

EVERGREEN SOUND WALL 'GRANCIA' NEAR LUGANO, SWITZERLAND

ON THE EUROPEAN NORTH-SOUTH INTERSTATE: GOTTHARD PASS TO THE ITALIAN BORDER

For sound protection of a residential area just North of the city of Lugano, Switzerland, a sound wall was erected. The selection procedures involved various competitive systems, yet only the plantable and prefabricated concrete crib wall was accepted, because there was excellent experience with it some 30 miles, 45 kilometers, further north on the very same Interstate highway.

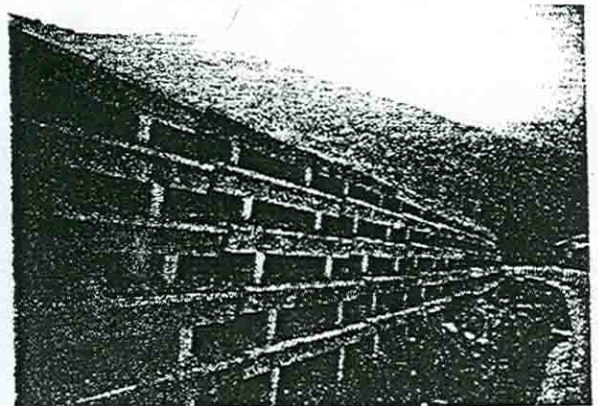
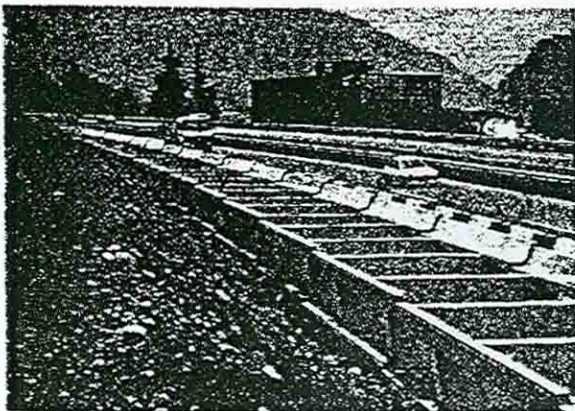
The sound wall is half a mile, 800 m long and 13 to 23 feet, 4 to 7 m, high and concrete panels of 6.5 feet, 2 m on top of it, thus a total height of 20 to 30 feet, 6 to 9 m, part of it covered by a earth fill material on the mountain side.

The individual stacks of Evergreen units are spaced 4 to 6 inches, 0.10 to 0.15 m apart instead of the usual 1/2 inch or 20 mm. This is to absorb rather large settlements expected from the continuous concrete slab foundation on soft subground with a modulus of deformation ME or E of only 1400 psi, 10 MN/m², resulting in several inches of settlement.

The wall consists of 1400 precast Evergreen units, fabricated in a nearby factory. On special request some of the base units are of oversize width of 10.2 to 11.2 feet, 3.10 and 3.42 m, which had to be transported across the city of Lugano in the very early morning hours to avoid disrupting the city traffic.

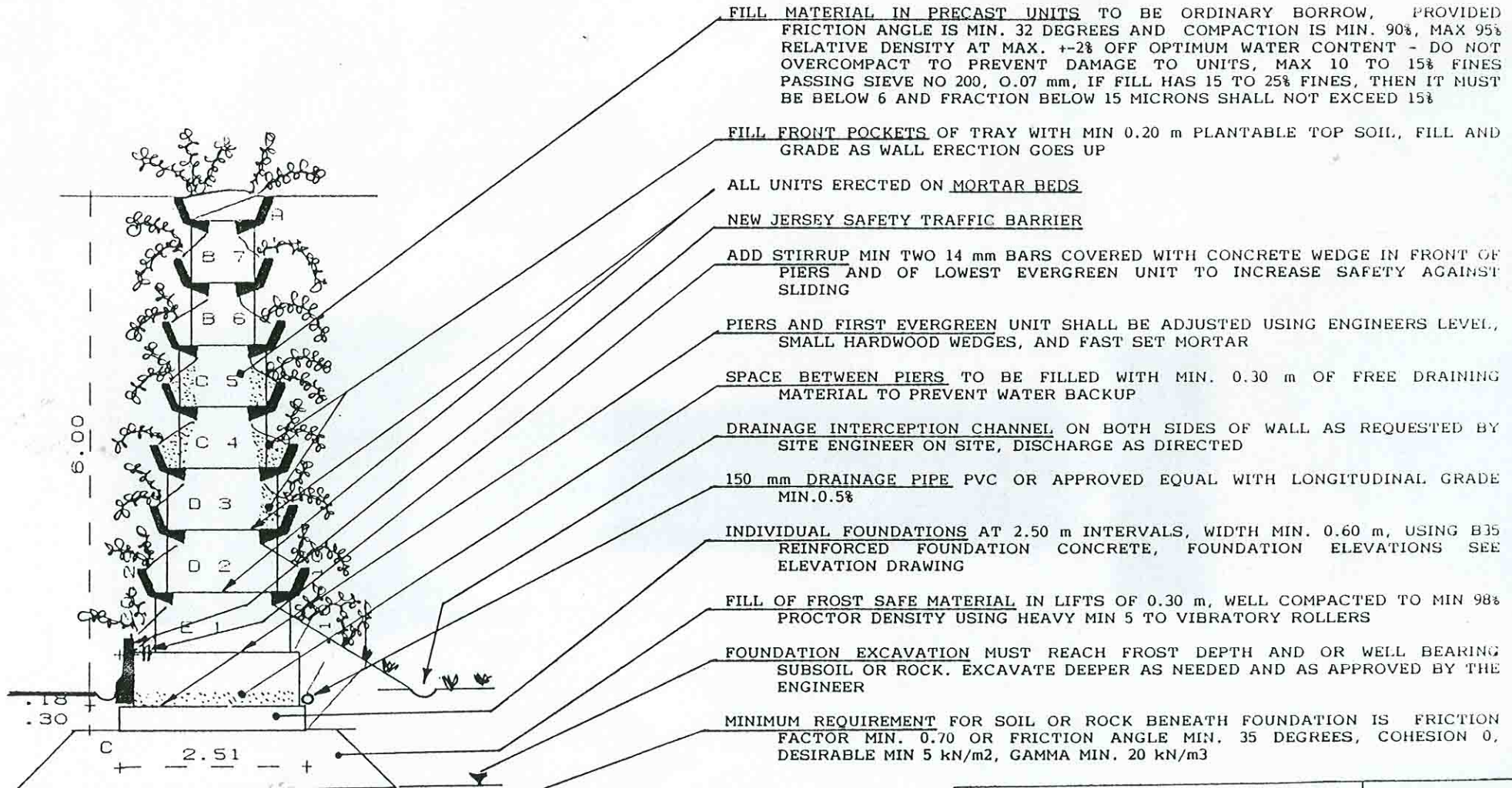
The reason for the extra width was not structural requirement, yet the architectural design and the request for wide volume of earth fill to accumulate moisture for the plants to survive more easily the dry season.

Erection of the wall was completed a few months ago and the development of plants will be monitored closely.



TYPICAL SECTION

PRECAST SOUND ABSORBING EVERGREEN WALL FOR HAGAPARK, STOCKHOLM



- FILL MATERIAL IN PRECAST UNITS TO BE ORDINARY BORROW, PROVIDED FRICTION ANGLE IS MIN. 32 DEGREES AND COMPACTION IS MIN. 90%, MAX 95% RELATIVE DENSITY AT MAX. +2% OFF OPTIMUM WATER CONTENT - DO NOT OVERCOMPACT TO PREVENT DAMAGE TO UNITS, MAX 10 TO 15% FINES PASSING SIEVE NO 200, 0.07 mm, IF FILL HAS 15 TO 25% FINES, THEN IT MUST BE BELOW 6 AND FRACTION BELOW 15 MICRONS SHALL NOT EXCEED 15%
- FILL FRONT POCKETS OF TRAY WITH MIN 0.20 m PLANTABLE TOP SOIL, FILL AND GRADE AS WALL ERECTION GOES UP
- ALL UNITS ERECTED ON MORTAR BEDS
- NEW JERSEY SAFETY TRAFFIC BARRIER
- ADD STIRRUP MIN TWO 14 mm BARS COVERED WITH CONCRETE WEDGE IN FRONT OF PIERS AND OF LOWEST EVERGREEN UNIT TO INCREASE SAFETY AGAINST SLIDING
- PIERS AND FIRST EVERGREEN UNIT SHALL BE ADJUSTED USING ENGINEERS LEVEL, SMALL HARDWOOD WEDGES, AND FAST SET MORTAR
- SPACE BETWEEN PIERS TO BE FILLED WITH MIN. 0.30 m OF FREE DRAINING MATERIAL TO PREVENT WATER BACKUP
- DRAINAGE INTERCEPTION CHANNEL ON BOTH SIDES OF WALL AS REQUESTED BY SITE ENGINEER ON SITE, DISCHARGE AS DIRECTED
- 150 mm DRAINAGE PIPE PVC OR APPROVED EQUAL WITH LONGITUDINAL GRADE MIN.0.5%
- INDIVIDUAL FOUNDATIONS AT 2.50 m INTERVALS, WIDTH MIN. 0.60 m, USING B35 REINFORCED FOUNDATION CONCRETE, FOUNDATION ELEVATIONS SEE ELEVATION DRAWING
- FILL OF FROST SAFE MATERIAL IN LIFTS OF 0.30 m, WELL COMPACTED TO MIN 98% PROCTOR DENSITY USING HEAVY MIN 5 TO VIBRATORY ROLLERS
- FOUNDATION EXCAVATION MUST REACH FROST DEPTH AND OR WELL BEARING SUBSOIL OR ROCK. EXCAVATE DEEPER AS NEEDED AND AS APPROVED BY THE ENGINEER
- MINIMUM REQUIREMENT FOR SOIL OR ROCK BENEATH FOUNDATION IS FRICTION FACTOR MIN. 0.70 OR FRICTION ANGLE MIN. 35 DEGREES, COHESION 0, DESIRABLE MIN 5 kN/m², GAMMA MIN. 20 kN/m³

HAGAPARI.WPS 31.1.92 9206

WHITE ARKITEKTER

HAGAPARKEN LINVÄVARTORPET
FÖRSLÄG TIL EVERGREEN
BULLERAVSKÄRMNING ETAPP 1
NOISE ABSORBING WALL NO 1 AND 2

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DATE 30.1.1992
SCALE 1:50
CHECKED: PJP
REVISED:
Nr 19206-1



GEOLOGY
FOUNDATIONS
GEOTEXTILES
CRIBSWALLS

Conclusions

Conclusions for noise abatement walls base on the "Temporary Recommendation for Noise Abatement Walls along Highways" (RLSW, Richtlinien für Lärmschutz an Strassen) as of April 9, 1974, new edition 1978.

Accordingly the typical coefficient for noise absorption is :

$$\Delta L_{A, \alpha, Str} = 8 \text{ dB(A)}$$

Accordingly the tested noise absorbing wall must be qualified to be fully absorbing.

Stuttgart, February 23rd, 1981
2 enclosures

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Abteilungsleiter:

Projektmanager:
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(partial publication of this report is permitted only with written approval by the Department for Physik of Structures of this Institute)

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Schallabsorptionsgrad nach DIN 52212 (Ausgabe 1961)

musterprüfung

Antragsteller: EVERGREEN GmbH, Stuttgart

Noise absorption coefficient according German Industrial Code DIN 52212(ed.1961)

Testing of sample : for EVERGREEN GmbH, Stuttgart

Type of sample

Concrete elements in a wooden frame 400mm = 1' 3/4" high filled with dry soil and plants.

Dimensions of sample tested: 4.78 x 1.6 x 0.74 m
= 15' 8 1/4" x 5' 3" x 2' 5 1/8"

weight of element without earthfill : about 620 kg/m³ = 127 psf

weight of element including earthfill : about 1462 kg/m³ = 300 psf

The EVERGREEN elements consists of concrete type B 35 equals standard strength of 35 MN x m-2 = 4977 psi

The structure was put on the floor of the acoustic hall for testing.

Prüffläche S 12 m²
Hohlraum V 164 m³

f in Hz	125	250	500	1000	2000	4000
α_n	0,56	0,66	0,78	0,85	0,91	0,93

Bemerkungen:

untersucht bei 19 °C
und 76 % relativer Luftfeuchtigkeit
im Hohlraum

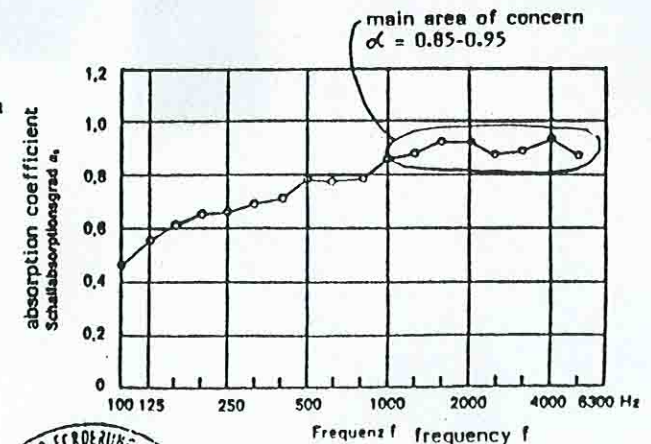
zur Erhöhung der Diffusität
im Hohlraum eingehängte Platten:

- 9 Platten 0,9 m x 0,9 m
- 9 Platten 1,4 m x 1,4 m

$$\Delta L_{A, \alpha, Str} = 8 \text{ dB(A)}$$

Die Lärmschutzwand gilt
nach RLSW (1974) als
vollabsorbierend.

according to RLSW
the wall is
fully absorbing



Terzrauschen
Terzfilter

Prüferort Nr.
GS 33/31

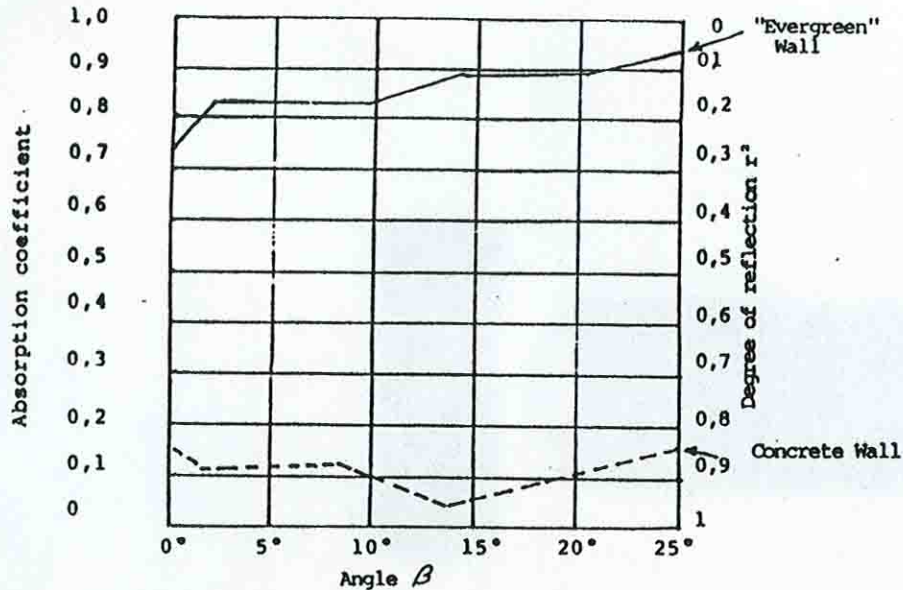
Stuttgart 23.2.1981

INSTITUT FÜR BAUPHYSIK, STUTTGART
Gesellschaft zur Förderung der angewandten Forschung e.V.

Prof. Dr. F. P. Mechel

The arithmetical mean value of the absorption coefficient in the frequency range between 125 and 4000 Hz was used for the graph of the directional dependency of the absorption coefficient.

Directional dependency of the degree of reflection for a concrete wall and an "Evergreen" noise-protection wall:



The results of the measurements from the 13th November, 1979, on a flat concrete wall are included as a comparison in the above graph. An additional comparison measurement on a grown earth wall yields no measurable reflections.

6. COMMENTS

As already mentioned in chapter 4 with noise-absorbing walls, detrimental reflection should be reduced. For the evaluation of the degree of reflection it is obvious that apart from the strength of the reflected wave the direction of the reflection is also significant. Ordinarily the absorption coefficient is applied instead of the degree of reflection.

The absorption coefficient α can be determined using the formula $\alpha = 1 - r^2$ from the measurements of reflection.

The West German guidelines for absorbing noise protection walls refer only to the "statistical" absorption coefficient for a diffused sound incidence, whereas the report over emissions protection for national highways relates the absorption coefficient only with sound reflection on the opposite road side. This means that for an absorption coefficient of e.g. 0.9 only 10% of the sound incident energy on the protection wall may reach the receiver as a reflected wave, 90% of the sound energy has to be partly absorbed and partly shifted in other directions

For the evaluation of absorbing noise protection walls in Switzerland usually the following limiting values are applied (see appendix 15)

Requirements for noise absorbing walls

Absorption values for the "Evergreen" noise protection wall

	Absorption Coefficient				
	125-4000 Hz		500-2000 Hz		
	AFS 1) 1974	ETH 2) 1976	ASF 1) 1974	ETH 2) 1976	
Requirements for noise absorbing walls	0,6	0,7	0,8	0,9	
Absorption values for the "Evergreen" noise protection wall	20°	0,92	0,92	0,95	0,95
	3-20°	0,86	0,86	0,87	0,87
	0-2°	0,78	0,78	0,78	0,78

□ Swiss requirements fulfilled

▨ Swiss requirements not fulfilled

1) Report 1974 State Department for road construction and open channel facilities (AFS)

2) Lecture: noise abating, Prof. A. Lauber, 1976, ETH (Swiss) Federal Institute of Technology, Zurich)

The "Evergreen" noise-protection wall fulfills all Swiss requirements for absorption in the frequency range of 125-4000 Hz.

In the frequency range of 500-2000 Hz the requirements from ASF (State Department for Road Construction and open channel facilities) 1974 are met for angles of incidence, respectively for reflection, larger than 2°.

According to the lecture "street noise" at the Swiss Federal Institute of Technology, Zurich, 1976, the requirement in the frequency range 500-2000 Hz for angles of incidence and reflection larger than 20° are met.

In West Germany the "guidelines" for noise-protection walls in the Federal Republic of Germany" are applied for the evaluation of the absorption. These guidelines distinguish between reflecting, partially absorbing and fully absorbing walls (see appendix 16).

The "Evergreen" noise-protection wall fulfills the requirements for partially absorbing walls for angles of incidence and reflection up to 10°; also for angles larger than 10° the requirements are fulfilled for fully absorbing walls.

Working group
Section Road Traffic

State Dept. for Air
Transport

Signed: P. Graf

Department for Noise
Control

P. Graf

Signed: E. Schurter

E. Schurter

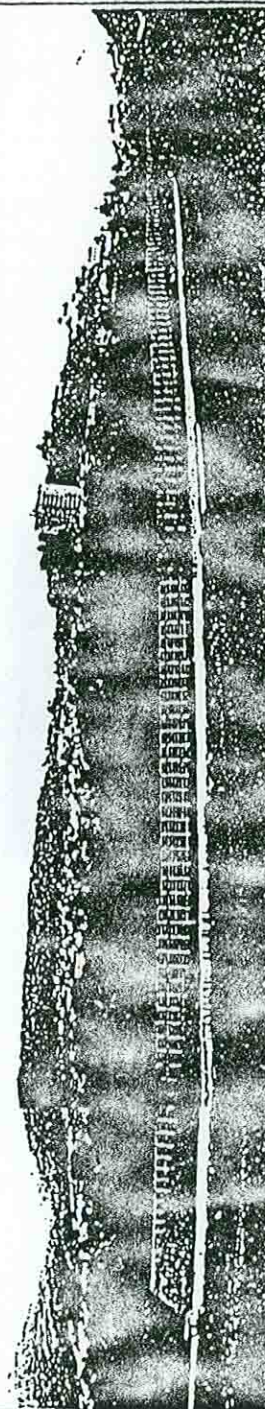
8058 Zurich, the 11 December 1979 WE/ik

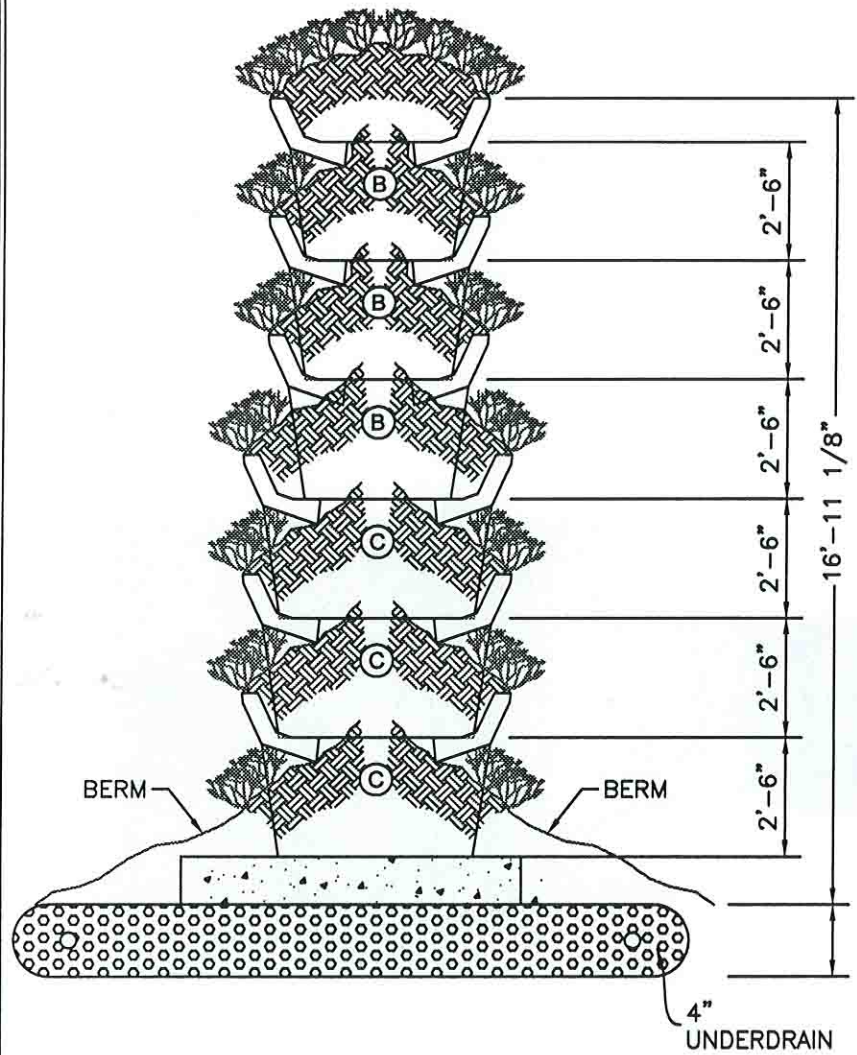
Member of the Working Group: W. Egli

SITUATION

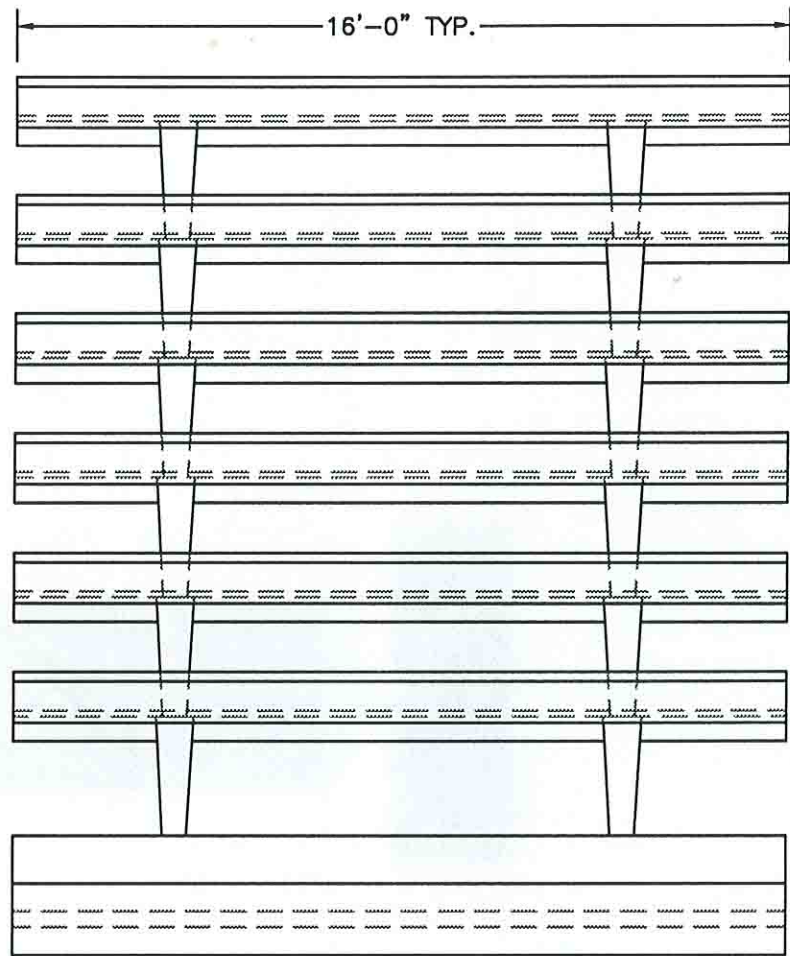
Appendix 1

"EVERGREEN" noise-protection wall
In Aarburg, at the new railway line Bern-Alten of the
Swiss Federal Railways (SBB)





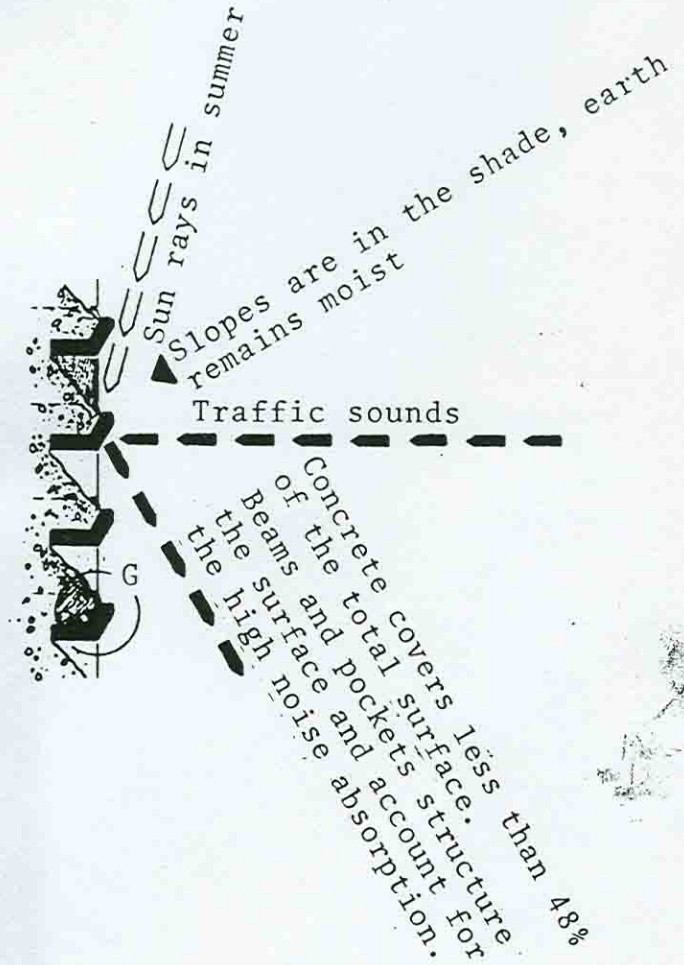
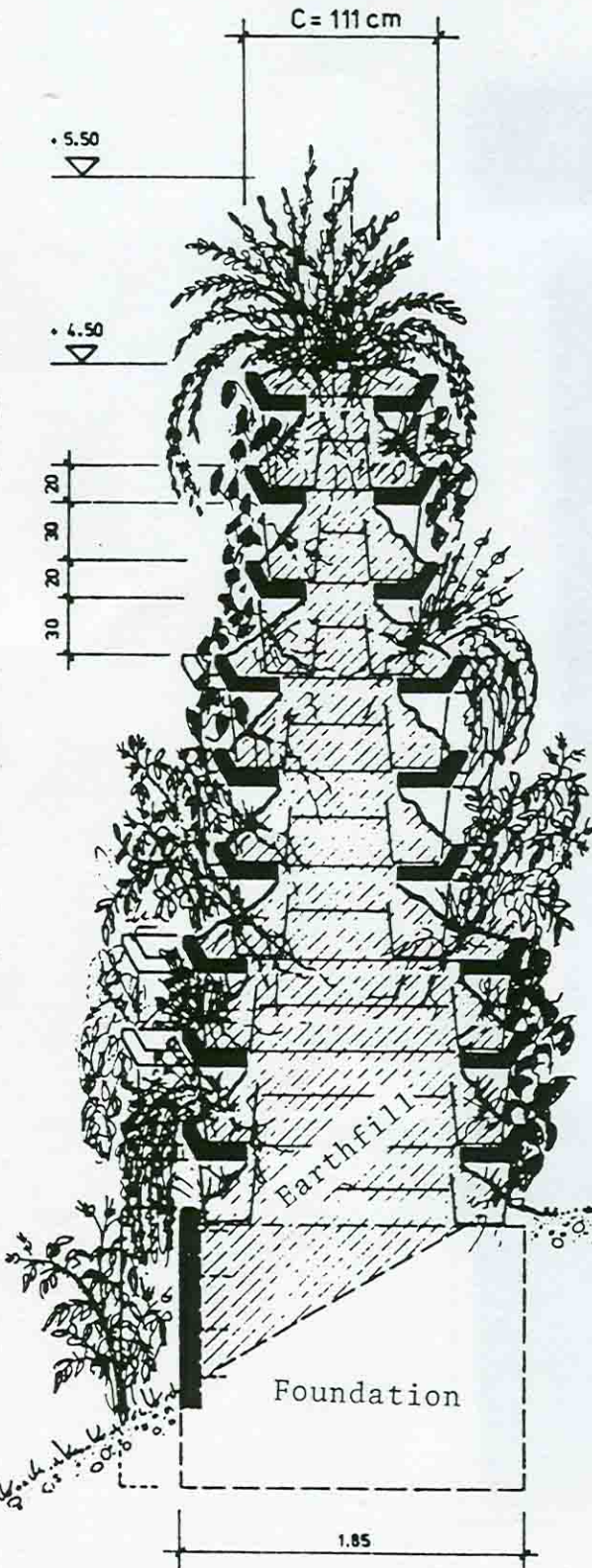
END VIEW



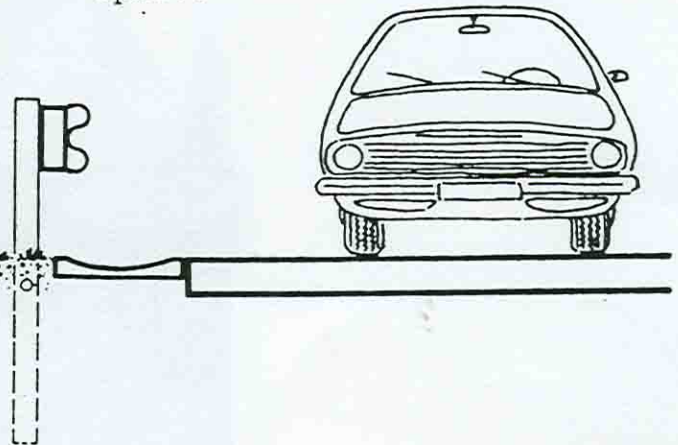
PROFILE VIEW

REVISIONS		PROJECT:	EG-MACRO NOISE WALL STACK W/"B" & "C" UNITS & BERM
		LOCATION:	
		OWNER:	
		ENGINEER:	MICHAEL J. KISTNER
		CONTRACTOR:	
		MANUFACTURER:	KISTNER CONCRETE PRODUCTS, INC.
		PRODUCT DESIGNATION:	EG-MACRO NOISE WALL STACK W/"B" & "C" UNITS
		SCALE:	1/4" = 1' DRAWN BY: CAE DATE: 6-6-01 DWG. NO: EG-MNWBERM2
		DESIGNED BY:	MJK CHECK 1: CAE CHECK 2:

This is of particular interest if aesthetic environmental aspects are to be considered.



G The front edge fill with top soil provides excellent plant growth capabilities. The plant pockets cover more than 50% of the total surface to encourage plants to use the space.



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