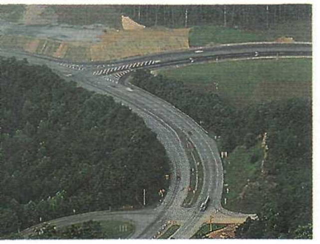
membrane. Groundwater will be carried from the tunnel via underdrains placed just below the roadway level of the tunnel. A 10-inch concrete liner to be placed over the membrane will act as a secondary tunnel support as well as a base for the final interior surface. The concrete liner will be cast-in-place and installed using movable metal forms.

On the face of things, an aesthetic masterpiece



The prime directive of the Cumberland Gap project is to effectively reroute traffic from America's second largest national historical park with minimal environmental impact. Toward that end, efforts have been made to integrate exterior features with the surrounding landscape. For example, the use of sandstone masonry, dark brown weathering steel, and earth-tone concrete blends new and existing structures with their surroundings. And native trees and shrubs are used for landscaping — a final blend of the man-made with the natural.

New Technology–how it helps perserve and enhance the natural beauty

Precast element walls and soil-nailed walls are products of two new design technologies now in use at the tunnel entrance. Vegetation, native to the area, is planted in the wall shelves to green and soften the appearance of the harsh rock cuts above. The walls above them are called "soil-nailed" because steel rods have been placed in the earth to stabilize and reinforce the near-vertical slope face. The facing is a colored concrete grout which blends into the natural surroundings.

Environmentally speaking...

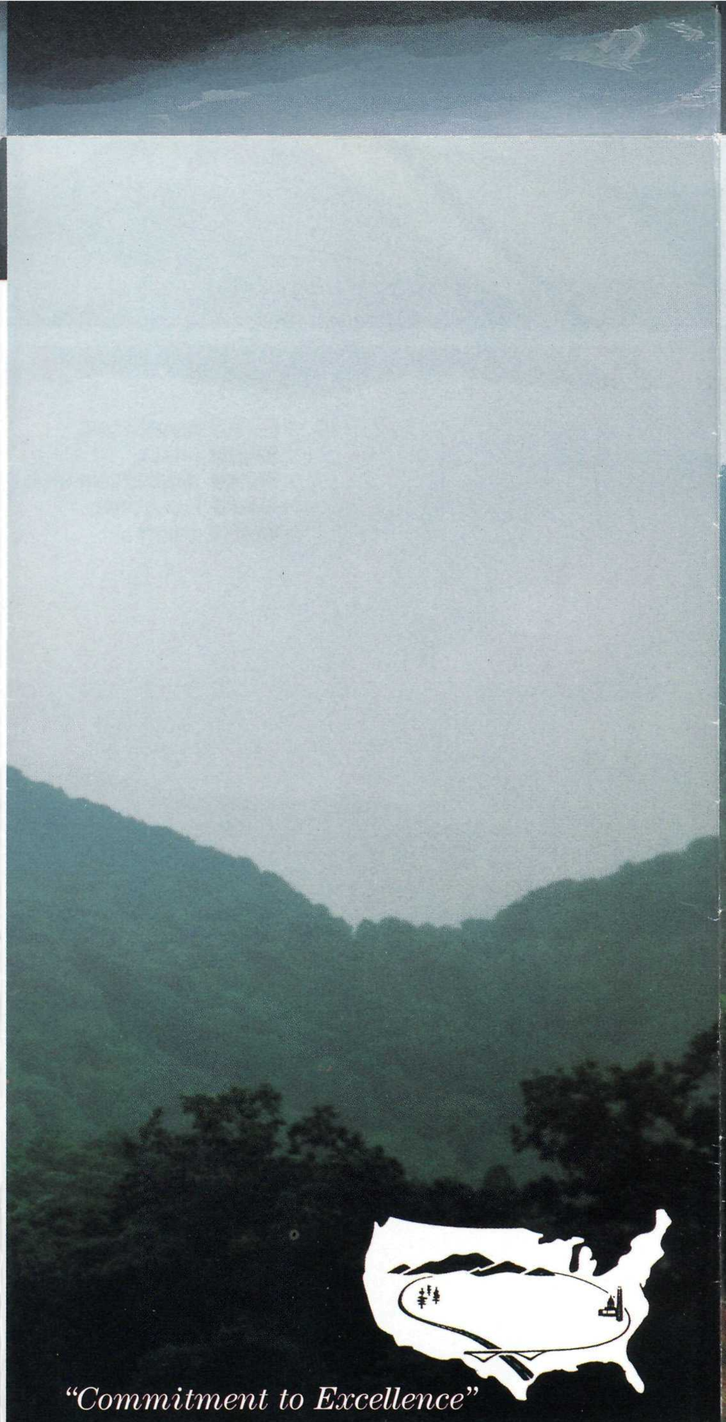
To minimize stream pollution, the latest developments in erosion control and soil bioengineering techniques are currently in use. Most notable are those utilizing live, dormant willow cuttings to provide stable and aesthetic creek bank protection, as well as stream redirection. Early seeding of excavation slopes and embankments, as well as sediment basins, silt fences, straw bales, berms, and log dams, has also helped reduce erosion of the soil.

Water in the forms of (1) surface drainage in natural gullies, (2) rain runoff, and (3) outflow from the tunnel construction will continue to be automatically sampled and tested continuously seven days a week.

For travelers, safe passage through America's history

The safe operation of the tunnels is a high priority. The Cumberland tunnels pose specific challenges that will be met in the following ways:

- Fire, rescue, and towing crews dedicated to tunnel emergencies will be on-call 24 hours per day.
- Tunnels will have their own water storage tanks for fire-fighting purposes.
- Ventilation will be continuous via turbine fans hung from the ceiling every 600 feet, and air quality will be monitored constantly by electronic sensors.
- Illumination will be provided by low-pressure sodium and fluorescent lights, and include a "transition zone" at tunnel entrances to help drivers' vision adjust to the artificial light.
- Pedestrian crossovers for emergency access between tunnels will be reachable every 300 feet.
- Variable message signs will allow the tunnel operator to communicate with motorists. AM and FM radio signals can also be overridden to broadcast priority messages.
- Vehicular crossovers at tunnel entrances will allow for two-way traffic in either tunnel if one of them must be closed.
- Portal buildings at entrances will house state-of-the-art ventilation, lighting, and communications systems, as well as closed-circuit cameras and magnetic loop detectors for traffic control.
- Pull-off lanes for trucks, oversized vehicles, and those transporting flammables or corrosives will be placed at each approach. These vehicles will be ushered through the tunnels individually at regular intervals.
- Trucks hauling explosives will not be allowed in the tunnels.



"Commitment to Excellence"

Federal Highway Administration
Eastern Federal Lands Highway Division
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Sterling, Virginia 20166

Additional information can be obtained by calling N. Vivian Hanna at (703) 404-6201.

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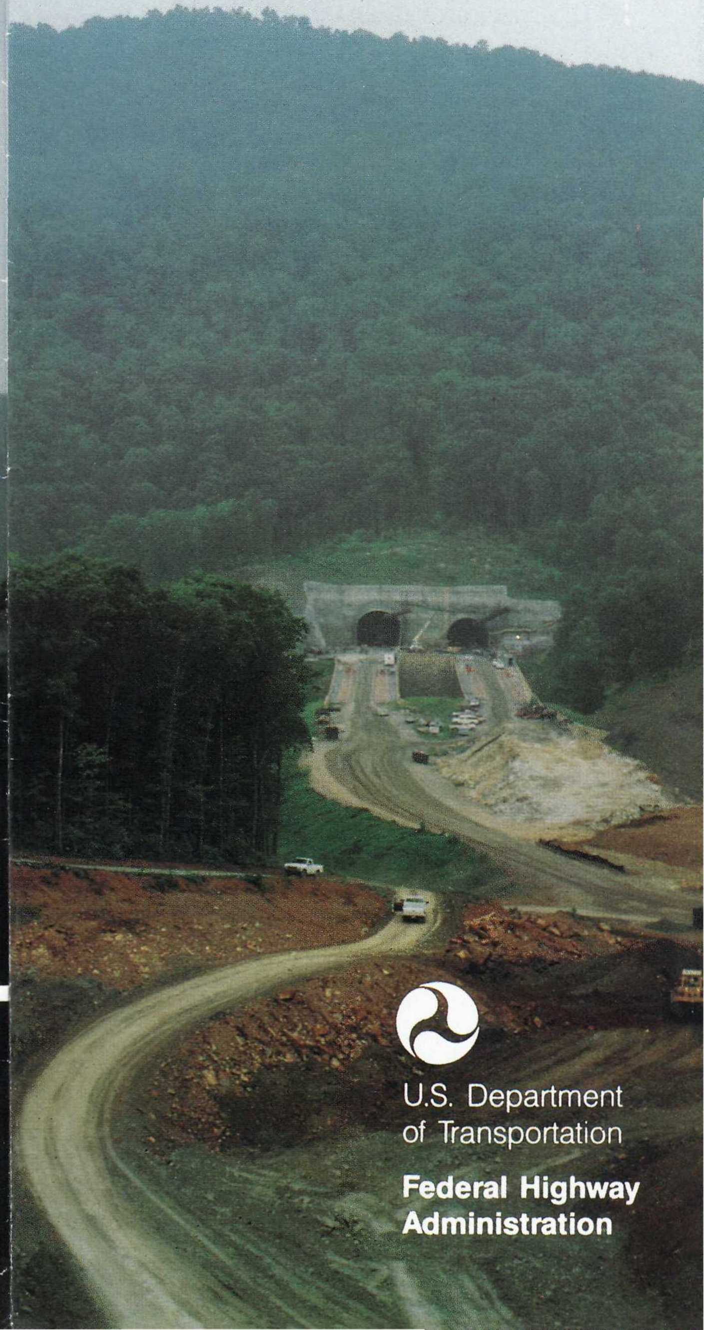
The Cumberland Gap Tunnel Pioneering A New Route To The Past



U.S. Department of Transportation

Federal Highway Administration

Technology at the heart of Cumberland Mountain

Where the state lines of Virginia, Kentucky, and Tennessee meet at historic Cumberland Mountain, the technology for the future is saving a part of the past.

Pioneers once entered this gateway to the west here, through the famous notch in the mountain known as Cumberland Gap. Today, the Federal Highway Administration and the National Park Service have undertaken a large and complex journey of their own — the creation of twin vehicular tunnels, each nearly a mile in length, that will bring travel through the gap into the 21st century, to preserve one of our Nation's most historic routes.

The Cumberland Gap Tunnel project is a massive design and construction task combining many areas of engineering expertise with innovative construction techniques — one of the Federal Highway Administration's and National Park Service's most challenging projects to date. It includes the construction of a pair of 4600-foot-long, two-lane tunnels through solid rock and rerouting a major highway to enable the restoration of the area to resemble as closely as possible the path used by the pioneers of the late 1700's — all while adhering to ongoing concerns of safety, National Park Service interests, and the Gap's unique environment.

Design and construction on a scale as grand as the Gap

Administered by the Federal Highway Administration's Eastern Federal Lands Highway Division for the National Park Service, the Cumberland Gap project brings together the expertise of many design consultants and construction firms in perhaps one of the most ambitious construction projects ever encountered in the southern Appalachian region.

When the endeavor is completed, there will be:

- Five miles of new four-lane approaches to the tunnels
- Two highway interchanges — one at the park entrance and another at the intersection of US 25E and US 58
- Seven roadway bridges — four in Kentucky and three in Tennessee
- One 200-ft railroad bridge — a steel box girder type recognized by the American Institute of Steel Construction for design excellence
- The repair of an abandoned railroad tunnel under existing US 25E — a tunnel that will house electrical, telephone, cable, and water lines under the new US 25E/US 58 interchange
- Two pedestrian bridges on hiking trails and three parking areas inside the park.

Exploring the inner Mountain

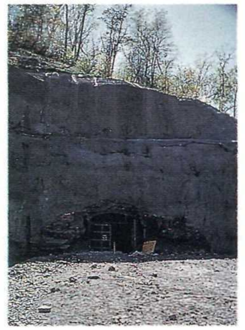
First, geologists examined the exposed rock on the surface of the ground and identified the rock types and structures of the stratigraphic section at the tunneling site.

Second, a small-diameter, horizontal 2000 foot-long core hole was drilled to provide greater geologic detail. The resulting rock core provided site-specific and detailed information about rock type and rock quality over nearly half of the proposed tunnel. Strength and classification tests were performed on the sample cores to determine how the rock would react to drilling and blasting for excavation and to estimate the necessary support needed for the tunnels.

Third, a pilot or exploratory tunnel, 10 feet high, 10 feet wide, and 4100 feet long, was excavated. The pilot tunnel served many purposes:

- it exposed the sequence of the layers of sandstone, limestone, and shale along the main tunnel alignment
- it exposed caverns with small streams in the limestone layer
- it helped to define drill-and-blast excavation methods and the tunnel support techniques (rock bolts and shotcrete) to be used in the main tunnels
- it revealed significant sources of groundwater from which the flow rates were measured and determined the waterproofing and water treatment requirements
- it determined that after the blasting operation, no explosive gases were present in the tunnel excavation
- it exposed the presence and quantity of environmentally hazardous materials (pyritic rock and coal) and the method for their disposal.

All of these findings were instrumental in the design of the main tunnels — the tunneling techniques used and the type of equipment to be used. In short, the pilot tunnel helped to predict nature's response to the larger tunnels to be built.



Excavating the tunnels

The tunneling process is the excavation of the tunnel shape through the rock in small increments — each increment representing a "round." The "round" measures the forward advancement (in feet) of the excavation process, which consists of drilling, blasting, ventilating, mucking, and installing the support. A "cycle" is the time (in hours) to complete the "round." The quality of the rock determines how many feet can be extracted in each "round" and the amount of time ("cycle") it takes to install the necessary support before a subsequent "round" can be excavated. For example, Category I primarily consists of high-quality sandstone and limestone. The forward advancement ("round") in Category I is 10 feet. The amount of time ("cycle time") required to complete the "round" is approximately 12 hours.

The excavation consists of "top heading" — excavating and supporting the upper two-thirds of the tunnel — followed by "benching" — excavating and supporting (stabilizing) the lower one-third of the tunnel.

"Top heading" construction sequence consists of the following:

Holes are drilled in the top two-thirds of the tunnel and explosives are loaded and detonated in a carefully designed sequence to achieve the proper balance between sufficient breakage of excavated material and minimal damage to surrounding rock.

Following the blast, the tunnel is ventilated to clear the explosion gases, and air quality measurements are taken to ensure safe return to the tunnel; the blasted material ("tunnel muck") is hauled from the tunnel and stockpiled for future use to obliterate the rerouted portion of US 25E, to construct the four-lane highway approaches, to improve a nearby park road, to construct roadway embankments and parking areas, and to aid in the reconstruction of the old "Wilderness Road."

The exposed top part of the tunnel arch ("crown") and face are "scaled" (scraped off) using drill equipment or hand tools to remove loose rock. The crown area is then reinforced with rock bolts, rock dowels, lattice girders (if needed), and shotcrete, creating a rock arch over the tunnel. The decision to use either bolts, dowels, or lattice girders and the thickness of shotcrete (2-6 inches, plain concrete or reinforced with steel fibers) depends on the category of rock and the necessary support required.

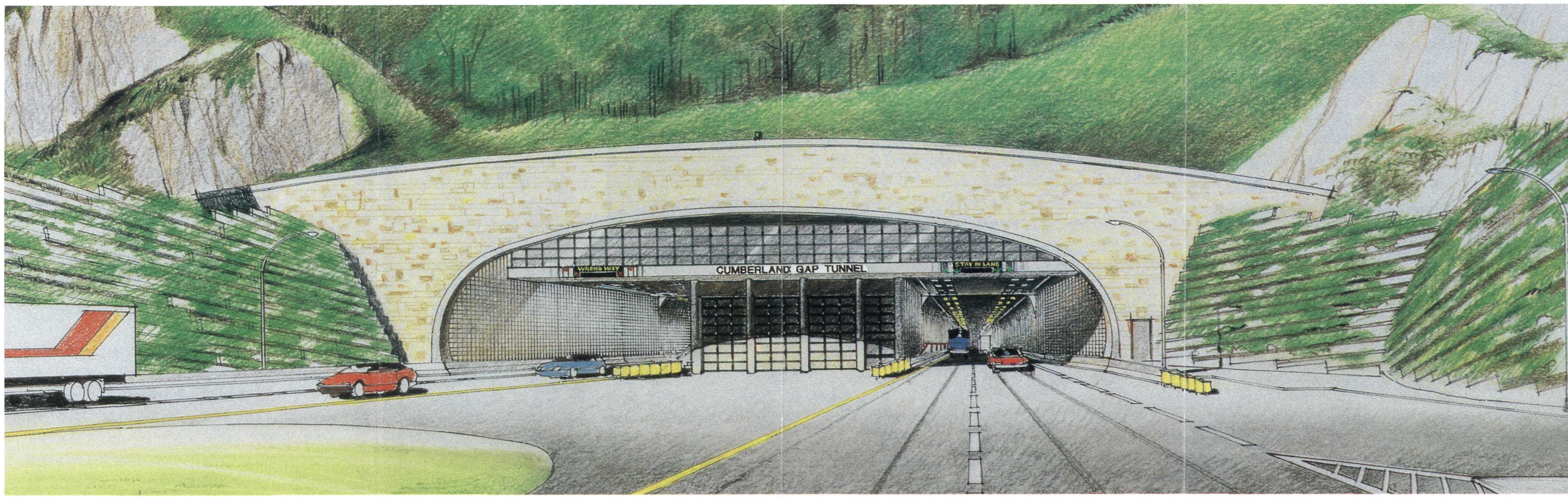
"Benching" construction sequence consists of the following: First, the center portion (within 5-feet of each sidewall) of the lower one-third of the tunnel is drilled, blasted, and mucked out, following the same procedures as for the "top heading." The 5-foot spacings on both sides of the lower one-third of the tunnel ("side slashes") are left to act as buttresses and to prevent the blast pressure from damaging the remaining walls. Second, the "side slashes" are drilled, blasted, mucked out, and stabilized by rock bolts and shotcrete, corresponding to the ground support used for the "top heading."

Tunnel lining and drainage

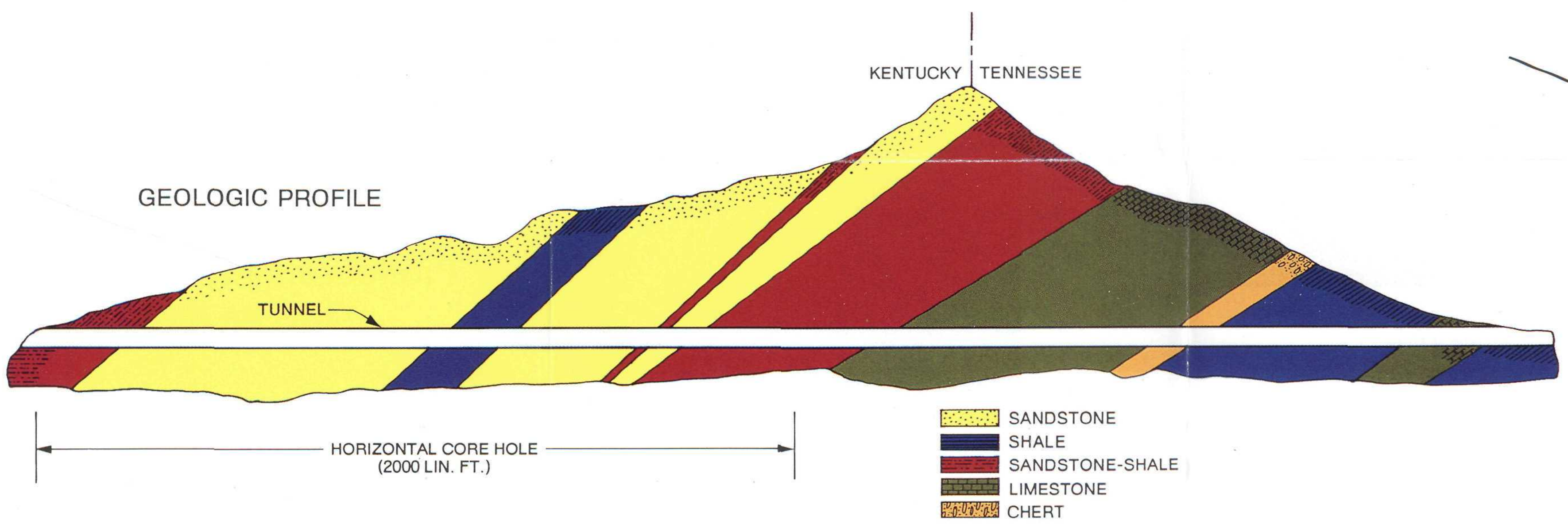
To allow drainage from around the tunnels and to keep water from seeping into the finished tunnel, the entire crown and sides behind the concrete tunnel lining will be blanketed with a waterproof (plastic)

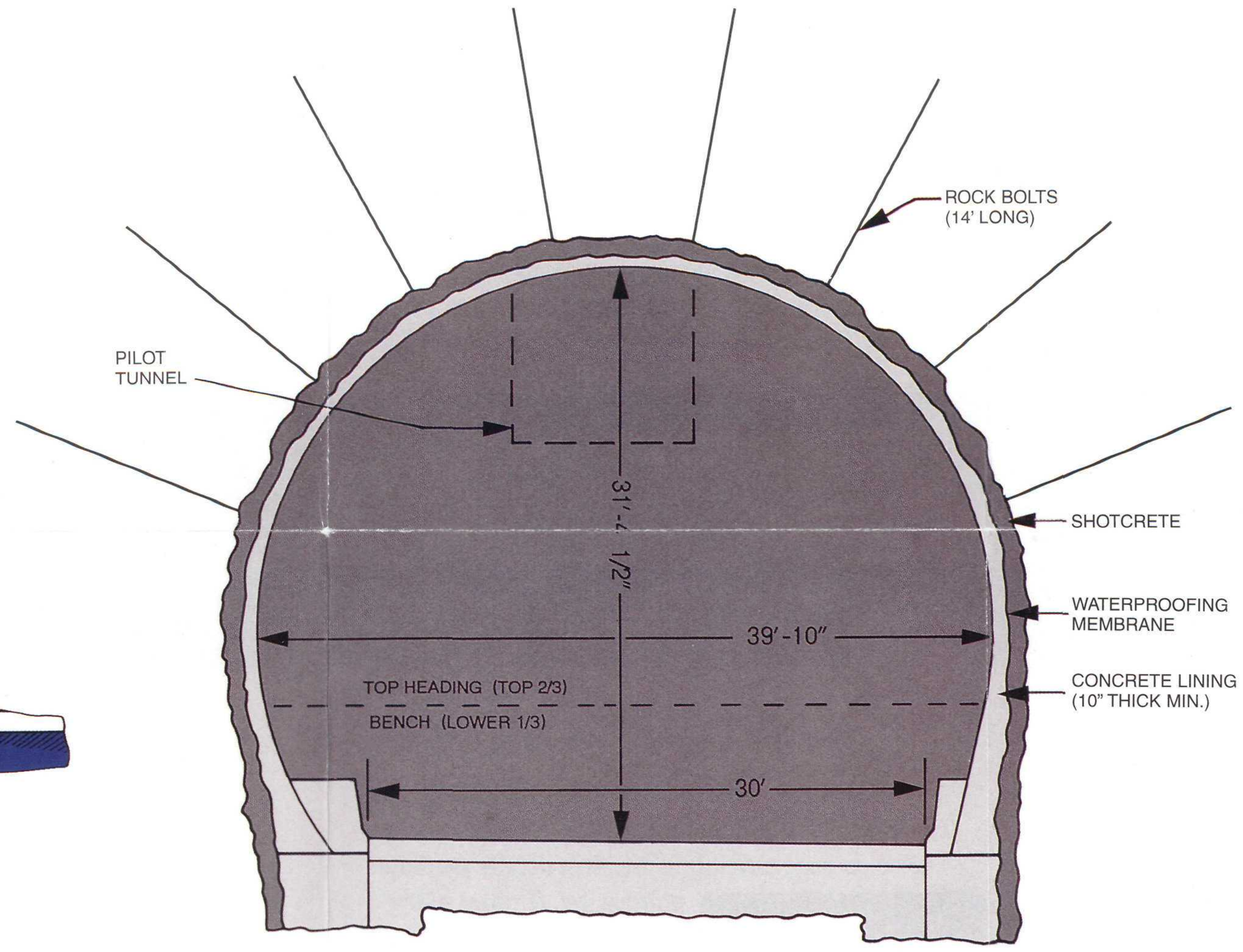
GROUND SUPPORT CATEGORIES

Category	Rock Type	Support	Maximum Round Length
I	high-quality sandstone/ limestone	rock dowels shotcrete/plain	10 feet
II	weathered sandstone/ competent shale	rock dowels shotcrete/plain	10 feet
II.5	combination of II & III — (worse than II, better than III)	rock dowels shotcrete/ reinforced	10 feet
III	very weathered shale/closely jointed sandstone	rock bolts, shotcrete/ reinforced	6 feet
IV	siltstone, mudstone, soft shale	lattice girders, spiles, as needed shotcrete/ reinforced	4 feet



Rendering is artist conception.

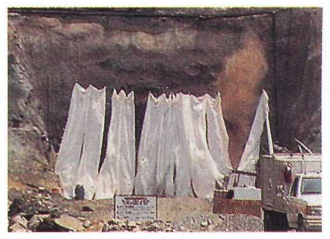




TYPICAL TUNNEL SECTION


Drilling


Loading Explosives

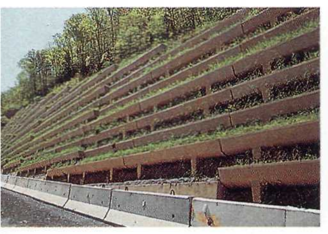

Blasting


Mucking


Shotcrete


CSX Railroad Bridge


Approach Bridges/Tenn. Portal


Precast Element Wall


Soil-nailed Wall


Visitor Center Interchange Bridge


Pedestrian Bridge