

7.. PRINCIPLE OF CONSTRUCTION

7.1 LIVING BARRIER

THE GREEN BARRIER® AND GB® ECONOMY



THE GREEN NOISE BARRIERS

PileByg a/s Villerup Hovedgaard DK-9800 Hjørring www.pilebyg.dk +45 98962071 info@pilebyg.dk

7.. PRINCIPLE OF CONSTRUCTION

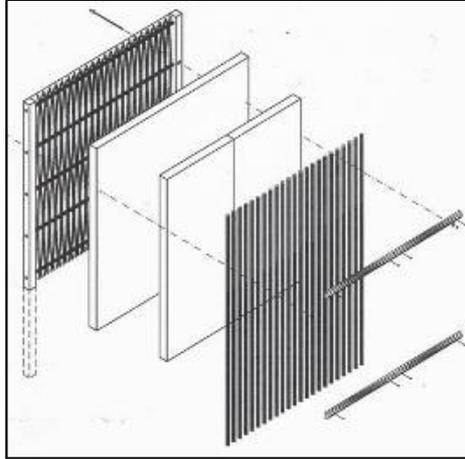
7.1 LIVING BARRIER

7.1.1 DESIGN

THE GREEN BARRIER® AND GB® ECONOMY

The Green Element Living

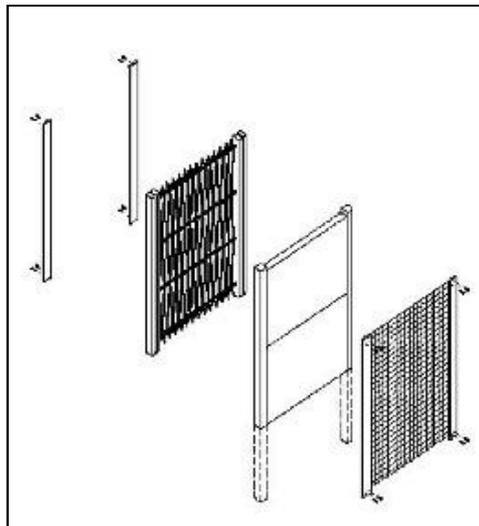
As opposed to the barriers built in conventional materials only and then decorated with plants, THE GREEN BARRIER® in living willow is on the one side, in itself a living structure. The acoustic barrier consists of willow elements arranged in parallel. A combination of a dried



woven on one side and a living side with willows on the other constitute a living frame around a self-sup-porting RockDelta rock wool core. The woven and living combination of a sandwich structure is erected and "planted" at the site and after a short while the willow elements take root. This system is described more thoroughly on the following pages.

The Green Element living - ECONOMY

The living barrier, Economy has two different designs for living willow.. A simple one (see fig. To the right). It is constructed with one woven side combined with a metal mesh side. The metal mesh side has cuttings planted along the barrier. On the woven side, evergreens or similar are planted. The principle applied for THE GREEN



BARRIER® with long rods planted into the field can however also be applied for the ECONOMY version (se fig. In the top of the page).

THE GREEN NOISE BARRIERS

PileByg a/s Villerup Hovedgaard DK-9800 Hjørring www.pilebyg.dk +45 98962071 info@pilebyg.dk

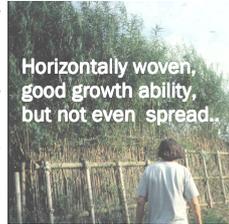
7.. PRINCIPLE OF CONSTRUCTION

7.1 LIVING BARRIER

7.1.2 PRODUCT DEVELOPMENT

THE GREEN BARRIER®

The design principle takes its outset in the first generation of green barriers built in willow. These barriers were built with a soil core, framed by facades of horizontally woven willow rods (Green Walls), sometimes combined with wooden posts. The woven facades of willow rods should set root in the soil core and maintain and fasten the soil core to ensure static parameters. The soil core is supplied with an irrigation system implemented, sometimes on more levels to ensure that the root setting from the horizontally woven willow rods would succeed and create the intended green barrier. However, this construction principle was very sensitive to draught, if the irrigation system should fail. Further, problems could occur with a very unstable and mobile soil core. Especially the need for irrigation taken into account. Worst case scenario could be a barrier with rotten willow facades causing the whole



construction with the unstable soil core to slowly disintegrate (see fig.). Taking the very attractive aspects of the first green barrier walls into account but aiming at a transformation of the technique, the system had to undergo a product development with focus on core and static, clone selection and production process and characteristics of growth physiology and “green engineering”. The barrier concept changed thereby considerably. 1) New core of mineral wool, a self-supporting material with certified life expectancy and noise abatement qualities., and which is form stable as opposed to the soil. 2) Refined clones and “new logistics” on handling of living rods. Respecting the biological requirements of willows, eg. planting the willow vertically (directly into the ground) and not weaving the willow rods horizontally, and thereby allowing much more growth ability and strength to remain in the willow rods. 3) Combining the living side with dried woven panels to avoid living willow panels on North directed facades.

Today, the the barrier is CE-marked according to European standard.

THE GREEN NOISE BARRIERS

PileByg a/s Villerup Hovedgaard DK-9800 Hjørring www.pilebyg.dk +45 98962071 info@pilebyg.dk

7.. PRINCIPLE OF CONSTRUCTION

7.1 LIVING BARRIER

7.1.3 GROWTH PHYSIOLOGY

THE GREEN BARRIER®

Considerably amounts of resources and research have been invested in the development of a strong and robust living side of a barrier. Varieties of willow, logistics on harvest, handling, sorting and planting of these, the very use of willow rods in a construction as such, and of course the maintenance are just some the most paramount aspects of the know-how surrounding THE GREEN BARRIER. More than 120 ha. of willow plantations and an arboretum of more than 100 varieties of willow alone works as outset. Some of the most crucial aspects of choosing a living barrier side for a “dead” one would be the consideration of the following growth physiological issues.

Willow Roots

The question of root growth from willow is crucial. Different research has been made, and these results, combined with PileBygs experience gained since 1988 leads to the following “rules of the thumb”:

- A dense amount of willow roots are normally to be found in the upper 20-40 cm level of topsoil, reaching out on an area of a 1 meter radius around the stool. However, smaller roots can of course be seen further away from the stool, the willow tree has a large root zone.
- The roots can in principle penetrate drainage pipes and this should be taken into account. With a safety distance of 1,5-2 meters from drainage, the willow should not cause a problem, premising that the willow barrier is maintained as prescribed. The willow barrier is established along roadsides without problems, as long as the safety distance is taken into account.
- The willow tree does not set out root suckers, as the poplar tree does. Willow only shoots from stool of the very rods planted in the barrier. The willow will therefore not spread.
- Cultivation of willow plantations shows that the willow is not sensitive to root damage of some extent. If root damage occurs, well performed maintenance is however crucial, for instance when it comes to irrigation and nourishment.



THE GREEN NOISE BARRIERS

PileByg a/s Villerup Hovedgaard DK-9800 Hjørring www.pilebyg.dk +45 98962071 info@pilebyg.dk

7.. PRINCIPLE OF CONSTRUCTION

7.1 LIVING BARRIER

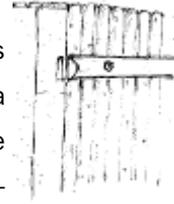
7.1.3 GROWTH PHYSIOLOGY

THE GREEN BARRIER®

Increase in growth and natural selection

A very crucial aspect of the design of the barrier is the horizontal lather, attached to the rods with a protection band: This system has been tested since 1994 and has proven to be able to ensure the following:

- Avoid the rods from destroying each other in windy weather. Rods planted vertically in the ground will, if planted next to each other without fixation, rub each other into pieces. The lather system fixates the rods and allow room for stem growth and natural selection. Some stems will die, and others take over and ensure an even foliage and shooting.
- Press the willow rods to produce shoots from top to bottom to spread and even green surface.
- Generating the new growth in side branches, and thereby limits the growth of the mother stem.



Salt

Different varieties of willow tolerate different levels of salt in water, soil and air. Along roadsides with very high amounts of salt used during winter, a safety distance of 3-5 meters from the roadside should be taken into account.



Light

For a sound and evenly spread shooting, the barrier needs light, as willow is a very light-dependent tree. PileByg can therefore not recommend the living willow barrier side applied, for instance on north-sides, next to high walls or large trees and bushes, which would shadow for the willow barrier. The dried woven willow panels are applied to avoid such designs.

THE GREEN NOISE BARRIERS

PileByg a/s Villerup Hovedgaard DK-9800 Hjørring www.pilebyg.dk +45 98962071 info@pilebyg.dk

7.. PRINCIPLE OF CONSTRUCTION

7.1 LIVING BARRIER

7.1.3 GROWTH PHYSIOLOGY

THE GREEN BARRIER®

Maintenance

The maintenance guideline should at all times be followed, and the maintenance newsletter is send to all customers without costs, to ensure that the irrigation system, pruning etc is not forgotten.

Should an oversight occur, the barrier system is helped by the fact that the rods are planted directly in the ground and therefore receive water as everything else in nature.

Tests show, that even after 1-3 years without irrigation, a barrier can be brought back to top performance by resuming irrigation, pruning etc. Alternately, ivy or similar evergreen plants can be planted at the foot of the barrier, and thereby change the character of the barrier to a zero maintenance barrier. This should however be performed in cooperation with PileByg a/s. See reference examples in chapter 4, Maintenance.

Replacement of element.

However, should irretrievable damage have occurred, old elements can be replaced with new ones, as shown on the figure, without considerably costs.



Sources:

- Newsholme, C.** (1992) Willows, the Genus *Salix*., B.T. Batsford Ltd, London
- Rytter, L.** (1989) Distribution of roots and root nodules and biomass allocation in young intensively managed grey alder stands on a peat bog. *Plant and Soil*, 119 71-79.
- Rytter, R-M.** (1997) Fine root Production and carbon and nitrogen allocation in basket willows. Doctoral Thesis. Swedish University of Agricultural Sciences, Uppsala.
- Rytter, R-M. & Hansson, A-C.** (1996) Seasonal amount, growth and depth distribution of fine roots in an irrigated and fertilised *Salix viminalis* plantation. *Biomass and Bioenergy*, 11 (2/3) 129-137.
- Elowson, S. & Rytter, L.** (1993) Spatial distribution of roots and root nodules and total biomass production in a grey alder plantation on sandy soil. *Biomass and Bioenergy*, 5 (2) 127-135.
- Elowson, S. & Rytter, L.** (1988). Dynamics of leaf minerals, leaf area, and biomass from hardwoods intensively grown on a peat bog. *Trees*. 2: 84-91.
- Heilman, P.E., Ekuan, G. & Fogle, D.** (1994) Above and below-ground biomass and fine roots of 4-year-old hybrids of *Populus trichocarpa* x *Populous deltoides* and parental species in short rotation culture. *Canadian Journal of Forest Research*, 24 1186-1192
- Mackie-Dawson, L. A. & Atkinson, D.** (1991) Methodology for the study of roots in field experiments and the interpretation of results. In *Plant Root Growth: An Ecological Perspective*. (ed. D. Atkinson) pp 25-45. Blackwells. London.

THE GREEN NOISE BARRIERS

PileByg a/s Villerup Hovedgaard DK-9800 Hjørring www.pilebyg.dk +45 98962071 info@pilebyg.dk

7.. PRINCIPLE OF CONSTRUCTION

7.1 LIVING BARRIER

7.1.4 DEFLECTION - LIVING SIDE COMBINED

THE GREEN BARRIER®

Living side combined with dried, woven panels or metal mesh.

Wind load deflection performance is an important consideration in assessing the suitability of barriers in windy locations or where crash protection is required.

When using a design of living elements in combination with woven panels or metal mesh. The Green Barrier in living willow is subject to standardized civil engineering calculations as the woven panel side is structurally made out of timber and galvanised steel of known structural properties.

All projects delivered by PileByg a/s is constructed and calculated according to current standards. Moreover is the PileByg barrier concept undergoing the final paperwork in the CE-mark procedure for Road traffic noise reducing devices –specifications DS/EN 14388.

For further details, please ask for specific calculations according to project requirements.

All calculations are produced by officially approved civil engineers on static.

THE GREEN NOISE BARRIERS

PileByg a/s Villerup Hovedgaard DK-9800 Hjørring www.pilebyg.dk +45 98962071 info@pilebyg.dk

7.. PRINCIPLE OF CONSTRUCTION

7.1 LIVING BARRIER

7.1.4 DEFLECTION - DOUBLE LIVING PANELS

THE GREEN BARRIER®

Living barrier panels on – both sides.

PileByg and RockDelta® have undertaken wind load deflection tests on a freshly installed Green Barrier with living willow on both sides. This test represents the worst-case scenario, as once established, the willows will be more stable than immediately after establishment.

Description of test barrier

The test barrier was constructed from living willow rods of 3-5 cm diameter, although mainly 4 cm Ø rods. The rods are held firmly in the vertical plane by horizontal larch batons. See general technical specification in the diagram below. The dimension of the test barrier is 2.20 linear meters (two panels each measuring 1.1m) and with a height of 3.2m. The RockDelta® soundproof core material is placed between the panels to a width of 240mm representing two thicknesses. In one end of the barrier a 280 mm x 50 mm larch pillar is erected and fixed to the element. The end is boarded off as required to leave tidy.

The barrier is 3.20 m high above ground when finally planted; the finished length of 3.3m is made up of two full width (1.1m) panels with a half panel at each end measuring 0.55m. A trench was dug using a standard tractor mounted excavator. The barrier is erected directly into the soil and planted to a depth of 80cm ensuring that the elements were aligned vertically. The construction method is identical to that used in a commercial situation. The use of an excavator-mounted bucket gave rise to loosening of the soil at the edge and ends of the trenches.

THE GREEN NOISE BARRIERS

PileByg a/s Villerup Hovedgaard DK-9800 Hjørring www.pilebyg.dk +45 98962071 info@pilebyg.dk

7.. PRINCIPLE OF CONSTRUCTION

7.1 LIVING BARRIER

7.1.4 DEFLECTION - DOUBLE LIVING PANELS

THE GREEN BARRIER®

Application of pressure representing wind or impact on the barrier

To achieve an even distribution of force on the barrier, a number of positions were used to provide fixings for the pulling equipment. The pull was taken with a U shaped band, mounted using four M12 “pieces of studding” running through the barrier. The pull on the barrier was made at 1.8 m above terrain. To even the power pressure on the barrier, The U-formed band was mounted on the side of the barrier from where the pull was taken. A digger was used to make the pull. The deflections were measured at a height of 1,8 m above terrain, both during the pull and after to see if any residual effects had occurred.

Measurements of the force were made using a calibrated force meter. Varying the crane weight controlled the force. The crane was equipped with a digital reading display. The accuracy of the crane weight was 15 kp. Max measure was 10000 kp. The digital displayed showed an interval of 10 kp.

The force was not applied to the middle of the barrier, as the barrier was lower than projected when the wind pressure was calculated. It is not recommendable to put up a barrier higher than 3,2 m with 80 cm of the rod buried into the soil (this would equate to a 4 m long rod/cutting). The force should then be 11% lower corresponding to 283 kp per panel when the point of the centre of pressure was 1.6 m above ground level. The force was, therefore, 452 kpm per panel at the "stool"/bottom of the barrier. As the centre of pressure is raised to 1.8 m above ground level, the power must be reduced to 251 kp per panel to have a corresponding force.

Corrections were made to the barrier vertical alignment after the test was complete with the excavator without problem.

THE GREEN NOISE BARRIERS

PileByg a/s Villerup Hovedgaard DK-9800 Hjørring www.pilebyg.dk +45 98962071 info@pilebyg.dk

7.. PRINCIPLE OF CONSTRUCTION

7.1 LIVING BARRIER

7.1.4 DEFLECTION - DOUBLE LIVING PANELS

THE GREEN BARRIER®

Force kp per linear m (=	Deflection cm	Deflection on release of force cm	Remaining deflection curve cm
0	189	-189	0
370	196	-196	0

Taring after the barrier had been given a push of 370 kp, compensating for wind pressure

700	209	-209	0
1070	215	-208.5	Max 6.5 cm
2000	237,5	206	10 cm comparing to earlier measure / 16,6 cm comparing to start position.

It was calculated that the pull should be 318 kp per running meter to be comparable with the wind conditions at location/site as Fløng (terrain 0.05, 7.5 m above terrain, form factor 1,2). DS410 was applied to calculate the test and the thesis is documented by enclosed description of revision 03 dated 24 March 1999. It is recognised that conditions in the UK may vary significantly from this, but the data clearly shows that a design wind condition in excess of 700pa per linear meter is easily achievable with no noticeable permanent deflection. It is not possible to provide individual post loading comparisons, as they are not appropriate.

At 700 kp linear meter the deflection was 7%. After the force of 1000pa was applied, a permanent deflection of between 0 and 3.6 % was measured. At an applied force of 2000 kp it was still not possible to overturn the barrier and the permanent deflection curve was measured to be 9.1 %.

THE GREEN NOISE BARRIERS

PileByg a/s Villerup Hovedgaard DK-9800 Hjørring www.pilebyg.dk +45 98962071 info@pilebyg.dk

7.. PRINCIPLE OF CONSTRUCTION

7.1 LIVING BARRIER

7.1.4 DEFLECTION - DOUBLE LIVING PANELS

THE GREEN BARRIER®

According to the standard, loading with 2.54 kN/m² should produce no deflection. The load of 1.75 times the normal load of 1.45 kN/ m² = 2.54 kN/ m² no maximum permitted deflection is stipulated. The purpose of this test is to find out if there will be any damages on the sound barrier element; I.e. that the element does not collapse and that neither the steel nor the stone wool shows any cracks. However, the Green Barrier is a 'soft', living structure in terms of its mechanical stiffness and would not be expected to remain vertically static under load.

At this test a deflection of approximately 15 mm was measured and the element showed no damage whatsoever.

Conclusion

The tests indicate that the sound barrier has a very good stability just after installation. The tests further indicate that the sound barrier are not able to overturn even with influences which are four times bigger than the calculated wind influences correspond to 27 meter/second at the given location (Fløng). Fløng is not typical because the top of the barrier is placed on a 7.5 meters high bank -a unusual place to erect a sound barrier. These conditions indicate that the sound barrier will be exposed to less influence under more usual circumstances.

THE GREEN NOISE BARRIERS

PileByg a/s Villerup Hovedgaard DK-9800 Hjørring www.pilebyg.dk +45 98962071 info@pilebyg.dk