, as far as practicable, in order to prevent the infiltration of surface water.

9.7 Ground support for packing

Only small contact stresses are permitted for packing, because of the lack of embedding in the soil and also because of the relatively small load bearing widths used in practice. Packing is liable to sink into the soil and cause considerable settlements. Packing shall be kept under observation when placed on particularly yielding soils. In the event of yielding or loosening, an underlay shall be provided and the load bearing surfaces shall be enlarged as necessary.

For a foundation soil with a low load bearing capacity, additional measures shall be adopted. If several elements are laid side by side without any gaps in order to increase the bearing widths, an interconnection shall be created, e.g. by cross-stacking.

For a foundation soil which can be travelled over (e.g. by trucks), the following design soil pressures, p, can be used in the calculation for square and rectangular packing with dimensions:

$$1 \leq \frac{l}{b} \leq 3$$

where

l is the length of packing in the ground contact zone;

b is the width of packing in the ground contact zone:

b = 20 cm: p = 100 kN/m^2;

b = 30 cm: p = 150 kN/m^2;

$b \geq$ 40 cm: p = 200 kN/m^2.

Interpolation shall be conducted for intermediate values.

For installation on hard (paved) locations, higher design soil pressures can be considered.

10 Other structural components

10.1 General

Besides the calculation the load bearing capacity of materials or accessories, which relates directly to the safety of the public shall be verified either by manufacturer conformity certificate or test.

EN or national standards shall be applied for the following devices:

— steel wire ropes (cables): EN 12385-1, EN 12385-2, EN 12385-3 and EN 12385-4;

— chains: EN 818;

— natural fibre ropes;

— synthetic material ropes;

— clamps for wire ropes;

— rope drives;

— eye hooks;

— roller buckles;

— shackles;

— safety harnesses;

— safety ropes;

— turnbuckles;

— webbings;

— ratchets.

Open hooks shall not be used in bracings. Hooks with a safety catch are not considered to be open hooks.

10.2 Design resistance

The design value of the resistance, R_d, for components according to 10.1 shall be calculated according to the relevant Eurocodes or national standards. For all other components that are not regulated by any standard the design value of the resistance shall be calculated as follows:

$$R_d = \frac{R_{min}}{\gamma_M} \tag{15}$$

where

R_{min} is the minimum breaking load;

$\gamma_M = 2,0$ is the partial safety factor for a material property for both nonlinear behaviour or linear behaviour, including a risk of damage for frequent dismounting.

10.3 Synthetic fibre ropes

As regard fibre ropes made of synthetic fibres, the values given in Table 6 shall apply depending on the ultimate limit state.

Table 6 — Partial safety factor γ_M for synthetic fibre ropes

Rope diameter d [mm]	Partial Safety factor γ_M
12	4,0
14	3,3
16	3,3
≥ 18	2,7
NOTE Synthetic fibre ropes according to EN ISO 1141, EN ISO 1346 and EN ISO 1969.	

10.4 Ratchets

For straps with ratchets, the partial safety factor of γ_M = 2,0 shall be applied on the complete system tested regarding ultimate limit loads. Ratchets shall be secured against accidental opening.

11 Manufacture and supply

11.1 General

Suitably competent persons shall be engaged in the manufacture of tents. Constant attention shall be paid to the inspection of components and raw material, including consumables.

The manufacturer shall ensure the specified level of quality for each component of tents and determine the standard of manufacture necessary to achieve this, in accordance with design specification.

When manufacturing the load bearing structure the series of standards EN 1090 shall be adhered to.

11.2 Certificates

Certificates on material or components according to relevant EN standards shall be done at least for the following items:

— steel, aluminium and timber for load bearing members;

— standardized components, if there is no agreed or general method of calculation;

— burning behaviour.

Hooks, safety hooks, shackles, turnbuckles or other accessories shall be considered as certified, if they are marked by the manufacturers according to existing standards.

If necessary, correction of the design resistance shall be done according to the specific use.

Ropes, chains etc. shall be supplied with certificate showing the guaranteed minimum breaking load.

11.3 Observation of the design specification

The manufacturer shall ensure that the design specification is fully incorporated into the completed tent and that the quality of the materials use and the manufacture procedure meet the design specification.

This shall be confirmed by an inspection.

11.4 Description of installation and operation procedures

The description of installation and operation procedures shall give information concerning:

— type of tent, the main design characteristics, possible varying installations, the main dimensions, the dimensions of exits and entrances, the working and operating process;

— installation and operation of the tent;

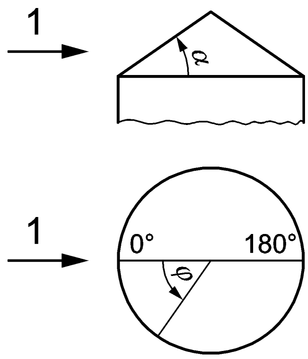
— safety devices which are or become effective in exceptional situations (i.e. instructions concerning snow, wind, anchorage and fire).

12 Special design and manufacture criteria

Special design and manufacture criteria are presented in the informative Annex B.

Annex A
(informative)

Pressure coefficients for closed tents of round shape



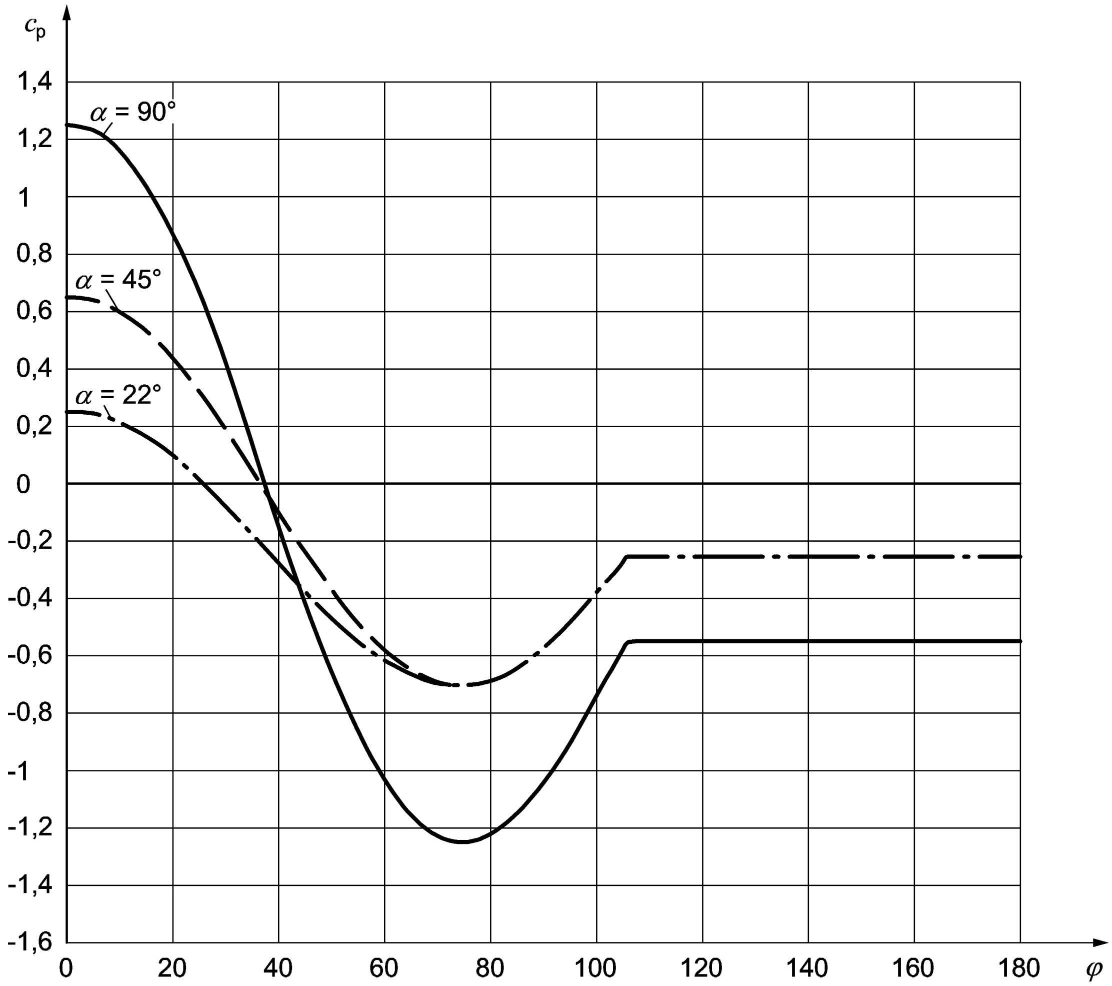
Key

1 direction of wind

φ peripheral angle

α angle of the pitch (45° or 22° or 90° (wall))

Figure A.1 — Round shape tent



Key

c_p pressure coefficient

φ peripheral angle

α angle of the pitch (45° or 22° or 90° (wall))

Figure A.2 — Pressure coefficients c_p for round shape tents

The pressure coefficients, c_p, given in Figure A.2 include a constant internal pressure coefficient, c_{pi} = - 0,25.

The pressure coefficient, c_p, may be limited to 1,0 for the transverse loading of the perimeter poles.

Annex B
(informative)

Special design and manufacture criteria and operation

B.1 General

All components should be in conformity with the relevant EN standards or in absence of the relevant EN standards by agreement with the parties involved.

The minimum internal headroom should be 2,3 m for frame elements and 2 m for textile element.

The average clear height of tents should be not less than 2,5 m.

B.2 Escape routes

B.2.1 Common recommendations

Enclosed rooms with an area of more than 100 m^2 should have at least two exits, as far apart as possible, leading in the open having at least a width of 1,2 m and a height of 2,0 m. At least one exit should be suitable for wheel chairs.

Calculating the width of the escape routes 0,6 m should be taken for any 100 persons dependent. Interpolation is not allowed. The minimum clear width should be 1,2 m.

Without proof of the seats the number of occupants of a tent should be calculated as follows:

— 2 people / m^2 if seated;

— 3,5 people / m^2 if standing;

— Areas not accessible to visitors may be neglected.

B.2.2 Design of emergency exits

Emergency exits shall be clearly marked in accordance with EN ISO 7010 and visible at all times during operation.

An emergency exit should be an exit on an escape route. The clear width has to correspond to the escape route width.

Doors should open in the direction of escape. The installation of doors in emergency exits should not weaken the load bearing structure of the tent.

B.2.3 Layout of escape routes

The maximum distance from each seat or place to reach an emergency exit leading in the open should not be more than 30 m unless more special measures are taken.

The maximum distance from a seat or place to an escape route should not be more than 10 m.

B.3 Stairs

Stairs which are used by the public should be at least 1,2 m in width and if relevant they should correspond to the width of the escape routes.

B.4 Burning behaviour

Walls, fabrics used for decorations and all other materials (except planed wood with a thickness of more than 20 mm) should have a flame retardance. Materials used for roofs at 2,3 m height or higher need not to be flame retardant.

Safety cables of pole structures and cables for wind-bracings should be made of non-inflammable materials.

B.5 Textile connection

According to their design documents textile fabrics should be ready-made in such a way that the forces acting on them are absorbed and transferred safely; this includes that the dimensions are met and that the serviceability is ensured.

Common textile connections are:

— mechanic type (seam, elastic ropes, hooks, plates, zips, sewing);

— chemical - physical type (welding, gluing);

— or mixed.

It is possible to make connections in a way clearly specified and defined as below.

There are three connection classes:

— 1st class: connections made by a qualified manufacturer using methods defined (specifying all the parameters and work conditions) by the coated fabric manufacturer or by the membrane assembler and tested according to EN 15619;

— 2nd class: connections made by qualified personnel using methods defined (specifying all the parameters and work conditions) by the coated fabric manufacturer or by the membrane assembler and initially tested and repeatability checked by visual peeling test;

— 3rd class: other connections, permitted only for secondary elements and whose failure will not create unfavourable load cases or effects reducing the safety of the tent.

In the design the connection class should be chosen in accordance with the structure type.

For tents with primary load bearing structure textile connection can be of 1st or 2nd class.

For membrane tents, the connection should be of 1st class.

The test results and the related test specimen should be filed together with all information allowing reproduction. The files should be retained for 5 years.

B.6 Heating and cooking systems

An electrical heating system may be installed in tents.

Other heating systems should be put outside of the tent at a sufficient distance away.

The warm-air generators should be equipped with heat exchangers supplying indirect heat into the structure.

To prepare meals and drinks tents may be equipped with cooking devices in kitchens. These areas should be separated from areas accessible to visitors.

The heating system should comply with the relevant EN standards or in absence of the relevant EN standards by agreement with the parties involved.

B.7 Electrical equipment

The electrical equipment should comply with the relevant EN standards or in absence of the relevant EN standards by agreement with the parties involved.

B.8 Fire extinguishers

Types and numbers of extinguishers should be in accordance with EN 3.

Annex C
(informative)

Examination and approval

C.1 Examination

C.1.1 General

Tents should be inspected.

NOTE In some member states there are national regulations for use and operation.

C.1.2 Qualification

The following experts with relevant experience in the field of tents should be available during the design, if appropriate:

— civil engineers (calculation, design);

— electrical experts (safety of electrical systems);

— welding engineers (weld and material approval);

— material and test engineers (laboratory examination, non-destructive test methods).

C.2 Procedures for examination, test and approval

C.2.1 General

As a general rule all safety relevant design documents as well as the completed tent should be subjected to review and inspection in accordance with national regulations for use and operation.

The relevant certificate should be only granted after a successful examination. The results of the various examinations should become an integral part of the tent book.

The following tests should be performed:

A: Initial approval of tent;

B: Periodic thorough examination;

C: Examination after modification, repair and accidents, see different steps of A;

D: Installation examination.

C.2.2 Identification

All relevant documents of tents should be identified as follows:

— reference to this European Standard (i.e. EN 13782);

— country;

— name of manufacturer;

— year of production;

— technical identification;

— number of batch;

— burning behaviour.

C.2.3 Initial approval of tents

C.2.3.1 General

Each tent should be subject to an initial approval, this should comprise of:

— design review;

— inspection of construction work.

C.2.3.2 Review of design and construction documents

The design documents should be reviewed and checked; this has to be certified:

— completeness;

— correctness of all the assumptions with respect to the input values for the static analysis;

— correctness of the design calculation of all load bearing components, their connections and joints;

— compliance with the present standard.

C.2.3.3 Inspection of construction work

The inspection of the construction work should be carried out at the manufacturer or at the first installation of the tent respectively. It should be checked and certified:

— conformity with the approved technical specification (main dimensions of the tent, dimensions of the components including their connections and joints, material used, corrosion protection);

— manufacturing process (if appropriate);

— correct execution of welds;

— existence of necessary verifications and certificates concerning material properties, fire protection, welding etc.

C.2.4 Inspection after repair, modification and accidents

The tent and associated parts should be subject to a further examination before being taken back into use following any repair, any modification or any alteration likely to have affected the integrity of the tent.

C.2.5 Report

The result of the initial approval, the examination after modification, the periodic thorough examination and the installation examination should be recorded.

C.3 Tent book

C.3.1 General

The tent book associated with the tent should include the design documents which provide detailed information with respect to operating data, method of construction, instruction relating to operation and maintenance, repairs and modifications as well as to examinations.

The tent book should be available as a document on each erection site for evidence.

C.3.2 Content

The tent book should comprise especially the following documents:

— design and operation descriptions;

— general design drawings (clear presentation of the entire facility, i.e. on a 1:100 or 1:50 scale);

— detail drawings (accurate illustrations of the structural components and their connections, i.e. on a 1:10 or 1:5 scale; other scales are possible only if clearness is not reduced);

— static analysis;

— reports according to C.2.5 as well as reports on any other inspections, if applicable;

— instructions written in the language of the user and the country of destination (at least either in German, English or French) covering erection and dismantling, maintenance, list of all parts requiring periodic replacement.

C.4 Periodic thorough examination

Each tent should be examined prior to the end of a period given in the tent book.

The period between two thorough examinations should be done according to local regulation but should not be longer than 3 years.

In general the examination should be carried out on the erected tent. Exceptionally there can be the possibility to check the tent being dismantled.

Mainly the following checks should be performed:

— correct erection;

— check of the structure, especially of modified, repaired or exchanged parts;

— identification of damages, tearing and corrosion;

— check of safety devices (if appropriate);

— fulfilment of conditions from previous examinations.

C.5 Installation examination

C.5.1 General

Tents should be subjected to an installation examination after each new installation, carried out by competent experts.

C.5.2 Extent of installation examination

The following procedure should be performed:

— observance of the conditions imposed by the tent book and their fulfilment;

— correct packing and anchoring according to the plans with respect to the local ground conditions;

— checking of anchorage;

— conformity with the construction documents, existence of all essential load-bearing components inclusive of bracing comparison of forms and cross-sections of load-carrying components. Attention is to be paid to the correct incorporation, staircases, platforms, linings, decorations and similar equipment;

— suitability of the site of tent;

— state of conservation of the essential load-bearing construction parts (random check on site);

— fastening.

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