

ACOUSTIC ELEMENT

The invention relates to acoustic elements for interior use.

It is well known to form planar acoustic elements such as ceiling tiles and acoustic panels for walls for interior use, to provide acoustic benefits in interior spaces.

- 5 These are routinely formed from a MMVF panel, having a facing, which is usually made of a glass fibre veil/fleece. This type of product can also include a paint or other coating layer over the glass fibre veil.

Examples of acoustic elements of this general type include those described in US3183996, US9909310, EP3365508 and US9758909.

- 10 US3151700 describes acoustic ceiling and wall panels which are made more attractive and less difficult to clean by providing a primary surfacing component providing raised regions to make a pattern, covered by a secondary surfacing material which is a resinous film. Bonded swirl mat or bonded strand mat, glass textile, glass fabric, chopped strands of glass fibres or other mineral material can
- 15 be used as the primary surfacing component underneath the secondary surfacing material. The primary surfacing component is never exposed to the surface and surface properties, both mechanical and aesthetic, are determined by the surface film component.

- Key properties that acoustic element products of this general type need to exhibit
- 20 are of course appropriate acoustic properties, such as i) high absorption A-class and ii) low transmission, whilst retaining good fire resistance. Another important property is physical robustness.

- There is a potential problem with the conventional type of product mentioned above in that glass fibre veil and paint facings are easily damaged during
- 25 installation. Any damage to the surface is easily visible and commonly means that the entire tile or board has to be discarded or recycled if that is possible in the specific case.

Glass veil facings also tend to have different physical properties in the transverse and machine directions, and it would also be desirable to provide more uniform physical properties in this regard.

5 CN102817415 describes a basalt fiber wall insulation board for various insulation uses, comprising a compressed basalt needlefelt mat.

It would be desirable to provide acoustic elements which exhibit greater physical robustness and resistance to damage, and also can exhibit equally good acoustic properties, and sometimes even improved acoustic properties, without compromising important fire resistance properties. It remains important for the
10 surface that faces the interior to have good aesthetics so this should not be compromised. It would be desirable for the elements to have the capability to provide improved aesthetics and/or aesthetics differentiated from a conventional plain finish.

According to a first aspect of the invention, there is provided a planar acoustic
15 element, comprising: an acoustic panel having first and second opposed major faces, wherein at least the first major face is provided with a fibrous facing which is exposed, wherein the panel is formed of man-made vitreous fibre (MMVF) and wherein the fibrous facing is formed of nonwoven inorganic chopped strand mat.

It has been found that the use of such a facing to form the exposed surface of an
20 acoustic element has the advantage that the elements are firstly more resistant to damage during transport, handling and installation, relative to conventional elements faced with a mineral fibre veil and/or paint, and secondly any damage that does occur is less visible. This makes the transport and installation process more straightforward and leads to reduced wastage of materials.

25 A further handling advantage is that the acoustic elements do not need degassing periods after removal from packaging. Degassing can be a requirement for some other comparable products.

Acoustic elements having chopped strand mat coverage can be simply cut with a box cutter, generate little dust and fibres are pleasant to the touch.

The use of chopped strand mat at the exposed surface also provides the ability to have differentiated aesthetics at the interior surface. The elements of the invention can exhibit aesthetics echoing wood wool cement panels, without the lower fire resistance associated with wood wool cement panels, and whilst providing acoustic properties. The exposed surface can even interact positively with interior and/or interior illumination, in particular in the case where the inorganic fibre forming the chopped strand mat is basalt fibre or glass fibre. The chopped strand mat provides an exposed surface which can be resistant to UV and can exhibit reduced discoloration.

The chopped strand mat facing can be open and porous, meaning that it does not negatively impact acoustic properties of the acoustic element as a whole.

Furthermore, where sound is reflected by the chopped strand mat the random and uneven structure of the chopped strand mat facing provides a diffused sound reflection. Thus, the acoustic properties of the acoustic panel remain generally unchanged.

According to a second aspect of the invention, there is provided a ceiling formed of a plurality of acoustic elements according to the first aspect of the invention. The exposed fibrous facing faces towards the interior space.

According to a third aspect of the invention, there is provided an interior wall faced with acoustic element according to the first aspect of the invention. The exposed fibrous facing faces towards the interior space.

According to a fourth aspect of the invention, there is provided the use of at least one acoustic element according to the first aspect of the invention as a ceiling panel, wherein the exposed nonwoven inorganic chopped strand mat facing faces towards the interior space.

According to a fifth aspect of the invention, there is provided the use of at least one acoustic element according to the first aspect of the invention as an acoustic interior wall panel, wherein the exposed nonwoven inorganic chopped strand mat facing faces towards the interior space.

- 5 “Acoustic panel”, “acoustic tile”, “acoustic MMVF panel” and the like as used in this description refer to materials that absorb sound, i.e. acoustic insulation materials. For example, man-made vitreous fibre (MMVF) panels have a very high porosity and an open surface which play a large part in the acoustic absorption capability of the panels.
- 10 The acoustic panel comprises two opposed major faces and one or more minor faces that extend between the major faces.

The MMVF acoustic panel may be produced by splitting a MMVF substrate and sanding the cut surface.

- For an acoustic panel to have useful sound attenuation properties for use as, for example, a ceiling tile or a wall tile, the porosity is typically high. Porosity of an acoustic panel can be measured according to methods known to those skilled in the art of acoustic building materials.
- 15

Preferably the acoustic panel is rectangular. Namely, the major faces are preferably rectangular.

- 20 The acoustic panel generally has the form of a conventional panel, so that at least one minor face extends between two major faces, which are generally parallel. The acoustic panel will have a thickness that is defined by the distance between and perpendicular to the two major faces.

- The acoustic panel used in the invention comprises first and second major faces which are generally substantially parallel, and one or more minor faces extending between the major faces. Usually the major faces are substantially planar and are substantially rectangular (often square), although other shapes are of course possible.
- 25

The acoustic panel is a MMVF panel. Typically it is formed of coherent MMVF bonded with a binder. The acoustic panel will usually be planar. The acoustic panel will usually be rigid.

5 The first major face of the panel is provided with a fibrous facing that is formed of nonwoven inorganic chopped strand mat. Preferably only the first major face is provided with the fibrous facing that is formed of nonwoven inorganic chopped strand mat.

10 In preferred embodiments the second major face is provided with a different facing, of a conventional type for an acoustic panel. For instance, the second major face may be provided with a protective cover layer. This cover layer may be fibrous or filamentary tissue. The cover layer could be woven or nonwoven. If present, a cover layer could also be porous or airtight, depending on the purpose and installation method (such methods include mechanical fixation via screws or brackets or adhesives). Porous cover layers on the second major face are
15 preferably combined with suspended ceiling installations to improve the acoustic absorption properties. Airtight surfaces can be used to limit sound transmission between rooms via ceiling or wall cavities. A cover layer on the second major face can be formed of a material having different properties to that on the first major face, because functional properties are more important than aesthetic on that
20 second major face. For instance, aluminium can be used as an airtight surface.

Chopped strand mat is a known material. It is a kind of sheet felt made of inorganic fibre which is cut and then bonded together with binder. Usually the cut fibres are laid randomly. Examples of fibres are glass fibres and basalt fibres. Preferably the inorganic fibre is basalt fibre. Basalt fibre gives particularly good impact
25 resistance. Basalt fibre gives good fire properties.

Example oxide compositions of suitable fibres for the inorganic fibrous facing are as follows, all amounts quoted as wt% as oxides and all iron oxides being quoted as Fe_2O_3 :

SiO_2 Al_2O_3 TiO_2 Fe_2O_3 CaO

	%	%	%	%	%
	50 - 60	12 -20	0.5 - 4	5 - 11	5 -11
	MgO	Na ₂ O	K ₂ O	P ₂ O ₅	MnO
	%	%	%	%	%
5	3 - 7	0.5 - 6	0.5 - 6	0 - 2	0 - 1

First example composition:

	SiO ₂	Al ₂ O ₃	TiO ₂	Fe ₂ O ₃	CaO
	%	%	%	%	%
	55,1	15,6	0,9	9,3	6,9
10	MgO	Na ₂ O	K ₂ O	P ₂ O ₅	MnO
	%	%	%	%	%
	5,2	3,8	2,3	0,4	0,2

Second example composition:

	SiO ₂	Al ₂ O ₃	TiO ₂	Fe ₂ O ₃	CaO
15	%	%	%	%	%
	52,3	17	2,8	8,7	8,8
	MgO	Na ₂ O	K ₂ O	P ₂ O ₅	MnO
	%	%	%	%	%
	4,3	1,8	1,1	0,3	0,1

Fibres are generally made from a drawing process. Often the fibres are multifilament strands. Generally such multifilament strands are formed of a plurality of parallel filaments of inorganic material. Fibres in the form of

multifilament strands may be twisted or untwisted. If twisted then the twist is preferably only slight.

Preferably fibre diameter in the fibrous facing is greater than 0.5 mm. Preferably fibre diameter in the fibrous facing is not more than 2 mm. In the case of multifilament strands the diameter of the filaments that make up the multifilament strands will be proportionally less. During processing it has been observed that the fibres may deform, and the diameter may change. In some cases the fibres are flattened and the width exceeds 2mm and are in some embodiments up to 3 or 4 mm.

- 10 During the tests performed and observation on the performance of the acoustic element as described it seems that one characteristic which further provides positive effects to the impact resistance is the fibre length of the fibrous facing. Accordingly, in one embodiment the fibre length in the fibrous facing is above 30mm, in another embodiment it is above 40 mm and in yet another embodiment it is above 50 mm. The fibre length may be in the range of 30 to 150 mm, preferably 40 to 150 mm or more preferably 50 to 150 mm. In one embodiment the fibre length is from 50mm to 110 mm.

In a further embodiment the different fibres in a CSM may vary in length, in particular within the ranges previously mentioned.

- 20 Fibre diameters are quoted as median diameter. The median diameter of the fibres can be obtained automatically using a scanning electron microscope (SEM) to measure the diameter of the fibres and counting the number of fibres in the sample.
- 25 When the fibres of the inorganic fibrous facing are multifilament strands, then the fibre diameter is that of the strands. The diameter of the filaments can be determined by separating the filaments and obtaining the median diameter in the manner as described for the fibres.

Determination of fibre length in the inorganic fibrous facing can be done manually by measuring by caliper individual fibres. Fibre lengths are quoted as median length. Fibre length is defined by a producer of a chopped strand mat, who is able to set its machinery to cut the roving (string) into a specific fibre length.

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In the case of the fibres being multifilament strands, preferably the number of filaments per strand is at least 10. Preferably the number of filaments per strand is not more than 50.

10 Preferably the fibrous facing has basis weight in the range 150 to 450 gsm, preferably at least 250 gsm. Examples are in the range 150 to 250 gsm, and in the range 300 to 400 gsm.

Preferably the fibrous facing has thickness 0.3 to 1 mm. Thickness can be determined by means of a digital caliper.

15 The binder used for bonding the fibres of the chopped strand mat can be for instance powder or emulsion binder. The binder content, expressed as combustible content, can be in the range 2 to 8%, for instance at least 2.5%. Binder content can be chosen to give specific advantages. Using at least a certain amount such as 2 % ensures that the fibres are well set in the fibrous facing. If too much is used however, the fibrous facing can become too stiff and is difficult to roll
20 for transport and use in the factory.

Chopped strand mat products are available commercially. JP2004 122549 describes chopped strand mat for use as a laminate with polyurethane foam as an interior finish for cars, and such a material can also be used in the invention as the fibrous facing.

25 The fibrous facing is generally bonded to the first major face of the acoustic panel with an adhesive. This adhesive may be any of the materials used as binder for the fibrous facing itself, and may be the same binder. This adhesive may be any of the materials used as binder for the MMVF acoustic panel itself, as discussed below, and may be the same binder. Other binders may be used.

The panel may typically have a length in the range of 600 to 2400 mm, which is standard length in Europe, but other lengths could be relevant. For instance for some applications, such as wall panels, the length can be up to 2700 mm.

- 5 The panel may typically have a width in the range 300 to 1200 mm. The panel may typically have a length in the range 300 to 2000 mm. For instance typical panels may have dimensions 600 x 600 mm or 1200 x 600 mm.

The panel may have a thickness in the range 10-100 mm, preferably 10-50 mm. The thickness of the panel corresponds with the average distance between the two major faces, measured normal to the major faces.

- 10 The one or more minor faces of a panel suitable for use as a ceiling panel may have a 3D profile. A edges and B edges are both possible. For mounting using concealed mechanical fixations there will be recesses and grooves to accommodate the suspension means, such as common grid systems based on inverted T-profiles.
- 15 MMVF panels suitable for use in the invention may have a density of 50 to 180 kg/m³, preferably 80 to 150 kg/m³. This density of MMVF is particularly suitable for acoustic suspended ceiling panels. Preferred MMVF tile densities are 55 to 175 kg/m³ and 65 to 165 kg/m³. MMVF panels having density towards the lower ends of these ranges are especially preferred for use in the invention.
- 20 The MMVF panel may comprise a bonded, nonwoven three-dimensional network of MMVF. The MMVF can for example be stone fibres (e.g. basalt fibres), glass fibres, slag fibres, ceramic fibres.

Preferably, the MMVF are stone fibres.

- Stone fibres may have the following composition, all amounts quoted as wt% as oxides and all iron oxides being quoted as Fe₂O₃:
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SiO ₂	25 to 50, preferably 38 to 48
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	Al ₂ O ₃	12 to 30, preferably 15 to 28
	TiO ₂	up to 2
	Fe ₂ O ₃	2 to 12
	CaO	5 to 30, preferably 5 to 18
5	MgO	up to 15, preferably 4 to 10
	Na ₂ O	up to 15
	K ₂ O	up to 15
	P ₂ O ₅	up to 3
	MnO	up to 3
10	B ₂ O ₃	up to 3

An alternative stone fibre composition may be as follows, all amounts quoted as wt% of oxides, and all iron oxides being quoted as Fe₂O₃:

	SiO ₂	37 to 42
	Al ₂ O ₃	18 to 23
15	CaO + MgO	34 to 39
	Fe ₂ O ₃	up to 1
	Na ₂ O + K ₂ O	up to 3

The MMVF nonwoven three-dimensional network of the MMVF panel may be bonded using any suitable binder. Suitable binders include phenolic, epoxy, acrylic, water glass, polypropylene, polyethylene, and bicomponent binders.

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In one preferred embodiment, the MMVF that form the panel are of the same type as the inorganic fibres that form the inorganic chopped strand mat. For instance if the chopped strand mat is formed of basalt fibres then it can be advantageous for the MMVF to be basalt fibres. Similarly, if the chopped strand mat is formed of glass fibres, then the MMVF can be formed of glass fibres. This allows for the product to be recycled as a whole, without the need to be separated before recycling, thus allowing for circularity in easier manner.

The acoustic element of the invention exhibits greater robustness than prior acoustic tiles having a different facing.

- 10 An additional benefit of this improved robustness is improved circularity because a more resilient product gives more opportunity for re-use and refurbishment, rather than repair, recycling or sending to waste.

The acoustic element of the invention has excellent fire properties. Preferably it has a PCS value no more than 2.5 MJ/kg.

- 15 It is possible to provide a product in fire class Rtf as per EN 13501-1 class A without the use of any flame retardants, in particular when the chopped strand mat and MMVF of the panel are based on basalt. This is superior to, for instance, traditional wood-cement boards that require flame retardants to obtain such a performance and do not have acoustic properties as advantageous as elements of the invention.

The acoustic elements of the invention preferably have a sound absorption α_w at least 0.8; meaning that it will be at least a class B absorber.

- 25 To contribute to achieving such good acoustic properties of the acoustic element, preferably the chopped strand mat facing exhibits openness and/or low or negligible air flow resistance. Preferably the air flow resistance is not more than 0.03 kpas/m², for instance in the range 0.02 to 0.03 kpas/m². As a result, acoustic properties are mostly given by the underlying acoustic panel.

In contrast with ceiling tiles that are faced with some types of glass fibre fleece, and have directionality, the acoustic elements of the invention have non-directional appearance. They are thus easier to install as they can be placed in any direction offering the same light reflection, gloss and looks in whichever direction they are
5 installed.

Preferred gloss of acoustic elements of the invention is at least 2.0 G.U., preferably at least 3.0 G.U., for instance about 4.0 G.U. When the fibres of the chopped strand mat are basalt fibres then this has the further advantage the exposed surface of the acoustic element has a metallic look without need of being
10 painted.

The invention also provides a suspended ceiling comprising a support grid and a plurality of ceiling tiles which are acoustic elements as described.

The invention also provides an acoustic ceiling comprising a plurality of suspended vertical baffles, wherein the vertical baffles are acoustic elements as
15 described.

The invention also provides acoustic elements for use as island acoustic panels, i.e. acoustic panels which are suspended from a ceiling independent of any grid system, typically with exposed edges.

The invention also provides the acoustic elements for use in acoustic walls. An
20 acoustic wall may comprise a grid system with a plurality of uniformly arranged acoustic elements according to the invention. Alternatively, an acoustic wall may comprise one or more individual acoustic elements, optionally having exposed edges, mounted individually to a wall. A further alternative comprises a plurality of the acoustic elements in elongated form suspended from a ceiling to form a
25 curtain.

The acoustic elements in accordance with the invention are useful in a variety of acoustic solutions for ceilings and walls.

The acoustic elements may be arranged in an array, supported by a grid. Such grid systems are applicable for both walls and ceilings, the latter of which is typically referred to as a suspended ceiling.

Individual acoustic elements may be mounted on a wall. Individual acoustic tiles
5 may also be suspended from or mounted to a ceiling individually, with the major faces substantially parallel to the floor. This setup for ceilings is often referred to as acoustic islands. Another mode for implementing acoustic tiles individually is vertical baffle ceilings. Individual acoustic panels are suspended from a ceiling and may have one or more exposed edges. Similar to a vertical baffle ceiling, a
10 plurality of long and narrow baffles may be suspended from a ceiling to form an acoustic curtain as a room divider or privacy screen.

The invention also provides a planar acoustic element, comprising: an acoustic panel having first and second opposed major faces, wherein at least the first major face is provided with a fibrous facing which is exposed, wherein the panel is
15 formed of man-made vitreous fibre (MMVF) and wherein the fibrous facing is formed of nonwoven inorganic fibre fabric having basis weight at least 200gsm, preferably at least 250 gsm.

All features and potential uses of the first aspect of the invention are applicable to this further aspect.

20 BRIEF DESCRIPTION OF DRAWINGS

Figure 1 is a cross section through an acoustic element product according to the invention.

Figure 2 is a photograph of an acoustic element product according to the invention.

25 Figure 3 is a close-up photograph of chopped strand mat for use as the fibrous facing.

Figure 4 shows photographs of an acoustic product according to the invention after testing in the example below.

Figure 5 shows photographs of a comparative acoustic product after testing in the example below.

- 5 In Figure 1 a planar acoustic element is shown which comprises an acoustic MMVF panel 1 having first and second opposed major faces, wherein the first major face is provided with a fibrous facing 2 which is exposed. The fibrous facing is formed of nonwoven inorganic chopped strand mat. In this embodiment there is a cover layer 3 on the second major face.
- 10 In Figure 2 a stone wool panel is shown with a chopped strand basalt mat facing, visible on the first major face.

In Figure 3 it can be seen that the chopped strand mat used is formed of fibres which are multifilament strands. These multifilament strands are each formed of parallel basalt filaments.

15 **Example 1**

Ball Drop Test

This test consists in dropping a ball of certain diameter and weight at different controlled heights to measure damage caused on a ceiling tile.

Ball sizes

- 20 The following balls were used during the test:

15mm diameter, 14g

25mm diameter, 64g

35.5mm diameter, 184g

50mm diameter, 512g

68mm diameter, 1320g

Dropping heights

The different balls were dropped from different heights to identify the point at which the ceiling tile top coverage suffers a significant damage. Lowest dropping height was set at 10cm and was varied in increments of 10cm till reaching 100cm maximum.

Recording the damage

Damage was considered to be any visible harm caused to the ceiling tile such a crack, perforation, or delamination of the top fleece. Nonvisible damage such as that caused in the wool that is masked by the fibrous facing were not considered/recorded as a damage.

Test specimens

The following materials were tested:

Stone wool tile of density 150kg/m³ faced with basalt chopped strand mat (CSM) of basis weight 350gsm.

Color-All Charcoal 09 in 150kg/m³ density and painted glass fleece CS21 from ROCKFON.

Test and Results

Stone wool with basalt CSM fibrous facing

20	Ball size, weight	Distance	Observation
	Ø 15mm, 14g	10 – 100cm	All impacts successfully passed
	Ø 25mm, 64g	10 – 100cm	All impacts successfully passed
	Ø 35.5mm, 184g	10 – 50cm	All impacts successfully passed

5 Ø 35.5mm, 184g 60 – 100cm The deformation on the wool is important (about 2cm wide and 2mm deep mark) causing delamination between the CSM and the wool panel; however, the CSM remains intact and looks unaffected.

 Ø 50mm, 512g 10 - 40cm The deformation on the wool is significant (about 4cm wide and 6mm deep mark) but the visuals of the tile remain acceptable as the CSM masks up the wool deformation.

10 Ø 50mm, 512g 50 - 100cm The deformation on the wool is important (about 4cm wide and 6mm deep mark) causing delamination between the CSM and the wool panel; however, the CSM remains intact and looks unaffected.

15 Ø 68mm, 1320g 10 - 20cm The deformation on the wool is extreme (about 4cm wide and 6mm deep mark) but the visuals of the tile remain acceptable as the CSM masks up the wool deformation.

 Ø 68mm, 1320g 30cm – 100cm The deformation on the wool is extreme (about 4cm wide and 6mm deep mark) causing delamination between the CSM and the wool panel; however, the CSM remains intact and looks unaffected.

20 As a general observation, the wool suffers some deformation already with 184g impact; however, due to the randomness of the CSM and the long fibres, the visuals and effect of such an impact are masked up. The CSM keeps its properties during the entire test up to an impact of 1,32kg from 1m height.

25 Figure 4 shows photographs of the stone wool product having a CSM facing after testing. It can be seen that although there is some damage this is hardly noticeable.

Color-All tiles: Charcoal

Ball size, weight	Distance	Observation
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	Ø 15mm, 14g	10 – 100cm	All impacts successfully passed
	Ø 25mm, 64g	10 – 100cm	All impacts successfully passed
	Ø 35.5mm, 184g	10cm	Impact successfully passed
5	Ø 35.5mm, 184g	20 – 100cm	The glass top fleece cracks. The higher the impact, the longer the cracks.
	Ø 50mm, 512g	10cm	Impact successfully passed
	Ø 50mm, 512g	20 – 50cm	The glass top fleece cracks. The higher the impact, the longer the cracks.
10	Ø 50mm, 512g	60-100cm	Impact perforates the glass fleece. Very evident damage.
	Ø 68mm, 1320g	10cm	The glass top fleece cracks. The higher the impact, the longer the cracks.
15	Ø 68mm, 1320g	20-100cm	Impact perforates the glass fleece. Very evident damage.
20	The glass fleece of Color-All Charcoal already at low impact presents cracks which clearly are highly undesirable in the visuals of ceiling tiles. Moreover, as from 512g, the impact is creating cracks and perforations on the fleece.		

Figure 5 shows photographs of the stone wool product having a glass fleece facing after testing. It can be seen that there is significant visible damage.

Conclusions

25 Visuals of the stone wool ceiling tile faced with CSM remain acceptable even when impact on the tile is up to 3 times higher than those ones with glass top fleece.

Failure mode on tiles faced with CSM is usually delamination of the CSM.

Glass fleeces are sensitive to impact: cracks and perforations are already observable at very low impact forces.

Example 2

A follow up drop test was done on a basalt CSM 300gsm, a glass CSM 200gsm and a glass CSM 375 gsm covering a stone wool panel with a density of 80kg/m3.

In addition, a Rockfon CleanSpace Essential acoustic panel was also tested for comparison. This is formed of a stone wool panel with a density of 80kg/m3
5 provided with a glass veil of 120gsm.

Four test setups with three different drop heights in each were performed for each sample.

In the first test setup a ball with a diameter of 15 mm and weight of 14 grams were
10 dropped at 1000mm, 1250mm and 1500mm.

In the second test setup a ball with a diameter of 25 mm and weight of 64 grams were dropped at 1000mm, 1250mm and 1500mm.

In the third test setup a ball with a diameter of 35.5 mm and weight of 184 grams were dropped at 1000mm, 1250mm and 1500mm.

15 In the fourth test setup a ball with a diameter of 50 mm and weight of 512 grams were dropped at 1000mm, 1250mm and 1500mm.

Glass veil 120gsm

Ball diameter [mm]	Ball weight [grams]	Drop height [mm]	Damage assessment
15	14	1000	No visual damage
15	14	1250	No visual damage

15	14	1500	Important local damage (crack). Very visual
25	64	1000	Important local damage (crack) +/- 2cm wide. Very visual
25	64	1250	Important local damage (crack) +/- 3cm wide. Very visual
25	64	1500	Important local damage (crack) +/- 4cm wide. Very visual
35,5	184	1000	Important local damage (crack) +/- 4cm wide. Very visual
35,5	184	1250	Important extended damage (crack) +/-7cm wide. Very visual
35,5	184	1500	Important local damage (crack) +/- 7cm wide. Very visual
50	512	1000	Important extended damage (crack) +/-8cm wide. Very visual
50	512	1250	Important extended damage (crack) +/-10cm wide. Very visual
50	512	1500	Important extended damage (crack) +/-10cm wide. Very visual

The glass veil, representative of a state of the art acoustic tile, passed the drops from 1000mm and 1250 mm in the first test setup. However, it failed all other tests with important damage in the form of visible cracks into the stone wool. Where

extended damage was observed cracks even propagated out from the local impact area of the ball.

Basalt CSM 300gsm

Ball diameter [mm]	Ball weight [grams]	Drop height [mm]	Damage assessment
15	14	1000	No visual damage
15	14	1250	No visual damage
15	14	1500	No visual damage
25	64	1000	No visual damage
25	64	1250	No visual damage
25	64	1500	No visual damage. Slight feeling of wool damage if touched
35,5	184	1000	Medium visual damage. CSM lift due to wool bump. CSM remains unbroken
35,5	184	1250	No visual damage. Slight feeling of wool damage if touched
35,5	184	1500	Medium visual damage +/-2cm. CSM lift due to wool bump. CSM remains unbroken
50	512	1000	Severe visual damage +/-3cm. CSM lift due to wool bump. CSM remains unbroken

50	512	1250	Severe visual damage +/-3cm. CSM lift due to wool bump. CSM remains unbroken
50	512	1500	Severe visual damage +/-3cm. CSM lift due to wool bump. CSM remains unbroken

The basalt CSM 300 gsm passed the first and second test setups. At the third and fourth test setups bumps in the CSM became observable as visual damage. However, no cracks in the CSM or exposure of the wool panel below the CSM was observed.

Glass CSM 375gsm

Ball diameter [mm]	Ball weight [grams]	Drop height [mm]	Damage assessment
15	14	1000	No visual damage
15	14	1250	No visual damage
15	14	1500	No visual damage
25	64	1000	No visual damage
25	64	1250	No visual damage
25	64	1500	No visual damage
35,5	184	1000	Severe visual damage +/-3cm. CSM lift due to wool bump. CSM remains unbroken

35,5	184	1250	Severe visual damage +/-3cm. CSM lift due to wool bump. CSM remains unbroken
35,5	184	1500	Severe visual damage +/-3cm. CSM lift due to wool bump. CSM remains unbroken
50	512	1000	Low visual damage +/-2cm. CSM lift due to wool bump. CSM remains unbroken
50	512	1250	Low visual damage +/-1cm. CSM lift due to wool bump. CSM remains unbroken
50	512	1500	Low visual damage +/-2cm. CSM lift due to wool bump. CSM remains unbroken

Similar to the basalt CSM 300gsm, the glass CSM 375gsm passed the first and the second test setup. At the third and fourth test setups bumps in the CSM became observable as visual damage. However, no cracks in the CSM or exposure of the wool panel below the CSM was observed.

Glass CSM 200gsm

15	14	1000	No visual damage or dent
15	14	1250	No visual damage or dent

15	14	1500	No visual damage or dent
25	64	1000	No visual damage or dent
25	64	1250	No visual damage or dent
25	64	1500	No visual dent, only small wool indent
35,5	184	1000	Medium visual damage +/- 2cm. CMS remains unbroken
35,5	184	1250	Medium visual damage +/- 2.5 mm. CMS remains unbroken
35,5	184	1500	Medium visual damage +/- 2.5 mm. CMS remains unbroken
50	512	1000	Severe visual damage +/- 3.5 mm. CMS remains unbroken
50	512	1250	Severe visual damage +/- 3.5 mm. CMS remains unbroken
50	512	1500	Severe visual damage +/- 3.5 mm. CMS remains unbroken

The glass CSM 200gsm performs almost as well as the corresponding 375gsm. Moreover, just as the other CSM layers a visual bump was observable in the third and fourth test setup, however, no cracking or tearing occurred of the CSM itself.

5 Conclusion

Both the glass CSM and the basalt CSM provides substantial protection to the wool panel below. This is concluded as the glass veil 120 gsm cracks already in the first test setup. The CMS covered wool panel does not experience deformation or cracks before the third test setup.

- 5 Moreover, even in the third and fourth test setup where visual damage, such as bumps, are observable the CSMs remains intact.

Furthermore, it is noted that the different CSMs perform almost identically even though the gsm varies. One reason for this is suspected to be the fibre lengths of the fibres in the CSM, which are substantial longer than in regular glass fleeces,
10 such as the glass veil 120 gsm above.

Considering the above tests, it is seen that both glass and basalt CSMs in the range of 200gsm – 375gsm, such as glass CSMs between 200gsm – 375 gsm and basalt CSMs between 300gsm – 350gsm, perform well and can be used as a fibrous facing in order to increase the robustness of an acoustic element as
15 described herein without reducing the acoustic properties thereof.

Inspection of fibre orientation

Following EDANA's standard NWSP 40.0.RO (20), Fibre orientation distribution of nonwoven Fabrics, five samples of a 300gsm CSM were evaluated using a microscope with camera and image analysis.

- 20 The inspection showed an alignment index of 0.02; 0.00; 0.18; 0.0 and 0.23 for the five samples. An alignment index at zero or so close to zero as shown above means that there is a very uniform fibre distribution at all analysed angles.

Such a uniform fibre distribution contributes to the visually appearance of the material in that no predominant fibre orientation is visible. In other words, the
25 chopped strand mat will have the same visual properties and appearance in any installed direction. Thus, when used as a facing on a panel to provide an acoustic element as described herein, the acoustic element can be installed without consideration to the orientation of the acoustic element. This facilitates and

speeds up the installation an acoustic ceiling using acoustic elements as disclosed herein.

Accordingly, in one embodiment the fibrous facing may have an alignment index of between 0 and 0.5, and particular between 0 and 0.25.

- 5 Furthermore, the uniform fibre distribution also contributes to that the mechanical properties, such as the impact resistance, are similar in all directions.

EMBODIMENTS

1. A planar acoustic element, comprising:

- 10 an acoustic panel having first and second opposed major faces, wherein at least the first major face is provided with a fibrous facing which is exposed, wherein the panel is formed of man-made vitreous fibre (MMVF) and wherein the fibrous facing is formed of nonwoven inorganic chopped strand mat.

2. An acoustic element according to embodiment 1 wherein the fibrous facing is glass and/or basalt chopped strand mat.

- 15 3. An acoustic element according to embodiment 1 or embodiment 2, wherein the fibrous facing has basis weight in the range 150 to 400 gsm.

4. An acoustic element according to any preceding embodiment wherein the fibrous facing has fibre diameter greater than 0.5 mm.

- 20 5. An acoustic element according to any preceding embodiment wherein the fibrous facing has fibre length in the range 30 to 150 mm.

6. An acoustic element according to any preceding embodiment wherein the fibrous facing has thickness 0.3 to 1 mm.

7. An acoustic element according to any preceding embodiment wherein the fibres of the fibrous facing are multifilament strands.

CLAIMS

1. A planar acoustic element, comprising:

an acoustic panel having first and second opposed major faces, wherein at least the first major face is provided with a fibrous facing which is exposed, wherein the
5 panel is formed of man-made vitreous fibre (MMVF) and wherein the fibrous facing is formed of nonwoven inorganic chopped strand mat and has a basis weight in the range 150 to 450 gsm.
2. An acoustic element according to claim 1 wherein the fibrous facing is glass and/or basalt chopped strand mat.
- 10 3. An acoustic element according to any preceding claim wherein the fibrous facing has fibre diameter greater than 0.5 mm.
4. An acoustic element according to any preceding claim wherein the fibrous facing has fibre length in the range 30 to 150 mm.
5. An acoustic element according to any preceding claim wherein the fibrous
15 facing has thickness 0.3 to 1 mm.
6. An acoustic element according to any preceding claim wherein the fibres of the fibrous facing are multifilament strands.
7. Use of an acoustic element according to any preceding claim as a ceiling panel or an acoustic interior wall panel, wherein the exposed nonwoven inorganic
20 chopped strand mat facing faces towards the interior space.
8. Use of an acoustic element according to any of claims 1 to 6 as cladding for an interior building surface.
9. Use of an acoustic element according to any of claims 1 to 6 as a suspended ceiling island or baffle.

10. A ceiling formed of a plurality of elements according to any of claims 1 to 6.
11. An interior wall faced with a plurality of elements according to any of claims 1 to 6.