International Soil Bioengineering Trip Report

When: May 17-31, 1998

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Where: Germany and Switzerland

Primary Hosts: Joachim Tourbier, Technical University, Dresden, Germany; Beat Scheuter, Scheuter & Partner, NaturaBau, Belp, Switzerland

Other Hosts: Private soil bioengineers in Germany, faculty at the University of Halle and the University of Erfurt, municipal and canton engineers, research assistants from the Technical University in Dresden, and the University at Erfurt, manager of a former East German commune farm.

Soil bioengineering has been used in Europe longer than in the United States. It is taught in the universities, and private practitioners make their living installing erosion control with these methods. The NRCS team made arrangements to see the work of the Germans and Swiss, to learn things they do that insure the success of their installations and that help them decide what practices to use in what situations. This summary of what was learned is offered to provide technology transfer to other NRCS staff and conservation partners. The demonstration sites chosen by the hosts offered a broader perspective on erosion control than anticipated so the comments below on lessons learned cover many topics.

Note: The figures mentioned in this document are in a separate file to download, for the sake of those with computer equipment that cannot handle figures. A separate file of photos will be available at a later date.

1. The Europeans try to encourage natural processes to proliferate.

   A. Topsoil. Eastern Germany has numerous former mine sites, from whence coal was mined before the reunification of Germany. These sites tend to be dry and nutrient poor. They are too large in extent to topsoil practically. Also, if the site were topsoiled, the plants would grow in the topsoil layer, but would not send roots into the lower layers which have poorer soil quality. The roots are needed in the natural soil to hold it in place. Therefore, the hosts at the sites in eastern Germany reported that no topsoil is used, and instead vegetation is chosen carefully that grows naturally in the existing soil on the site.

   B. Seeding Rates. With limited nutrients, the plants will compete with each other for the scarce resources of water and nutrients. If the full 15 grams/ sq. m of seed is put on the site, it initially greens up nicely, but soon the competition sets in and the slope is covered with plants struggling and competing for scarce resources. Instead the Germans seed only 2 grams per square meter, and the few plants have sufficient resources to grow. The plants must develop extensive root systems to reach out for the nutrients and water, and hence hold the soil much better. No fertilizer was used on the reclaimed mine sites when seeding. (see photos 2 and 3)

   C. Mulch. The Germans harvested hay from a nearby area that had a seed bank that they felt would do well on the reclaimed mine site. This hay was used as mulch, providing cover to keep the seed cool and soil moist for germination, and also providing a ready seed bank for plants that may be suited to the former mine site. At one location where this technique was used, Burgdorf identified 25 different species of plants in a square meter. The site had test plots where they had 1) seeded only; 2) seeded and mulched as described here, and 3) added no seed or mulch but let natural processes prevail. The portion with condition #2 clearly had the densest vegetation and most diverse, with condition #1 next. The control site with no seeding or mulching (#3) had large rills. Also, the Germans have concluded that using mulch on a mine site causes the site to revegetate itself about 5 years faster than sites where no mulch is used. In one area the mulch was blown away by the wind, so plugs of reed canary grass were used to shelter the seed while germinating and becoming established.

D. Larger Diameter Live Stakes. On dry sites, and sites where vegetation competes for scarce resources, the Germans found it is better to use live stakes with a larger diameter than smaller ones. It seems like the larger stakes have more reserves that allow them to become established well and more vigor for starting new sprouts. See note under Section 5A below also.

E. Concentrated Flow. On a former mine site, fascines were buried in the thalweg of a constructed waterway that conveyed flow down a slope. Other portions of the waterway were left in bare soil, and had extra willow cuttings just thrown into the conveyance area of the channel. It was clear that the portions with fascines buried just below the flow line had grown best and provided the most erosion control. In concentrated flow, a series of live stake check dams was having success catching sediment and encouraging vegetal growth. Photo 4 shows a checkdam made of willow stakes that are sprouting. At another site, the slope was steeper and longer so rock was used with live stakes to build check dams down the slope. See Photo 5.

F. Lack of Carbon. On one former mine site, the site manager decided to introduce no carbon to the poor soil. As a result, nothing grows there, and nothing lives there. The Germans have thus learned that carbon is essential when seeking vegetation growth on former mine areas. One researcher stated that he needs at least 100 grams of dry mulch per square meter to assist vegetation with becoming established. The mulches are heavy on carbon but not necessarily heavy in nitrogen.

G. Reforestation. This is not considered a good technique in former east German mines because the soil is naturally quite poor, compared to any soil that the seedlings may have grown in. The percentage of plants that die is quite high, as they don't adapt to the poor site conditions.

H. Reuse of existing vegetation. On a road construction project on the autobahn, the trees growing on the site before construction were harvested and stored in a nursery with the native soil from that area to grow in. Then, after construction was complete, these trees were planted back in the area adjacent to the roadway. On a mine site, the willows were harvested from the mine pit for planting on the slopes in bioengineering brush layers; they were somewhat adapted to the site so grew reasonably well, especially in areas where there was a little water. See photo 6.

I. Successional Processes. The Germans encouraged the species that are part of a natural succession that will lead to erosion protection of slopes. They would study what is naturally experienced and then try to enhance the conditions for the species that are in the successional chain.

J. Use Appropriate Vegetation. Our Swiss host uses a seeding mix with more fertilizer and flowers and legumes (the mix on one site had daisies, clover, black medic, red clover, trefoil) when seeding on subsoil. On sites where it was not desirable to have willow growing tall and uncontrolled, a cultivated species of willow was used (nursery grown) to control growth. Where growth could be rampant, a native species of willow was used (cheaper, readily available). Higher on the slope where there is likely to be less water, flowering species were used which tolerate drier conditions compared to grasses.

K. Live Stake Tips. Our Swiss host likes to cut his live stakes so that they only stick up from the ground 1-2 cm. The tops dry less this way. Workers seem to stand on the live stakes and damage them more if they're taller. The sprouts that come from the stakes are stronger if they start at the ground level in his opinion.

L. Net and Coir Mesh Staking. In some installations in Switzerland, coir mesh was staked with U stakes 4" wide, 10-12" high and made out of 1/4" rebar. Also, galvanized netting was used to hold gravel in place in critical spots, held in place with these "U" stakes.

M. Species Diversification. At first, willow was heavily used as an erosion control plant because of its quick growth. Now they try to use minimal willow and encourage species diversity with alder, dogwood, hawthorn, aspen and poplar.

2. Lakeshore Protection

A. Cribwalls and Gabions. A former mine in eastern Germany had been allowed to fill with water and became a lake adjoining a town. The sides of the lake had been protected with cribwalls, where the lowest layer of soil was wrapped with a non-woven geotextile and the layers above that had been wrapped with coir mesh. These had been planted with willow branches, two different species. It was clear that one species had colonized much better than the other. Also, gabions were used in some areas, with joint plantings of willow. The waves were reported to be 2 meters high (about 6 feet) on this lake. No lakeshore erosion was seen where these measures were installed. See Photo 7.

B. Constructed Bays. In Switzerland, our host showed us a lake where he had constructed three points out into the lake to develop two sheltered bays, one for swimming and one for wind surfing. Our host described that he drove wooden pilings into the lakebed and wrapped them together with steel bands. Then metal netting was nailed to the posts, coir mesh used to line the area and the area filled with subsoil. At the water line, two fascines were installed and then a brush mattress above that. (see Figure 1) On the top of the constructed point, he seeded and used coir mesh. He also planted small trees and shrubs. Gravel wedges were installed in the lake bed to dissipate wave energy out in the swimming area. Refer to Figure 2. The waves were 10-20 cm (4-8") high in the bays and 60-80 cm (24-32") high outside the bays.

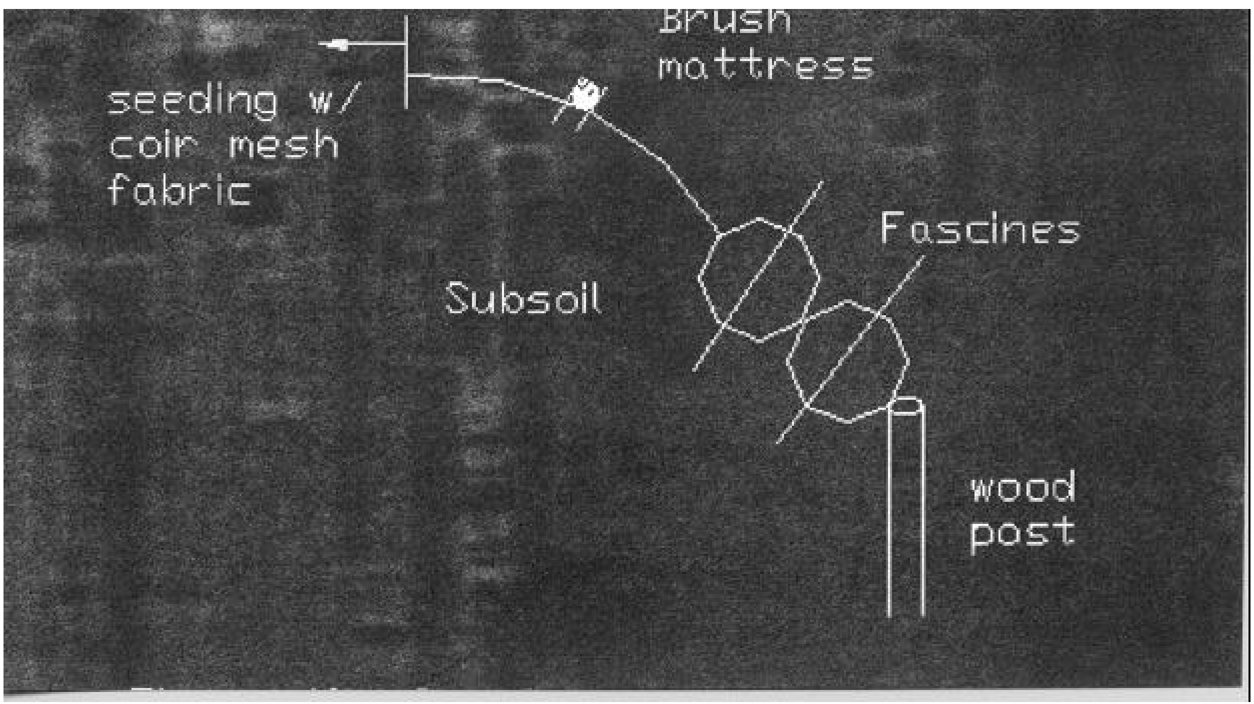

Figure 1. Cross-section of constructed bay in lake.

C. Grow Ahead. In reclaimed mine sites, an elevation was determined where the eventual water line would be for the lake when the mine site filled with water, and soil bioengineering techniques were used to start vegetation at this level so it could be nurtured and maintained and be flourishing by the time the water reaches that level. It would then stand up better to wave attack.

D. Slope Angle. The Swiss have found that if the beach slope is 8 degrees to 12 degrees the beach materials move back and forth with the water but are not eroded away. If the angle is steeper, they have erosion of the beach.

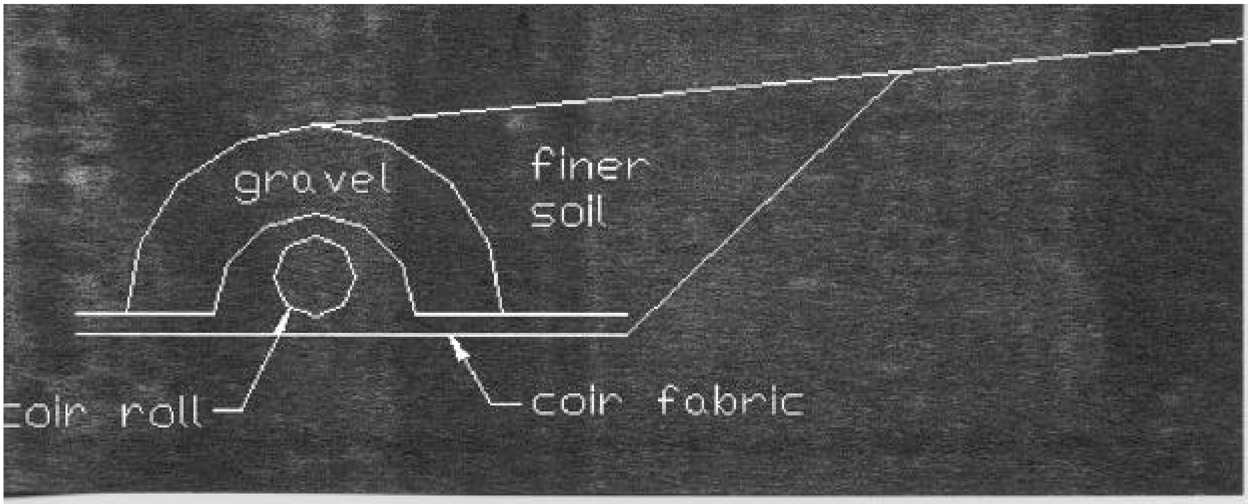

Figure 2. Wave dissipation structures installed in the lakebed in front of the beach areas.

3. Erosion Control Techniques

A. Dead Fascines. Vegetation that is not meant to grow is bundled into fascines and embedded in hillsides as a way to limit soil movement and control erosion while the seeding is becoming established on a site. Diagonal patterns across slopes could easily be seen in sites where the vegetation has recently become established. See Photo 8. Along a highway in Dresden, one side had been seeded the year before and the grass was filling in the slope well. On the other side, the highway department was installing fascines and seeding a slope. It was all covered with soil so the fascines could not be seen, but the rains would expose just a small amount by the time the seeding began to take hold. The fascines would deteriorate with time. These dead fascines were installed on slopes that were 1:1. See Photo 9.

B. Natural Stakes. On one site, the lower part of the trunk of a small conifer was used as a stake. The lowest ring of branches was trimmed to about 4-6” lengths. The trunk was shaped on the top end to be sharp enough to be a stake, and then driven into the ground to hold coir mesh in place. The portions of the branches that remained helped secure the coir mesh until the vegetation became established. See Photo 10.

C. Policy. German policy dictates that a site that is developed must have no increased runoff, no increases in pollutant runoff, and no less infiltration than what it had before development. They call this the blue-green technology.

D. Drier sites. Research under the rainshadow of a bridge on the autobahn is showing that species like roses can flourish in bioengineering techniques on drier sites. The Germans installed brush layers with and without roots on the cuttings. Both seemed to do fine.

E. Technique Tricks. 1) In Switzerland, the brush mattress was installed with a small log anchored across the brush mattress, held by stakes with a figure 8 of wire between them. See Photo 11. This technique was used at a site in Minnesota in October 1998 as a test to compare the technique with wire lacing over a brush mattress. 2) In Germany, fascines in a wet area were kept in place with large nails driven into stakes on either site of the fascines. This kept the fascines from floating. See Photo 12. 3) Our Swiss host used tar paper/roofing felt at the lower edge of the trench for brush layers, as this area is hard to compact well and the water concentrates here. The roofing felt keeps the water from being a problem.

F. Temporary Drainage. Our Swiss host would install a drainage system in slopes with a known water or seepage problem. The drain tile was needed for the first 2-3 years until the willow became well enough established to take up the excess water.

G. Dual Purpose Groin. One groin system in Switzerland had a boat landing area built into it: a vertical side with steps for passengers to climb out before pulling the boat up on the shore.

H. Constructed Channel. Our Swiss host had built a channel with an intentional low flow portion for 1) fish passage and 2) to keep the velocity higher so the sediment wouldn't drop out. An over-sized culvert was used and soil placed about 1' high inside the culvert to construct a low flow channel even where it had to pass through a culvert. See Photo 19. One side of the channel was constructed wider at a lower elevation to have a floodplain. Some shading is needed over a channel to minimize vegetation growth in the bottom which can choke the capacity of the channel. Our Swiss host recommended that about 2/3 of the channel length be shaded.

I. Channel. For a stream in Switzerland, our host is planning an acceleration area where the small stream enters a larger river. He will use rocks to narrow the channel and steepen it. This will prevent backwater from the larger river from entering the channel and depositing sediment as the water slows.

J. Topsoil Philosophy. Our Swiss host believes in taking off the topsoil adjacent to a river or stream as it 1)reduces the flow of nutrients into the stream since they're mostly in the topsoil, 2) soil itself doesn't wash into the stream, 3) the farmers don't want to use the land if the topsoil is gone so he can have a buffer for the stream, 4) less maintenance on plants since the growth is reduced by growing in subsoil, and 5) more native animals seem to come around.

4. Alternatives to Hard Engineering

A. Scour Hole. Around the perimeter of a constructed scour hole were brush layers with fascines staked on top of them. A series of rocks was laid in a ladder type formation to bring the water safely down and through the basin from an outlet pipe that was about 42" in diameter. The rocks were laid such that 1/3 of their size was above the ground and 2/3 of their size was below the ground. The stones used were angular, more rectangular and from a local quarry. Some rocks seemed to be scattered around inside the basin also for energy dissipation. Along the channel leading away from this outlet basin were fascines along the creek bank. The growth was very dense. It was planted in the spring of 1995 and 3 years later the willow were 20 feet tall. See Figure 3 for sketches of the techniques used on this site. The fascines on the outside of the stilling basin were laid around the outside for defining and stabilizing the basin. The size of the scour basin seemed to be similar to those NRCS uses but not as deep. The brush layer willows had grown much better than those in the fascines as they were tied back further in the soil. The brush layering vegetation causes the water to drop its sediment. The brush layering can be done with the assistance of machinery so can be more efficiently installed. This bioengineering solution is an alternative to the traditional riprap scour hole used in America.

B. Vegetative Strips. In Switzerland, vegetative strips were used to establish plant growth on steep slopes. The professional measured the slope and designed panels for the slope of material that resembles galvanized heavy-gage chicken wire. These panels are hung on the slope using anchors drilled in at the top and jute mesh underneath the wire and on top of the natural slope. On top of the wire mesh coir mesh is attached. Strips of coir mesh and wire mesh are attached to the wire mesh and form diagonal pockets against the slope when they are extended with a piece of wire. These pockets are filled with soil that gives plants a place to take hold and become established. The wire mesh is held against the slope with rebar. See Figure 4. For the first two years after installation, the plants largely grow in the pockets. But beginning about the third year, the plants spread into the natural soil and cover the slope with greenery and root mass that hold the soil from erosive forces. On the slope face where there is a change in soil layer, a horizontal pocket is used as water tends to flow between the layers. This allows the water to be caught and started safely down the diagonal pockets toward the ground. These systems were installed by workers wearing rock climbing gear and moving up and down the slopes in harnesses. This system is effective for shallow erosion but not for deep-seated failures. See Photos 13 through 17.

<u>C. Green Gabions.</u> In Switzerland green gabions were used. The rectangular structure was made of reinforcing wire similar to that used in the United States for reinforcing in concrete slabs, except it was galvanized. The "box" was lined with coir mesh fabric and then filled with a mixture of rock and subsoil, providing strength and a growing medium. Vegetation was planted on top and growth spread to all sides that were open to the daylight. The openings in the wire mesh are 3"x 3" to 5" x 5". See Photo 18.

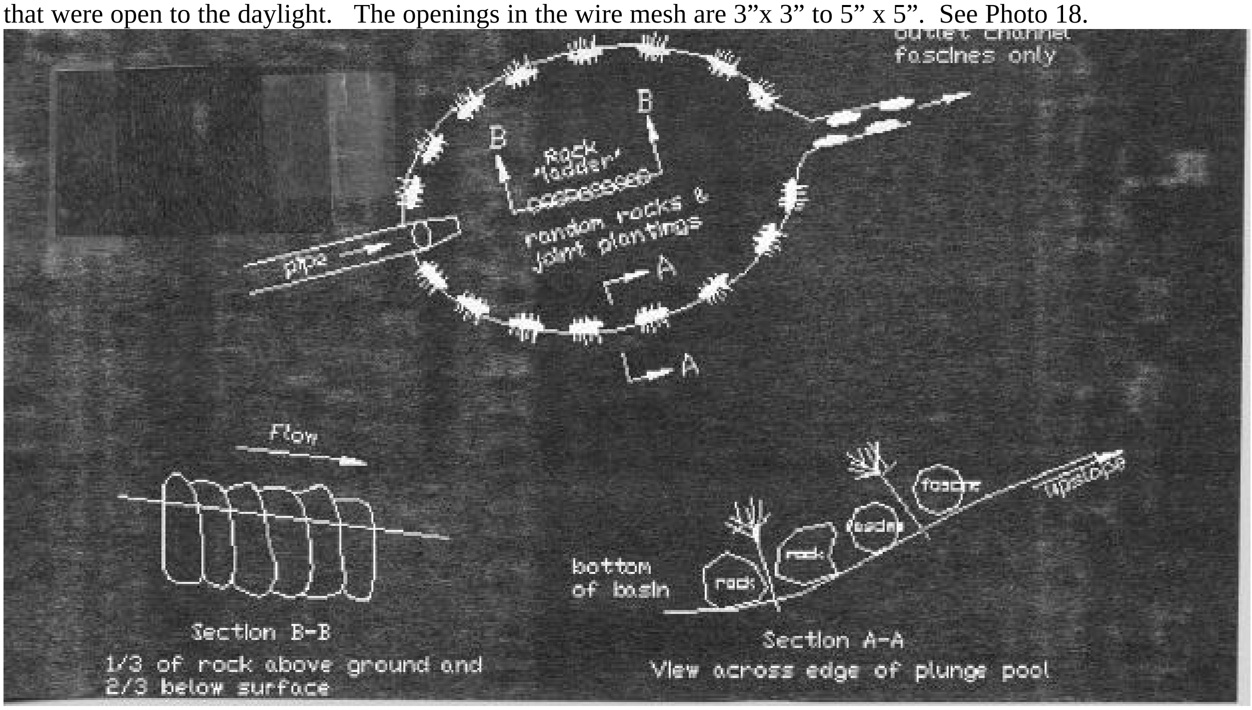

Figure 3. Scour hole constructed with soil bioengineering.

<u>D. Anchored Green Gabions.</u> These are similar to the gabions described above, except that as each layer is added in height a metal pipe is driven through the gabion into the natural soil/rock, and a concrete mix or mortar mix is pumped through the pipe where it infiltrates the soil and forms a "bigfoot" that anchors the gabion in the native rock/soil. The metal pipes for the various layers are tied together with braces similar to what is used for scaffolding. See Figure 5.

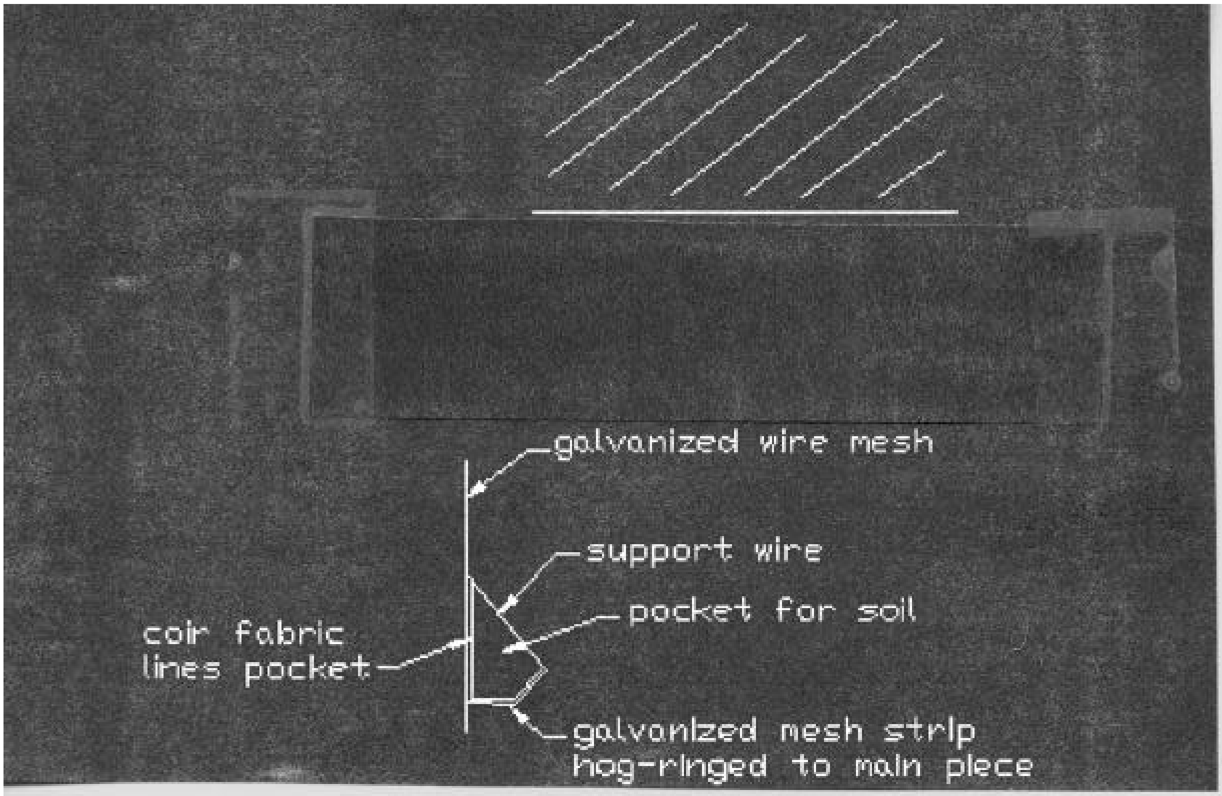

Figure 4. Vegetated strips: front view and side view detail.

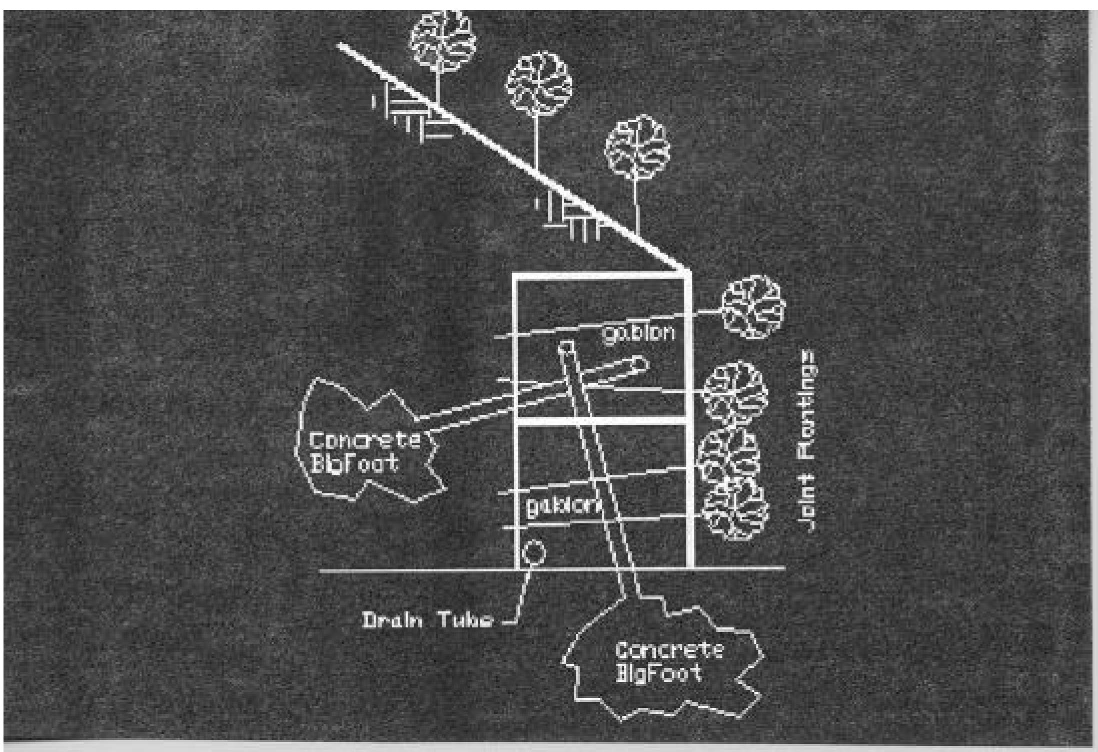

Figure 5. Anchored green gabions, using "bigfoot" concrete anchor.

E. Greening Up Vertical Faces. Metal support chairs, similar to those used to hold reinforcing mesh in concrete slabs, had been attached to concrete walls to allow climbing plants to cover the surface of the concrete wall. The species could be flowering types or vine types. Metal support chairs can also be anchored on natural soil/rock faces to aid in greening up those faces too. At the base of these vertical growth areas is one place that our hosts would use topsoil instead of relying on the natural soil to provide sufficient vigor for a climbing plant.

5. Miscellaneous

A. Climatic Differences. We concluded that some climatic differences make bioengineering easier to install in Germany. Tourbier said that the rains are slower, more gentle, and don't have the peak intense period that we have in the U.S. Also, the climate, with limited snow, and longer spring gives vegetation a good start. The willow seems to delay developing the dense, dry bark that we see in the U.S. on larger diameter willow. The larger diameter willows seemed to have much vigor and readily sprouted on all parts of the thicker branches, compared to what we see in the US.

B. Proposed Buildings need to be Pre-approved. We saw a configuration of boards in the air. This is the roofline of a proposed building. It must stay in the location for a period of time and then the whole community votes whether the building should be built or not.

C. Stone for treatment. Volcanic stone from Hungary was used for wetland treatment systems in Italy and Switzerland. It is very porous and encourages microbial action with the large amount of surface area. A chemical reaction occurs which removes nitrogen and phosphorous.

D. Vegetation to Remove Odor. At a wastewater treatment plant, a man was placing 1.5 meters of a vegetation mix that came from the Czech Republik on the rooftop of a building. A pipe would bring the air up through the vegetation and the vegetation would remove the odors. The vegetation was covered with coir fabric to keep insects out. They sprinkle this with water to keep it moist. The vegetation was moss and (erika = Latin name). This material comes from an arid area and doesn't decompose like other vegetation. Air purification is the goal.

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