The invention relates to an arrangement for stabilizing supporting structures for equipment, plants, buildings and other construction works. It serves simultaneously for bracing corresponding structures and stabilizing them against vibrations, in particular those that are caused by earthquakes.

For this purpose, supporting elements that are adjacent to one another will be braced together by means of tension elements, such as tension cables, tension rods or beam ties, wherein, according to the invention, at least one uniaxially acting additional element, which is formed as a parallel connection between at least one spring and at least one viscous or viscoelastic damper, is disposed in between the tension elements. The tension elements, which brace the supporting elements to one another and the one or more additional elements disposed in between them form a stabilizing unit according to the invention, within which the tension elements and the one or more additional elements are connected to one another in series. According to the invention, a prestressing is produced for the tension elements by means of the additional elements.
ARRANGEMENT FOR STABILISING SUPPORTING STRUCTURES

[0001] The invention relates to an arrangement for stabilising supporting structures for equipment, plants, buildings and other construction works. The proposed arrangement thus serves simultaneously for bracing corresponding structures and stabilizing them against vibrations, in particular those that are caused by earthquakes. Preferably, the arrangement according to the invention serves for stabilizing framing constructions.

[0002] It has been known for a long time, in particular in the building trade, to statically stabilize supporting structures, such as framing structures, for example, of tall buildings, by bracing elements, whereby the appropriate bracing elements bring about a load reduction of the structure. Here, the so-called “support triangle” or the bracing of framing structures by means of diagonally disposed bracings, which are incorporated load-free in a corresponding supporting structure, is particularly familiar. It is also known to stabilize tall buildings, such as steel towers, for example, by tension cables or tension rods. The above-named measures are very effective, in fact, with respect to the static stabilization of the most varied supporting structures and are indispensable in many cases, but they are effective only with limitations in the case of dynamic loads that may occur, such as are characteristic in the case of intense vibrations caused by earthquakes. At least, it is not possible with these measures to provide a uniaxial stabilization against dynamic loads or the stabilization of a structural element such as, for example, an element of a framing structure, with only one frame brace. Rather, in order to obtain a certain stabilization effect against dynamic loads, it is necessary to arrange appropriate bracing elements such as beam ties, for example, in pairs and oriented in opposite directions to one another. An appropriate arrangement that reproduces this prior art is shown, for example, by FIG. 9. A comparable solution is also disclosed by U.S. Pat. No. 6,233,884 B1.

[0003] With respect to the protection of construction works against vibrations as caused by earthquakes, the use of dampers, particularly viscous dampers, has been proposed in different ways in the past. An appropriate solution employing a damper inserted diagonally into a framing structure is disclosed, for example, by WO/01/73238 A2. The solution that is shown, however, is associated with the disadvantage that it must be designed very solidly or massively due to the alternating tensile and compressive loads, as are typical in practice, particularly in the case of earthquakes, in order to minimize the danger of buckling that exists with compressive loads for dampers or for fastening elements of the damper or the connection elements, respectively, given their structure. This requirement of a sturdy or massive design is accompanied by relatively high costs when the named solution is employed. In addition, the damper does not contribute to the static reinforcement of the supporting structure. Rather, for this purpose, as can be seen from FIG. 5 of the named document, special bracing elements are disposed on the supporting structure, for example, in other frames of a framing structure.

[0004] The object of the invention is to provide a solution that makes possible an effective, yet cost-favorable stabilizing of supporting structures both from a static as well as a dynamic perspective.

[0005] The object is solved by an arrangement with the features of the principal claim. Advantageous embodiments or enhancements of the arrangement of the invention are given by the subclaims.

[0006] The arrangement according to the invention serves for stabilizing supporting structures for technical objects, such as equipment, plants, buildings or other construction works. Supporting structures that consist of supporting elements that are formed as supports or horizontal supporting girders and/or form a framing structure, will be stabilized with it. Thus, in a way known in and of itself, supporting elements that are adjacent to one another will be braced together by means of tension elements, such as tension cables, tension rods or beam ties. According to the invention, however, at least one uniaxially acting additional element that is formed as a parallel connection between at least one spring and at least one viscous or viscoelastic damper is disposed in between the tension elements. The tension elements which brace the supporting elements with one another and the one or more additional elements disposed in between them form a stabilizing unit according to the invention. The tension elements and the one or more additional elements are connected to one another in series within the stabilizing unit that is formed in this way. In a way that is essential to the invention, a prestressing is produced for the tension elements by means of the additional elements. In this way, the stabilizing unit forms a static reinforcement for the supporting structure, but it also acts in a load-reducing manner, even in the case of strong dynamic loads, for example, due to vibrations that are caused by earthquakes. By prestressing the cables or beam ties, compressive forces do not arise in the stabilizing unit under the effect of earthquakes. The damping and the spring rigidity of the stabilizing unit formed by the arrangement according to the invention thus are effective also in the case of alternating stresses (alternating between tensile and compressive stresses) in an advantageous manner, since only the static tensile force is increased or decreased by the earthquake forces. Expensive or other, additional compressive reinforcements that prevent a buckling of the stabilizing unit under pressure are usually not necessary. At the same time, the prestressing of the tension elements causes the rigidity or loading capacity of the stabilizing unit to contribute to removing the loads caused by earthquake forces. Therefore, the unit also serves for (static) reinforcement. The damping of the system as well as its resistance will be effectively increased in order to take up earthquake forces.

[0007] The spring or springs of the additional element disposed in between the tension elements may involve screw-type pressure springs according to one possible embodiment of the invention. A tension element and an additional element are coupled by means of a coupling element loaded with the compressive force of the screw-type pressure spring or springs, which deflects this compressive force and transfers it to the tension element as tensile force.

[0008] The spring or springs of the additional element, however, may also be designed as a tension spring, whereby a tension element and this additional element are then coupled by a coupling element, by means of which the tensile force of the tension spring or springs that acts on these springs is transferred almost directly to the tension element.

[0009] With respect to the joining of the stabilizing unit, there are also many different possibilities in the sense of the arrangement according to the invention. For example, the stabilizing unit can join together the supporting elements of a
framing structure. According to one possible configuration that is relevant in practice, a diagonal reinforcement for the frames of a framing structure is thus formed by the stabilizing unit, wherein the stabilizing unit preferably joins together two corner points of the frame.

[0010] The arrangement according to the invention, however, can also be formed in such a way that the supporting elements that are adjacent to one another, which are joined together by means of a stabilizing unit, involve parts of supporting structures of different technical objects, thus, for example, supports of the framing structures of two buildings that are adjacent to one another.

[0011] The invention will be explained once more in more detail below on the basis of embodiment examples. In the appended drawings are shown:

[0012] FIG. 1A schematic representation of a first embodiment of the arrangement according to the invention

[0013] FIG. 2 The schematic representation of another possible embodiment

[0014] FIGS. 3-5 Modifications of the embodiments explained above or possibilities for their combination

[0015] FIGS. 6-8 Possibilities for joining the arrangement according to the invention to supporting structures

[0016] FIG. 9 The schematic representation of an arrangement for the bracing of supporting structures according to the prior art

[0017] FIG. 10 The schematic representation of a solution known from the prior art for stabilizing construction works against vibrations caused by earthquakes.

[0018] FIGS. 1 and 2 each show, in schematic representation, possible embodiments of the arrangement according to the invention. These are contrasted to the arrangements which are also shown schematically in FIGS. 9 and 10, and which are known from the prior art, on the one hand, for the static stabilization of construction works, and, on the other hand, for their protection against vibrations caused by earthquakes. For a better clarification of the effect obtained with the arrangement according to the invention, arrangements known from the prior art, which are shown in FIGS. 9 and 10, will first be discussed briefly. FIG. 9 shows schematically a supporting structure 7 formed as a framing structure 10, which is statically stabilized by diagonally disposed reinforcing elements 11, 11', for example, corresponding braces. As was already emphasized initially, arrangements such as these, in which the braces are inserted free of load into the supporting structure, have proven suitable for static stabilization. As far as intercepting dynamic stresses is concerned, however, it is not sufficient to stabilize such a framing structure 10 by means of only one reinforcing element 11 acting uniaxially. Rather, as shown in FIG. 9, it is necessary to arrange corresponding reinforcing elements 11, 11' in pairs and to arrange them oriented in opposite directions to one another. However, even with this measure, only a comparatively small protection is afforded against dynamic vibrations, for example, those caused by earthquakes.

[0019] FIG. 10 shows schematically an arrangement for the dynamic stabilization of a construction work or the like, as it is known from the prior art cited initially. A preferably viscous or viscoelastic damping element 12 is incorporated in an essentially diagonal arrangement in a supporting structure 7 also formed as a framing structure 10. A statically reinforcing effect, however, is not provided by such a damping element 12. In order to achieve a sufficient stability against stresses alternating between tensile and compressive stresses, which are accompanied by an elevated danger of buckling, particularly in the case of compressive stress, a very sturdy or massive design of the damping element 12 is necessary. The damping element 12 that is shown does not contribute to diverting the static forces caused by the structure itself, so that special reinforcing elements must be provided for this purpose.

[0020] In contrast to this, an effective stabilization of supporting structures 7, 7' simultaneously under both static as well as dynamic stresses is achieved by the solution according to the invention, as it is shown in FIGS. 1 and 2 in two possible variants. Therefore, the arrangement also possesses a very simple form, which makes it cost-effective for its manufacture and installation, on the one hand, and, on the other hand, allows it to be adapted very simply to different special features and requirements; it also can be retrofitted, for example, for existing construction works or support systems for equipment. The basic principle according to the invention is common to both variants. Accordingly, a stabilization of the structure is produced by means of tension elements 1, 1', such as beam ties or tension rods, in between which are disposed a viscoelastic additional element 2, 2', i.e., in parallel, a spring 3, 3' and a viscous or viscoelastic damper 4, wherein the tension elements 1, 1' are prestressed by means of the additional element 2, 2'. The two schematically shown variants differ to the extent that in the design according to FIG. 1, a tension spring 3 is used, whereas in the variant according to FIG. 2 a screw-type pressure spring 3' is used. Consequently, the viscoelastic additional element 2, 2' disposed in between the tension cables or tension rods 1, 1' is coupled in different ways, as can be seen from the figures. According to the variant of FIG. 1, the additional element 2 and the tension elements 1, 1' are joined together by coupling elements 5, 6, which transmit the tensile force of the tension spring to the tension elements almost directly. In contrast, the coupling elements 5', 6' in the embodiment according to FIG. 2 act in a force-deflecting manner, by transmitting the compressive force, with which they are loaded by the pressure spring 3', as a tensile force to the tension elements 1, 1', which determines the prestressing of the tension elements 1, 1'. In the given representations of the invention, the reference numbers 3 and 3' as well as the reference numbers 4 thus refer also, optionally, to groups of springs 3, 3' or dampers 4 disposed in parallel, wherein appropriate groups with suitable geometry adapted to one another are employed in practice.

[0021] According to the invention, the arrangement that serves for stabilizing a supporting structure 7, 7' is configured in such a way that at least one viscoelastic additional element 2, 2' is disposed in between the tension elements 1, 1' bracing adjacent supporting elements 8, 9, 9', 10, 10' of the supporting structure 7, 7', and is connected to them in series with the formation of a stabilizing unit. This, of course, leaves open the possibility that several viscoelastic additional elements 2, 2' are disposed within one stabilizing unit. Optionally, the variants for the connection between tension elements 1, 1' and additional elements 2, 2', which are shown in FIGS. 1 and 2, may also be combined with one another. Appropriate possibilities are illustrated by FIGS. 3 to 5.

[0022] Likewise, just as the respective layout of the components of the arrangement according to the invention, for example the size and thickness of the beam ties 1, 1', the prestressing force or the spring constant of the spring or springs 3, 3' of the viscoelastic additional element 2, 2' or the dimensioning of its damper 4 depend on the respective special
features, such as type of supporting structure 7, 7 and site of installation, as well as the loads that are anticipated, different possibilities or requirements for the type and manner of installation of the arrangement and its connection with the principal system of the one or more supporting structures 7, 7' are applied as a function of the named factors. As an example of this are the possibilities shown schematically in FIGS. 6 to 8, but these are not to be considered the only possibilities.

[0033] FIGS. 6 and 7 show two possibilities for a diagonal connection of the arrangement according to the invention with the supporting elements 8, 9, 9' of a supporting structure 7 in the form of a framing structure 10; these are distinguished by the selection or positioning of the connection points between supporting structure 7 and the stabilizing unit. Whereas the stabilizing unit formed from the beam ties and the additional elements 2, 2' corresponding to FIG. 6 connects two corner points of the frame of a framing structure 10, according to FIG. 7, it is bounded by the lengthwise sides of two supporting elements 8, 9 of the supporting structure 7 that are adjacent to one another and connected with one another. FIG. 8 shows the example of a horizontal connection of the supporting structures 7, 7' of two different technical objects or framing structures by means of the stabilizing unit formed from tension elements 1, 1' and an additional element 2, for example, the connection of two towers or poles or one tower with one pole.

[0034] In addition to the simple construction and the low costs that result for its use, the arrangement according to the invention has the following advantages:

[0035] Due to the fact that alternating stresses (alternating tensile and compressive stresses) can be taken up by the arrangement, the furnishing of one reinforcing field or one frame of a framing structure consisting of a multiple number of grid-like frames joined together can be sufficient for the earthquake protection of a system or a technical object such as a building.

[0036] The stabilizing unit formed from the combination of tension elements and viscoelastic* (viscoelastic) additional element(s) can engage in the direct vicinity of the framing nodes and usually requires no other special

* sic; viscous?...Trans. note, reinforcement, unlike the solutions known from the prior art.

[0037] The earthquake resistance of the structure is essentially improved with correct layout.

[0038] The arrangement can be applied in new construction or for earthquake resistance of existing structures.

[0039] The three-dimensional orientation does not play a role with the use of uniaxially acting dampers. Thus, either a horizontal or vertical reinforcement of supporting structures can be achieved.

[0040] The arrangement or the total system is easy to model dynamically. In actual use, additional static loads occur, which are frequently found in equilibrium.

[0041] The arrangement is easy to install—usually, no extensive additional measures are necessary. The existing support system or the supporting structure is usually not changed, but only complemented by additional rigidity and damping.

[0042] The arrangement operates purely passively—a special input of energy and a control mechanism are not necessary.

[0043] The arrangement is nearly maintenance-free and does not wear.

[0044] A standardizing, for example, for different prestressing forces, is conceivable.

[0045] The arrangement can be used in a very versatile manner due to the above-named advantages.

LIST OF REFERENCE NUMBERS USED

[0046] 1. 1', 1' Tension element (tension cable, tension rod, tension strap or beam tie)
[0047] 2. 2' Additional element
[0048] 3. Tension spring
[0049] 4. (Screw-type) pressure spring
[0050] 5. Viscous or viscoelastic damper
[0051] 6. Coupling element
[0052] 7. 7' Supporting structure
[0053] 8. Girder
[0054] 9. 9' Supports
[0055] 10. 10' Framing structure
[0056] 11. Reinforcing element
[0057] 12. Damper

1. An arrangement for stabilizing supporting structures for technical objects, such as equipment, plants, buildings or other construction works, whose supporting structures consist of supporting elements, which are formed as supports or horizontal support girders and/or form a framing structure, wherein supporting elements that are disposed adjacent to one another are braced together by means of tension elements, such as tension cables, tension rods or beam ties is characterized in that at least one uniaxially acting additional element that is formed as a parallel connection between at least one spring and at least one viscous or viscoelastic damper is disposed in between the tension elements and the tension elements that brace the supporting elements to one another and the one or more additional elements that is/are disposed in between them form a stabilizing unit, within which the tension elements and the one or more additional elements are connected to one another in series, and a prestressing of the tension elements is produced by means of the additional elements, so that a static reinforcement for the supporting structure is formed by the stabilizing unit, which also acts to reduce the load in the case of strong dynamic stress, for example, caused by earthquakes.

2. The arrangement according to claim 1, further characterized in that the spring or springs of an additional element are formed as screw-type pressure springs, wherein the coupling between a tension element and this additional element is provided by a coupling element loaded with the compressive force of the screw-type pressure spring or pressure springs, and this element deflects this compressive force and transfers it as tensile force to the tension element.

3. The arrangement according to claim 1, further characterized in that the spring or springs of an additional element are formed as tension springs, wherein the coupling between a tension element and this additional element is provided by a coupling element, by means of which the tensile force of the tension spring or tension springs acting on it is transferred to tension element.
4. The arrangement according to one of claims 1 to 3, further characterized in that the stabilizing unit connects the supporting elements of a framing structure with one another.

5. The arrangement according to claim 4, further characterized in that a diagonal reinforcement for the frames of a framing structure is formed by the stabilizing unit.

6. The arrangement according to claim 5, further characterized in that the stabilizing unit connects two corner points of the frame of a framing structure with one another.

7. The arrangement according to one of claims 1 to 3, further characterized in that the supporting elements that are adjacent to one another and which are connected to one another by means of a stabilizing unit that is formed from tension elements and additional elements involve parts of supporting structures of different technical objects.