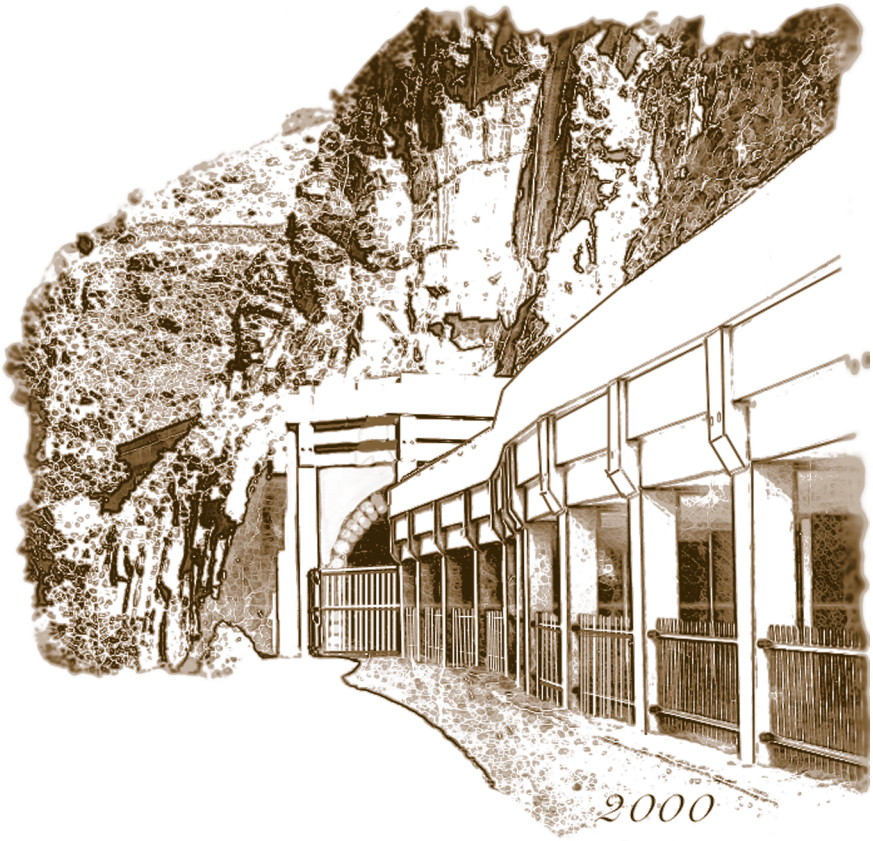
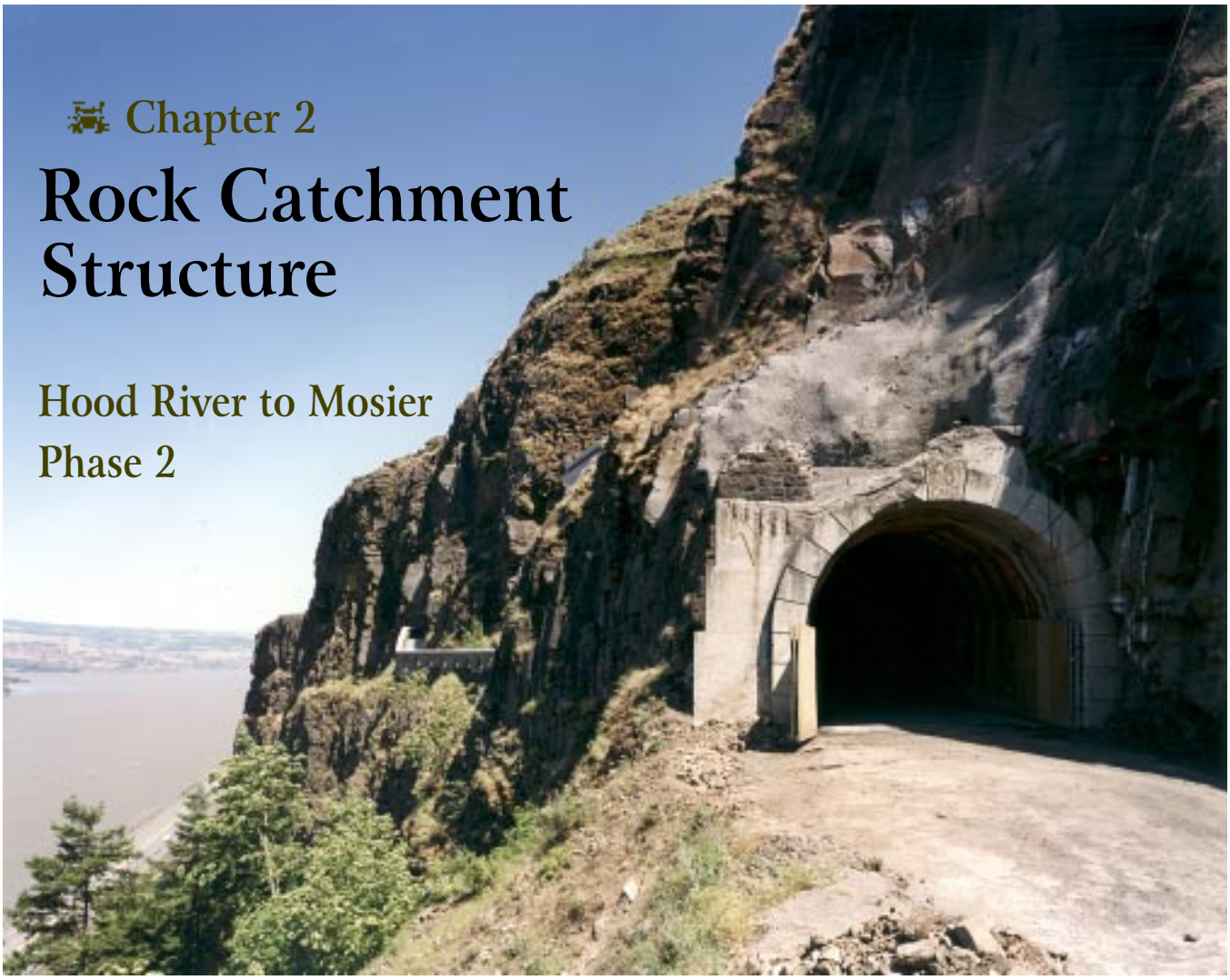
Rock Catchment Structure



Hood River to Mosier - Phase 2

Chapter 2



Chapter 2

Rock Catchment Structure

Hood River to Mosier Phase 2

In February of 1998, the second phase of the construction at the Mosier Tunnels started. The Troutdale ODOT Project Manager office administrated the contract to build the 708-foot-long Rock Catchment Structure at the West End of the Tunnels. Lee Holloway of HNTB would be the designer of record and Woodward Clyde would be hired to perform the geotechnical work. JAL Construction of Bend, Ore. was selected as the prime contractor to build the project. The original estimate for the job was $2.2 million.

Top: West Portal of the Mosier Twin Tunnels in spring of 1998.

Right: Interstate 84 and Union Pacific railroad tracks are located just below the Twin Tunnels.

ODOT initially considered constructing a traditional "shed" structure west of the tunnels to deflect rocks away from the roadway and protect pedestrians. However, the rocks would continue falling down and land on the Union Pacific Railroad mainline and Interstate 84 below. Instead, ODOT looked into alternatives and eventually chose a structure that would "catch" a design level 5000-pound rock falling 250 feet.

The "catchment structure" employs a simple column and deck design similar to the viaduct along the HCRH just east and west of Multnomah Falls, but incorporates some unique and clever features. The catchment structure consists of two-foot by two-foot columns supporting a two-foot thick concrete roof. Covering the roof was to be six feet of "cellular" concrete, a mixture of concrete and foam, covered by one foot of pea-gravel.

To discuss a location in the 708-foot-long structure, the designer used "bent" numbers. Each bent is a structural element containing the north footing and column, the beam across, the south footing and column, and the connection to the rock anchors (corbels). The Catchment Structure consists of 60 such bents.

JAL Construction chose to build the elements of the structure in a lineal manner so that one item was mostly completed for the length of the structure before the next one was started. In May of 1998, JAL brought American Geotech to the site to install all of the rock anchors, but even before they were able to start drilling for the anchors, loose rocks at the West Portal and throughout the job site were an issue. Work had to be added to the contract to scale the obvious loose rocks and to secure others with rock bolts. ODOT had not anticipated this, since scaling had been done on the cliff face in the Phase 1 contract. After intense negotiations with JAL, ODOT came to the conclusion that the scaling performed in the first contract was substandard, and with a high priority for the safety of its workers and JALs workers, it was agreed that ODOT would pay for the rockbolting and scaling. ODOT would also gain more than a safety value from the scaling. It was thought that the more material that could be removed from the cliff face now, the less that would have to be removed from the top of the structure after it was completed.

Loose rock at the West Portal had to be dealt with before starting construction.

Canadian Guncrete drilling for the rock bolts above the West Portal.

Contract change orders were written and American Geotech installed 300 lineal feet of rock bolts. After the bolts were installed near the portal they began drilling for the anchors for the structure and performed the scaling out in front of the operation. By the time the scaling was done, they had removed more than 2,000 cubic yards of loose rock from the cliff face.

Another problem that came up early in the job was a large fracture in a knob of rock that the structure would be built against. Not only was the knob massive in size but, due to neighboring geologic formation concerns, it could not be removed. Since rock anchors would be installed through the knob and massive tension later applied to the anchors, there was a concern that the structural element holding the tension of the anchors would fail, causing the fractured knob to collapse and crumble to the ground. It was decided that grout would have to be injected into the fracture. This stabilization cost the contract an additional $13,723.

American Geotech performed an amazing job of scaling. They would repel down the cliff face and, using hand tools, pry the loose rocks off the cliff. No injuries occurred during the work. To assist in the operation, a geotechnician was on-site to help assess which rock formations should be scaled. There was constant concern that some areas could not be made safer and possibly even be made worse if scaling was attempted.

Above Left: More than 2,000 cubic yards of rock was removed from the cliff face.

Left: American Geotech scaling the cliff above the work site.

Below: Material scaled from the cliff face.

John Henry drill mounted to CAT trackhoe.

Geoff Krug of American Geotech installing the rock anchors into the cliff face.

In areas too narrow to drill holes with the trackhoe, an "air track" driller was used.

After the material was scaled from the cliff face, it was hauled to Gorge Quarry about two miles east of Hood River on the Historic Highway. The material was later used by ODOT Maintenance to reinforce a stream bank along the Hood River.

With the cliff face scaled, American Geotech was able to proceed with installing the rock anchors that would secure the structure to the cliff. A total of 356 five-inch-diameter holes had to be drilled into the cliff face for the installation of the anchors. The layout of these anchors was extremely complicated and can be considered "a lesson learned." The challenge was to get the anchors in the correct location so that when the concrete deck was built at a predefined height, it could connect right into them. The problem was that the distance between the cliff and the south column was constantly changing. Another design element that made this even more complicated was the concrete element built around the anchors, known as a "corbel", was on a different slope than the deck. JAL's goal was to build a corbel that would extend out three feet from the cliff face. The bottom of the corbel would be at the same elevation as the bottom of the deck. However, this did not happen. In many cases, the deck had to be extended at a different slope to catch the corbel around the anchors.

With the hole locations survey, American Geotech drilled the holes and installed the anchors. An anchor was essentially a 25-foot-long piece of 1 3/8 inch diameter high-strength steel bar. After the bar was inserted, grout would be injected into the hole. This process would bond the deepest eight feet of the bar into the cliff. The rest of the bar was covered with different materials that would allow it to "stretch" during a later process of tensioning the anchors. By the end of the process, 9,131 feet of bar were installed on the project and 168,636 pounds of grout were injected into the holes.

9,131 feet of rock anchors were installed on the project.

When American Geotech was finishing installation of the anchors, JAL began building the structure. Their first step was to build the footings and columns the length of the job. For the most part, except for rockfall events, the work was very straightforward. After a dozen of the footings were poured, a second operation followed behind building the columns after the footings cured. The one "lesson learned" here concerned the use of column forms. Some of the first columns poured used some older four-piece steel forms. This produced columns that have slight curves and a seam part way up. After many pours JAL finally worked with their supplier and had different forms delivered that produced a higher quality column.

The threat of falling rock became a reality on Sept. 18, 1998. A storm had rolled through the night before and a sizeable rockfall scattered the work area about 600 feet from the West Portal. No one was injured, but the concern for rockfall was greatly heightened.

Hood River Sand and Gravel supplied the concrete used to construct the rock catchment structure. The same 4,000 p.s.i. mix was used throughout the structure, but everything above

Concrete footing and column rebar before the concrete of the columns were poured.

After saw cutting the pavement, JAL used a trackhoe to excavate the footing holes, but then had to clean up and square the holes by hand.

Below Left: Steel forms that could be quickly bolted together and quickly removed were used to construct the concrete columns.

Top Right: First large rockfall during construction – September 1998.

Middle Right: In October of 1998, JAL started building the columns for the structure.

Bottom Right: Rock anchors were installed before construction of the columns could take place.

To hold the steel forms in place, the column forms were braced together and, in some places, bolted to the cliff face and ground. Due to the cold temperatures in October, JAL used insulated blankets to keep the concrete warm during the curing process.

After the forms were removed, the concrete columns were wrapped with plastic-covered burlap and an insulated blanket. A series of PVC pipes carried a constant drip of water to each column during the curing process.

After the columns had cured, it was obvious that some additional touch-up would have to eventually be performed on the concrete to give it a finish free of stains and discolorations.

Looking westward over the column and anchor work. American Geotech was drilling at the west end while JAL constructed columns near bent 25. Each step in the construction process progressed from east to west (bottom to top of photo).

ground contained a coloring agent. This produced a concrete dark gray in color. The dark gray was desirable so that the structure would not "stand out" as a bright light gray concrete-colored structure altering the look of the Mosier cliffs from key viewing areas in the Gorge. Many "lessons learned" are related to the concrete. The first one that came early in the job was that two coloring agents were identified as being approved in the contract. One was much cheaper than the other. JAL bid the job figuring on using the cheaper product. It was later identified that the cheaper product was not compatible with the air-entrained concrete that we would be using in the structure. ODOT made an additional payment of $36,000 for the coloring agent that would be compatible with the required concrete mix.

Most of the Catchment Structure is only 10 feet off of the ground and 11.33 feet between the

Construction of Column #2 against the cliff face.

The columns near the West Portal support a concrete deck 20 feet 9 inches off the ground, so the West Portal can be fully viewed.

columns. The exception is the first 24 feet at the West Portal of the Twin Tunnels. It was decided during the development phase to make the structure only as high as needed for maintenance and emergency vehicles, but to raise it up near the West Portal so the full height of the Portal can be seen. The bottom of the concrete deck near the West Portal is 20 feet, nine inches.

The first two columns on the cliff side are very different than all of the rest. They actually were poured against the cliff face. Due to the different size, JAL had to form both of these using plywood.

Over the weekend of Nov. 23, 1998, the largest rockfall during the project occurred. Rock came down in two locations. One was located near the middle of the structure at bent 35, and the second was located just off the west end of the

Column #2 during the removal of the forms. The concrete matched very well.

Left: The talus slope above Bent 35 released a sizeable rockfall, damaging some new columns.

Middle Left: The largest rock that fell during the winter of 1998-99 was in a rockfall near the West Portal. It was larger than a basketball.

Middle Right: Small baseball-to-football sized rocks fell during the winter shutdown.

Bottom: JAL and American Geotech examine damage to an air track driller, which occurred as a result of the rockfall on Nov. 23, 1998.

structure. It is believed that a heavy rain and windstorm triggered both events, but they were very different in nature. The rockfall at bent 35 was the result of a release of random-sized material, ranging from golf ball-size to some twice the size of basketballs coming out of a talus slope. This talus slope at the top of the

Top Left: Forming of test corbel at Bent 7.

Bottom Left: Steel I-beams supported on columns extend to the cliff face to support the construction of the corbels.

Top Right: JAL inserting the anchor plate over the rock anchors in a corbel. An eight-inch drain pipe was installed in the corbels to provide drainage for the deck.

Bottom Right: ODOT inspector Ryan Murray examines a corbel prior to concrete placement. One of JAL's challenges was for the rebar and forms to match the angularities of the cliff.

cliff at bent 35 would pose a problem for the rest of the project. The massive rockfall at the west end is thought to have started from one large "van sized" rock that released from the top of the cliff. As it came down it knocked other boulders loose. During the earlier scaling work on the project, the crew actually tried to pry this one rock loose, but due to its size, they could not get it to budge.

The large rockfall event occurred at the very end of the column construction phase. After the rockfall was cleaned up, JAL removed the forms from the columns and made a scheduling decision. In the contract, ODOT advised contractors to not work during the "rockfall season." After seeing the amount of rock that can come down, JAL closed the job for the winter.

A few times during the winter shutdown, Project Inspector, Kevin Bracy visited the jobsite to monitor the worksite. It was found that no real large rockfall events occurred, but numerous small rockfalls occurred between each visit.

When JAL returned to the work site in the spring of 1999, their first task was to construct the cliff connections or "corbels." The corbels would be the concrete elements that would surround the rock anchors in the cliff face. After this block of concrete cured, the concrete anchors could be tensioned to hold a design load of 142 kips (142,000 pounds).

Back in August of 1998, JAL had constructed a "test corbel." This was required in the contract to verify that this corbel design would work. The corbel passed the test by not having any cracking or movement during the tensioning. JAL also accomplished something else during the process. They learned that their original idea on how to build the corbels was not going to work. It was thought that a series of triangular braces could be placed under the forms to support the concrete. After struggling through the test corbel, JAL looked for better options that would be faster and safer. The second technique was determined just before they started building the columns in the fall of 98. When they formed the columns, they

placed a two-inch piece of PVC pipe through the column near the top. This would allow them to insert a steel pin through the concrete column so support brackets could be bolted on. With support brackets on each side on both the north and south column, a steel I-beam could be set on them and extended to the cliff face.

Once JAL had the working platform in place, they could build the forms for the corbels and place the steel reinforcement. One of the challenges for JAL was to build a formwork for the concrete that matched the cliff face. They developed tools and "tricks" as the project progressed. After the reinforcement cage was placed over the anchors, an anchor plate was placed over each anchor. The plate would provide a bearing surface so the anchor could later be tensioned.

There were four different types of cliff connections on the project. The type used would basically depend on how far the cliff face was from the south column. Different types of connections utilized two different types of mechanisms to connect the corbel to the deck. Basically, if the corbel was far from the column, an anchor plate was bolted to the corbel and then rods extending from the plate would be in the concrete pour for the deck. If the corbel was near the south column, steel reinforcement stuck out of the corbel and would therefore be in the concrete deck when it was poured.

Once the corbels were poured and cured JAL could bring American Geotech back to the job site to tension the anchors. A hydraulic ram was attached to each anchor and then pulled the anchors until it reached a load of 166 kips. This basically means that the 25-foot steel anchor rod was stretched about 1¾ inches and then locked in place. This tension would help secure the structure to the cliff.

After the anchors were tensioned and locked off, the corbels had to be completed before the concrete deck was poured against them.

Myron Swiggert of JAL trims a side form scribed to match against the cliff face. If the forms did not fit tight against the cliff face, concrete would pour through during placement.

Looking east from bent 14 in June of 99 over columns and corbels.

Geoff Krug of American Geotech tensions the rock anchors, securing them to the cliff.

Rigo Casimiro of JAL finishes capping the rock anchors in the corbels.

Mid Columbia Asphalt paving at the Twin Tunnels.

The deck between bents 3 and 4 was the first to be placed.

The excess steel rod of the rock anchor had to be cut off and then capped to protect it from corrosion and any chance of loosening over the years to come. The face of the corbels required different preparation before the deck pour. Some had to have the concrete roughened and others had to have a felt joint installed to keep a contraction joint between the deck and corbel.

Part of the Rock Catchment project was to place a new 1½ inch layer of asphalt on the roadway under the structure. JAL chose to complete this work before the deck was built, since the height of the deck would not allow the trucks carrying the asphalt to raise their bed and dump the mix into the paving machine. The asphalt placement went well. The lesson learned during this phase of work was that the planned quantity of mix to be used did not take into account that some of the roadway to be paved over had been completely demolished due to rockfall over the years. An additional 158 tons of asphalt had to be used to rebuild sections of the road. This resulted in an over-run of almost $16,000.

With a sufficient number of corbels built, JAL was able to start work on building the concrete deck. They were able to build the deck utilizing the same holes in the columns that had been used to support the beams during corbel building. As their schedule and techniques developed, they were able to build the corbels and deck on the same working platform.

JAL utilized W12x53 steel I-beams extending across the columns to the cliff face. Between the I-beams they would place Efco galvanized steel E-beams with a trapezoidal cross-section. The big challenge came when trying to build a smooth deck between the tops of the south columns and the corbels. In some cases, all four were at different elevations. If one walks from the east end to the west end of the structure, the learning curve for this work becomes obvious.

Upper Left: Steel I-beams supported the working platform for deck construction.

Middle Left: Between the I-beams, JAL placed galvanized steel E-beams to support the wood forms.

Lower Left: Formwork between corbels and columns of different elevations was very challenging.

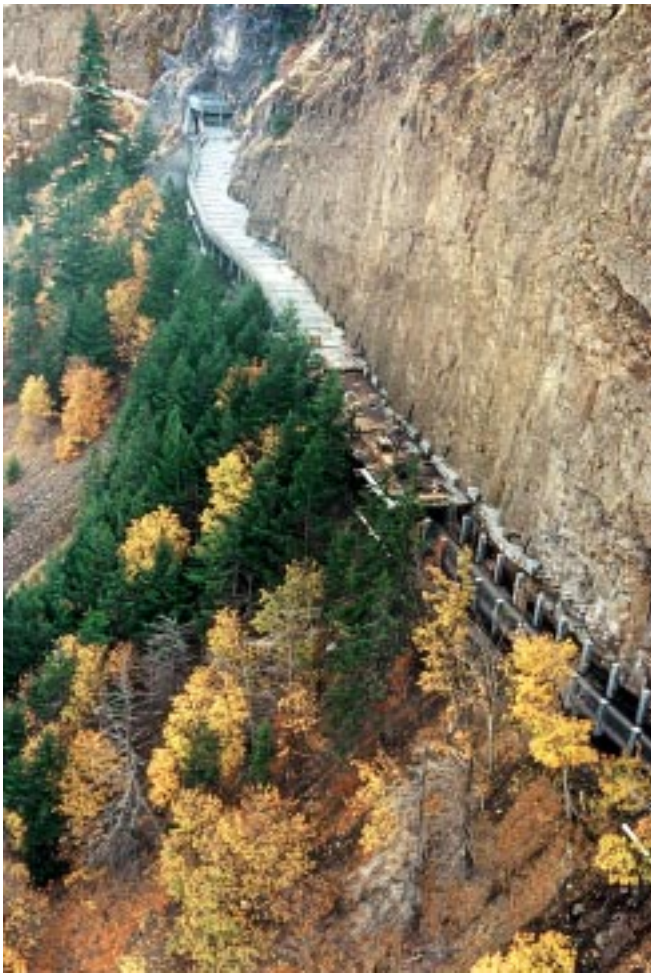
Upper Right: View from atop the Twin Tunnels of JAL pouring the deck between bents 4 and 5 and also forming corbels between bents 47 and 49.

Upper Right: American Geotech places wire mesh netting over the talus slope atop the cliff face at Bent 32.

Middle Right: In September of 1999, rocks peppered the new deck at Bent 28.

Top Left: View from atop the Twin Tunnels as the pouring of the deck progresses.

Bottom: JAL Foreman, Mark Walters, supervises one of many successful concrete placement operations. Most of the concrete for the job was dumped into a bucket that was lifted by a crane and poured into place.



Aerial photograph looking east over the structure in the fall of 1999. In this photo, American Geotech had just finished stressing the corbels and JAL was starting on building the forms for the concrete deck from bent 38 to 48.

During the construction of the corbels, a few rocks continued to rain down around Bent 32. JAL skipped past this area during the construction of the corbels. JAL, Canadian Geotech, and Woodward Clyde geo-technicians investigated and concluded that there was a talus slope at the top of the cliff. The talus was mostly composed of a mix of softball-to-basketball sized rocks at the lower end of the slope and some larger boulders higher up. The voids between the rocks were filled with a sandy soil type of material. When the talus was saturated during a rainstorm, it would become unstable and, due to the steep angle of the slope, material would fall off the cliff to the work area below. After meetings with ODOT and OSHA, it was decided that a wire mesh netting could be anchored over the talus to help secure the slope. The mesh was installed and JAL felt safer under it and resumed work. Later that summer, some rocks did fall after a night of very heavy rain, but luckily, no rocks fell during good weather while work was in progress. After the project was completed, the mesh was removed from the slope and hauled off. The additional cost to the contract to install and remove the mesh was $28,800.

By the fall of 1999, JAL had become very efficient at constructing the deck. A working platform was being stretched across 10 bents and the corbels and decks could be poured on the same platform. Once the working platform was constructed, JAL would form up every other one, remove those side forms and just fill in the decks between them without any additional formwork. In December of 1999, JAL finished the construction of the concrete deck.

In October of 1999, before the completion of the deck, JAL decided to start other elements of work. Their next task was to place the fascia panels. These were precast concrete blocks that would be placed on the top front edge of the concrete deck to provide support for the six

Preparing to pour every other deck between bents 50 and 60.

The final decks were poured in December of 1999.

Type CC fascia panels manufactured at Morse Bros. in Harrisburg, Ore.

JAL setting a type BB fascia panel in place.

feet of cellular concrete and pea-gravel that was to be placed on top of the concrete deck. There are four different fascia panel designs with different dimensions (AA,BB,CC,DD). Only the AA panel is actually bolted to the structure at each column. The other three are all placed in rows and held in place by the AA panel, the weight of another panel on top of it, and the weight of the pea-gravel. The design theory is that if a large rockfall occurs, energy from the rock can be absorbed in the pea - gravel, cellular concrete and the panels. Even if the panels are knocked off the deck, they can be replaced at a much cheaper cost than having to rebuild the structure. Morse Bros. in Harrisburg, Ore. manufactured the panels. If any of the panels need replacement, More Bros. and ODOT have working drawings to make new ones.

Since there is not an access road in front of the entire structure, JAL had to lift the panels up onto the west end, then move them into place. Once lifted onto the deck with a crane, the panels were moved to their proper location with a forklift. The crane had to be brought under the structure to lift the panels into place up on the upper deck of bents 1-3.

Once three of the four panels were in place, the rock catchment "container" could be filled. First, a drainage membrane had to be placed on the concrete deck. This would allow storm water to flow over and around the cellular concrete and through the drains in the deck. The next step was to lay out a waterproof membrane that would completely wrap the cellular concrete. Keeping the cellular concrete dry after it cured was important because, if the cellular concrete became saturated, it would develop different physical properties and change the way the energy from the falling rocks would be transmitted through it into the structure.

Top Left: JAL setting a BB panel in place on the upper deck at the West Portal.

Middle Left: To match the cliff face, JAL cut the panels to fit.

Bottom Left: Looking east from Bent 15 at finished deck and fascia panels.

Top Right: In November of 1999, after the placement of the fascia panels, another large rockfall occurred at Bent 28. It occurred overnight, during a storm.

Bottom Right: The November rockfall was thought to have come from approximately 20 feet above the deck. A large boulder measuring more than two feet across, landed on the deck, but did not cause any damage.

Looking east from Bent 16 over the drainage mat and the waterproof membrane that is in the process of being spread into position.

JAL attaches the membrane to the cliff, to be held in place during the placement of the cellular concrete.

In early December of 1999, JAL was ready to pour the cellular concrete. Of any item of work in this structure, the cellular concrete was the most unique. Issues about the cellular started soon after the contract began in 1998. JAL and the contractor they hired (Mid West Cellular Concrete) were concerned that the specified range of strength for the cellular was too tight. This range of 135-150 psi was very important to Lee Holloway, designer of the structure. If the cellular concrete was too soft, a large boulder could pass through the cellular and damage the deck. If the cellular was too hard, a boulder could hit the cellular and the energy from the impact could travel through the cellular and damage the deck. The cellular had to catch and hold the design boulder. The contractor's concern was that, even though a consistent mix could be produced, the testing of it's strength could not accurately show such a specific strength. In a compromise, the specified range of strength was widened to 120-165 psi. In hindsight, this was only an exercise in team work and negotiations, since the final in-place strength was within the original specified range.

Since JAL wanted to start placing the cellular concrete before the deck was even finished, they had Mid West Cellular set up their batch plant at the east-end of the Mosier Twin Tunnels. The lesson learned from this part of the work is to never set up any type of concrete batching plant in a sensitive area near completed work. Even though the plant was small and simple, there were continuing accidents that made a huge mess.

Cellular concrete batch plant at the East Portal of the Mosier Twin Tunnels.

When the cellular concrete is batched, it looks like mushroom soup. It is a simple mix of cement, fly ash, a foaming agent and water. The foaming agent is a soap-like substance that essentially adds air bubbles to the mix. The

Lines bringing cellular to the deck from the batch plant broke, making a mess during construction.

When placed on the structure, the cellular concrete has the consistency of mushroom soup.

The foaming agent for the cellular concrete is injected into the mix in a liquid state.

To get the cellular concrete to grade on the slope of the structure, it had to be placed in separate lifts held in place by bulkheads.

day after the cellular is placed, it can be walked on and a piece of it, when held, is similar to a very light piece of pumice rock.

Since the cellular concrete, when placed, is such a viscous material, JAL had to construct bulkheads to form small pools to build up the cellular on the slope of the structure. This was very challenging since they were building the wood bulkheads on the waterproof membrane and didn't want to punch holes through it. The "stair-step" method did prove to work well. Separate pools were filled throughout this phase of the work and, then toward the phase end, a thicker mix was spread over the top to achieve the final grade.

The pouring of the cellular concrete was mostly going well until Dec. 14, 1999. JAL had built a bulkhead around bent 23 and was expecting to have Mid West Cellular spend most of the day filling the pool up with about 300 cubic yards of cellular. Around midday, after pumping approximately 130 cubic yards of cellular, the bulkhead broke. The cellular flowed down the deck like a mudflow. Since JAL had started the cellular before the decks were done, the cellular flowed into areas not

completed. When it got near Bent 40, it flowed into their work area and then into the drains and onto the ground, below. It was a big mess! In the final phases of the project JAL, spent a lot of time and did a great job cleaning up the mess.

During placement, a bulkhead broke and cellular concrete flowed down the structure like a mudflow.

Cellular concrete placement at bents 3-20.

When the bulkhead broke, the cellular concrete flowed through the drainage holes in the deck and onto the ground below.

After the experience of having the bulkhead break, JAL rethought the method of building the bulkheads. The bulkheads became a bit more elaborate and were nailed through the membrane, which was later patched. From then on, the placement went well, except for a few accidents when the four-inch line bringing the cellular to the deck broke, creating an additional mess.

View from atop the Mosier Twin Tunnels during the cellular concrete placement.

Above: Craig Herkal and Jeff Canada of Mid West Cellular spread a thin lift of thicker consistency cellular concrete to achieve the final grade.

Left: Looking east from Bent 35 over the fascia panels and cellular concrete wrapped in a waterproof membrane.

After the cellular concrete was finished, JAL removed the wood form from the front edge and finished wrapping the waterproof membrane over the top of the cellular concrete. The lesson learned for the waterproof membrane was never fully understood. To this date, JAL still insists that they used more membrane than ODOT measured neat line and paid for, but cannot explain why. One idea was that there were wrinkles in the membrane that caused the use of extra material. Effort should always be made to agree on the quantity placed with a contractor before the next stage of work occurs.

The next item of work for JAL was to get one foot of pea-gravel spread across the cellular concrete and into the gap between the front face and the fascia panels. The pea-gravel would catch all of the smaller, average-sized rocks and protect the membrane and cellular concrete.

JAL had found two pieces of equipment that are common to mining work. An All Track 1500 tracked low-profile dump truck and 307 CAT Excavator could be used on top of the cellular concrete. The equipment traveled on tracks so it would not get stuck in the pea-gravel. JAL had the pea-gravel dumped at the west end of the structure and then used a trackhoe to lift the material up on top of the structure. After building a bed of material, the trackhoe then lifted the small excavator up and onto the pile of pea-gravel. After the small excavator spread the pea-gravel across the first couple of bents, the small dump truck was lifted onto the deck. It then hauled loads of pea-gravel down the structure, dumped them, and then went back over it to get another load.

Looking east at the pea-gravel operation at the west end of the structure.

All Track 1500 tracked dump truck hauling pea-gravel.

During the pea-gravel operation, JAL had to also place the fourth type of fascia panel. The Type DD panel had to be placed on top of the pea-gravel that was placed between the front edge and the other fascia panels. After the Type DD panel was placed, pea-gravel had to be filled over the bottom edge to secure them. JAL accomplished this by leaving a berm of pea-gravel along the front edge. After the Type DD panel was placed, the berm of pea-gravel was pushed over onto the panel.

Type DD fascia panels are placed on top of the pea-gravel.

Looking east over the finished pea-gravel in late April of 2000.

Within one month after completion, small rocks were being caught on top of the structure.

Another element of the project was to stain the Mid-Catchment Structure. Since its completion in 1996, the Mid-Catchment Structure between the Mosier Twin Tunnels had been an eyesore to travelers in the Gorge. To minimize its appearance from key viewing areas in the Columbia River Gorge, JAL hired Livingston Construction from Olympia Washington. Jill Livingston used a product called Permeon that was custom batched so the finished color would match the surrounding rock as closely as possible.

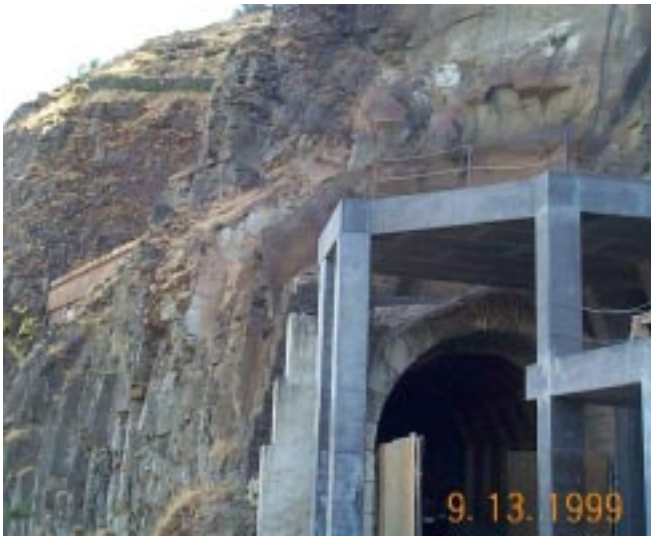
After its completion, the Mid Catchment Structure between the Mosier Twin Tunnels was an eye sore to travelers in the Gorge but, since the application of Permeon, it now blends in with the surrounding rock.

In a test area, the Permeon was first applied to the backside of a column. After the color was confirmed, Permeon was applied to the entire structure and was also applied to an area of shotcrete above the west portal of the tunnels. Three coats were applied over a seven-month period. The lesson learned with the

Test application of Permeon on the Mid Catchment Structure stains the bottom portion of a concrete column.

Permeon product was to be patient. It is a chemical that basically causes the surface to "rust" to a desired color. It soaks into the concrete and, as it is exposed to UV light, it darkens. It is thought by some that two applications might have been enough for the Mid-Catchment. Another lesson learned was to be very careful not to get Permeon anywhere where it is not desired. After it is absorbed and dries it is very difficult to remove! Another lesson learned with the Permeon was that,

Permeon is applied as a spray. Be careful with over-spray!



Three weeks after its application, the Mid-Catchment Structure and shotcrete area above the West Portal began to blend in with the surrounding rock.

depending on the porosity of the surface, it is absorbed at different rates. If a surface absorbs more, it will become darker. This was evident on the Mid-Catchment Structure, whose current appearance now seems to indicate that, during construction, different forming material and different finishing techniques were used. The color of the structure is now dark, but not all the exact same shade. Still, the work was considered a success. When driving on I-84, people need to know where to look to find the structure. At a price of $40 per square yard, it cost $14,482 to apply the Permeon to the Mid-Catchment Structure and to the shotcrete above the West Portal.

Due to different surface textures, the Permeon was absorbed at different rates, resulting in different shades and darkness levels as seen in the Mid-Catchment Structure.

Another challenge that JAL faced during construction of the structure was how to get an acceptable finish on the surface of the concrete. After the forms from the columns and the deck were removed, there were pockets that had to be filed and, partly due to different forming materials, the surface was very discolored. Since a coloring agent had been added to the concrete at the Hood River Sand and Gravel batch plant, it became very difficult to mix up a small amount of grout to patch the holes. But, after a short learning curve, this was accomplished. To tackle the discoloration issue, JAL decided to sandblast the entire surface of the structure. This process was supported for many reasons. First, the sandblasting would give the surface of the

structure a consistent appearance. Second, the surface would appear roughened and more "mature." Third, the roughened surface would give mosses and lichens a roughened surface where they could grow. Fourth, if OPRD had to deal with painting and vandalism, the graffiti could be sand blasted off, and not painted over with paint that would never match. The lesson learned here was that, even when coloring is added to concrete, the owner should be more specific on how the finished surface should appear. A contractor of less than the high professional caliber of JAL would have really struggled with the finish issue on this project.

After removing the forms, the surface of the structure had many discolorations.

After sand blasting, the surface was uniform in color and texture.

To achieve an acceptable finish, JAL sandblasted the Rock Catchment Structure.

Looking west from Bent 20 after the installation of all of the fence sections.

With the construction of the concrete phase of the structure complete, JAL started mounting the gates and fences. The quality of this architectural element is worth noting. The gates and fences were manufactured at True Line Steel in Bend, Ore. The company is owned and operated by Mike Deswert. Each gate and fence element was custom built with an obvious attention to high-quality workmanship.

The gates and fences were built at True Line Steel in Bend, Ore.

Each individual fence section was custom built with high quality workmanship.

The fence and gate phase of construction cost $70,000. The purpose of the fences was to make a diligent attempt to keep pedestrians out of the rockfall zones. It was understood that, no matter how large or extravagant the fences, some people would insist on climbing over or around them. After lengthy development meetings, a design that balanced safety and architectural beauty was agreed upon. The lessons learned from this part of the work were complex. The gates and fences were designed for a type of structure that had never been built before. Different types of gates and fences had to be constructed but, no matter how much planning was involved, different challenges and subsequent solutions were realized. Issues such as the direction gates should open and the location of locking mechanisms came up many times. Luckily, JAL was the type of contractor that could quickly participate in an effort to find a solution and then work in cooperation with ODOT to perform the work.

Highway entrance gate at the Mosier end.

In the development phase of the first Twin Tunnel restoration project, the work needed to restore the East and West Portals was discussed, but was eliminated due to funding limitations. Near the end of the Phase 2 project, additional funding was identified and ODOT negotiated with JAL and added a $25,000 element of work. The goal of the portal restoration work was to repair the damage that had occurred to the portals since the Twin Tunnels were closed in 1954. The East Portal had been covered with rock up to the top of the portal keystones. Over the years, the concrete above the keystone had been used as a backstop for gun target practice and it's surface was peppered with divots. To restore this portal, JAL sandblasted the entire concrete surface, patched the holes and divots with grout, and then applied a concrete slurry to the entire surface to achieve a uniform appearance.

East Portal before reclamation work.

East Portal after reclamation work

Top: JAL installing the gate at the East Portal of the West Twin Tunnel.

Left: It is estimated that the rockfall, which occurred above the West Portal and broke part of the portal off, occurred shortly before this photograph taken in March of 1992.

The repair work on the West Portal would require more work. In 1992, a very large rock fall occurred that tore off the top-left section of the portal. JAL had to first sandblast and chip away all of the loose concrete. The next step involved connecting onto the existing square-style steel reinforcement and structurally rebuilding the entire top of the portal. During this work, the cap and upper keystone sections also had to be rebuilt. After this work was performed, the entire surface was covered with a grout slurry that gave a finished appearance.

In April of 1999, part of the original stone portal was still visible behind the broken concrete portal.

JAL structurally rebuilt parts of the portal, utilizing a concrete slurry to match existing stonework.

West Portal after JAL restoration work.

Fences installed at the Mid Catchment Structure.

Installation of the entrance gate at the West End of the structure.

Installation of the gate between bent two and three.

On June 9, 2000, the temporary fences were removed and the public was allowed to travel under the Rock Catchment Structure and through the Twin Tunnels, re-opening the Hood River to Mosier section of highway to the public after 46 years.

With the Catchment Structure complete and all of the gates and fences installed, the decision was made to take down the fences that had been keeping pedestrians out of the work area since 1995. On June 9, 2000, the catchment structure was opened for public use. The final cost of the construction of the Phase 2 project was $2.7 million.

During a final inspection in late June 2000, another rockfall was found on top of the structure. A basketball-sized rock was caught by the pea-gravel and no damage occurred.

Top Right: Rockfall found in late June of 2000.

Bottom Right: Close-up of rockfall found in late June of 2000. Notice small divot on left side of picture.

JAL construction crew at job completion. From right to left: Mark Waters, Harvey Slade, Rick Corrigan, Albert Netters, Myron Swiggert, and Rigo Casimiro.

Rock Catchment Project key players. (From Left to Right) Kevin Bracy of ODOT, Lee Holloway of HNTB, Mark Walters of JAL, and Rick Corrigan of JAL.

JAL Construction is credited with much of the success of the project. Throughout the project, JAL's owners, engineers, superintendents, and construction staff exhibited the highest quality of professionalism and workmanship.

Communication between a contractor and the owner is vital on any project. Due to the unique complexity of the Rock Catchment Structure, the importance of an open communication path was huge. In hindsight, this was one of the biggest lessons learned, and can be partly credited for the success of the project. The communication path between Mark Walters of JAL, Kevin Bracy of ODOT, and Lee Holloway of HNTB never faltered during the entire project. When contract disagreements occurred, they were quickly resolved in a professional manner.

View from atop the Mosier Twin Tunnels of the Rock Catchment Structure, completed in June of 2000.

The biggest challenge now for the Rock Catchment Structure is maintenance. Before the construction of the structure started, ODOT and the Oregon Parks and Recreation Department entered into an Inter-Governmental Agreement (IGA) to manage and maintain it. At this point, discussions are still occurring to create a plan to identify a budget.