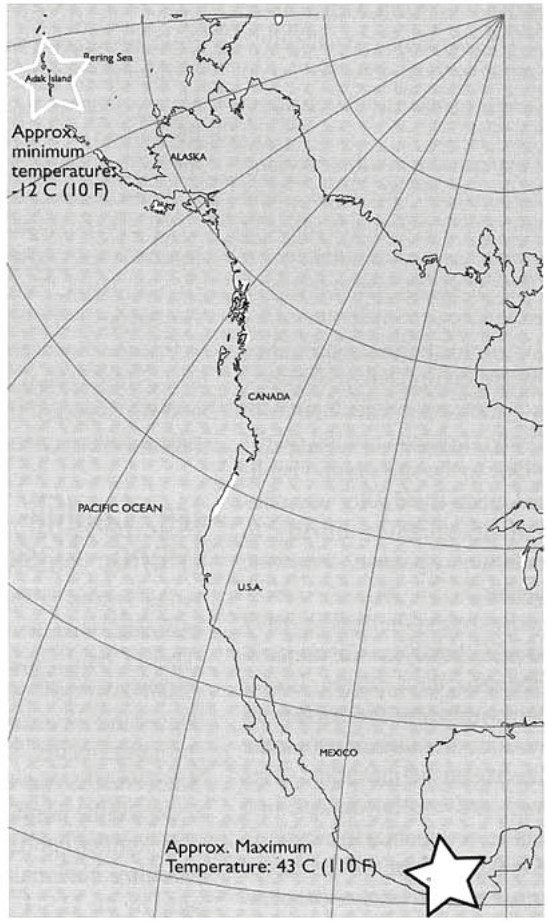
Fire and ice

Earth's weather extremes seem to demand equally different erosion control materials, but that's not necessarily the case.

By Dwight Cabalka and Phil Newton



FIRE AND ICE ARE THE MOST REFERENCED opposites in nature. Over the centuries poets and musicians have written these words time and time again. The phrase has become a common part of our vernacular that conjures vivid images of environmental extremes over which humans have virtually no control.

In a climatic sense, fire brings to mind a white-hot sun beating down upon a parched landscape where vegetation struggles to survive, and water is scarce. On the other hand, ice turns our thoughts to a snowy blast driven by a frigid wind across a treeless tundra. Quite a contrast, isn't it?

The phrase "fire and ice" represents the range of conditions under which erosion control materials must perform. The areas that need erosion control run the gamut from cold, high-latitude regions to the hot equatorial belt. We naturally assume that these extremes require different solutions. After all, a well-insulated snow suit necessary for survival in frozen regions is not the apparel of choice at the fiery side of the spectrum. This does not carry over into erosion-control best-management practices (BMPs), however.

In the two, very different case studies that follow, a common BMP, excelsior erosion-control blanket, demonstrates its ability to meet the environmental challenges of both climate extremes. The conditions of a large highway construction project in southern Mexico represent fire, the first extreme we'll examine. We'll then explore the icy end of the spectrum typified by a landfill-closure project in Alaska.

Fire: Highway 131, Oaxaca, Mexico

Oaxaca (pronounced Wa-HA-ca) is a city with a population of 600,000, located approximately 500 kilometers southeast of Mexico City. It is also the capital of the State of Oaxaca and the destination of many tourists. The nearby Zapotacas Indian ruins, built in about 1,500 A.D., are national treasures which draw 3,000 to 4,000 visitors per day.

To reach the area, visitors and locals alike drive the Autopista, also known as Mexico Highway 131. The Autopista runs north from Oaxaca approximately 250 km to Mexico Highway 150, which ultimately leads to Mexico City. As it winds its way northward, the Autopista rises to an elevation of approximately 3,240 m above sea level.

The heat is on

The climate of this Mexican region is characterized by long, hot summers where the temperature often exceeds 43 C. Because of the high altitude, the area is bombarded with approximately 35% more ultraviolet radiation than low-altitude locations. In the fall a rainy season occurs, during which time the region receives most of its annual rainfall, totaling approximately 35 to 46 cm. Individual storms may drop 7.5 to 15 cm in just one hour. This concentrated precipitation, combined with the otherwise generally dry conditions, places severe stress on plants and demands preventative measures for controlling erosion on construction sites prior to the establishment of vegetation.

In 1996 the Caminos y Puentes Federales (the Mexican federal highway administration) identified the need to improve the Autopista. The authorities hired Corporacion Nacional de Construcciones SA de CV, a major Mexican highway construction company, on a design-build contract basis to improve a 6-km-long section of the Autopista. The final design included widening and repaving, as well as plans for regrading to accommodate the cross-section and alignment improvements.

Long, steep slopes were needed for execution of the grading design through the difficult terrain of this section of the Autopista. Even with the use of curbing and storm water drains, these slopes would become likely targets for erosion during the rainy season. Fill embankments reached lengths of up to 67 m and slopes of up to 2H:1V. When these conditions were considered along with the rocky, nutrient-deficient subgrade, it became obvious that erosion-control measures were needed.

Quenching erosion's thirst

In rocky soil, the loss of surrounding smaller soil particles from overland or sheet flow often leads to instability of the larger rocks and stones. Recognizing this, a special seed mix of six select native grass species was designed for revegetation of the site. In addition, the reclamation design included water-absorbing polymer pellets to provide the developing plants badly needed water during the initial dry seasons.

To assure complete coverage, the seed and polymer pellets were distributed by hand on the disturbed areas at the rate of 120 kg/hectare. Now the trick was to figure out how to keep the soil, seed and polymer pellets in place until vegetation became established.

After field experiments with straw and coconut materials which achieved less than desirable results, the decision was made to use excelsior erosion-control blankets for the project. The material selected was Curlex-I Quickgrass, manufactured by American Excelsior Co., Rice Lake, Wis. The blankets were comprised of approximately 540 g/m^2 of aspen excelsior with UV-resistant polypropylene netting on the top side only. Due to the site's high visibility, the optional green-dyed color was chosen for its aesthetic qualities. Finally, to minimize the amount of joints, 2.4 m-wide rolls were selected.

The installation began on April 1, 1997 and continued periodically, as site preparation allowed, for about three months. Larger rocks were removed from the surface to create a fairly smooth, uniform subgrade. The blanket was rolled out in vertical strips down the slopes and was terminated in a shallow 15 cm-deep trench at the top.

Typical 15 x 2.5 cm steel wire staples were used to mechanically anchor the blanket to the subgrade. The strips were overlapped slightly to allow for installation of a common staple with an overall installation rate of approximately 1 staple/m^2. When completed, the installation totaled approximately 58,300 m^2.

The seeds began germination almost immediately, relying on water captured both by the polymer pellets and the highly absorbent excelsior fibers. Although the seasonal dry conditions occurred during this critical period, the seedlings were able to take root and grow. The shading effect of the blanket moderated the soil temperature and prevented the "burnout" that would have occurred otherwise.

With the recent onset of the rainy season, several extraordinary events have taken place. In September the area was pounded by the remnants of Hurricane Paulina, and in October the area was blasted again, this time by the left-overs from Hurricane Olas. Both events dropped a significant amount of rainfall in a short period on the project. Heavy damage was anticipated. However, the barbed excelsior fibers clung tightly to the subgrade and prevented both the loss of soil and of the emerging vegetation.

"We were surprised that the blanket remained intact, given the intensity of these two storms," says Antonio Lozano Dominguez, project manager for Caminos y Puentes Federales. "And these weren't just light showers; they were major events, and we expected that the site would experience severe erosion. But it didn't."

Ice: landfill closures, Adak Island, Alaska

Adak Island is located off the Alaskan mainland, near the west end of the Aleutian Island Chain, approximately 1,300 miles (2,090 km) west-southwest of Anchorage. The island is bordered by the Bering Sea to the north and the Pacific Ocean to the south. Since World War II, the U.S. military has occupied the northern portion of the island. The southern portion is part of the Alaska Maritime National Wilderness and is managed by the U.S. Fish and Wildlife Service.

During World War II, Adak Island was the site of two large military air bases: Davis (U.S. Army) and Mitchell (U.S. Navy). In 1943, Adak had a population of more than 100,000 troops, but by the 1950s only a small group of men were stationed there. When the Cold War escalated, however, the population grew, reaching almost 6,000 by 1990.

With the wind-down of the Cold War in the early 1990s, closure of the air bases was announced, and in April 1997, the final contingent of military personnel left Adak.Over this 50-year period, the military developed two landfill sites which were to be capped and protected against erosion as part of the base-closure activities.

The Bering Sea world

Adak Island was born millions of years ago from extreme geologic events, including powerful volcanic eruptions. As a result, the Island's topography is characterized by dramatic hills, valleys, cliffs and Arctic lakes with very few level areas. The airfields were either carved out of the valleys or located on earth-filled tidal lakes.

Adak's maritime climate is equally challenging, characterized by persistently overcast skies, high winds, and frequent, often violent, cyclonic storms originating in the northern Pacific Ocean and Bering Sea.

Photo 1. Green-dyed excelsior erosion control blanket protects 2H:1V slope along the Autopista north of Oaxaca, Mexico.

Weather conditions can be very localized, with fog, low ceilings, precipitation and clear weather all possible concurrently within a distance of just a few miles. Storms occur in all seasons, but the most frequent and severe occur during the winter. Working in the constant harsh weather is difficult, with delays and occasional interruptions required due to hazardous conditions.

Annual precipitation averages 162 cm (64 in.), the majority of which falls as rain. Though snowfall averages about 254 cm (100 in.) per year, highly variable weather conditions and strong winds rarely allow it to achieve a depth greater than 30 to 60 cm (1 to 2 ft). In the winter, the temperature can fall to -12 C (10 F) and storm winds can exceed 100 knots per hour (185 kph), resulting in wind chills well below 0 F.

These difficult environmental and geologic conditions lead to the development of a maritime tundra ecosystem dominated by mixed grasses, sedges, forbs and low-growing woody heaths with lichens and mosses. If you're looking for shade, you won't find it—there are no native trees on Adak.

A time for closure

As part of the Adak Island base-closure program, the White Alice and Roberts Landfills were slated for capping, erosion control and revegetation. The smaller of the two, the White Alice facility, encompassed about 3.6 hectares (9 acres), while the Roberts site covered about 23.9 hectares (59 acres) of disturbed land. Although the topography varies considerably, the slopes on these two sites range from 5% up to 25% (4H:1V) with lengths ranging from just a few meters up to 61 m (200 ft). These projects presented several difficulties because of regulations to be fulfilled and a goal of completing work in a single construction season.

The new 1996 regulation 18-AAC-60 (Subtitle D), administered by Alaska Department of Environmental Conservation (ADEC), mandated that the final landfill cover be a minimum of 15 cm (6 in.) of topsoil placed over a low-permeability fill material. However, there is no ready source of topsoil on the island, and attempts to gather such would have required destroying adjacent sensitive tundra.

The short planting season, dictated by the extreme environmental conditions, made it likely that seeding operations would need to be conducted the following spring. Therefore, an erosion-control blanket that could withstand the harsh winter conditions in an unvegetated state needed to be selected.

Transportation costs for shipping material and equipment to Adak are extremely high and must be planned well in advance of construction. Labor costs also are very high compared to similar work on the mainland. This is due to the difficult working conditions and multiple skill requirements, since only a few individuals have to be qualified to perform many varied tasks. These challenges often affect the selection of construction materials, and simple-to-install, lightweight products are preferred.

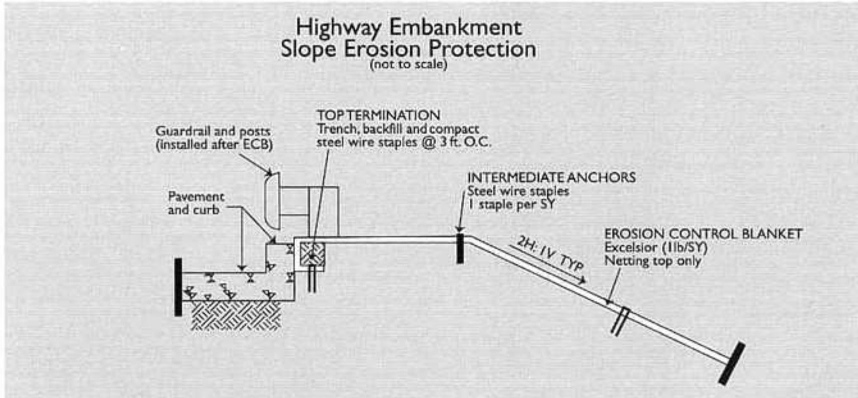


Figure 1. Cross-section of highway embankment, slope erosion protection.

Challenges met

To meet these challenges, URS/Greiner (URS/G), Seattle, consulting engineer for the project, and the Navy were able to secure waivers from ADEC. Though the agency wanted to minimize disturbance of the tundra, it was firm in its desire for adequate soil cover that would not erode away but endure long after the Navy left the island. In lieu of the mandated 15 cm-thick (6 in.) topsoil layer, ADEC agreed to an alternative plan using a 10 cm-thick (4 in.) layer of amended soil with a thicker low permeability cover material beneath, as long as an effective erosion-control blanket was included in the design.

A variety of potential erosion-control blankets and nettings were evaluated with the Revised Universal Soil Loss Equation (RUSLE), appropriately adjusted for Alaska, as recommended by the USDA-NRCS (U. S. Department of Agriculture-Natural Resource Conservation Service) in Fairbanks, Alaska. The consultant determined that either jute or excelsior materials would be acceptable, based on their ability to provide lasting erosion protection in a high-wind, Arctic environment. Very lightweight materials that lacked fiber interlock, such as straw, were determined to be unsuitable. The specified anchor materials and density were similar to the project in Mexico.

The Roberts Landfill project was awarded to Ahtna Construction, Glenn Allen, Alaska, which subcontracted the revegetation and blanket work to Tango Construction, Homer, Alaska. The White Alice Landfill was contracted to Nuggett Construction, Anchorage, Alaska, which chose to do the revegetation and blanket work in-house. Both firms ultimately opted to use an excelsior blanket similar to that used on the Oaxaca site. The only difference was the use of a natural, rather than green-dyed, color.

"We definitely prefer the lighter weight of the excelsior blankets over that of jute," says Tom Bartlett, Tango Construction vice president and project manager. "They (excelsior blankets) saved us literally thousands of dollars in shipping costs and were much easier to handle on the job site."

Blanket installation on the White Alice Landfill began in June, 1997 and continued through August. Since the work could be

Photo 2. Excelsior erosion-control blanket covers Roberts Landfill, Adak Island, Alaska.

completed within the approved planting window, hydraulic seeding of the site with a mix of native species was completed-When unexploded ordinance was discovered on the Roberts Landfill, construction work and blanket installation were delayed until late 1997 or early 1998. Seeding will not take place until next spring. When completed, these installations will total approximately 226,000 m^2 (270,000 yd^2).

Bryan Haelsig, P.E., the Navy's project manager with Engineering Field Activity Northwest relates, "The island has already been hit by several major winter storm events, but the excelsior blanket appears to be working satisfactorily. During construction, an extreme wind event in excess of 80 knots per hour (148 kph) occurred which required re-stapling of a few edges, but it wasn't a big deal. It appears that our consultant and contractor made the right choices."

Benefits of excelsior blankets

As these case studies demonstrate, the high water-absorbing capacity, mechanical fiber interlock, and "hook-and-loop fabric" effect of their barbed edges with the subgrade, make excelsior erosion-control blankets well-suited for both environmental extremes. Excelsior is a generic name that Webster's Dictionary defines as, "a kind of fine wood shaving." To produce excelsior blankets, trees, typically aspen (*Populus tremuloides*), are harvested to provide the source material.

The wood is carefully stacked and then air-dried for about 12 to 18 months, until the moisture content has reached an appropriate level for processing. The dried logs then are cut into short blocks and special horizontal "knives" shave the wood into thin, wide ribbons, much like a common planar does. Almost simultaneously, a second set of vertical knives cuts the ribbons into a number of narrow strips.

This process creates curled fibers and unique barbs which protrude from the sides of the fibers. These fibers are evenly distributed to form a mat and combined with either a synthetic (polypropylene) or organic (jute or twisted kraft paper) netting.

Immediately prior to installation, the intended slope or channel is graded to a relatively smooth condition to assure direct contact between the finished grade and the blanket. Large obstructions such as tree roots, rocks and dirt clods are removed. Without proper preparation, the blanket will not achieve the necessary contact with the soil, and rilling or gullying may occur.

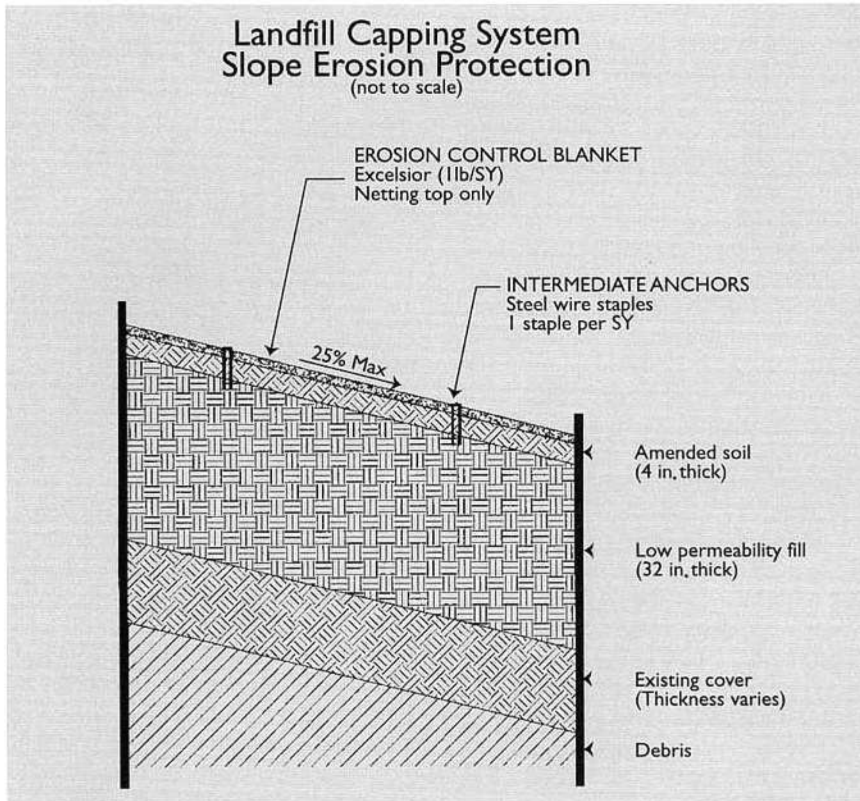


Figure 2. Cross-section: Landfill capping system with slope erosion protection.

Application of amendments and seeding also are performed prior to blanket installation. In some cases where schedules dictate, such as the Adak Island project, these operations may be accomplished after the excelsior installation, however.

The excelsior blanket typically is secured with steel wire staples, 15 to 22 cm (6 to 9 in.) long and 2.5 to 5 cm (1 to 2 in.) high, at the perimeter of the blanketed area and the at joints between strips. The staples also are used as intermediate anchors within each strip. The installation rate for staples varies from $^1/_2$ to 2 staples/m^2 (y^2), depending on the severity of the application.

Anchor density is influenced by soil type, compaction, steepness and the anticipated rates of revegetation and storm water runoff. In some cases, the perimeter of the blanketed area is also terminated in a shallow trench 15 to 22 cm (6 to 12 in.) deep.

The meteorological conditions in these case studies highlight environmental extremes that vary considerably from the fiery equatorial regions to the icy polar zones. In addition to site topography, variations in temperature, precipitation and other weather conditions make each job site unique. The fundamental challenge of erosion control—reducing soil loss—is the same, however. The unique material properties of excelsior erosion control blankets can meet the range of environmental challenges. GFR

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