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WO-A2-2008/016295
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DESCRIPTION

Field of the invention

[0001] The invention relates to a blast protection wall.

Background

[0002] Blast protection walls, also known as "blast walls", are designed to maintain a closed wall surface when exposed to an air pressure surge from an explosion, to shield the space behind the wall from the explosion. Blast wall design is discussed in a paper titled "Implementation of blast resistance requirements on offshore installations" by D.H. Groeneveld and P.C. Goudswaard published by the institute of Marine Engineers and presented at WMET '91 "Offshore Operations Post Piper Alpha" February 6-8 1991, pages 12-1 to 12-8.

[0003] Conventionally, blast walls are made from a metal plate with stiffening beams connected to the plate or from corrugated metal panels, e.g. with a periodical trapezoidal cross-section. The article notes that the deflection amplitude of the wall needs to be limited to avoid damage. Conventional static design for loaded structures does not suffice to ensure this. Static calculations apply when loads vary at time scales that are much longer than wall resonance frequencies. In contrast, time plays an important role in blasts, as the blast forces may excite resonance modes of the wall, which may result in deflections of greater amplitude than in the static case with the same load amplitude. Moreover, the amplitude of the deflection due to blasts depends not only on the possible amplitudes of air pressure variation due to the blast but also on their time dependence and the effect of wall mass and stiffness on the resonance frequencies. The conventional walls have to be designed to absorb the vibration energy, due to both elastic and plastic deformation of the wall surface.

[0004] Apart from the dynamic deformation of the wall, the article also discusses the connection between the blast wall and the supporting structure (posts, in fill panels) needs special attention, because considerable forces must be transmitted. The article discusses use of beams with flanges reinforced by braces or stiffeners, or using box girders.

[0005] To minimize the dynamic deflection amplitude of the conventional walls, high wall stiffness is desirable, but for constructive reasons the wall mass should be limited. The conventional solutions achieve a compromise by using stiffening beams connected and corrugated metal panels. But to achieve sufficient blast resistance relatively thick corrugated of stiffened metal plates are needed, which results in considerable weight.

[0006] KR101599930 discloses a bullet and explosion proof panel unit that has a sandwich structure in which an aluminum foam panel and a bulletproof board are laminated between outer shell plates. A steel back plate is provided between the panel unit and support beams, which may extend vertically and horizontally, and are attached to the back surface of the back plate.

[0007] Explosion energy is absorbed in the aluminum foam layer. To prevent accumulation of fatigue, a vibration damping plate is located between the back plate and the outer shell plate of the panel unit. The vibration damping plate may be a thin sheet of rubber or synthetic resin. The vibration damping plate absorbs vibrations This prevents accumulation of fatigue in the outer shell plates due to repeated small impacts, by preventing vibration and noise from being generated.

[0008] Furthermore a corrugated front panel may be provided in front of the sandwich panel. Spacers containing a rectangular pipe filled with foamed aluminum may be provided between the sandwich and the corrugated front panel. An explosion in front of the front plate will deform the front plate. The spacer partially absorbs the energy transmitted from the front plate to the sandwich panel, thus improving the energy absorbing capability.

[0009] In KR101599930 a back plate that covers the whole of the back surface is indispensable to provide explosion resistance. The sandwich foam panel only serves as an absorptive cladding. Thus the wall needs to be quite heavy to withstand explosions. The corrugated plate on the front has to catch the initial impact, which will result in considerable deformation of the corrugated plate, which in turn diminishes its contribution to the overal strength.

[0010] GB2453048 discloses the construction of a blast proof building using prefabricated blast proof structural panels. Each panel includes a structural core in the form of a rigid metal framework between an inner skin and an outer skin. The outer skin contains layers of metal and a cementitious board behind those layers, to act as a thermal break. The outermost layer of the skin is secured to the structural core using pins or screws or other mechanical fixings.

[0011] The panels are secured to the inner structure of the building using brackets that allow independent movement of the panels. The brackets are located on vertical pins that extend from the inner structure, the brackets having oversized apertures to receive the pins leaving a clearance that enable the brackets to move relative to the pins and the inner structure of the building.

[0012] DE102012105628 discloses a wall panel formed by a sandwich of a fiber core material between metal layers.

Summary

[0013] Among others it is an object to provide for a lighter blast protection wall.

[0014] A blast protection wall is provided that comprises

- a sandwich wall panel comprising a first and second metal plate;
- a support structure comprising support posts, for supporting the sandwich wall panel;

characterized in that

- the sandwich wall panel comprises a layer of fibers between the first and second metal plate, the layer of fibers interconnecting the first and second metal plate; and the blast protection wall comprises
- a mechanically plastic baffle connected between the support structure and the sandwich wall panel.

[0015] A sandwich wall panel can be made light compared to conventional wall panels of blast protection walls. However, because of its low weight, the sandwich wall panel transmits air pressure impact pulse forces more directly to the supporting structure, which may lead to more significant motion of the supporting structure and possible damage. The mechanically plastic baffle mediates the forces between the sandwich wall panel and the support structure. Plastic compressibility of the baffle serves to absorb part of the blast energy before it is transmitted to the support structure. The impact pulse forces may cause vibrations of the support structure, but the mechanically plastic baffle reduces the maximum movement caused by the vibrations. In this way the risk of damage is reduced.

[0016] As used herein "mechanically plastic baffles" are designed to deform plastically under forces (preferably by plastic folding under forces), in particular compression forces exerted between the sandwich wall panel and the support structure, without excluding that the mechanically plastic baffles can also deform partly elastically. Preferably, a mechanically plastic baffle is used that is compressed substantially elastically under compression without plastic compression (or at least less plastic compression than elastic compression) at least in an initial range of relatively smaller compressions, and is compressed plastically under compression in a further range of relatively larger compressions. Preferably, the mechanically plastic baffle comprises a surface that is configured to fold plastically, developing folds along one or more fold lines (including crumpling), when a force is exerted via the sandwich wall panel.

[0017] The mechanically plastic baffle may comprise a mechanically plastic folding zone that folds plastically under compression only when the baffle is compressed over more than a predetermined distance between the sandwich panel and the support structure. This may be realized by using a mechanically plastic folding zone that is connected to the sandwich wall and pushed toward the support structure until a contact is made between it and the support structure, so that the mechanically plastic folding zone starts folding inelastically when it contacts the support structure, e.g. by folding on an edge of the support structure or by crumpling under pressure between the support structure and the sandwich panel. The same may be realized by a mechanically plastic folding zone that is connected to the support structure, the sandwich wall or a structure on the sandwich wall panel being pushed towards the plastic folding zone until contact is made with the sandwich wall or the structure on the sandwich wall panel.

[0018] In an embodiment the mechanically plastic baffle comprises a plastic folding zone located in a path of transmission of forces from the sandwich wall panel to the support structure. The plastic folding zone folds inelastically when large forces are transmitted. For example, the plastic folding zone may be designed to fold inelastically over an edge when forced by the forces between the sandwich wall panel and the supporting structure, or it may be designed to crumple. i.e. to fold freely, so that energy is irreversibly absorbed by folding.

[0019] In an embodiment wherein folding on an edge is used, the supporting structure has an endorsing surface facing the sandwich wall panel, the mechanically plastic baffle comprising a spacer portion located beyond an edge of the endorsing surface, when seen in projection perpendicular to the sandwich wall panel, the spacer portion being connected between the sandwich panel and the plastic folding zone, the plastic folding zone comprising a metal plate or metal plate part extending from the endorsing surface to the spacer portion, so as to enable the spacer portion to exert a force to fold the metal plate or metal plate part over the edge of the endorsing surface. The metal plate or metal plate part may extends obliquely from the endorsing surface to the spacer portion. In this way a combination of elastic and inelastic compression is provided.

[0020] In an embodiment wherein crumpling is used the mechanically plastic baffle comprises a crumple wall extending in a direction between the support structure and the sandwich wall panel, over no more than part of a distance between the beam and the sandwich wall panel under force free conditions when no force is exerted to reduce the distance between the supporting structure and the sandwich wall panel. The mechanically plastic baffle may comprise a combination of a crumple wall and a folding zone that is designed to fold inelastically over an edge. For example the crumple wall and the folding zone may be designed to start plastic deformation sequentially during increasing compression.

[0021] The support structure may comprise a plurality of beams attached in parallel to the support posts and a plurality of mechanically plastic baffles, each connected between a respective one of the beams and the sandwich wall panel. In this way large wall area can be protected. In an embodiment a corrugated plate is provided on at least part of a surface of the sandwich panel. This makes it possible to achieve the same protection with fewer beams. In an embodiment the corrugated metal plate is located on the same side of the sandwich wall as the beam. In this way the sandwich panel shields the corrugated metal plate

Brief description of the drawing

[0022] These and other objects and advantages will become apparent from a description of exemplary embodiments using the following figures

Figure 1 shows a cross-section of a wall panel

Figure 2 shows wall comprising a wall comprising intermediate bars

Figure 3 shows a cross-section of an embodiment

Figure 4 shows a force-displacement relation of a plastic deformation body

Figure 5 shows an embodiment with a crumple wall

Figure 6 shows an embodiment with a corrugated backing

Figure 7a,b show an embodiment a further mechanically plastic baffle

Detailed description of exemplary embodiments

[0023] Figure 1 shows a cross-section of a sandwich wall panel. NL8701813 describes similar light weight sandwich wall panels, but it is not concerned with blast resistance. The wall panel comprises a first metal plate 10, a second metal plate 12 and a fiber layer 14 between the first metal plate 10 and the second metal plate 12. By way of example, first and second metal plate 10, 12 may one millimeter thick steel plates. Also by way of example, fiber layer 14 may be 200 millimeter thick and preferably at least 100 millimeter so as to provide significant explosions resistance. Fiber layer 14 may be made of mineral fibers. A mineral wool like the wool called stone wool may be used for example. Use of mineral fibers provides for a fire resistant wall. The fibers at the opposite surface of fiber layer 14 are adhesively connected to first and second metal plate 10, 12 and in fiber layer 14 the fibers are adhesively interconnected to each other e.g. by a resin. For explosion resistance purposes, fiber layer 14 preferably has a mass density in a range of above 100 kg per cubic meter, and more preferably above 150 kg per cubic meter, e.g. 200 kg per cubic meter. This is considerably higher than fiber layers used for thermal isolation purposes. (normally 40-60 kg/m3) The fibers in fiber layer 14 extend substantially perpendicularly to first and second metal plate 10, 12, i.e. the statistical distribution of the fiber directions peaks for a direction perpendicular to first and second metal plate 10, 12, or at least at no more than an angle of thirty degrees from the perpendicular direction.

[0024] The sandwich of relatively thin metal plates with a fiber layer 14 provides for a high bending inertia in response to air pressure forces on the wall panel, and provides a light weight construction compared with corrugated metal plates or metal plates with stiffeners that are conventionally used in blast resistant walls.

[0025] Figure 2 shows a wall with mounting posts 22 (also referred to as support posts), horizontal beams 24, intermediate bars 20 and a row of vertical sandwich wall panels 26. Each wall panel comprises a sandwich as shown in figure 1. The vertical wall panels are arranged in the plane of the wall. Although a wall with a plurality of sandwich wall panels is show, it should be appreciated that instead a single sandwich wall panel could provide the entire wall surface. In figure 2 only the first metal plates 10 of the wall panels are shown. Mounting posts 22 are anchored to the floor and/or ceiling, e.g. to Other construction elements (not shown) or the ground. Horizontal beams 24 are mounted horizontally at different heights on mounting posts 22. Horizontal beams 24 may be I beams. Intermediate bars 20 are mounted horizontally on horizontal beams 24. Surfaces of Intermediate bars 20 back up the sandwich wall panels. First metal plates 10 are attached to these surfaces of intermediate bars 20.

[0026] Although the wall made of vertical panels is shown by way of example, other configurations are possible. For example, the wall may comprise of only a single panel, or the panels may be horizontal panels at different heights. Similarly, intermediate bars 20 and beams 24 may be vertical intermediate bars 20 and beams 24 and further support structures may be present. Each intermediate bar 20 may extend over a plurality of wall panels, as shown, but in another embodiment separate intermediate bars may be used for different wall panels.

[0027] Because of the light weight of the sandwich, its inertia is small. When it is exposed to a blast pressure wave it will move much faster than conventional, heavier corrugated metal plates or metal plates with stiffeners. This movement will be arrested by the support structure formed by mounting posts 22, horizontal beams 24 and intermediate bars 20. The sandwich transmits the forces resulting from the blast much faster to the support structure than conventional blast resistant walls with metal- plate only surfaces. In the conventional blast resistant walls, the time dependence of the forces on the support structure differs significantly from that of the blast pressure, because it is affected by the dynamic effects within the wall. As a result, the dynamic response of the support structure does not play an important role for conventional blast resistant walls. In contrast, the transmission of the forces by the light weight sandwich, makes the dynamic response of the support structure important.

[0028] To reduce the risk of damage due to dynamic vibration amplitudes excited in the support structure by the transmission of forces by the sandwich, the support structure contains a mechanically plastic baffle, that is, a body of which at least part is plastically (inelastically) deformable so as allow a compression of the body. For example, the body may comprise a plastic deformation zone such as a crumple zone dimensioned to absorb a significant part of the dynamic energy by plastic deformation. To avoid misunderstanding it is noted that the word "plastic" herein refers to the physical nature of the deformation of the body (that it provides for inelastic deformation), and not to the chemical composition of the body. The mechanically plastic baffle may e.g. be made of metal. An embodiment will be illustrated wherein this is done by means of the intermediate bar 20.

[0029] Figure 3 shows a cross-section of an embodiment of a an embodiment of intermediate bar 20. Intermediate bar 20 has what will be called an "omega" cross-section, i.e. a cross-section with feet portions 30 and a portion that connects the feet via a loop that has a width that is wider than the distance between the feet portions. The omega cross section allows the loop to be compressed.

[0030] As illustrated, the portion that connects the feet portions 30 via an angled loop comprises oblique neck potions 32, spacer portions 34 and a front surface 36. Feet portions 30, oblique neck potions 32, spacer portions 34 and surface 36 may be made from a metal plate, folded at the transitions between feet portions 30, oblique neck potions 32, spacer portions 34 a front surface 36, so that all of these portions are parts of the same plate. Alternatively, connected plates may be used, so that part or all of the portions may be formed by individual plates. Oblique neck potions 32 extend from feet portions 30, widening the cross-section from where feet portions 30 run over into oblique neck potions 32. Front surface 36 extends in parallel with feet portions 30. Spacer portions 34 connect front surface 36 to oblique neck potions 32.

[0031] Beam 24 has a beam surface that forms an endorsing surface in parallel with the first metal plate 10 of the wall panel, thus providing indirect endorsement to the sandwich wall panel. Beam 24 may be an I beam, in which case the endorsing surface may be the top cross part of the "I". Feet portions 30 are attached to beam 24 on this endorsing surface. Oblique neck potions 32 widen intermediate bar 20 beyond the edges of this endorsing surface of beam 24 on both sides of the endorsing surface. Spacer portions 34 extend perpendicularly to this surface, and seen in projection perpendicular to the sandwich wall panel surface they are located beyond the edges of the endorsing surface. Front surface 36 faces the first metal plate 10 of the wall panel. The omega cross-section preferably extends at least substantially over a length of beam 24 where beam 24 backs up the sandwich wall panel. As user herein, "substantially" means that short interruptions or shortfall at the end are not excluded, as long as they do not affect blast resistance.

[0032] In operation, when a blast occurs, the sandwich wall panels transmit blast forces to support posts 22 via beam 24 and intermediate bar 20. For forces below a threshold the forces are substantially elastic. Dynamically, the system of support posts 22, beam 24 and intermediate bar 20 can be modelled as a series of masses connected by springs for such forces. Such a system has a number of vibration modes, each with its own natural vibration frequency, and with coefficients that relate the mode vibration amplitude to vibration amplitudes of the different masses. The total displacements of the masses are sums of the vibration amplitudes of the different masses for the different modes.

[0033] The initial forces due to the blast cause an excitation of a combination of the vibration modes, each with its own amplitude and phase. The combination of vibration modes corresponds to time dependent changes of the displacement of components of the support structure, both as a whole and relative to each other. At the initial time of the impact of the blast pressure, the combination corresponds to zero displacements and non zero time derivative of the displacement of the surface of intermediate bar 20 that backs up the wall panels.

[0034] During the time development of the pressure and event after the pressure has settled, the excitation of the vibration modes may continue to give rise to relative motion of the masses. Because the natural vibration frequencies of the modes may differ, interference effects may arise according to which the effects of the modes on the vibration amplitudes of the displacements of the masses periodically alternately add up and subtract. This could result in damage, e.g. failure of support posts 22.

[0035] A mechanically plastic baffle such as a bar with the "omega" cross-section of intermediate bar 20 is used to reduce the amplitudes of the modes in the course of time in the case of large amplitude vibration, by absorbing part of the mode energies as plastic deformation. As long as the vibration amplitudes are sufficiently small, they result in substantially elastic deformations at the folds between the potions of intermediate bar 20, causing a decrease of the angle between oblique neck potions 32 and the surface of beam 24. However, once the vibration amplitude becomes so large that this angle reduces to zero, the forces transmitted to oblique neck portions 32 by spacer portions 34 cause oblique neck portions 32 to fold plastically (i.e. inelastically) around the edges of the beam surface of beam 24 that forms the endorsing surface.

[0036] A mechanically plastic baffle such as intermediate bar 20 is characterized by the relation between its amount of compression and the reaction force that it produces. More specifically, terminal surfaces of the mechanically plastic baffle may be identified, which are the surfaces via which the mechanically plastic baffle transmits the reaction force, in the present case to the beam and the sandwich wall panel. The relation between the amount of compression and the reaction force is the relation between reaction forces force F and the difference X between the displacements of the terminal surfaces, also referred to as the relative displacement X.

[0037] Figure 4 schematically illustrates the reaction force F as a function relative displacement X that characterizes a mechanically plastic baffle. This figure may also be taken to show the relative displacement X as a function of the compression force exerted on the mechanically plastic baffle. The figure illustrates that the mechanically plastic baffle is irreversibly compressed when the relative displacement exceeds a threshold, resulting in a reduction of the relative displacement at zero force.

[0038] The displacement-force relation of the mechanically plastic baffle has a first part 41 that corresponds to elastic deformation (e.g. due to bending at the folds of intermediate bar 20). In this first part 41 the displacement X increases proportionally with force F. In the first part 41, this increase is reversible: if the force F decreases the displacement X decreases in the same way as it has increased, thus returning the energy (force F times change of displacement DX) that has been punt into it. The reversibility is indicated by arrows showing possible directions of displacement changes.

[0039] If the force F exceeds a plastic deformation threshold, e.g. when angle between oblique neck potions 32 and the surface of beam 24 becomes so small that no further elastic bending of the fold between feet portions 30 and oblique neck potions 32 is possible, an irreversible displacement change DX occurs with continued or increasing force F.

[0040] This is illustrated by a second part 42 of the displacement-force relation of the mechanically plastic baffle. The irreversibility is indicated by single showing the one possible direction of displacement changes. The dynamic stiffness of mechanically plastic baffle (the slope of the F-X relation) in the second part 42 is generally less than in the first part 41. By way of example, a horizontal second part 42 is shown, which corresponds to a constant reaction for and zero dynamic stiffness, but alternatively a sloped second part 42 is possible. In the second part 42 the displacement X is irreversible: if the force F decreases, the displacement X will not return to the previous displacement at the same force values. Thus the energy absorbed during the irreversible displacement of second part 42 is not returned, or at least not all of the energy (force times displacement) absorbed in the second part 42 is returned.

[0041] Instead of returning to first part 41, the displacement will follow a displacement-force relation according to one of a number of third parts 43a-b, dependent on the displacement reached at the time when the relative displacement and the force start to decrease. The displacement may be reversible in the third parts 43a-b per se. Different third parts 43a-b correspond to different displacements Xa, Xb at zero force, which expresses the effect of the plastic deformation. The third parts 43a-b may be similar except for an offset.

[0042] When the intermediate bar 20 is used as a mechanically plastic baffle, the second part 42 results from plastic folding of oblique neck potions 32, with possibly also a contribution from angle changes at the original folds. When the force decreases, the folds in oblique neck potions 32 remain, whereas an increase in the angle at the original folds, such as between feet portions 30 and oblique neck potions 32, respond to the force decrease, which corresponds to one of the third parts 43a-b.

[0043] The plastic deformation changes the amplitudes and possibly the phase of the excitation of the vibration modes when the relative displacement of the surfaces of the mechanically plastic baffle in the connection between the beam 24 and the sandwich panel (e.g. intermediate bar 20) exceeds a threshold. As a function of time, the excited vibration modes may cause the relative displacement of the terminal surfaces of the mechanically plastic baffle such as intermediate bar 20 to move from first part 41 to second part 42. In this case the stiffness changes, and with it the vibration mode properties.

[0044] When the relative displacement of the terminal surfaces of the plastic deformation returns to one of the third parts 43a-b, the vibration mode behavior may be substantially restored. But the zero-force equilibrium displacement will have changed and the energy that is not returned by the mechanically plastic baffle will have been drained from the energy of the vibration modes. This reduces the maximum forces transmitted to support posts 22. In this way the risk of damage due to dynamic vibration amplitudes excited in the support structure is reduced.

[0045] It should be noted that the omega shaped intermediate bar 20 is only an exemplary embodiment to achieve this. Other types of mechanically plastic baffle may have different structures or added elements. Such bodies may provide for constructions to fold of one or more plastically foldable parts on edges under influence of a force originating from the sandwich wall panel, as illustrated in figure 3, or fee folding (crumpling).

[0046] For example, as shown in the cross section of figure 5, a crumple wall 50 e.g. of metal may be added in the omega shaped intermediate bar 20, extending over part of the initial distance between the sandwich wall panel and beam 24. Crumple wall 50 may extend from the side of the sandwich wall panel 52 or from the side of beam 24. Crumple wall 50 may be a pipe wall or a flat wall, extending horizontally behind the sandwich. One or more pipes may be used along the length of intermediate bar 20. The flat wall may extend along this length (e.g. in horizontally behind the sandwich). More than one crumple wall may be used in parallel. Optionally cross-connections my be provided between parallel crumple walls to ensure that the walls crumple rather than that they bend only bend at one point. Optionally a force spreading plate may be provided between the crumple wall and the sandwich wall panel, to spread the force on the sandwich wall panel.

[0047] In operation, crumple walls 50 do not affect the vibration modes as long as the distance of compression of intermediate bar 20 is less than the part of the distance between the sandwich wall panel and beam 24 that is left open by crumple walls 50. When the compression becomes larger, crumple walls 50 are crumpled, that is, they are shortened by plastic deformation under a compression force, resulting in an irreversible displacement similar to the second part 42 of the force-displacement characteristic. The energy used for crumpling is drained from the vibration modes.

[0048] In the illustrated embodiment, the size of the crumple walls, i.e. the distance over which they extend between the sandwich wall panel and the beam, is selected so that the crumple walls will start to crumple before the oblique portion starts folding on the edge of the beam surface. This has the advantage that the two plastic deformation effects start sequentially during increasing compression, which may serve to drain more energy.

[0049] Preferably, the mechanically plastic baffle provides for a combination of elastic and plastic deformation, the latter arising or becoming larger than the former only when the exerted forces exceed a threshold. This has the advantage that relatively small forces on the sandwich wall panel can be handled substantially by elastic deformation only, without irreversible changes. The omega shaped cross-section provides for such a combination.

[0050] In other embodiments, resilient elements such as springs may be used in parallel with a mechanically plastic baffle between the sandwich wall panel and beam 24. Any type and shape of mechanically plastic baffle may be used. The mechanically plastic baffle may be of any suitable material, such as metal or a polymeric plastic material.

[0051] The maximum useful distance between successive beam 24 is limited by the expected blast pressures and the strength of the sandwich wall panel. Optionally, the blast pressures that can be handled can be increased without reducing the distance between successive beams 24 by adding a reinforcement to sandwich wall panel. Figure 6 illustrates an embodiment wherein a corrugated plate 60 attached to at least part of one of the metal plates of the sandwich wall panel 62 is used for this purpose. Because the sandwich wall panel 62 is used, this corrugated plate 60 can be much lighter than the corrugated plates that are conventionally used on their own as blast resistant walls. Corrugated plate 60 may be a corrugated metal plate, but alternatively other materials such as a resin impregnated corrugated fiber mat, a polymer plate etc. may be used. Preferably, the corrugated plate 60 is located on the same side as the support posts (not shown), facing away from the expected source of blasts. This enables the sandwich wall panel to shield the corrugated plate 60. Because the corrugated plate 60 is shielded from the initial blast by the sandwich wall panel, more of the ability of the corrugated plate 60 to contribute to the strength of the construction is preserved. The corrugated plate 60 may be interrupted, leaving the sandwich panel exposed where the sandwich panel is backed up by the mechanically plastic baffle.

[0052] Preferably, the sandwich wall panels hang on the baffle, attached by rivets, bolts, welding or another connection. Similarly, the baffle preferably hangs on the beam, attached by rivets, bolts, welding or another connection. But alternatively other structures may be used for keeping the sandwich wall panels and/or the baffles vertically in place in the absence of blasts, in which case the baffle need only transmit forces from the sandwich wall in a horizontal direction.

[0053] In a further embodiment of the blast protection wall, the blast protection wall comprises one or more further mechanically plastic baffles, each coupled between a horizontal beam and a vertical mounting posts.

[0054] Figures 7a,b show an example of an implementation of this embodiment. The x, y and z are used to indicate a horizontal direction in parallel with the wall, the direction perpendicular to the wall and the vertical direction respectively. In the example a further mechanically plastic baffle 70 is used in the connection between a horizontal beam 24 and a surface of a vertical mounting post 22. Vertical mounting post 22 is indicated by hashing. A mounting bracket 74 may be used to connect horizontal beam 24 and a central part 71 of further mechanically plastic baffle 70, so that central part 71 lies next to vertical mounting post 22.

[0055] Further mechanically plastic baffle 70 may be a metal plate containing a number of folds. As shown in figure 7a, further mechanically plastic baffle 70 may have a central part 71 connected to horizontal beam 24 e.g. via mounting bracket 74, and feet parts 72 connected to surface of a vertical mounting post 22 and transition parts connecting central part 71 to feet parts 72.

[0056] For example, vertical mounting post 22 may be an I beam with an I shaped cross-section, feet parts 72 being connected to the cross surface flange of the I beam that is furthest from horizontal beam 24, and the transition parts extending obliquely to bridge at least part of the height of the central part of the I beam of vertical mounting post 22. Further mechanically plastic baffles may be provided on one side or on both sides of vertical mounting post 22. One or more further mechanically plastic baffles may be provided at each crossing of horizontal beams 24 and vertical mounting posts .22

[0057] Seen in projection in the xz plane a main part comprising central part 71 and the transition parts of further mechanically plastic baffle 70 lies beyond an edge of the surface of vertical mounting post 22 to which feet parts 72 are connected, e.g. beyond the width of vertical mounting post 22, with feet parts 72 extending from the main part and overlapping vertical mounting post 22.

[0058] In operation, when a sufficiently strong explosion occurs, further mechanically plastic baffle 70 will fold plastically around the edge of the surface of vertical mounting post 22 to which feet parts 72 are connected, thus further reducing the transfer of energy from the sandwich wall panel (not shown) to vertical mounting post 22, without taking up excessive space.

[0059] Preferably as many parts as possible provide for plastic deformation and, if present, the further mechanically plastic baffle also provides for plastic deformation. The more plastic deformation, the more energy is absorbed. The absorbed energy is equal to the exerted force times the amount of displacement. In the case of plastic deformation the exerted force has to be above a threshold needed for plastic deformation. Thus, the more distance is provided for plastic deformation, the greater the absorption. By providing more plastically deformable elements this distance is increased. Thus, for example, if only plastic deformation of a steel plate is used, the absorbed energy is limited by the thickness of the plate. Use of folding plastically deformable elements creates greater absorption.

REFERENCES CITED IN THE DESCRIPTION

Cited references

Patent documents cited in the description

- KR101599930 [0006] [0009]

- GB2453048A [0010]
- DE102012105628 [0012]
- NL8701813 [0023]

Non-patent literature cited in the description

- Implementation of blast resistance requirements on offshore installations**D.H. GROENEVELDP.C. GOUDSWAARD**WMET '91 "Offshore Operations Post Piper Alphainstitute of Marine Engineers1991020612-112-8 [0002]

Patentkrav

1. Sprængningsbeskyttelsesvæg omfattende

- et sandwichvægpanel (26), der omfatter en første og en anden metalplade (10, 12);

- en bærestruktur (22, 24), der omfatter bærestolper (22) til at bære sandwichvægpanelet (26);

kendetegnet ved, at

- sandwichvægpanelet (26) omfatter et fiberlag (14) mellem den første og anden metalplade (10, 12), hvilket fiberlag (14) forbinder den første og anden metalplade (10, 12) med hinanden; hvor sprængningsbeskyttelsesvæggen endvidere omfatter en mekanisk plasticprelplade (20), der er forbundet mellem bærestrukturen (22, 24) og sandwichvægpanelet (26).

2. Sprængningsbeskyttelsesvæg ifølge krav 1, hvor den mekaniske plasticprelplade (20) er delvist elastisk komprimerbar, idet den mekaniske plasticprelplade (20) omfatter en mekanisk plasticfoldezone (30, 32), der er konfigureret til kun at komme i kontakt med bærestrukturen (22, 24) eller sandwichvægpanelet (26) efter en afstand mellem bærestrukturen (22, 24), og sandwichvægpanelet (26) er reduceret med en forudbestemt mængde ved elastisk reduktion af prelpladen (20).

3. Sprængningsbeskyttelsesvæg ifølge krav 1, hvor den mekaniske plasticprelplade (20) omfatter en plasticfoldezone (32) placeret i en kraftoverføringsbane fra sandwichvægpanelet (26) til bærestrukturen (22, 24).

4. Sprængningsbeskyttelsesvæg ifølge krav 3, hvor bærestrukturen (22, 24) har en understøttende flade, der vender ind mod sandwichvægpanelet (26), hvilken mekanisk plasticprelplade (20) omfatter en afstandsdel (34), der er placeret ud over kanten på den understøttende flade, set i projektion vinkelret på sandwichvægpanelet (26), hvilken afstandsdel (34) er forbundet mellem sandwichpanelet (26) og plasticfoldezonen (30, 32), idet plasticfoldezonen (30, 32) omfatter en metalplade eller metalpladedel (32), der strækker sig fra den understøttende flade til afstandsdelen (34), for således at gøre det muligt for afstandsdelen (34) er udøve en kraft for at folde metalpladen eller metalpladedelen (32) over kanten på den understøttende flade.

5. Sprængningsbeskyttelsesvæg ifølge krav 4, hvor metalpladen eller metalpladedelen (32) strækker sig skråt til den understøttende flade.

6. Sprængningsbeskyttelsesvæg ifølge et hvilket som helst af de foregående krav, hvor den mekaniske plasticprelplade (20) omfatter en nopret væg (50), der strækker sig i en retning mellem bærestrukturen (22, 24) og sandwichvægpanelet (26), over ikke mere end en del af en afstand mellem bærestrukturen (22, 24) og sandwichvægpanelet (26) i en kraftfri tilstand, hvor der ikke øves kraft for at reducere afstanden mellem bærestrukturen (22, 24) og sandwichvægpanelet (26).

7. Sprængningsbeskyttelsesvæg ifølge et hvilket som helst af de foregående krav, hvor bærestrukturen (22, 24) omfatter en bjælke (24) placeret mellem bærestolperne (22) og den mekaniske plasticprelplade (20), hvor en overflade af bjælken (24) danner den understøttende flade.

8. Sprængningsbeskyttelsesvæg ifølge krav 7, hvor den mekaniske plasticprelplade (22) strækker sig mindst i alt væsentligt over en længde af bjælken (24).

9. Sprængningsbeskyttelsesvæg ifølge krav 6 eller 7, der endvidere omfatter en yderligere mekanisk plasticprelplade (70), der er koblet mellem bjælken (24) og mindst én af bærestolperne (22).

10. Sprængningsbeskyttelsesvæg ifølge et hvilket som helst af de foregående krav, hvor en bølgeplade (60) er tilvejebragt på mindst en del af en overflade af sandwichpanelet (26).

11. Sprængningsbeskyttelsesvæg ifølge krav 10, hvor bølgepladen (26) er placeret på den samme side af sandwichvægpanelet som bærestrukturen (22, 24).

12. Sprængningsbeskyttelsesvæg ifølge et hvilket som helst af de foregående krav, hvor bærestrukturen (22, 24) omfatter en flerhed af bjælker (245), der er forbundet parallelt med hinanden med bærestolperne (22), en flerhed af mekaniske plasticprelplader (20), der hver er forbundet mellem en tilsvarende af bjælkerne (24) og sandwichvægpanelet (26).

13. Sprængningsbeskyttelsesvæg ifølge krav 12, hvor bærestolperne (22) er vertikale bærestolper, bjælken (24) er en horisontal bjælke og den mekaniske plasticprelplade (20) strækker sig horisontalt mellem bjælken (24) og sandwichvægpanelet (26).

14. Sprængningsbeskyttelsesvæg ifølge krav 11, der omfatter en række af en flerhed af sandwichvægpaneler (26), hvor hvert sandwichvægpanel (26) omfatter en første og en anden metalplade (10, 12) og et fiberlag (14) mellem den første og anden metalplade (10, 12), hvor fiberlaget (14) forbinder den første og anden metalplade (10, 12) med hinanden, hvor stængerne (24) og den mekaniske plasticprelplade (20) strækker sig over rækken af flerheden af sandwichvægpaneler (26).

15. Sprængningsbeskyttelsesvæg ifølge et hvilket som helst af de foregående krav, hvor fiberlaget (14) er et mineraluld.

DRAWINGS

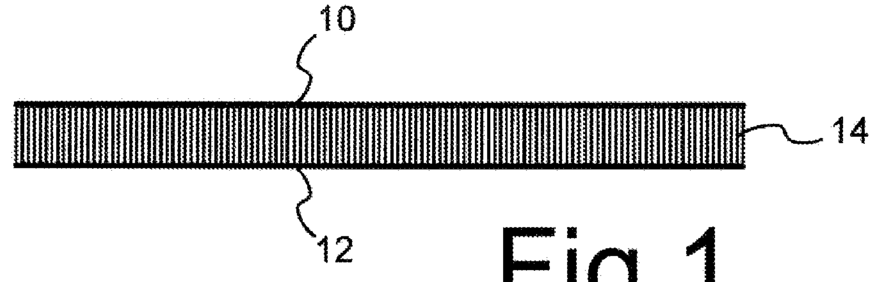


Fig.1

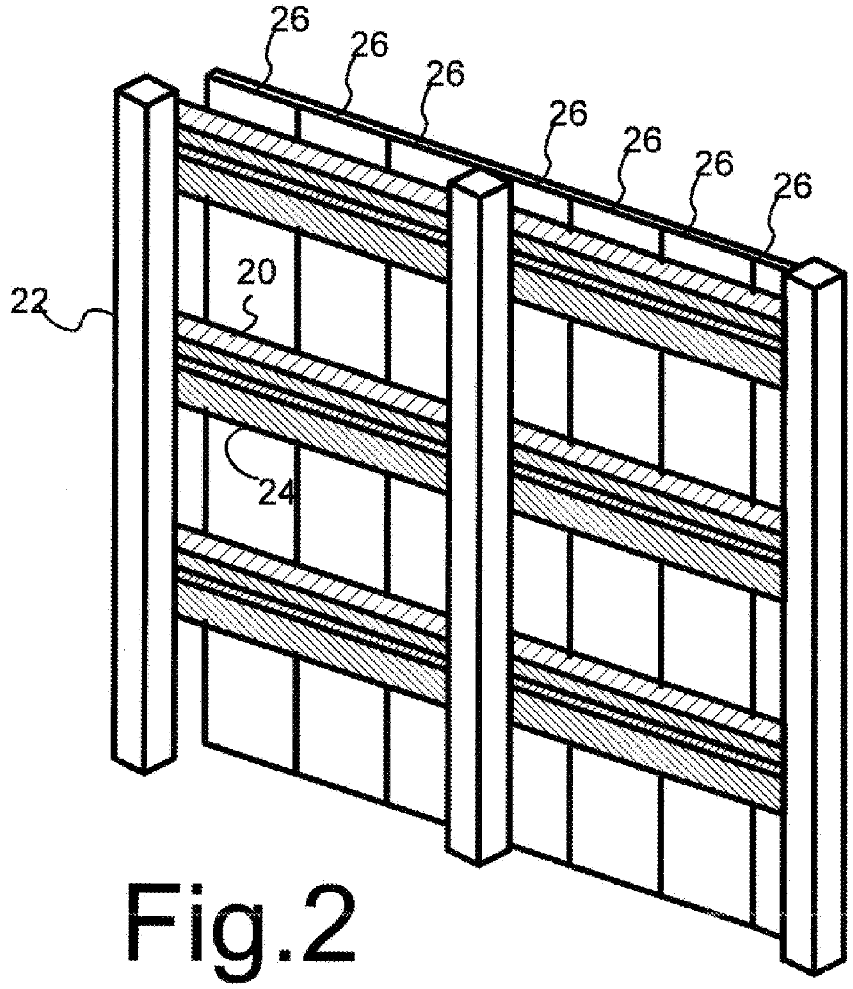


Fig.2

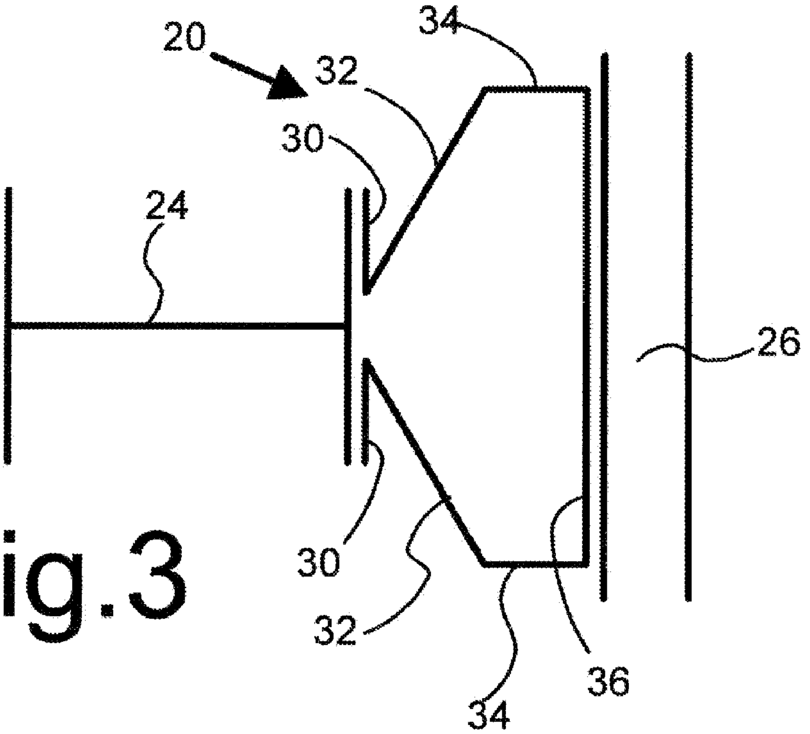


Fig.3

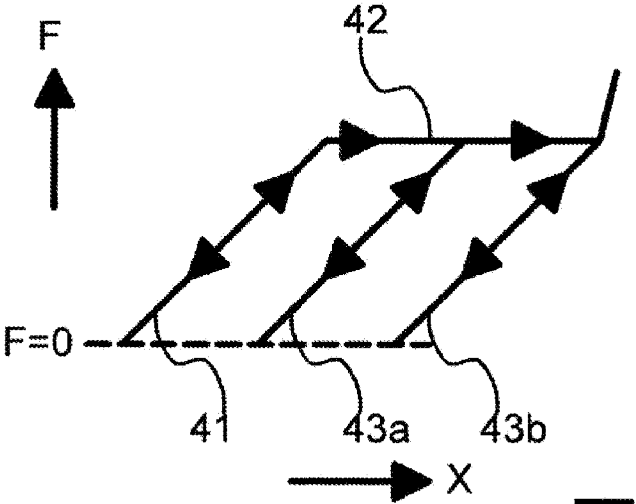


Fig.4

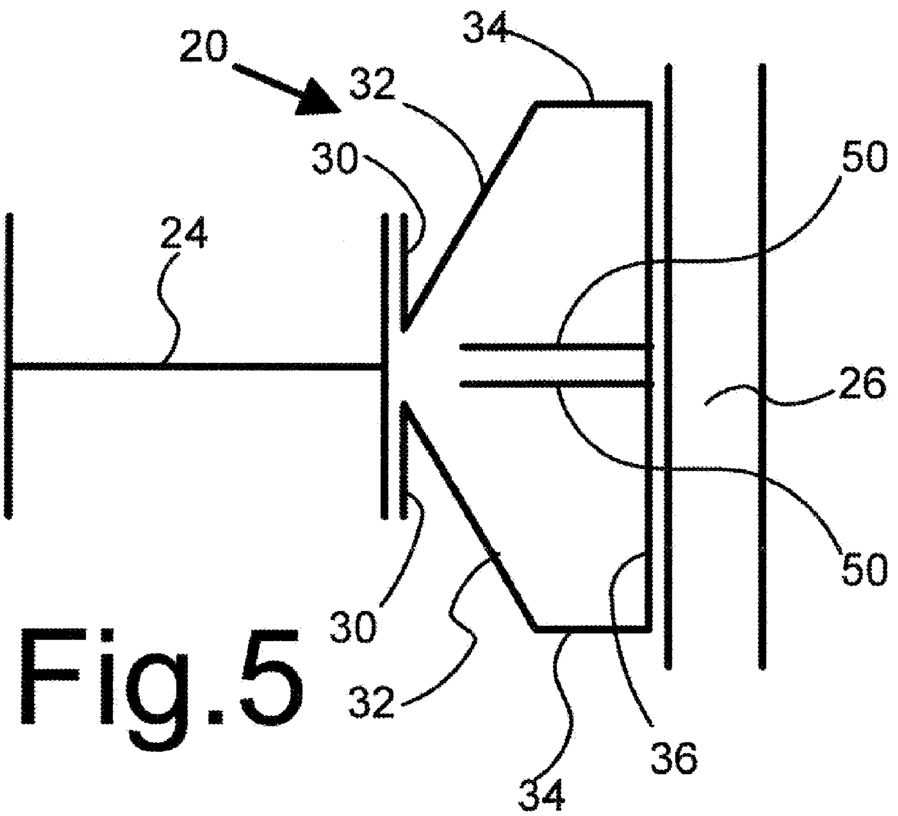
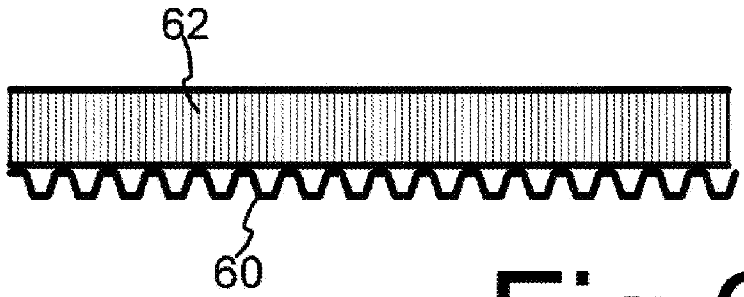


Fig.5



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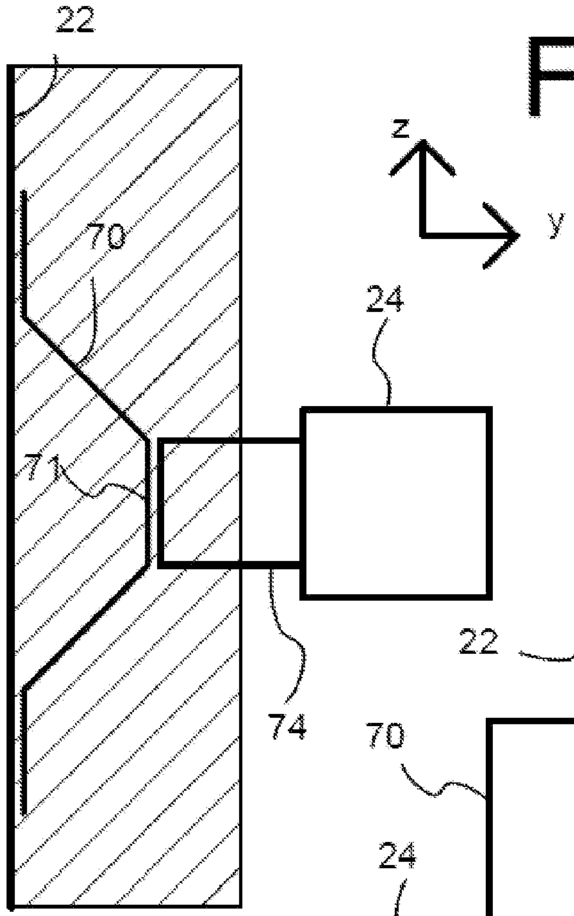

Fig7a

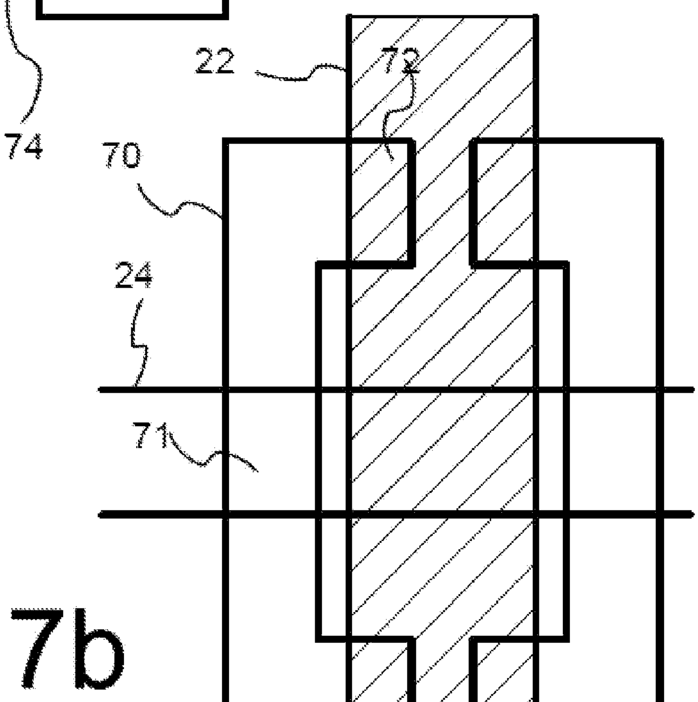

Fig.7b