# Load Deformation Behavior of sliding Elements used for structural bearings

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**Abstract:**
Sliding elements for structural bearings are designed in Europe according to EN 1337-2 resp. European Technical Approvals. One governing parameter in the design is the load deformation behavior of sliding elements. Hence, the derivation of the design formulas based on the actual state-of-the-art and their applicability are explained. Special regard is laid on the deformation capacity and the required ductility of sliding materials to accommodate the structural deformations even in case of non-planar backing plates.

**Keywords: sliding bearing, deformation of the backing plate of sliding elements, sliding material, depression, load deformation behavior**

## 1 Introduction

Sliding elements of structural bearings are designed in Europe according to EN 1337-2 resp. appropriate European Technical Approvals. As background information on various normative rules are so far only documented in working papers of the standardization committee, this paper derives and explains the normative regulation and formulas for the design of sliding elements with regard to boundary conditions for the load deformation behavior.

## 2 Structural Bearings

### 2.1 Technical standards and guidelines for the design of structural bearings

Structural bearings as load bearing structural components are regulated internationally in standards or technical approvals. After ca. 25 years of standardization work EN 1337 “Structural Bearings”, a series of standards, were introduced in Europe. The standard is based on the construction products directive [1], which came into force in 1988. The different types of structural bearings, which are currently used, are regulated in 6 harmonized part of the standard. The distinguishing feature is the tilting element.

- EN 1337-3: Elastomeric Bearings
- EN 1337-4: Roller bearings
- EN 1337-5: Pot bearings
- EN 1337-6: Rocker bearings
- EN 1337-7: Spherical and cylindrical PTFE bearings
- EN 1337-8: Guided bearings and restrained bearings

A general overview of the standard’s content is given in [2]. As EN 1337 defines product-specific and material-specific and not exclusively performance-related requirements, other than the specified types of bearings are regulated by means of European or national technical approvals. Already after a couple of years after introduction of the standard the complete series of standard are substantially revised by the technical committee TC 167 of CEN with regard to the collected experience.

According to the basic principle of the construction products directive designing and manufacturing of structural bearings according of the series of standards EN 1337 allows CE marking of these products and placing them on the European single market. For the usability, i.e. integration of the bearing in the structure and the fulfillment of special requirements, additional national regulations are required. In Germany a general technical approval of Deutsches Institut für Bautechnik (DIBt) regulates the equipment and usage of structural bearings with CE marking. The approval is bound to the manufacturer and restricted to the types of bearings, for which the manufacturer owes an EC-certificate of conformity.
In Germany currently, Annex O of chapter IV of DIN-Fachbericht 101 [3] regulates the determination of displacements and the design relevant forces for bearings and adjacent structural components. These rules supposed to be transformed into a NAD of DIN EN 1991 in the course of the implementation of the Eurocodes. On the European scale it is intended to insert similar rules in an annex of EN 1990.

2.2 Structural bearings with sliding parts

Modern structural bearings enable horizontal movements of the structure by deformation of the elastomeric bearing pad or in case of sliding bearings by sliding in a sliding plane.

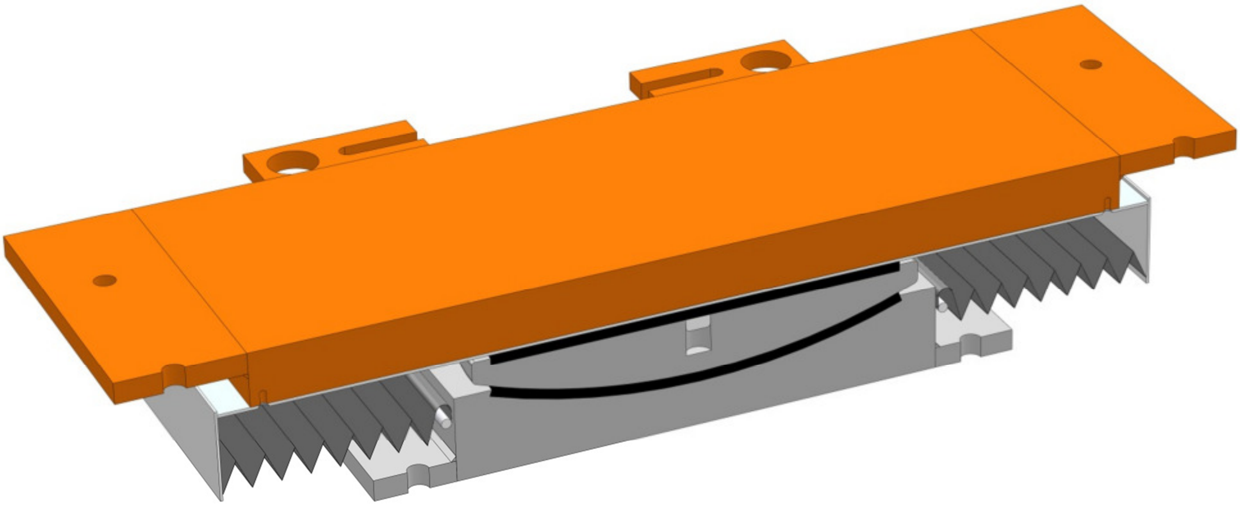

Figure 1 – Sliding spherical bearing

All types of bearings, which are harmonized in the series of standards EN 1337, can be combined with sliding elements to enable horizontal sliding movements. For this reason the sliding elements for structural bearings (listed in section 2.1) according to EN 1337 are only indirectly regulated in the harmonized part DIN EN 1337-2 [4]. This part of the standard complies in essence with the draft of the German standard DIN 4141-12 [5], which drafting was disused based on a European standstill agreement in 1994, and the general technical approval for sliding bearings, which were in force in Germany during the transition period till the implementation of EN 1337.

DIN EN 1337-2 regulates only the use of PTFE with dimples and lubricant in combination with austenitic steel as sliding elements for plane primary sliding surface. In the meantime the application of wear-resistant ultra-high molecular polyethylene (UHMWPE) has been established widely. The main advantages are a higher compressive strength, a larger temperature range of applicability as well as a smaller sliding resistance in face of higher sliding velocities and total sliding path. Various manufacturers owe already European technical approvals for spherical bearings equipped with this sliding material, which was firstly introduced in the market with trade name MSM® [6].

In all mentioned regulations and standards one find the same rules for the design of the backing plates for sliding elements. They are based on the combined load deformation behavior of sliding elements and adjacent structural components, which is the basis of the design. In case of different material combinations than the considered a revision of the boundary conditions given in the regulation is required. The following sections give an overview of the theoretical derivation of the design rules.

## 3 Design of backing plates for structural bearings

3.1 General

The basic criteria when designing the backing plate is the determination of the plate thickness with regard to surface area and loading. The surface area is influenced by the allowable pressure in the adjacent structural members and the required movement capacity. The following aspects should be regarded when determining the backing plate thickness:

- allowable contact pressure in the adjacent structural members and allowable stress of the plate itself
- deformation of the backing plate due to dead load and temporary live loads
- deformation of the backing plate during service life

3.2 Transmission of loads

The verification of the partial area loading of the adjacent concrete elements is carried out according to section 5.4.8.1 of DIN-Fachbericht 102 [7]. Commentaries can be found in [2]. Depending on the cylindrical compression strength $f_{ck}$ an appropriate large area for load propagation into the adjacent members of the backing plate is required. The thickness of the backing plate is used for the propagation of the transmitted pressure. The angle of load propagation depends on the properties of the adjacent components, materials and structural elements. The angle of load propagation shall be verified and should not be larger than 60°. Without further verification an angle of 45° is to be assumed.

Parts of steel superstructures, where concentrated loads are transmitted, shall be sufficiently stiffened. Spherical bearings are often arranged upside down, i.e. the sliding surface is at the bottom of the bearing, to prevent eccentric loading for the steel superstructure. For bearings with restraints the plate thickness is also influenced by the horizontal loads that have to be transmitted via external guidance or by a cross-sectional jump in the plate due to a keyway for an internal guidance. For spherical bearings without anchor plate but common concrete strengths the plate thickness $t_b$ can be determined approximately as a function of the design load $N_{Sd}$ using the following formula:

$$t_b \text{ [mm]} = 40 + 2 \cdot N_{Sd} \text{ [MN]} \quad (1)$$

3.3 Geometry

To guarantee a fitness for use acc. to DIN EN 1337-2 the surface of backing plates in contact with sliding materials or anchor and shimming plates shall be treated in such a way that the maximum deviation $\Delta z$ from theoretical plane surface shall not exceed 0,0003 x $d$ (diameter of the sliding material sheet) or 0,2 mm, whichever is greater. For avoiding irreversible deformation of the backing plate during transport or installation, which might reduce the fitness for use of the sliding plane, the minimum backing plate thickness shall be 4 % of the plate diagonal or 10 mm (whichever is greater). This application rule is based on German experience. It was for the first time established in DIN E 4141-12 but with a minimum thickness of 25 mm.

3.4 Load-deformation for serviceability limit state verification

The flexural stiffness of the backing plate influences only slightly the depression of adjacent structural members. The deformation of the backing plate due to depression of adjacent members shall be limited:

- to guarantee a minimum small clearance between adjacent backing plates,
- to ensure uniform pressure distribution in the sliding material taking into account the influence of the sliding material stiffness,
- to minimize the wear of the sliding material,
- to avoid any impairment of the intended movement capabilities.

If the deformations exceed the admissible values, the clearance between backing plate and mounting plate becomes unacceptably small and higher wear will occur. As this could endanger the long term fitness for use of the sliding element, this condition is considered as serviceability limit state. The deformation in case of given boundary conditions can only be limited by reducing the surface pressure, i.e. increasing the surface area or the plate thickness for a better load propagation, which is combined with a beneficial increase of the total stiffness.

## 4 Load deformation behavior of backing plates of sliding elements

4.1 General

The determination of the deformation of the backing plate of sliding elements requires complex calculation i.e. by means of finite element analysis in due consideration of different boundary conditions. Deutsche Institut für Bautechnik (DIBt) commissioned in 1998 a parametric study for the determination of deformation and stress of backing plates used for sliding bearings with PTFE [8]. Hence, a proposal for the determination of the required backing plate thickness was developed, which was introduced in the draft of German standard DIN E 54141-12 as well as in national general technical approvals that were valid at that time. These design rules were adopted entirely in DIN EN 1337-2. The basis of the computational procedure is summarized in [9]. The verification procedure is described in the following.

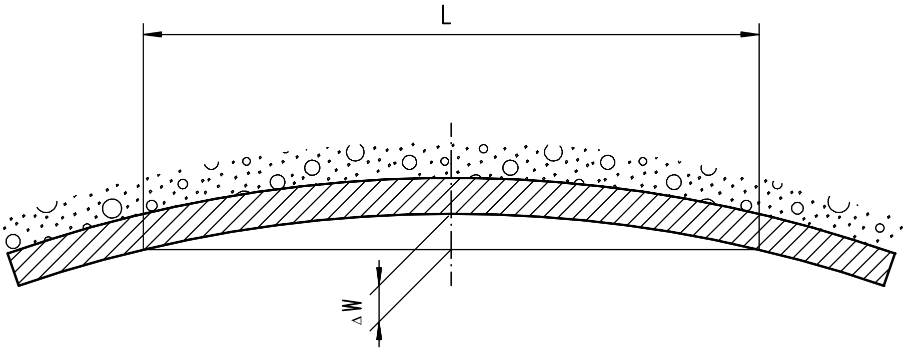


Figure 2 – Deformation $\Delta w$ of the backing plate

DIN EN 1337-2 regulates the admissible deformation of backing plates to ensure serviceability. The stress induced by the deformation should not exceed the limit of elasticity to avoid irreversible deformation. The mechanical model for a project-related verification of elastic deformation has to consider the effect of the deformation on the bearing components including the adjacent structural members regarding short and long term properties. For steel and concrete the design values of the material properties are given in EN 1993-1-1:2005 resp. EN 1992-1-1:2004. It is assumed that the pressure force is centric and design values of a fictious modulus of elasticity and a fictious poisson's ratio of the sliding material referred of the total sliding plate thickness can be used. In case of adjacent concrete components it is assumed that the modulus of elasticity of concrete or mortar reduces from 100 % to 80 % from the border to the center of the backing plate.

### 4.2 Backing plates attached to concrete

DIN EN 1337-2 describes a procedure for the determination of the deformation *Δw* for common materials. The verification that the steel does not yield can be omitted, if the limit of the deformation *Δw* is met and the concrete owes at least a strength class C25/30 acc. to DIN EN 206-1:200 and the steel at least a strength S355 acc. to DIN EN 10025-2:2004.
For circular steel plates, which are connected to concrete with a minimum strength class C20/25 and mortar bedding of appropriate strength, the largest relative deformation *Δw* related to the diameter *L* can be determined with the following formula:

$$\Delta w = \frac{0{,}55}{L} \cdot k_c \cdot \alpha_c \cdot k_b \cdot \alpha_b \tag{2}$$

with

$k_c = 1{,}1 + (1{,}7 - 0{,}85 \cdot d_b / L) \cdot (2 - d_b / L_0)$ if $L_0 \leq d_b \leq 2 \cdot L_0$

$k_c = 1{,}1$ if $d_b > 2 \cdot L_0$

$k_b = 0{,}30 + 0{,}55 \cdot d_b / L$

$$\alpha_c = \frac{N_{Qd}}{E_{cd}} + \frac{N_{Gd}}{E_{crd}}$$

$$\alpha_b = \left(\frac{L}{L + 2 \cdot t_b}\right)^2 \cdot \left(\frac{3 \cdot L_0}{d_b}\right)^{0{,}4}$$

where

$d_b$ diameter of the backing plate
$t_b$ thickness of the backing plate
$L$ diameter of the sliding material plate
$L_0$ reference diameter = 300 mm
$N_{Qd}$ compressive force due to design values of variable actions
$N_{Gd}$ compressive force due to design values of permanent actions
$E_{cd}$ design value of the Young's modulus of concrete (modulus of elasticity)
$E_{crd}$ design value of the reduced Young's modulus of concrete to include creep under permanent action/loading $N_{Gd}$ ( $E_{crd} \approx 1/3\ E_{cd}$ )

The approximation procedure can be also applied for square and rectangular plates, if they are idealized to circular plates of diameter $d_b = 1{,}13\ a_b$, where $a_b$ is the side of the square plate or the minor side of a rectangular plate.

In case of lower concrete or steel strength the stress verification can be also omitted, if the limiting value of the deformation *Δw* is reduced analogous [4]. Here it is assumed for simplification purpose, that on the basis of the concrete's modulus of elasticity resp. the steel yield strength a linear relationship between deformation resp. stress of diverse material combination exists. Because in the meantime higher concrete strengths with higher stiffness are used, it is recommend to update the parametric study [8].

### 4.3 Backing plates attached to steel

It can be assumed that the local deformation are negligible small in case of uniform load propagation (60° acc. to EN 1337) from load stiffeners to the lower flange, a possible double-disc gate or a back plate and the backing plate up to the sliding plane. Therefore generally in case of steel superstructures the top sliding plate is designed only according to design and construction aspects.

## 5 Design criteria for the load deformation behavior of sliding elements

### 5.1 General

Sliding elements in general are composed of a sliding material and a mating material using a suitable lubricant. Thermoplastic materials deliver an optimal performance as sliding material. Besides sliding properties, i.e. a very low sliding resistance and maximum wear resistance, the sliding material should have sufficient deformation capacity to compensate the deformation of the backing plate. The mating material requires a considerable higher surface hardness and a smaller surface roughness. For sliding bearings the application of polished stainless steel sheets on a supporting plate, which has to be designed according to the listed criteria to limit the deformation, has delivered an optimal performance in practice.

5.2 Load deformation behavior of sliding materials

In the course of the work on draft DIN 4141-12 extensive test series were conducted resp. data of the past collected for the determination of the load deformation behavior of PTFE. Basically compression tests of recessed PTFE sheets with rigid and plane load application plates were performed. The following properties were varied:

- Depth of the recess
- PTFE protrusion
- Total height of the PTFE sheet
- Total diameter of the PTFE sheet

The tests were performed at ambient temperature. The change of the PTFE protrusion was measured during 48 h. Due to the plastic material behavior the change of the protrusion increases nonlinearly with increasing pressure. It appeared that the main determining factor is the free PTFE edge, the ratio between this free edge and the compressed surface area (shape factor *S*) as well as the ratio between recess depth and protrusion.

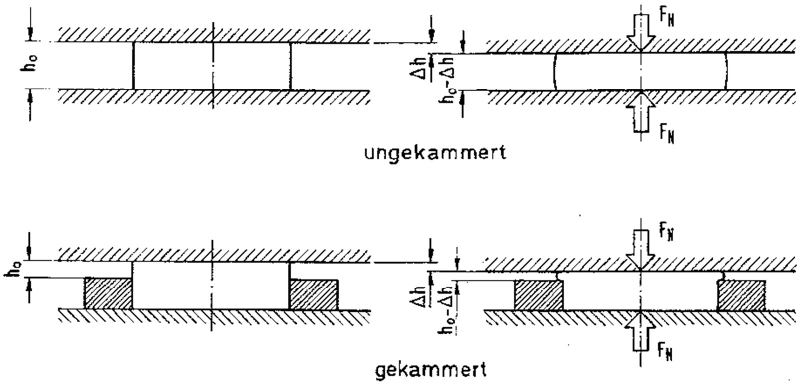


Figure 3 – Deformation behavior of PTFE white, free sintered and vertically compressed [10]

Within the framework of the test series the compressive strength of PTFE was defined as the pressure, under which the compression of the sliding material come to rest after 48 h, see also section 7.3.1.5 [10]. By defining a diameter dependent height of the protrusion h and the thickness of PTFE $t_p$ the characteristic compressive strength $f_k$ for effective structural bearing temperatures up to 30°C, see DIN EN 1337-2, can be given on the safe side:

$$f_k = 90\ \text{N/mm}^2 \quad \text{for} \quad h[\text{mm}] = 1{,}75 + \frac{L}{1200} \geq 2{,}2 \quad \text{and} \quad 2{,}2h \leq t_p \leq 8\text{mm}$$

Background information and the analysis of former load deformation tests are summarized in working document N253 of the working group WG3 of CEN-TC 167 [11]. Assuming a fictitious linear elastic behavior of PTFE and relating the deformation to the height of the protrusion *h* the mean modulus of elasticity becomes $E_{PTFE,h}$ ~ 270 N/mm$^2$ for a diameter $L$ = 155 mm and a pressure $p$ = 45 N/mm$^2$ and $E_{PTFE,h}$ ~ 200 N/mm$^2$ for p = 90 N/mm$^2$. If the compression of the PTFE under fixed boundary conditions is related to the total thickness of the PTFE sheet, the modulus of elasticity becomes $E_{PTFE,tp}$ ~ 400 N/mm$^2$ for a pressure of 45 N/mm$^2$. This value is the basis for more precise calculation in DIN EN 1337.

As the shape factor *S* plays a crucial role, the compression of sheets with diameter $L$ = 75 mm and 155 mm were compared. It was shown that the elastic compression of the sliding material with increasing diameter *L* runs asymptotic against 0. It was proved that an indirect proportional dependency of the stiffness $E_{PTFE,h}$ and the square root of the shape factor *S* exists. One can therefore say that

$$\frac{\Delta h}{h} = \frac{k}{\sqrt{S}} \quad \text{resp.} \quad \Delta h = 2 \times k \times \sqrt{\frac{h^3}{L}} \tag{3}$$

*k* is a pressure dependent stiffness constant. For the serviceability limit state verification with an applied pressure of 45 N/mm$^2$ the constant *k* is derived with regard to variance and number of samples based on statistical evaluation of experiments acc. to DIN EN 1990

- Mean value $k_{50\%} = 0,515$
- Standard deviation $= 0,065$
- Characteristic fractile $k_{95\%} = 0,515 + 1,647 * 0,065 = 0,622$

Table 1 shows a comparison of theoretical settlement $\Delta h$ in dependence of the stiffness and the geometrical boundary conditions acc. to DIN EN 1337-2.

Table 1: Settlement $\Delta h$ of PTFE-sheets and centric pressure $p$ = 45 N/mm²

| Diameter $L$ | Protrusion $h$ | $E_{tp}$ = 400 N/mm² | $k_{95\%}$ = 0,622 |
|---|---|---|---|
| 75 mm | 2,2 mm | $\Delta h$ = 0,48 mm | $\Delta h$ = 0,47 mm |
| 1500 mm | 2,7 mm | $\Delta h$ = 0,60 mm | $\Delta h$ = 0,14 mm |

A consideration of the shape factor is therefore essential for the assessment of the load deformation behavior.

In section 2.2 modern sliding materials on the basis of UHMWPE are mentioned. It is also a thermoplastic material but with a higher stiffness, which enables on the one hand to transmit higher contact pressures but on the other hand the geometric boundary conditions have to be adjusted to fulfill the serviceability requirements. For effective bearing temperatures up to 35 °C it is

$$f_k = 180\ \text{N/mm}^2 \quad \text{for} \quad h[\text{mm}] = 2,50 + \frac{L}{3000} \geq 2,2 \quad \text{and} \quad 2,65h \leq t_p \leq 10\text{mm}$$

Figure 4 shows the load deformation behavior of MSM® subjected to different pressures in comparison to PTFE.

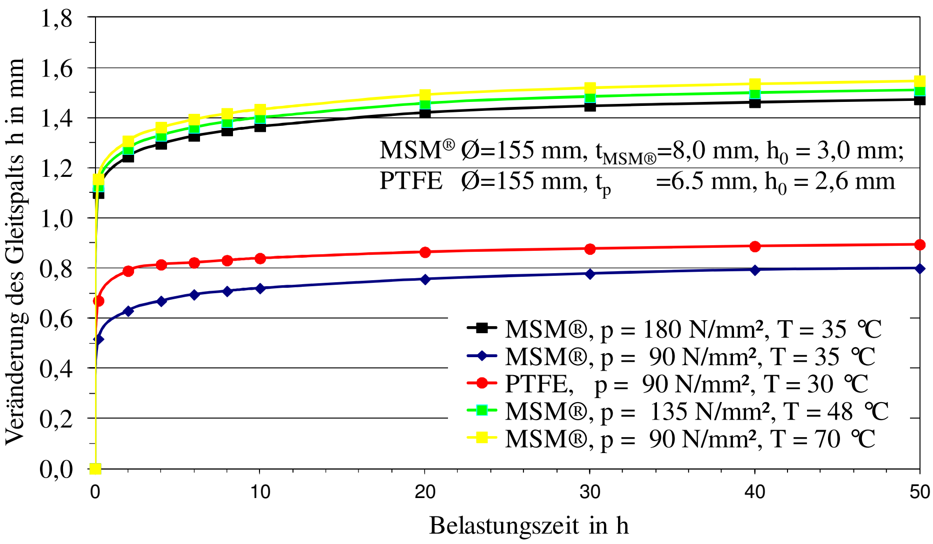


Figure 4 – Load deformation graphs of PTFE and MSM®

For sliding materials made from UHMWPE the European technical approval guideline CUAP 03.01/35 [12] was developed. The essential performance characteristics are:

- Elongation at break ≥ 250 %
- Ratio tensile strength/yield stress ≥ 2,5
- Ratio elongation at break/yield strain ≥ 13
- Minimum protrusion of 1 mm after 48 h of loading with a characteristic pressure
- Reduction of the protrusion $h$ after 48 h of loading with a characteristic pressure at least 1 mm ($h_0$/3)
- Maximum reduction of the protrusion $h$ = 0,1 mm due to wear after a minimum of 10 km sliding path

These performance characteristics are the general essential requirements for the load deformation behavior of sliding materials for structural bearings. At ambient temperature and a pressure of 90 N/mm² the following stiffness properties are evaluated for MSM®:

$E_{tMSM}$ = 900 N/mm², $k_{95\%}$ = 0,573

5.3 Design of the backing plate of sliding elements

Due to a constant pressure from vertical loading and assuming a stiff load application body the sliding material is compressed by $\Delta h_1$, see figure 5. Due to the load transmission a depression arises. The determination of $\Delta w$ of the depression is explained in section 4. If the curvature of the load transmission area becomes too large, there might be the risk that the sliding plate comes into contact with the supporting plate of the sliding material. Based on empirical experience An admissible value of the remaining protrusion $h_r$ of 1 mm resp. h/2 was chosen.

The basic consideration for the derivation of the limiting value is explained in the following.

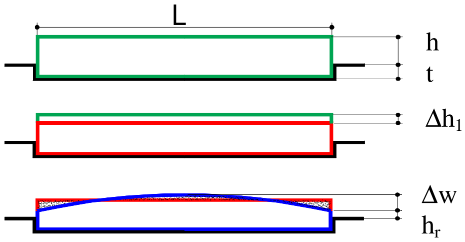


Figure 5 – Compression of sliding material

If a parabolic curvature and a constancy of volume are assumed for compressed PTFE, an admissible curvature of the load application body is derived by defining a admissible centre distance $\Delta w$. It is

$$h = h_r + \frac{2}{3}\Delta w_{zul} + \Delta h_1 \quad \text{resp.} \qquad \Delta w_{zul} = \frac{3}{2}\left(h - \Delta h_1 - h_r\right) \tag{4}$$

For simplification the influence of the parabolic shape was neglected (3/2→1) and a tolerance of height of the sliding material of 10% were assumed (h→0,9h) in DIN EN 1337-2. It is recommended to reanalyze these simplifications in the framework of revision of EN 1337-2. The condition $h_r \geq h/2$ is relevant, as the protrusion is always larger than 2 mm. Hence

$$\Delta w_{zul} = 1 * ( 0{,}9h - \Delta h1 - 0{,}45h ) = ( 0{,}45h - \Delta h_1 ) = h ( 0{,}45 - \Delta h_1/h ) \tag{5}$$

If the deformation of the backing plate exceeds the value $\Delta w_{zul}$, the distance between backing plate and mounting plate is insufficient and wear increases. It is defined as serviceability limit state, as this might reduce the fitness for use in the long term. The rigid body settlement $\Delta h_1$ due to loading depends on geometry and affecting pressure. It is determined experimentally. For sliding materials PTFE and MSM® regarding the stiffness values given in section 5.2 the following requirements are derived:

PTFE: $$\Delta w \leq h \times \left(0{,}45 - 2\sqrt{h/L}\right)$$

MSM®: $$\Delta w \leq h \times \left(0{,}45 - 1{,}708k\sqrt{h/L}\right) \quad \textit{with} \quad 0 \leq 1{,}708k \leq 1.0 \quad \textit{and} \quad k = \frac{\sigma_{MSM}[\text{N/mm²}] - 45}{78{,}5}$$

$\sigma_{MSM}$ is the mean pressure in the sliding surface due to the characteristic load combination and $k$ is the sliding material dependent stiffness constant.

$$\alpha_b = \left(\frac{L}{L + 2 \cdot t_b}\right)^2 \cdot \left(\frac{3 \cdot L_0}{d_b}\right)^{0{,}4}$$

The admissible deformation of the backing plate depends on material and geometry and lies within 0,5 mm and 1,25 mm. The existing deformation $\Delta w$ can be determined by means of the formula given in section 4.2.

It is shown that only the parameter $\alpha_b$ depend on the geometry of the backing plate, i.e. the thickness $t_b$. The term $L/(L + 2\,t_b)$ considers the influence of the load propagation. Hence, on the basis of the admissible deformation $\Delta w_{zul}$ the required plate thickness can be determined.

5.4 Design of the sliding material

Acc. to EN 1337-2 the verification of the maximum pressure is done by assuming a rigid load application body. The following condition shall be verified at ultimate limit state

$$N_{Sd} \leq \frac{f_k}{\gamma_m} \cdot A_r = \frac{f_k}{\gamma_m} \cdot \lambda \cdot A$$

where

| | |
|---|---|
| $N_{Sd}$ | is the design value of the axial force due to the design values of action |
| $f_k$ | is the characteristic compressive strength of the sliding material |
| $\gamma_m$ | partial safety factor for the sliding material |
| A | contact area of the sliding material |
| $\lambda$ | a coefficient of reduction to consider load eccentricity |
| $A_r$ | is the reduced contact area of the sliding surface whose centroid is the point through which $N_{Sd}$ acts with the total eccentricity $e$, which is caused by both mechanical and geometrical effects. $A_r$ shall be calculated on the basis of the theory of plasticity assuming a rectangular stress block. |

As it is shown that the backing plate of sliding elements deforms under loading, the sliding materials for structural bearings require sufficient ductility. Hence, the use of elasto-plastic sliding materials is necessary. Absolute elastic materials would be exposed at the edge to remarkably higher pressure than in the center. This effect can be considered as following:

- A simplified verification is done by assuming a parabolic curved backing plate of sliding elements and an initially plane sliding material sheet

- The deformation behavior is assumed to be elastic, i.e. $\Delta h/p$ = constant, where $p$ is the local pressure in the contact area and $\Delta h$ is the local deformation in direction of the pressure

- $L$ is the diameter of the circular sliding material sheet

- The backing plate of the sliding element is parabolically curved, at the vertex the relative deformation at ultimate limit state is at least 0,75 mm related to the diameter $L$ of the sliding material sheet, see section ??

- The requirement for entire contact in the sliding surface is $p_{min} > 0$ resp. $\Delta h_{min} > 0$

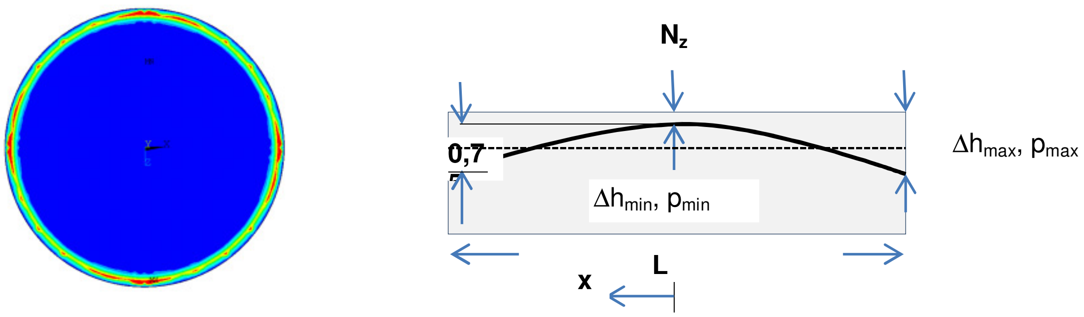


Figure 6 – Nonuniform pressure distribution for a pure elastic sliding material

For a mean pressure $f_d = f_k / \gamma_m$ and $\Delta h_m \geq 2/3 * 0{,}75 = 0{,}50$ mm it implies

$\rightarrow p/\Delta h \geq 0{,}50 * f_k / \gamma_m$ [N/mm³] = constant

By means of this condition and the derived deformation the pressure distribution can be determined, when assuming a parabolic curvature of the plate, by integration of the pressure along the contact surface. It is shown that the modulus of elasticity of a pure elastic sliding material $E_{tGW}$ to guarantee a complete contact with the sliding plate shall be not larger than:

$E_{tGW} \leq 1000$ N/mm²

## 6 Movement capacity of sliding structural bearings

Sliding bearings allow a movement by moving the sliding plate (bearing top section) relatively to the calotte resp. the bearing bottom section due to temperature, earthquake, traffic and wind. While the sliding velocity due to temperature change is very small, the movement velocity due to traffic (e.g. braking), earthquake and wind is considerably higher. In general it is distinguished between dynamic and static friction. The latter is considerably higher and has to be succeeded before a relative displacement takes place, i.e. a sliding between upper and bottom part.

Due to the deformation of the backing plate the pressure in the border area of the sliding material increases. Depending on the sliding material stiffness local deformation in the austenitic mating material, which is fixed at the backing plate, can arise. Due to the increased pressure in the border area as well as possible local deformation in the mating material the required breakaway force can increase, i.e. static friction, and can lead to higher wear and irregular dynamic movement behavior. In particular the sliding behavior of sliding isolation pendulum bearings for buildings can have other than the intended behavior due to the listed effects, as these bearings are only activated in case of earthquake while otherwise they a purely statically loaded. Investigations of the influence of the deformation of the backing plate on the sliding behavior of sliding bearings for different sliding materials were started in Lessloss project [13]. So far no quantitative results are available.

## 7 Conclusion

The deformation capacity should be regarded carefully when developing sliding materials for structural bearings in particular with a high compressive strength. It shall be guaranteed that the structure-related deformation should be compensated and that the required movement capacity due to missing ductility is not restrained. The present standards and guidelines are related only to materials like PTFE and UHMWPE. General material-independent design rules still require fundamental research.

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