# ARMORFORM® ARTICULATING BLOCK MAT EROSION CONTROL SYSTEM

## Salmon Creek Bridge
## Oakridge, Oregon

## Interim Report

# OREGON EXPERIMENTAL FEATURE PROJECT #OR89-05

**by**

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**Prepared for**

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Federal Highway Administration
Washington, D.C. 20590

**December 1993**

# ABSTRACT

The ARMORFORM® Articulating Block Mat (ABM) was constructed at the Salmon Creek Bridge abutments during the summer of 1991. The bridge is located on the eastside of Oakridge, Oregon. A construction report, prepared in October 1991, details the ABM construction. This report presents the ABM performance to date based on site visits performed in August 1992, August 1993, and September 1993; and discussions with field personnel.

Based on the field inspections, the ABM appears to be performing as intended. Because the nature of the ABM did not allow it to be wrapped around the bridge abutments, the corners of the mat were not keyed in. Of interest, is the northwest (upstream) bridge abutment area which had been undermined prior to construction. The northwest corner of the mat is currently exposed and could provide an avenue for failure during a major flood event. Riprap has been added but should be monitored to insure the corner is adequately protected, so that the streamflow is not allowed behind the mat.

The ABM will be inspected annually and during or immediately after any 25-year flood events. This study is expected to continue until 1996.

# SI* (MODERN METRIC) CONVERSION FACTORS

## APPROXIMATE CONVERSIONS TO SI UNITS

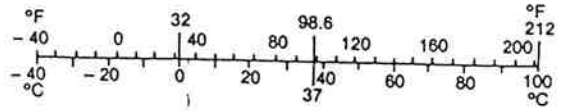
| Symbol | When You Know | Multiply By | To Find | Symbol |
|---|---|---|---|---|
| **LENGTH** | | | | |
| in | inches | 25.4 | millimetres | mm |
| ft | feet | 0.305 | metres | m |
| yd | yards | 0.914 | metres | m |
| mi | miles | 1.61 | kilometres | km |
| **AREA** | | | | |
| $in^2$ | square inches | 645.2 | millimetres squared | $mm^2$ |
| $ft^2$ | square feet | 0.093 | metres squared | $m^2$ |
| $yd^2$ | square yards | 0.836 | metres squared | $m^2$ |
| ac | acres | 0.405 | hectares | ha |
| $mi^2$ | square miles | 2.59 | kilometres squared | $km^2$ |
| **VOLUME** | | | | |
| fl oz | fluid ounces | 29.57 | millilitres | mL |
| gal | gallons | 3.785 | litres | L |
| $ft^3$ | cubic feet | 0.028 | metres cubed | $m^3$ |
| $yd^3$ | cubic yards | 0.765 | metres cubed | $m^3$ |

NOTE: Volumes greater than 1000 L shall be shown in $m^3$.

| | | | | |
|---|---|---|---|---|
| **MASS** | | | | |
| oz | ounces | 28.35 | grams | g |
| lb | pounds | 0.454 | kilograms | kg |
| T | short tons (2000 lb) | 0.907 | megagrams | Mg |
| **TEMPERATURE (exact)** | | | | |
| °F | Fahrenheit temperature | 5(F-32)/9 | Celcius temperature | °C |

## APPROXIMATE CONVERSIONS FROM SI UNITS

| Symbol | When You Know | Multiply By | To Find | Symbol |
|---|---|---|---|---|
| **LENGTH** | | | | |
| mm | millimetres | 0.039 | inches | in |
| m | metres | 3.28 | feet | ft |
| m | metres | 1.09 | yards | yd |
| km | kilometres | 0.621 | miles | mi |
| **AREA** | | | | |
| $mm^2$ | millimetres squared | 0.0016 | square inches | $in^2$ |
| $m^2$ | metres squared | 10.764 | square feet | $ft^2$ |
| ha | hectares | 2.47 | acres | ac |
| $km^2$ | kilometres squared | 0.386 | square miles | $mi^2$ |
| **VOLUME** | | | | |
| mL | millilitres | 0.034 | fluid ounces | fl oz |
| L | litres | 0.264 | gallons | gal |
| $m^3$ | metres cubed | 35.315 | cubic feet | $ft^3$ |
| $m^3$ | metres cubed | 1.308 | cubic yards | $yd^3$ |
| **MASS** | | | | |
| g | grams | 0.035 | ounces | oz |
| kg | kilograms | 2.205 | pounds | lb |
| Mg | megagrams | 1.102 | short tons (2000 lb) | T |
| **TEMPERATURE (exact)** | | | | |
| °C | Celcius temperature | 1.8C + 32 | Fahrenheit temperature | °F |




* SI is the symbol for the International System of Measurement

(Revised April 1989)

# ACKNOWLEDGEMENTS

The author would like to thank the following Oregon Department of Transportation (ODOT) personnel for their help in gathering information: Kevin Groom, Dave Bryson, Chuck Godfrey, and Paul Ferrigno. In addition, the author would like to thank Chris Dunn from the FHWA, and Keith Martin and Scott Nodes from ODOT, for reviewing the draft report.

# DISCLAIMER

**ARMORFORM® Articulating Block Mat Erosion Control System**

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# 1.0 INTRODUCTION

The ARMORFORM® Articulating Block Mat (ABM) was constructed at the Salmon Creek Bridge abutments during the summer of 1991. The bridge is located on the eastside of Oakridge, Oregon. The Vicinity Map and Location Map are shown in Figures 1.1 and 1.2, respectively. The construction of the ABM is detailed in a 1991 report entitled "ARMORFORM® Articulating Block Mat Erosion Control System Construction Report," available through the Research Unit. This report presents the ABM performance to date based on site visits performed in August 1992, August 1993, and September 1993; and discussions with field personnel.

The ABM is one type of fabric formed concrete. The system consists of a series of bags that are connected internally by grout ducts and a series of flexible polyester cables. The bags are filled with a cement rich concrete grout. When set, the concrete forms a solid mat, consisting of a series of connected blocks. The mat was selected for the site since riprap has a history of failure at this location. Continuous erosion of the streambed undermined the riprap. The ABM was selected as an alternative to riprap since it is a structurally integrated system that maintains its ability to protect against erosion even when undermined.

The original ODOT design terminated the ABM by burying it 4 feet into the channel banks. The design was modified, however, by the manufacturer due to the limitations of the product. That is, the fabric forms could not be terminated in a fan shaped pattern, as shown on the original ODOT plans. The construction report stated that the modification by the manufacturer could make the system less effective than the original design to control erosion from progressing by flanking around the end of the ABM. The original ODOT design and As-Constructed drawings are included in the construction report.

Prior to construction, the stream had washed out the west bank riprap just upstream from the northwest corner of the ABM. The riprap was replaced to protect the leading edge of the ABM under a price agreement with the contractor.

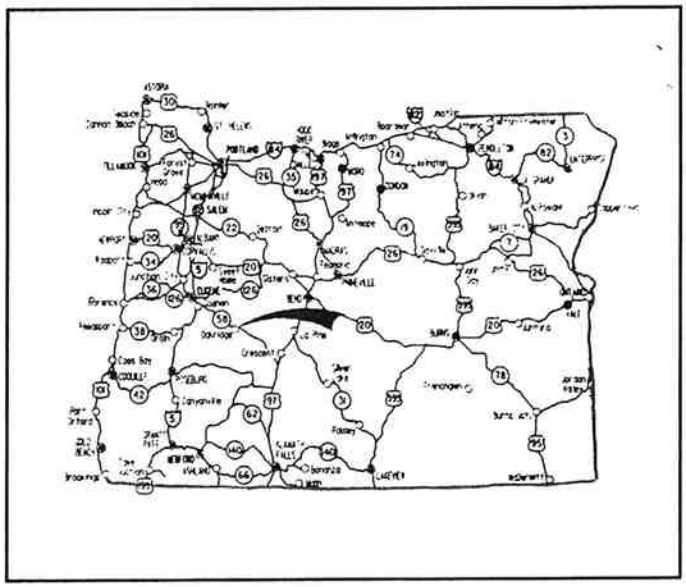

**Figure 1.1. Vicinity Map.**

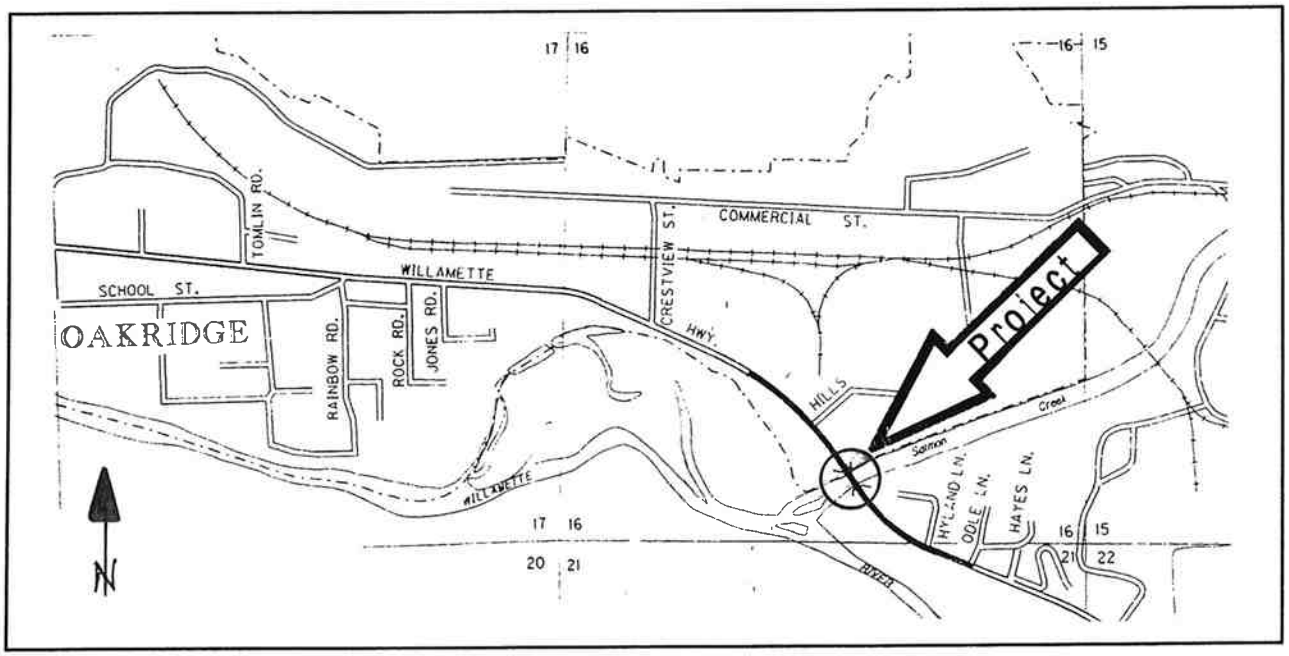


**Figure 1.2. Location Map.**

## 2.0 EVALUATION

Three detailed inspections have been made at the ABM site since the construction. The ABM has been evaluated for aesthetics, prevention of embankment erosion, prevention of pier and abutment scour, and performance and maintenance compared to loose riprap. The finished ABM is shown in Figure 2.1 which includes a photograph of the mat on the east side of the Salmon Creek Bridge.

Evaluating the aesthetic value of the ABM is difficult because it is a subjective quality. One opinion of the mat was that it was too white and uniform, so it did not blend in with the natural setting. Another opinion was that the mat looked nice and provided a finished look to the embankment. During the site visits, it was noted that the fabric enclosing the grout is slowing wearing away. As the material degrades, the gray grout will be exposed which may appear more natural looking. An additional visual effect is the staining that occurs on blocks that are submerged during high water. As the water level recedes in the summer months, the blocks are exposed and appear several shades darker than the higher blocks.

In general, the ABM appears to be preventing embankment erosion, and pier and abutment scour. The only concern is the northwest (upstream) corner. The northwest corner of the ABM is currently exposed with a 1 foot gap between the existing embankment and the edge of the ABM projecting into the creek. As noted earlier, riprap was added during construction at this location to protect the mat and prevent additional erosion. More riprap was added by ODOT maintenance staff a year later when excess material was available. Figure 2.2 shows a photograph of the erosion occuring at the corner. During site visits, it was noted that the downstream, southwest corner of the mat was also exposed. Both the northwest and southwest corner exposure can be attributed to the change in design from the original ODOT proposal to that provided by the manufacturer. As a consequence, the ABM was not buried to full depth on both sides of the pier. Because of the potential for the creek to flow behind the mat, the northwest coner is more critical than the southwest corner in the overall performance of the ABM.

The mat appears to be performing better than standard riprap. Since the streambed has a tendency to degrade, riprap could potentially be undermined leaving an exposed slope. This is evident on the northwest side of the mat where the bank has been undermined and riprap has rolled into the creek. As more and more riprap is lost into the creek, maintenance will be required to restore bank protection. ABM provides an added advantage over riprap since trees do not seed in on the ABM. Trees may present a site distance obstruction and/or make it difficult for maintenance workers to get access under a bridge.

From a safety standpoint, the ABM may be preferred over riprap. As noted during site visits, the mat is very easy to walk on and provides easy access down to the creek. Accessibility across the ABM may be an advantage in areas where foot traffic is anticipated.

The construction report recommended cutting through the ABM seams to create weep holes. The holes would provide additional drainage for water pressure behind the mat should a sudden drawdown occur after a flood. No weep holes were noted during the site visits.

**Figure 2.1. ABM on East Side of Salmon Creek Bridge.**


**Figure 2.2. Northwest (Upstream) Corner of ABM.**

## 3.0 CONCLUSIONS AND RECOMMENDATIONS

The ABM is performing as intended. The northwest corner, however, should be inspected regularly to insure that it is properly protected. During a major flood event, the creek could flow behind the ABM leading to failure.

The plans required that all edges of the ABM be keyed in; however, the ABM was not keyed in due to the limitations of the product. Future ABM projects should require all edges be keyed in and protected with riprap to prevent undermining and flow behind the mat.

Weep holes should be cut at approximately 5-foot intervals throughout the mat to add extra assurance that drainage will occur, as recommended in the construction report.

The ABM will be inspected on a yearly basis and during or immediately after any 25-year flood events until 1996.