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Structural bearings

Bearing systems for civil engineering structures forming part of traffic routes (bridges)

DIN 4141 Part 2

Lager im Bauwesen; Lagerung für Ingenieurbauwerke im Zuge von Verkehrswegen (Brücken)

This standard has been prepared by Section *Einheitliche Technische Baubestimmungen*. It has been recommended to the *Laender* building inspectorates by the *Institut für Bautechnik* (Institute for Building Technology), Berlin, for inclusion in the *Laender* building regulations.

The following standards form part of the DIN 4141 series:

DIN 4141 Part 1 Structural bearings; general design rules
DIN 4141 Part 2 Structural bearings; bearing systems for civil engineering structures forming part of traffic routes (bridges)
DIN 4141 Part 3 Structural bearings; bearing systems for buildings
DIN 4141 Part 4*) Structural bearings; transport, intermediate storage and installation
DIN 4141 Part 14 Structural bearings; laminated elastomeric bearings

Further Parts of this standard are in course of preparation.

Contents

1 Field of application

This standard applies to the bearing systems of bridges and to comparable bearing systems of other structures forming part of traffic routes.

2 Concept

A bearing system is the combination of all structural measures designed to transmit from one structural component into another the stress resultants (forces, moments) derived from structural analysis, and at the same time to facilitate the design deformations of the structural components at these locations.

3 Principles of bearing systems and dimensioning

3.1 Both the bearings as components of the structure and the bearing system shall be integral to the overall design of the structure. The following points shall be borne in mind in this connection.

- The supports of the structure and the possible movements of the bearings shall be specified.
- All effects (including constraints) on the bearings and resulting therefrom shall be followed up in the calculation, dimensioning, design and construction of the bearings and of the bearing support surfaces of the adjoining structural components. The effects of deformation of the structure and of its component parts shall be given similar consideration in so far as they exert an influence on the bearings.

3.2 The bearing system shall be designed with close clearances and low constraints, unless a design clearance and/or design constraints are envisaged or required for static, structural or functional reasons.

In the case of bridges for rail-mounted vehicles, the movement capacity shall, as a general rule, be restricted to movements in the direction of the track, in order to preserve the track geometry.

3.3 If the failure of a mounting (support), or the exceeding of a design or calculated maximum displacement value, cannot be excluded for a given type of bearing system, then appropriate precautions are to be adopted in this respect, if there is any risk of failure of the structure in the event of such an occurrence.

3.4 Specification of the bearing system will require determination and tabulation of the relevant calculated stress resultants and displacements (translational and rotational movements) by means of structural analysis.

*) At present at the stage of draft.

Continued on pages 2 to 5

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3.5 The presetting of the bearing shall be selected on the basis of the design data as specified in subclause 3.4 and shall generally ensure that no further adjustments (at least no on-site adjustments) need to be made to the bearing for it to function correctly after installation.

Movements of bearings which occur only once, e.g. as a result of differential settlement, shrinkage, creep and setting temperature, may be compensated by resetting the installed bearings while under load (see clause 5). In this case, the design movement capacity is restricted to movements which occur repeatedly.

3.6 If more than three bearings are used to support a structural component, bearings of different type or stiffness may only be used on condition that allowance may be made for their differing stiffness.

3.7 In cases where structural components are not constructed on the bearings, e.g. superstructures which are slid into position, the installation measures which will ensure the design load distribution are already to be specified at the design stage.

4 Drawing of the bearing system

A drawing of the bearing system shall be prepared as part of the working design for every structure mounted on bearings, using the symbols and nomenclature listed in table 1 in the September 1984 edition of DIN 4141 Part 1. This drawing shall include the following items with all significant dimensions:

a) plan view of the structure with the main loadbearing members and angle(s) of skew;
b) longitudinal section of the structure;
c) cross sections through the structure in the zone of the bearing axes, indications of relative elevation and inclinations in the zone of the bearings;
d) location and identification of the bearings;
e) vertical and horizontal bearing forces and, if applicable, force couples with their associated directions;
f) directions (individual proportions) and maximum permissible values of bearing translation and rotation;
g) bearing presetting values according to magnitude and direction with indication of the associated values of the effects (e.g. temperature); if applicable, alterations of the presetting values as a function of the effects and in exceptional cases, the inclination of the bearings according to magnitude and direction shall be stated;
h) required quality of the construction material in the bearing joint.

5 Basic design principles relating to the inspection, maintenance, adjustment and replacement of bearings

Bearings shall be capable of being inspected and maintained. For this purpose, bearings shall be easily accessible and both the bearing and the structure shall be suitably designed and constructed to permit such access.

The specifications of either DIN 1076 or DS 803[1], as applicable, shall be taken into account.

The time intervals for inspection shall also comply with those given in the above standards unless shorter time intervals have been specified in other Parts of this standard or in the relevant building inspectorate approvals.

If the subsequent adjustment of bearings after a single movement is to be a design feature of the bearings and of the structure, the lie of the bearing shall be checked and the adjustment made at a time appropriate to the probable course of the movement.

When adjusting or replacing bearings or bearing components, the risk of failure of the structure or of a structural component shall be totally excluded. The mounting positions and insertion points for the jacks, as well as the jacking forces, shall be permanently marked on the structure. Special components or special equipment which the peculiarities of the structure may require to be used for such work on the bearings shall be kept in store for that purpose. Their place of storage in the structure shall be permanently indicated at the point of application. The necessary measures for the above mentioned work on the bearings, the imposed loads which are not to be exceeded, the available clearances, and other conditions which are to be observed, shall all be specified in an instruction sheet which shall be filed together with the official documents and log for the structure (bridge log).

6 Bearing installation drawing

A bearing installation drawing featuring all the data required for the installation (such as dimensions, elevations, inclinations, lateral and longitudinal position, tolerances, qualities of the construction material in the bearing joint) shall be prepared.

The bearing installation drawing may be combined with the drawing of the bearing system to form a single design document.

DIN 4141 Part 4 deals with installation in greater detail.

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[1] Obtainable from the *Drucksachenverwaltung der Bundesbahndirektion Hannover* (Publicity department of the German Federal Railways Administration), Schwarzer Weg 8, D-4950 Minden.

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Standards and other documents referred to

DIN 1076	Civil engineering structures forming part of roads and paths; inspection and testing
DIN 4141 Part 1	Structural bearings; general design rules
DIN 4141 Part 4	Structural bearings; transport, intermediate storage and installation
DS 803	*Vorschriften für die Überwachung und Prüfung von Kunstbauten* (Specifications for the inspection and testing of structures) [1]

Further documents

[1] Eggert, Grote, Kauschke, *Lager im Bauwesen* (Bearings in building and civil engineering), *Verlag Ernst & Sohn*, Berlin, München, 1974 chapter 2.

[2] Eggert, *Vorlesungen über Lager im Bauwesen* (Lectures on bearings in building and civil engineering), *Verlag Ernst & Sohn*, Berlin, München, chapter 7.1.

Explanatory notes

General

"Bearing system" is a concept familiar to the designer. "Support conditions" and "boundary conditions" are often used synonymously. As a general rule, the concept "bearing" is not directly related to the concept "bearing system", which is an assumption, or working hypothesis for structural analysis purposes, after the design characteristics of the loadbearing structure have already been determined.

In many cases, the design engineer adopts assumptions which "err on the safe side" (e.g. pin jointing instead of elastic end-restraint), and the inspector may even concur in these assumptions when in special cases for certain limiting considerations they do not err on the safe side.

Bridges are, as a general rule, unclad, elongated load-bearing structures which are exposed to seasonal temperature variations and which are therefore inevitably subject to corresponding changes in length. Consequently, special structural components have been designed for the bearing systems of bridges, with the exception of very short bridges, for a very long time.

The linear rocker bearings which are still found on old bridge structures are unsuitable for modern bridge structures and hence obsolescent. The absence of rotational capacities about the longitudinal and vertical axes is generally incompatible with modern structures which, as compared with old bridges, exploit their load-bearing reserves to the full. See also [1] in this respect.

The reason for linear rocker bearings being mentioned at all in this standard is the need for guidelines in cases where existing structures are to be reconstructed. Engineers are nevertheless recommended to assess carefully whether it would not be preferable to replace these bearings with point rocker bearings in such cases, because even slightly exceeding permissible values (e.g., in the case of elastomer bearings) is better than retaining the linear bearing system, perticularly when that consists of roller bearings with a restricted deformation capacity.

Re subclause 3.1

As a general rule, a bearing system which optimizes the structure as a whole shall be selected in preference to a system which favours certain individual components only, such as the bearings.

Due allowance shall be made for the bearing system and the action of the bearings when designing the structure as a whole, together with its component parts, particularly those components which are especially influenced by the bearing system and by the action of the bearings, as well as the bearings themselves. Separate assessment of the structural components on either side of the bearing, without any account being taken of the reciprocal interaction of the bearings, and in particular without any account being taken of the deformations, can easily result in serious errors in the dimensioning of the bearings and of the other structural components, with potentially dangerous undersizing or one-sided oversizing which does not result in an inprovement of overall safety.

The elastic and permanent deformations of the sub-structures (such as slender piers, tall abutments) and of their lower and, in certain cases, lateral base joint, also form part of the deformations of the structural components. Particular attention should be paid to cases where several fixed points between the superstructure and the substructures are involved, and where the true fixed point (fulcrum) of the superstructure is only contingently situated on a particular substructure, and can vary for different load cases. Such deformations are particularly likely to promote bearing displacements.

Care shall be taken to ensure that the calculated assumptions made in respect of the stress resultants, stress magnitudes and stress distribution and also in respect of the deformations are effectively observed when designing and constructing the bearings and the structural components mainly affected by the bearing system.

In the case of sliding bearings, the "sliding track" shall be located on top in order to avoid any alteration of the load application point on the substructures. Where adequate stiffening of the superstructure in the sliding zone of steel bridges is not possible, the reverse arrangement is preferable, where the load application point will change in relation to the substructure with the displacement of the bearing.

Regarding the effectiveness of horizontal bearings it is to be borne in mind that a proportion of the horizontal forces will inevitably be dissipated through friction. DIN 1072 specifies how these effects are to be superimposed.

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Re subclause 3.2

A clearance in the bearing system is, while operative, capable of generating a different static system to the one intended. A clearance may also lead to an undesirable and possibly dangerous shock stress. For that reason the constructions adopted shall be designed with as close clearances as possible, especially if bearing forces with a tendency for uplift are likely to arise.

Of the eight theoretically possible constraint-free mounting systems using point bearings (see [2]), only one is practicable, namely the system which incorporates one single fixed bearing, one single bearing free to move in one direction only (towards the fixed bearing) and all the remaining bearings being free to move in all directions. All the bearings shall, in addition, accommodate rotational angles in all directions. Any deviation from the above arrangement will only increase the constraints. If the conditions are such that the horizontal forces are not capable of being absorbed by this bearing arrangement, then the requirement for a bearing arrangement as free as possible from constraint shall be met by arranging tha position and distribution of the bearings as favourably as possible. [1] features a few examples in this respect.

For steel cross girders, it is particularly important to consider the deformation in the longitudinal direction of the bridge when the bearing is in an eccentric position, and in certain cases also the effect of irregular changes in temperature. These effects are especially significant in respect of temperature-sensitive superstructures with steel carriageway slabs.

In the case of bearing systems of bridge superstructures which are not free from constraint, considerable and by no means negligible constraints may arise as a result of the twisting and arching of the superstructure. These constraints can exceed the other constraints by a large margin.

The arrangement of a number of fixed bearings on one axis side by side, and the resulting constraints are only justifiable on condition that the cost of compensatory measures (e.g. the necessary limitation of cracks in the adjoining reinforced concrete or prestressed concrete components) can be kept within economic limits. Similarly, the fixed bearing arrangement of the superstructure can only be distributed onto a number of adjoining piers in the case of long valley bridges (viaducts) with tall piers on the same condition.

If arched superstructures are fabricated in sections, additional investigations will be required to determine the lines of action and the constraints.

The use of different types of bearings on one and the same bearing axis of a superstructure is only permissible on condition that bearings of the same type are used on each support point. In this respect, for example, steel point rocker bearings and spherical rocker bearings corresponding to types 7a and 8b in table 1 of DIN 4141 Part 1, September 1984 edition, are considered similar bearings. If the above condition cannot be satisfied, the different stiffness and deformation of the different types of bearing shall be taken into account. A thorough stress analysis which also accounts for deformation is the main requirement to be met before individual bearings may be arranged next to one another for the absorbtion of line loads.

Re subclause 3.4

When calculating the displacement, the effect of angular torsion of the superstructure above the fixed bearing shall also be taken into consideration.

Dimensioning shall not be restricted to the consideration of the design constraints and deformations only, but shall also, where necessary, allow for non-design constraints and deformations (e.g. as a result of inaccurate installation) by means of additional calculations. Such installation inaccuracies shall, if necessary, be subsequently remedied.

In the case of prestressed concrete superstructures, the magnitude of bearing displacement will depend on, amongst other things, the magnitude of prestressing and on creep and shrinkage, whereas the direction of the displacement will depend on the shape of the loadbearing structure, on the location of the fixed point and on the guidance of the prestressing element. An accurate calculation is absolutely essential for the dimensioning and presetting of the bearings in the case of bridges where the superstructure is fabricated in sections.

Re subclause 3.5

If the assessment of the probable deformation due to settlement is doubtful or if an appreciable deformation of the foundations is a possibility at some future date, suitable steps shall be taken and, if necessary, suitable devices incorporated to make it possible to reset the bearings. The extent of this resetting shall take into account the settlement data contained in the expert's report about the foundations, the possible subsidences which may occur as a result of mining activities and the special circumstances relating to the structure.

The resetting of the bearings may also serve to dissipate the permanent load with an almost total absence of moments after the fading of creep and shrinkage of the superstructure and for the latter's mean effective permanent temperature. This applies to the substructure in particular but also to certain superstructures (for example arches). This permits smaller design values and also avoids additional creep effects, which would in turn increase the design values. The conditions which deviate from the above up to the moment of resetting shall, of course, be taken into consideration. This applies particularly to the green concrete which is then highly sensitive to creep. Resetting of the bearings does, however, entail additional risks and requirements. This shall be borne in mind when weighing up its advantages and disadvantages.

Re subclause 3.6 and subclause 3.7

Every civil engineer is well aware of the fact that structural components cannot be manufactured with such a high degree of accuracy that more than three supports will be absolutely level unless special measures are adopted.

Re clause 4

The following documents are, as a rule, required for the preparation of the drawing for the bearing system:

- site plan indicating the curvature of the flyover traffic route, angle of skew, plan view of the structure, width of the traffic lane, etc.;
- plan of the gradient indicating the inclination of the structure, gradient changes in the flyover traffic route etc.;

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- general drawing of the structure;
- description of the loadbearing system containing all main dimensions and data;
- details of probable and possible settlements of the foundations, effects arising from mining activities etc.;
- details of translational movements, bearing forces and rotational movements;
- cross section through the structure in the zone of the axes of the supports, drawings of the details of the superstructure and substructure in the zone of the bearings, in particular with regard to their effect on the design, calculations and loadbearing behaviour of the bearings;
- permissible compressive stresses for the concrete and mortar or reference to the relevant specifications covering these;
- if applicable, certificates of approval relating to the proposed bearings.

In special cases, for example in the case of arched girders and framed loadbearing systems, additional details shall be provided.

Re clause 5

The safe and reliable execution of inspection, maintenance and repair work on the bearings, and of the work connected with the adjustment of the bearing position and with the replacement of the bearings shall be ensured, and such work shall be as simple as possible. Adequate space shall be provided, even in piers, for the insertion of lifting jacks. The use of jacks can be dispensed with in exceptional cases, if the dimensions of the cross sections of the supports and piers are small, and if the latter are not too tall, and if the loads can be carried by the foundations with the aid of auxiliary supports.

If the expected service life of the structure is shorter than its design life, and if no necessity to replace bearings or bearing components during the service life is anticipated, while such a necessity is anticipated during the design life, then replaceability may only be dispensed with on condition that no danger will arise as a result of damage to a bearing in the structure when no longer in use.

An angular torsion on the support will occur even in the raised position, especially as a result of the imposed load; its effect shall be taken into account. In the case of a temporary supporting action on jacks, which are usually arranged on two lateral axes parallel to the bearing axis, one part of the jacks in the locked position will be subjected to a much greater load, as a result of angular torsion of the supports, than the load calculated on the assumption of an equal loadbearing action on all the jacks.

In the raised postion, or in any other position involving a release from the design support, a superstructure or other similar structural component shall be securely held by suitable means. Special securing means are, for example, required if a fixed bearing is raised, especially if it happens to be the only bearing, or if the hold for rocker walls, such as the backfill of rocker wall type abutments, is removed.

The compulsory information on the structure itself does not exempt the engineer from basing his preparatory plans for work on the bearings on the relevant documents which are kept in the log book of the bridge concerned.

Re clause 6

The installation instructions of the bearing manufacturer shall be taken into account in the preparation of the bearing installation drawing and during the actual installation of the bearings (see DIN 4141 Part 4). It is strongly recommended that arrangements are made in good time to have an experienced representative of the bearing manufacturer present on site during the installation of at least the first batch of bearings. His instructions can then be applied to the installation of the remaining bearings.

International Patent Classification

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