Glassfibre-reinforced concrete sound protection walls

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Summary

The aim of this report is to introduce to the technical public products with a new raw material basis for applications in road engineering. These products are elements of sound protection walls set on a base of glassfibre-reinforced concrete supports, whether in absorptive or reflective variant. The development of these components was not undertaken as a specific problem of single elements but rather as a complex system of building of sound protection walls, i.e. including details of placing into construction, anchorage, sealing of horizontal and vertical joints, elements of emergency exits and beginning and end sections.

KEYWORDS: glass fibre reinforced concrete, sound protection, absorptivity, reflectivity

INTRODUCTION

Currently sound protection walls are constructed from materials based on concrete, wood, sheet metal slabs, plastic recycled materials, transparent acrylic or polycarbonate glass, stones set within wire gabions, or land hills in combination with vegetation. Each constructional material used has its specific properties, which are transferred into the constructional system of sound protection wall and thus give to the whole construction suitable or less suitable parameters in terms of production, transportation and handling, installation, operational lifetime together with related maintainance in the given locality.

ASSESSMENT OF REQUIREMENTS FOR SOUND PROTECTION WALLS

Initially market research was undertaken to establish the available and commonly used types of absorptive walls together with evaluation of some their technical limitations:

- concrete supports with absorptive layer of lacunal aggregate
  - high weight
  - lowering of sound absorption capacity due to the additional coatings
- wood and plastic elements
  - low air transmission loss
  - low resistance of covering layer as sound absorber to water, insect and birds
  - short lifetime
  - insufficient statics in the case of larger heights of walls
- steel and other metal elements
  - low air transmission loss and the question of absorption capacity factor in view of frequency composition of traffic noise
  - contentious in terms of resistance to chemical de-icing substances and the question of lifetime.

Based on this evaluation the following parameters were determined, which the new product should reach:

1. Air transmission loss higher than 24 dB.
2. Sound absorption capacity higher than 10 dB with the highest absorption capacity factor ranging from 250 to 1000 Hz in the case of absorptive walls.
3. Sound reflectivity 0–4 dB in the case of reflective walls.
4. Resistance to chemical de-icing substances of fibreglass concrete shell – loss less than 300 g/m^2.
5. Resistance to frost, water, animal and plant pests, insects, fungi and bacteria.
6. Resistance of used materials to fire.
7. Weight under 800 kg of common component having module 4 m and height 1.5–2 m.
8. Mounting in steel or concrete columns with the minimum of joints, interspaces and lack of tightnesses in construction.
9. Resistance of the whole construction to wind load.

SOLUTION OF ABSORPTIVE SOUND PROTECTION WALLS

Based on the foreqoing defined goals, a solution was found by undertaking the following steps.

A. A glassfibre concrete shell component as a support and a soundproof element with dimensions 3940 × 1640 or 2220 mm with shell thickness 10 mm reinforced on four sides with a glassfibre concrete frame of height 110 mm and transverse ribs was designed to meet the static parameters for the highest wind load including extreme load in the front sections. Selected properties of glassfibre concrete components are shown in Table 1.

Properties	Declared values
Bulk density	2050 $kg.m^{-3}$
Absorptivity	10 % by weight
Moisture length changes	1.5 mm/m
Flexural strength	min. 11 MPa
Flexural proportional limit	min. 8 MPa
Flexural modulus of elasticity	15 GPa
Impact strength IZOD	8 $kJ.m^{-2}$
Frost resistance after 150 cycles	100 %
Class of reaction to fire	A 1

Table 1: Selected properties of glass fibre concrete

B. A measurement of the sound absorption capacity of mineral wool of type such as Rockwoll, Orsil and Isover with various thicknesses and bulk densities was carried out in the frequency range 80–300 Hz. Increasing the thickness of absorptive material increases the absorption capacity at low frequencies, which in view of the frequency composition of traffic noise is not so important. It is also not possible to reliably specify the influence of bulk density of tested materials. In the end Rockwool Techrock was selected with a thickness of 100 mm and bulk density of 80 kg/m^3.

C. A problem was the covering layer of the sound absorber, which was required to satisfy defined parameters in terms of sound infiltration, resistance to water infiltration and to mechanical damage or damage by insects. In the end solid micromesh glass fabric was selected, and was glued to the sound absorber and to the peripheral frame of the element, permitting air infiltration but not water ingress.

D. Larger-scale damage is inhibited by a high zinc-coated steel mat having diameter 5 mm with mesh size 150/150 mm, which covers the entire component area and acts as an aesthetic accessory.

E. The whole component periphery is bordered by a special kind of engrained recycled rubber of thickness 10 mm, which partly covers installations of mat endings and partly decreases the reflective area.

F. The vertical interface of single components is solved by the use of tongue and groove.

G. Sound protection elements are mounted in steel columns from HEA profiles. Static calculations were undertaken for various heights of sound protection walls selected for dimensional ranges of HEA profiles of between 140 and 220. Instead of steel columns it is possible to anchor the sound protection components as attachments to concrete columns.

EVALUATION OF BASIC PARAMETERS OF SOUND PROTECTION WALLS

In this way components with the following basic sizes – length 3940 mm, height 1640 or 2220 mm and thickness 120 mm (shell 10 mm + frame 110 mm) – were subjected to tests in accredited testing departments. The following results were obtained:

1. Evaluation of air transmission loss35 dB
2. Evaluation of sound absorption capacity10–11 dB
3. Resistance to water and chemical de-icing substances loss less than 100 g/m^2

These components also fulfill the wind load for wind area I and II including atypical starting components with element length 4 m.   Weight of components with length 4 m ranges from 350 to 420 kg depending on height.

SOLUTION OF REFLECTIVE SOUND PROTECTION WALLS

The sound protection wall system was also solved to fulfil the reflective function. The base of the sound protection reflective wall comprises glassfibre concrete plinth components lightened with a polystyrene core. Thus a relatively low weight was achieved. Plinth components having an area of 1 × 3 m weigh only 320 kg. A profile of this lightweight component is shown in Figure 1.

The facing side of the plinth is curved to increase the reflective area and to regulate the reflective waves. In the top part of the plinth there are moulded short-wave PFEIFERanchors which serve mainly for operation and installation of the sound protection wall. Design of the sound protection reflective wall is shown in Figure 2.

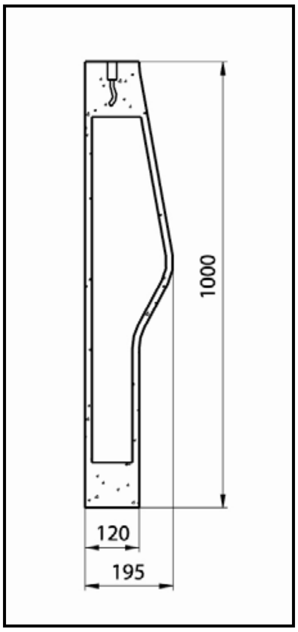

Figure 1: Profile of plinth component

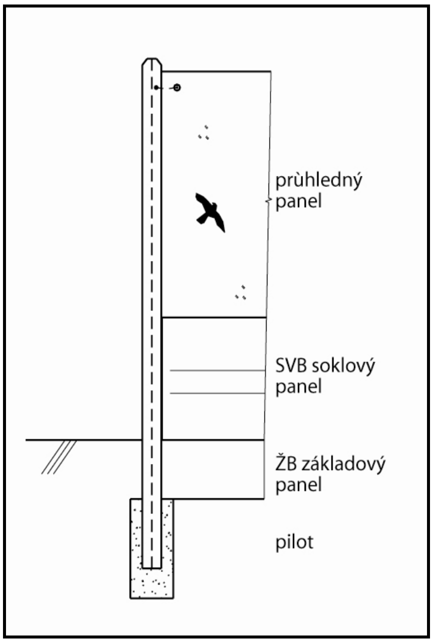

Figure 2: Design of reflective wall

On the foundation is placed a glassfibre concrete plinth component, on which is mounted the transparent panel. On the panel is mounted a sealing rubber and the front flange is pressed by means of clamping bars. This variant is designated RW01. Components are:

1. HEA column
2. transparent panel
3. plinth panel
4. clamping bar.

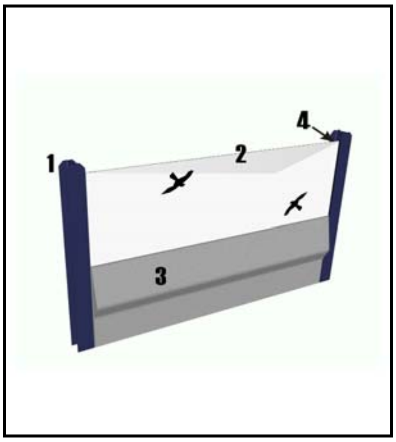

Figure 3: Design of sound protection wall RW01

To improve noise elimination the wall can be finished with a diffuser. This is a declination of ending 0.5 m of sound protection wall to the front side with angle 20° (variant RW02). Components are:

1. HEA column with an extension for diffuser
2. plinth panel
3. transparent panel
4. transparent panel of diffuser
5. clamping bars
6. holding elements.

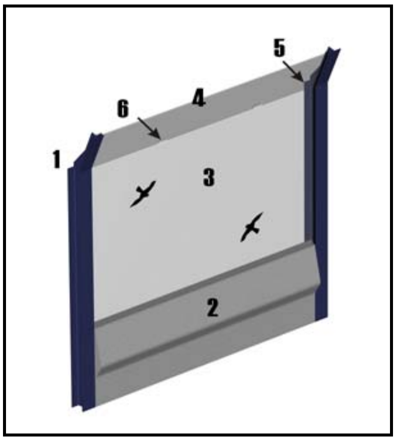

Figure 4: Design of sound protection wall RW02

Where a view through the sound protection wall is not required, a castellated GFRC shell element (variant RW03) can be mounted instead of the acrylated panel on the plinth panel. Components are:

1. HEA column
2. castellated shell GFRC component
3. plinth component.

Figure 5: Design of sound protection wall RW03

CONCLUSIONS

Glassfibre concrete sound protection walls:

- are easy to manipulate due to their lightness
- are easily and economically installable and eventually replaceable
- have a long lifetime and low maintenance requirements
- have high resistance to the effects of weather and pollution
- due to their high strength can withstand wind loads.

The result is a construction system of new technical quality products with suitable parameters, slight but sufficiently compact, with a possible architectonic solution of basic structural element and atypical elements, suitable both for the building of sound protection walls in annexes along existing roads and for the completion of new planned transport lines. The available options should cover all potential problem scenarios that can arise on roads.

In 2005 DAKO Brno Ltd placed a new product on the market named DAKOBET ALFA, which, with its system solution, size variability and cost savings on transportation and heavy assembly machinery, represents an advance in the building of sound protection walls.

Figure 6: Implementation of absorptive wall

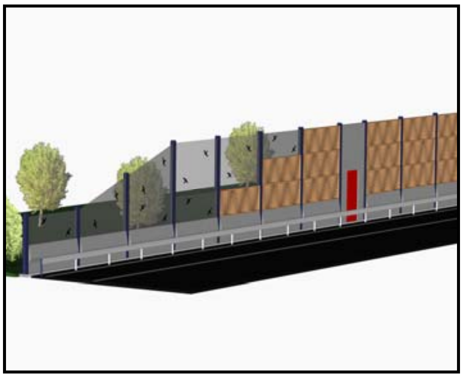

Figure 7: 3D visualisation of reflective wall

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