

**ADIEM II END TERMINAL FOR
CONCRETE BARRIER**

Final Report

**Experimental Features
Project #96-01**



Oregon Department of Transportation

ADIEM II END TERMINAL FOR CONCRETE BARRIER

Final Report

Experimental Features Project #96-01

by

Eric W. Brooks, E.I.T.
Research Specialist

for

Oregon Department of Transportation
Research Group
200 Hawthorne SE, Suite B-240
Salem OR 97301-5192

and

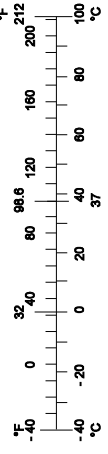
Federal Highway Administration
Washington, D.C.

March 2001

Report No. OR-EF-01-08	2. Government Accession No.	3. Recipient's Catalog No.	
4. Title and Subtitle ADIEM II END TERMINAL FOR CONCRETE BARRIER: Final Report		5. Report Date March 2001	
		6. Performing Organization Code	
7. Author(s) Eric W. Brooks, E.I.T., Research Specialist		8. Performing Organization Report No.	
9. Performing Organization Name and Address Oregon Department of Transportation Research Group 200 Hawthorne SE, Suite B-240 Salem, Oregon 97301-5192		10. Work Unit No. (TRAIS)	
		11. Contract or Grant No.	
12. Sponsoring Agency Name and Address Oregon Department of Transportation Research Group 200 Hawthorne SE, Suite B-240 Salem, Oregon 97301-5192		13. Type of Report and Period Covered Final Report 1997-2000	
		14. Sponsoring Agency Code	
15. Supplementary Notes			
16. Abstract On September 9, 1997, an ADIEM II (Advanced Dynamic Impact Extension Module) was installed on Interstate 5 near Salem, Oregon. The ADIEM II offered a redirecting, energy-absorbing crash cushion and end treatment for portable and permanent protection of concrete barriers. A three-person crew completed installation of the sloping concrete base and lightweight crushable concrete modules in about two hours. This device was selected for use as an end treatment because of space limitations imposed by steep fill at the site. The Oregon Department of Transportation Research Group monitored the performance of the system for three years, particularly the weather resistance of the crushable concrete modules. The modules developed soft spots after two years. An attempt was made to repair and re-coat the blocks. The new coating did not prevent soft spots. A corrugated plastic covering was also installed, and seemed to remain intact, though no analysis of the concrete inside the cover was performed. The lightweight concrete modules were replaced in October of 1999. The new modules were coated with a different type of water proofing material (Garna-Thane). By the spring of the following year a tear in the coating was found. In October 2000, one ADIEM installation was damaged by vehicular impact, but seemed to work as designed in absorbing the force. The blocks were difficult to remove and replace, due to debris in the track in the sloping base, and to the twisting of the wire reinforcing. ODOT has removed the ADIEM from the approved product list for temporary applications. It is not approved by ODOT for use on permanent installations.			
17. Key Words ADIEM, BARRIER, CRASH CUSHION, END TREATMENT		18. Distribution Statement Copies available from NTIS	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages	22. Price

SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS				APPROXIMATE CONVERSIONS FROM SI UNITS			
Symbol	When You Know	Multiply By	To Find	Symbol	When You Know	Multiply By	To Find
		<u>LENGTH</u>				<u>LENGTH</u>	
In	Inches	25.4	Millimeters	mm	Millimeters	0.039	inches
Ft	Feet	0.305	Meters	m	Meters	3.28	feet
Yd	Yards	0.914	Meters	m	Meters	1.09	yards
Mi	Miles	1.61	Kilometers	km	Kilometers	0.621	miles
		<u>AREA</u>				<u>AREA</u>	
in ²	Square inches	645.2	millimeters	mm ²	millimeters squared	0.0016	square inches
ft ²	Square feet	0.093	meters squared	m ²	meters squared	10.764	square feet
yd ²	Square yards	0.836	meters squared	ha	Hectares	2.47	acres
Ac	Acres	0.405	Hectares	km ²	kilometers squared	0.386	square miles
mi ²	Square miles	2.59	kilometers squared				
		<u>VOLUME</u>				<u>VOLUME</u>	
fl oz	Fluid ounces	29.57	Milliliters	mL	Milliliters	0.034	fluid ounces
Gal	Gallons	3.785	Liters	L	Liters	0.264	gallons
ft ³	Cubic feet	0.028	meters cubed	m ³	meters cubed	35.315	cubic feet
yd ³	Cubic yards	0.765	meters cubed	m ³	meters cubed	1.308	cubic yards
						<u>MASS</u>	
Oz	Ounces	28.35	Grams	g	Grams	0.035	ounces
Lb	Pounds	0.454	Kilograms	kg	Kilograms	2.205	pounds
T	Short tons (2000 lb)	0.907	Megagrams	Mg	Megagrams	1.102	short tons (2000 lb)
						<u>TEMPERATURE (exact)</u>	
°F	Fahrenheit temperature	5(F-32)/9	Celsius temperature	°C	Celsius temperature	1.8 + 32	Fahrenheit °F



NOTE: Volumes greater than 1000 L shall be shown in m³.

* SI is the symbol for the International System of Measurement (4-7-94 jbp)

ACKNOWLEDGEMENTS

The author would like to thank the following Oregon Department of Transportation (ODOT) personnel for their contributions and help gathering information for this report: Mike Dunning, Dan MacDonald, Joe Scheiman, Byron Inman, Sam Johnston and Joni Reid. In addition, the author thanks Don Gripne of SYRO, Inc. (now Trinity, Inc.) for his assistance on the project, and Steven D. Easton of Trinity, Inc. (SYRO) for supplying technical data on the ADIEM II.

DISCLAIMER

This document is disseminated under the sponsorship of the Oregon Department of Transportation and the United States Department of Transportation in the interest of information exchange. The State of Oregon and the United States Government assume no liability of its contents or use thereof.

The contents of this report reflect the view of the author who is solely responsible for the facts and accuracy of the material presented. The contents do not necessarily reflect the official views of the Oregon Department of Transportation or the United States Department of Transportation.

The State of Oregon and the United States Government do not endorse products of manufacturers. Trademarks or manufacturers' names appear herein only because they are considered essential to the object of this document.

This report does not constitute a standard, specification, or regulation.

ADIEM II END TERMINAL FOR CONCRETE BARRIER

TABLE OF CONTENTS

1.0 INTRODUCTION.....	1
1.1 BACKGROUND	2
2.0 PROJECT DESCRIPTION	5
2.1 PROJECT LOCATION AND ENVIRONMENT.....	5
2.2 DESIGN.....	6
2.3 INSTALLATION OF ADIEM II.....	7
2.4 COSTS	8
3.0 INSPECTIONS AND REPAIRS.....	9
3.1 FIRST INSPECTION.....	9
3.2 SECOND INSPECTION	9
3.3 FIRST REPAIR	10
3.4 THIRD INSPECTION	11
3.5 BLOCK REPLACEMENT	11
3.6 INSPECTION OF NEW INSTALLATION	12
3.7 ACCIDENT AND BLOCK REPLACEMENT.....	13
3.8 FINAL INSPECTION.....	14
4.0 CONCLUSIONS AND RECOMMENDATIONS.....	17
5.0 REFERENCES.....	19

APPENDIX A: Spring 1998 Inspection and QPL Status Memo

APPENDIX B: Fall 1998 Repair and Recoat

APPENDIX C: 1999 Inspections

APPENDIX D: Garna-Thane Product Information

TABLE OF FIGURES

Figure 1.1: The ADIEM II system	1
Figure 2.1: Project Location Map	5
Figure 2.2: Project Vicinity Map	5
Figure 2.3: ADIEM II Design (<i>Trinity 2000</i>).....	6
Figure 2.4: The Crushable Concrete Block (<i>TRR 1367</i>)	7
Figure 3.1: Soft Spots on Crushable Block	9
Figure 3.2: The Repair	10

Figure 3.3: Waterproof Cover on Block.....	11
Figure 3.4: Workers Install New Blocks	12
Figure 3.5: Cracks in a Block Removed in 1999.....	12
Figure 3.6: Tear in Garna-Thane Weatherproofing on Block	13
Figure 3.7: Damage from Vehicle Impact	13
Figure 3-8: Blocks Crushed by Impact.....	14
Figure 3.9: Example of Weatherproofing Condition on Southbound Blocks.....	15
Figure 3.10: Typical Block on Northbound Installation.....	15

1.0 INTRODUCTION

Guardrail end treatments are a critical traffic safety feature, yet are often difficult to install and maintain. The Advanced Dynamic Impact Extension Model II (ADIEM II) is an impact attenuator that would fit a number of locations and offers easy installation and maintenance features. It is described as a redirecting, energy-absorbing crash cushion and end treatment for portable and permanent protection of concrete barriers. The Oregon Department of Transportation (ODOT) was interested in evaluating the system in Oregon's wet environment.

The ADIEM II, manufactured by SYRO, Inc. (SYRO is now known as Trinity, Inc.), is shown in Figure 1.1. This end terminal crash cushion was developed by the Texas Transportation Institute as a low cost option. It utilizes lightly reinforced, ultra-low-strength Perlite concrete modules on an inclined concrete base, locked together to act as a unit. Because the Perlite concrete is susceptible to moisture, the blocks are coated with a protective covering. The modules are designed to crush upon impact, absorbing kinetic energy so the vehicle can make a controlled stop. If damaged, the modules can be slid out and replaced with new ones.



Figure 1.1: The ADIEM II system

In 1997, ODOT installed its first ADIEM II system on Interstate 5 near Salem, Oregon. The ODOT Research Group has monitored the installation for three years, with particular attention given to the weatherproofing of the crushable concrete blocks. This report documents the results of inspections and improvements by the manufacturer.

1.1 BACKGROUND

The ends of concrete barriers and portable concrete barriers present a troublesome safety problem. Some solutions, such as the sloping concrete wedge, are low cost, but their effectiveness in reducing injuries is questionable. Sand-filled barrels and steel barrel cushions are fairly low cost, but maintenance is difficult. They also require a wide median or roadside, which is often not available, especially in constrained construction areas. Further, barrel systems do not have side redirection characteristics. One option for end treatments in narrow zones are the narrow cushions that perform well in collisions, such as the GREAT CZ. These cushions, while used by ODOT, are costly.

The ADIEM II provides another alternative for narrow-area end treatments. ADIEM II met all Federal Highway Administration (FHWA) design standards and performed well in crash tests to National Cooperative Highway Research Program (NCHRP) 230 standards. These tests showed that ADIEM II can reduce injuries during head-on impacts. In a head-on crash test, a 1979 Lincoln sustained damage to the front bumper, grill and radiator, but the car remained upright on impact and no penetration of the passenger compartment occurred (*TRB 1992*). In actual work zone impacts, many cars were still driveable after the crash. Upon impact, the blocks are crushed and require replacement; the base is not usually damaged. In 1995, the ADIEM system was slightly modified and passed new NCHRP 350 safety requirements and is now marketed as the ADIEM 350 system.

The ODOT Qualified Products List (QPL) includes products that have been reviewed and approved for use by ODOT. Several products have been reviewed and approved as attenuators for temporary or permanent applications (including the Quadguard, Quadguard Elite, Low Maintenance Attenuator (LMA) and React 350). Based on an initial review of the product in 1994, the ADIEM II system was approved by ODOT as a temporary impact attenuator. In 1995, it was added to the Experimental Use List as a permanent impact attenuator, subject to a trial installation. A successful test of the ADIEM II terminal would provide a low-cost and easily repairable end terminal alternative for use in areas with space limitations.

Although the system has worked well in crash tests and has saved lives at temporary installations in other states, there were concerns about the durability of the waterproof coating and the crushable blocks. Other states have installed the system with mixed results. ODOT staff called three states that had approved the ADIEM system in 1997. Utah reported that some of the crushable concrete blocks were “falling apart.” Pennsylvania had concerns about the coatings but found the system acceptable. Washington also noted concerns about the modules’ coating, appearance, weight, and replacement. Both Washington and Pennsylvania found the system easier and less expensive to install than other end treatments, however (*UDOT 1997, PennDOT 1997, WSDOT 1997*).

Concurrent with the Oregon study, the Wisconsin Department of Transportation monitored an ADIEM installation for five years. The system functioned acceptably for two years, after which the modules required significant annual maintenance. The appearance and durability of the materials was considered poor, with extensive deterioration of modules including corrosion of reinforcing wire. No vehicular impacts occurred during the evaluation period. Due to concerns

about the integrity and strength of the units, researchers recommended that the ADIEM terminals not be used in Wisconsin (*Bischoff and Wilson 1999*).

ODOT Research Group monitored the coating longevity and operational features of the system to judge whether ADIEM II should be upgraded from experimental to accepted status for permanent applications in Oregon. This report documents the post-construction performance of the system and necessary repairs. A construction report on the installation and initial inspections of the ADIEM II system is also available from the ODOT Research Group (*Brooks 1998*).

2.0 PROJECT DESCRIPTION

2.1 PROJECT LOCATION AND ENVIRONMENT

The project is located on northbound Interstate 5 at milepost 248.31, about 9.7 km south of Salem, Oregon (see Figures 2.1 and 2.2). The ADIEM II was installed at the south end of a concrete barrier which protects traffic from a bridge end, and has a 4:1 fill slope. Space was limited because the shoulder barrier end, to which the ADIEM II was attached, was located near the edge of the fill. Level space to build a conventional buried-end terminal was not available because of the fill slope.

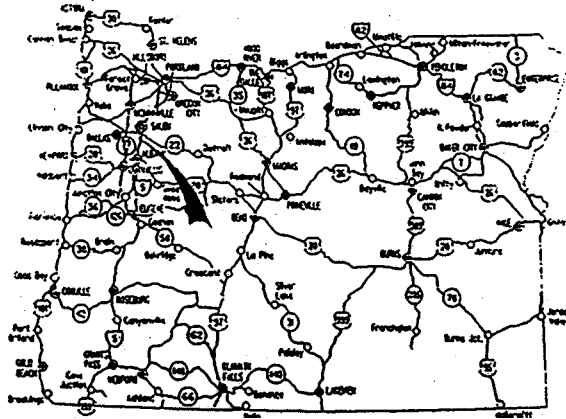


Figure 2.1: Project Location Map

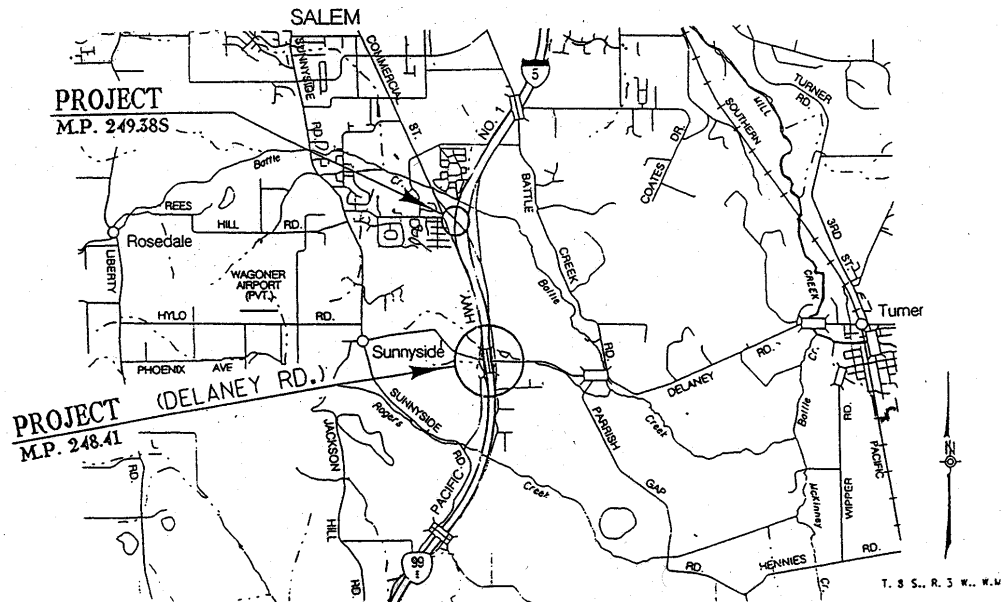


Figure 2.2: Project Vicinity Map

The system is located in a lane-changing area of a freeway that had an average daily traffic count (ADT) of more than 50,000 in 1997 (ODOT 1997). Traffic engineers have found that such sections have higher-than-average accident rates. Within three months of the ADIEM II installation in Oregon, a truck hit another temporary crash system in the vicinity.

The average annual rainfall for the Salem area is 1 m. The first two years after installation of the ADIEM II had above average rainfall, with 1.16 m in 1997 and 1.32 m in 1998. The five-month period before the second inspection in May 1998 was very wet, with 0.69 m of rain, 0.21 m above normal (NWS 2000a). At the May 1998 inspection, a substantial amount of moisture appeared to have penetrated the crushable concrete, resulting in a large number of soft spots (see Section 3.2).

Several freeze thaw cycles are also typical during the winter months. In the winter of 1997-1998, the Salem area had 35 freeze-thaw cycles; the 1998-1999 winter saw 37 occurrences; and 42 cycles were recorded in the winter of 1999-2000 (NWS 2000b). Combined with trapped moisture, a freeze-thaw event could weaken the crushable concrete. Some signs of this were found when the blocks were removed and replaced in 1999 (see Section 3.6).

2.2 DESIGN

The ADIEM II system is composed of two main parts: a wedge-shaped base and ten crushable concrete modules (see Figure 2.3). The base, fabricated using a conventional concrete mix design, is held in-place by twelve 25 mm x 60 mm steel pins which are driven through the base into the asphalt or gravel. A side pipe rail is cast on the base at automobile wheel-hub height to help redirect side impacts.

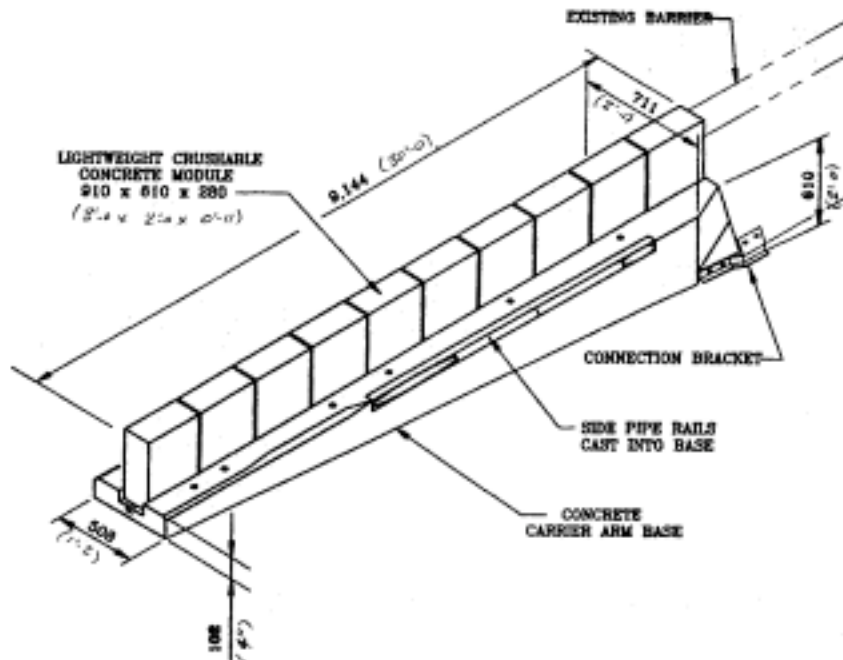


Figure 2.3: ADIEM II Design (Trinity 2000)

The crushable concrete modules are 610 mm high, 901 mm wide, and 280 mm deep. The blocks are made lightweight by replacing some of the aggregate with Perlite, a white granular filler sometimes used in potting soil. Varying densities of concrete and wire mesh are used in construction, with a 40 psi “zone” of low-strength concrete sandwiched between two thinner layers of 120 psi higher-strength concrete. Voids or hollow areas are built into the blocks to further lighten them, as shown in Figure 2.4. Because this type of concrete is porous, the blocks are coated with an acrylic latex to protect them from moisture. Each block weighs approximately 81.5 kg (180lb). The blocks are held in place by cast-in brackets, which slide into a steel slot on the base.

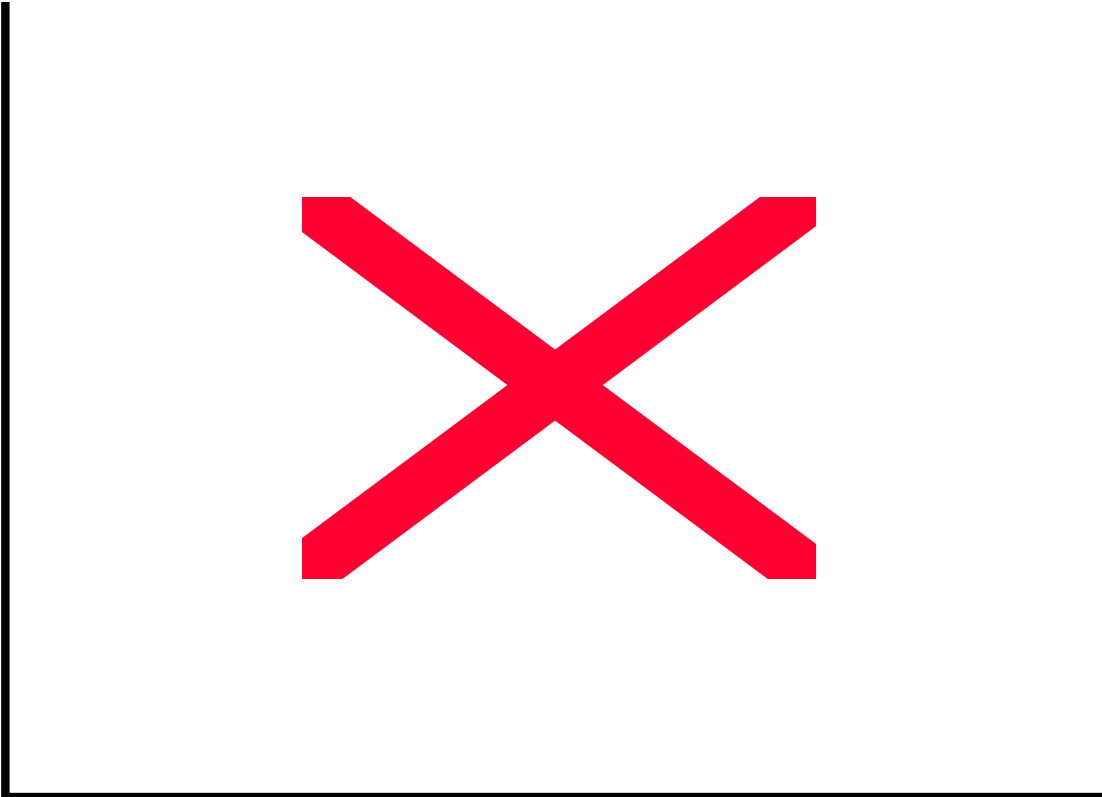


Figure 2.4: The Crushable Concrete Block (*TRR 1367*)

2.3 INSTALLATION OF ADIEM II

On September 9, 1997, an ADIEM II terminal end for concrete barrier was installed near the Delany Road overcrossing on Interstate 5. A three-person crew used an 8.2 metric ton forklift to complete the installation in about two hours (*Brooks 1998*). The crew leader, from Dirt and Aggregates Interchange, Inc., had been certified by SYRO, Inc. to install crash attenuation systems including the ADIEM II.

The base of the ADIEM II was secured to the road surface with long steel pins. The base was connected to the concrete barrier with a steel splice plate. Once the base was secured in place, the lightweight crushable concrete modules were inserted into the steel slot and slid into place. Two workers easily moved and installed the blocks. Special care was needed to avoid

damage to the crushable concrete and its covering while unloading and installing the blocks. The 81.5 kg (180 lb) blocks could not be lifted with equipment, but had to be loaded, unloaded and installed by hand.

The blocks had been covered with acrylic latex on all sides except the bottom. The bottoms were coated with a material that flaked off quite easily. Though the final step of the installation was to use an acrylic latex paint to cover any scratches or scars in the modules, the module bottoms were not accessible and could not be coated. A yellow and black warning chevron was attached to the south end of the ADIEM II with epoxy.

The Construction Report for this project outlined details of the installation and recommended close monitoring of the system under wet conditions, particularly around the bases of the blocks (*Brooks 1998*).

2.4 COSTS

The ADIEM II is a relatively low-cost barrier end treatment. The buried end terminal system may also be a lower cost system, but it requires a long runoff and substantial embankment, so it can be expensive if right-of-way has to be purchased. There are also cases where the necessary shoulder space is not available, as in the Delany Road installation.

Another narrow space end terminal, the GREAT CZ, costs about 30% more than the ADIEM II (the GREAT CZ was priced at about \$15,100 per unit in 1997). Producing a lower cost end terminal was one of the motivating factors for the Texas Transportation Institute's development of ADIEM II (*TRR 1367*).

ADIEM II prices can be negotiated with the manufacturer. In 1997, single units were available for \$11,000. An order of 20 units was sold at a unit cost of about \$8,000. Because they are manufactured in Centerville, Utah, they can be shipped to any of the western states within a few days. As the installation was relatively quick, overall costs to place the ADIEM system should be lower than for other standard end treatments.

3.0 INSPECTIONS AND REPAIRS

3.1 FIRST INSPECTION

On October 17, 1997, about six weeks after the ADIEM II was installed, Research staff performed a visual inspection of the end terminal. In general, the installation was in excellent condition. Three minor defects were found: discoloration, a soft spot, and a crack. The crushable blocks were no longer bright white but appeared somewhat dirty with yellow splotches. A 30-mm diameter soft spot had developed on the crushable block adjacent to the barrier. In the base, a small hairline crack was noticed on the east facing side; the crack had not been observed at the time of installation (*Brooks 1998*).

3.2 SECOND INSPECTION

A second inspection was made of the ADIEM II on May 28, 1998. This inspection consisted of visual observations, photographs and a "touch test" for soft spots. Only one soft spot was visible. This spot, which was reported on the first inspection, had increased in size. Other spots were found by touch. When a moist or soft spot was found, the area was defined by pressing hard with the thumb until the soft area was outlined. All but two of the blocks had at least one soft spot. Block 10, the block closest to the barrier, had the most soft spots with 5.



Figure 3.1: Soft Spots on Crushable Block

The end chevron had broken loose from the block and had been reattached using mechanics wire. The coating and epoxy were still on the chevron, but the coating had parted from the block. The

base was still in good condition. Stress cracks that were found on the small end of the base did not appear to be serious. The field report for this inspection can be found in Appendix A.

Following this inspection, the ADIEM II and its companion attenuator, the ADIEM 350, were removed from ODOT's Qualified Products List (QPL) as an impact attenuator for permanent installations (*ODOT QPL*). It remained approved for use as a temporary device (Appendix A).

3.3 FIRST REPAIR

In August of 1998, a second ADIEM installation replaced an end terminal treatment on the southbound off-ramp at Delaney Road. These ADIEM blocks also developed soft spots and a tear in the coating.

On September 9, 1998, a SYRO, Inc. representative made repairs on the crushable blocks on both north and southbound lanes. Most of the soft spots were dug out and refilled with a grout made for the ADIEM II system. After a half-hour cure time, the grouted areas were coated with Acrylink, a product from Isothermal Protective Coatings, Inc. used for coating roofs. Other soft areas were not grouted, but covered only with Acrylink. The repairs are described in a field report (see Appendix B). New coating was only applied to the repaired areas because, according to the SYRO, Inc. representative, the remaining coating was considered adequate to protect the module. The resulting appearance (see Figure 3.2) was not acceptable to ODOT, so further repairs were made, as described in the Section 3.4.



Figure 3.2: The Repair

A polypropylene plastic corrugated cover, developed by SYRO, Inc. to prevent water intrusion, was installed on one block of the southbound ADIEM. The installation was difficult because there was no clearance between the blocks. A better installation method would require removal of the blocks from the base, attaching the cover, and then re-installing the blocks onto the base. The color of the cover was yellow, which contrasted with the white coating of the other blocks, as seen in Figure 3.3.



Figure 3.3: Waterproof Cover on Block

On October 19, 1998 the ADIEM II crushable block modules were re-coated with Acrylink. This time, all of the blocks on the northbound installation were completely covered, and ODOT approved of the appearance. The field report is included in Appendix B.

3.4 THIRD INSPECTION

The third inspection was made of the ADIEM II on April 22, 1999. This inspection included a look at the installation in the southbound lanes. The southbound unit, which was installed in August 1998, had only a few soft spots. The plastic corrugated cover placed last year was still intact and looked good.

However, the northbound unit contained several soft spots. Some of the problem areas were found in the same places as in 1998, and had re-appeared despite the repairs. A location diagram is shown in Appendix C. The general appearance of the blocks was only fair, with some bubbling of the coating and some staining.

3.5 BLOCK REPLACEMENT

On October 5, 1999, new crushable concrete modules were installed at the northbound ADIEM II system. A Trinity, Inc. representative was on hand to oversee the removal of the old blocks and replacement with new. Two ODOT maintenance workers completed the task in two hours (see Figure 3.4). As with the initial installation, the blocks had to be loaded, unloaded and installed by hand, without equipment which could damage the blocks or coating. To transport and replace 10 blocks, workers had to lift or move an 81.5 kg weight approximately 60 times, raising concern about the stresses to workers backs. Appendix C contains the detailed report.

The concrete bases of two of the blocks were crumbled, and pieces of concrete in the tracks made removal of the blocks difficult. Deep cracks were found on one block when it was removed from the base. These cracks were near one of the plastic inserts in the block (Figure 3.5).



Figure 3.4: Workers Install New Blocks



Figure 3.5: Cracks in a Block Removed in 1999.

The new blocks were coated with silver Garna-Thane (see Appendix D for MSDS sheet). It, like Acrylink, is a roofing material. No soft spots were found on the new blocks.

3.6 INSPECTION OF NEW INSTALLATION

In April of 2000, a brief inspection was made of the ADIEM II system. The southbound modules were showing some bubbling and soft spots. There was a tear in the covering in one of the new modules in the northbound lane (Figure 3.6).



Figure 3.6: Tear in Garna-Thane Weatherproofing on Block

Though the new Garna-Thane covering appears to be less susceptible to weather, the concerns remained about the high level of maintenance required to protect the lightweight concrete.

3.7 ACCIDENT AND BLOCK REPLACEMENT

In October 2000, the southbound ADIEM was hit by a vehicle, with several blocks damaged. The impact, to the 4th, 5th and 6th blocks, also visibly damaged the 7th and 10th blocks (see Figures 3.7 and 3.8). The 10th block, nearest to the concrete barrier, was pushed onto the barrier approximately 0.33 m. Because no responsible party could be determined (the vehicle left the site and did not file an accident report), details about the accident are not available. The system apparently worked as designed, with the blocks absorbing the impact.



Figure 3.7: Damage from Vehicle Impact.



Figure 3.8: Blocks Crushed by Impact

District crews reported that the damaged blocks were difficult to remove, as the reinforcement was twisted. They also said the removal and reinstallation was slowed by debris in the track. The crew replaced the damaged blocks with blocks that had been removed from the northbound ADIEM installation the previous year. The blocks showed signs of deterioration due to moisture. Crews also noted damage to the coating on undamaged blocks that may have been caused by debris thrown by motorists or flung from vehicle tires.

When asked about their experiences with maintaining crash cushions, the district crews preferred other impact absorbing systems that used bags and sand, or barrels. They complained about the amount of lifting required in handling the ADIEM blocks; one worker complained of back problems after removing and installing blocks. Other cushioning systems allow the use of a winch or lift to assist in moving the devices.

3.8 FINAL INSPECTION

A final inspection of the ADIEM system, on January 31, 2001, included both the north- and southbound installations. Figure 3.9 shows an example of the severe peeling and bubbling of the coating which was found on several blocks on the southbound system. These blocks were coated with Acrylink. Where exposed, the concrete had soft spots and crumbling areas.



Figure 3.9: Example of Weatherproofing Condition on Southbound Blocks

The blocks on the newer, northbound installation were in much better condition, but were beginning to show slight bubbling and cracking (see Figure 3.10). Because the installation was fairly new, inspectors agreed that the Garna-Thane weatherproofing also appeared inadequate for long term protection of the blocks from moisture intrusion.



Figure 3.10: Typical Block on Northbound Installation

4.0 CONCLUSIONS AND RECOMMENDATIONS

The ADIEM II installation is quick. A trained but inexperienced contractor completed the work on this project in less than one day. Replacement of the crushable blocks was accomplished by two workers in two hours. Care must be taken in handling the blocks to avoid damage to the crushable concrete and its protective covering.

Soft spots appear frequently in the crushable blocks, which must then be repaired or replaced. Attempts at various methods of waterproofing the blocks have not been successful in producing a long-lasting crushable block under the wet climate conditions of western Oregon. There were also problems keeping the chevron attached to the blocks. After installation in 1997, the blocks were repaired once and replaced after two years.

The base of the ADIEM II unit has remained sound since installation. Minor cracks in the base do not appear to affect the structure or function of the device.

The ADIEM II has been removed from ODOT's Qualified Products List for both temporary and permanent applications. The ADIEM 350 has also been rejected for use as a permanent impact attenuator. Potential alternatives on the QPL include the Quadguard, Quadguard Elite, Low Maintenance Attenuator (LMA) or the React 350. As new products are approved for use, they will be added to the QPL.

ODOT recommends considering the ADIEM 350 for temporary installations only, because of the high non-impact maintenance of these units. The device has been conditionally approved for temporary applications, and with accommodations for ongoing maintenance (preferably the contractor/owner provides and maintains the system), the ADIEM 350 may provide a good option for narrow work areas.

5.0 REFERENCES

Bischoff, Debra and Joe Wilson, "Evaluation of the ADIEM (Advanced Dynamic Impact Extension Module)", Wisconsin Department of Transportation, Madison, WI. February 1999.

Brooks, Eric W., ADIEM II End Terminal for Concrete Barrier, Construction Report, Oregon Department of Transportation Research Unit, Salem, Oregon. March 1998.

National Weather Service (NWS), Preliminary 1998 Weather Summary for Salem, and Preliminary 1999 Weather Summary for Salem, at http://www.wrh.noaa.gov/cgi-bin/Portland/product.pl?SLE_1998REVIEW and http://www.wrh.noaa.gov/cgi-bin/Portland/product.pl?SLE_1999REVIEW. 2000a.

National Weather Service (NWS), Preliminary Local Climatological Data, from <http://www.wrh.noaa.gov/portland/CF6/>. 2000b.

Oregon Department of Transportation (ODOT), "Qualified Products List", Construction Section, continuously updated, <http://www.odot.state.or.us/tsconstruction/>.

Oregon Department of Transportation (ODOT), 1997 Transportation Volume Tables, Transportation Data Section, Transportation Systems Monitoring Unit, Salem, Oregon, June 1998.

Pennsylvania Department of Transportation (PennDOT), telephone conversation with Paul Kokas, June 1997.

Transportation Research Board, Transportation Research Record Number 1367: Development and Evaluation of Roadside Safety Features, Highway and Facility Design, National Research Council, National Academy Press, Washington DC, 1992

Trinity Industries, Inc., "ADIEM-II ISO Schematic," Highway Safety Systems Division, Dallas, TX. <http://www.highway-safety.com/adiemiso.htm>. 2000.

Utah Department of Transportation (UDOT), telephone conversation with Tammy Maxwell and Glen Schulty, June 1997.

Washington Department of Transportation, memo from Donald K. Nelson to Don Gripne of SYRO, dated October 1, 1997.

APPENDIX A

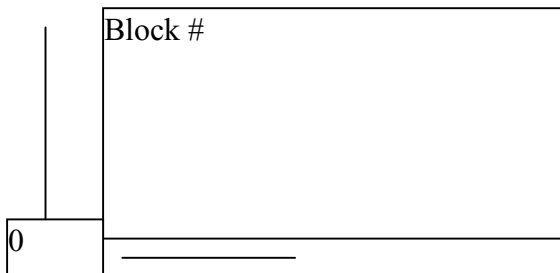
SPRING 1998 INSPECTION & QPL STATUS MEMO

SOFT SPOT LOCATION TABLE

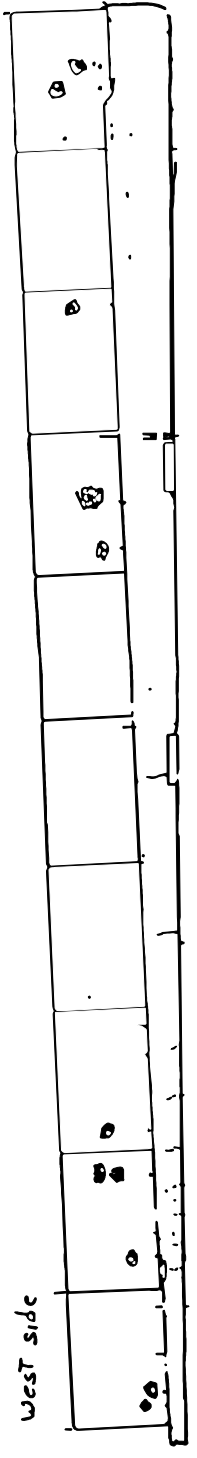
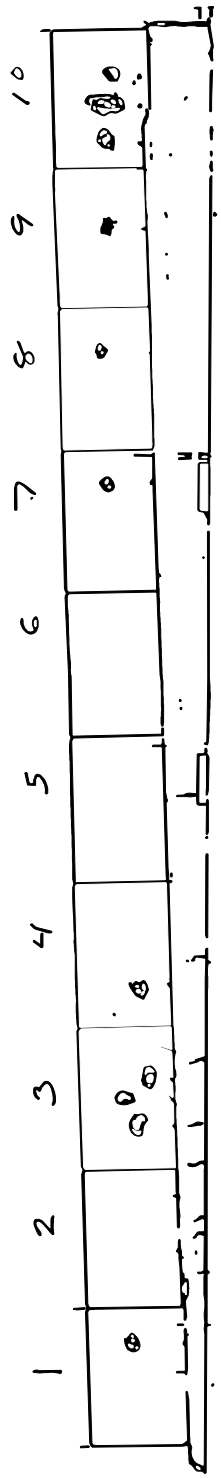
Inspection 5/28/98



Block #	Side	Horz meters	Vert meters	Dia mm.	Shape
1	East	0.66	0.30	25.4	cir
1	West	0.12	0.12	38.1	cir
1	West	0.18	0.14	38.1	cir
2	West	0.21	0.18	38.1	cir
2	west	0.73	0.27	38.1	cir
2	west	0.73	0.46	38.1	cir
3	East	0.27	0.20	50.8	cir
3	East	0.44	0.17	38.1	cir
3	East	0.53	0.30	63.5	cir
3	west	0.11	0.30	50.8	cir
4	east	0.23	0.15	101.6	cir
4	east	0.40	0.20	50.8	cir
7	east	0.69	0.32	19.05	cir
7	West	0.12	0.12	1.5x.61	rec
7	west	0.46	0.18	2.1x1.5	rec
8	East	0.61	0.30	25.4	cir
8	West	0.79	0.26	50.8	cir
9	east	0.50	0.26	1.8x.61	rec
10	East	0.12	0.18	76.2	cir
10	East	0.40	0.23	101.6	cir
10	east	0.56	0.17	50.8	cir
10	West	0.38	0.23	50.8	cir
10	west	0.53	0.17	50.8	Cir

□



The origin was taken as the south edge and base of the block



 Soft spots noted May 28
 Stress cracks in the base

Soft spots on the crushable blocks and stress cracks in the base plotted on the diagram of the ADIEM II



Oregon

John A. Kitzhaber, M.D., Governor

Department of Transportation

Operations Support Section

800 Airport Road SE

Salem, OR 97310

(503) 986-3000

FAX (503) 986-3096

June 22, 1998

FILE CODE:

MAT 3-4

DON GRIPNE
SYRO INC
5216 BRASSFIELD DR
OLYMPIA WA 98501

Product: **ADIEM 350/ADIEM II**
Category: **Impact Attenuator – Permanent**

ODOT No. 1663

Your product was submitted for review to the Product Evaluation Committee of the Oregon Department of Transportation (ODOT) with the following conclusions:

- An ODOT installation at Delaney Road in Salem has increased in soft spots, from one to twenty-three, in less than a year. Plus, we are having trouble keeping the chevron attached.
- As you are aware, other agencies are having problems with this unit.

At this time, we are removing this product from our Qualified Products List for the category listed. It will still be allowed as a temporary device.

We will keep your information on file for future review.

If you have any questions, call me at the Materials Laboratory (503) 986-3059.

Mike Dunning
New Products Coordinator

DMD:nj
newprod\cannot.fin

c: Victoria Kinne
FHWA
530 Center St NE Ste 100
Salem OR 97301
Liz Hunt, Research
Chris Bailey, Roadway
Dave Greenberg, Standards

APPENDIX B

FALL 1998 REPAIR & RECOAT



DATE: September 16, 1998

RES 6 #96-01

TO: File

FROM: Eric W. Brooks
Research Specialist

**SUBJECT: Site visit for ADIEM II END TERMINAL
I-5 , Milepost 247.9, (Near the Delany Road Oxing)**

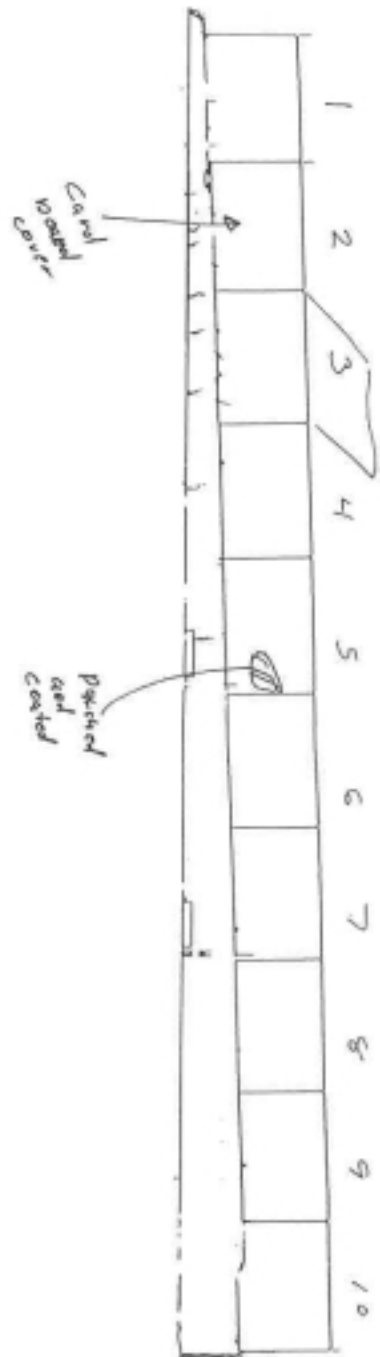
On September 9, 1998 Don Gripne, a consultant for SYRO, made repairs on the crushable blocks at both the northbound and southbound ADIEM II Units on the above mentioned project. Several soft spots were found in the northbound unit in May of 1998. The southbound unit, which was installed in August of 1998, also had a few soft spots and one tear in the coating. SYRO elected to dig out the soft spots and fill the holes with grout and re-coat the grouted surface rather than replace the blocks. (See attached drawings)

The grout was made by SYRO for the ADIEM II. It was mixed with water and applied to the dug out soft spot. In about one half hour the surface had cured hard enough to be coated with Acrylink, which is made by Isothermal Protective Coatings, Inc. for coating roofs.

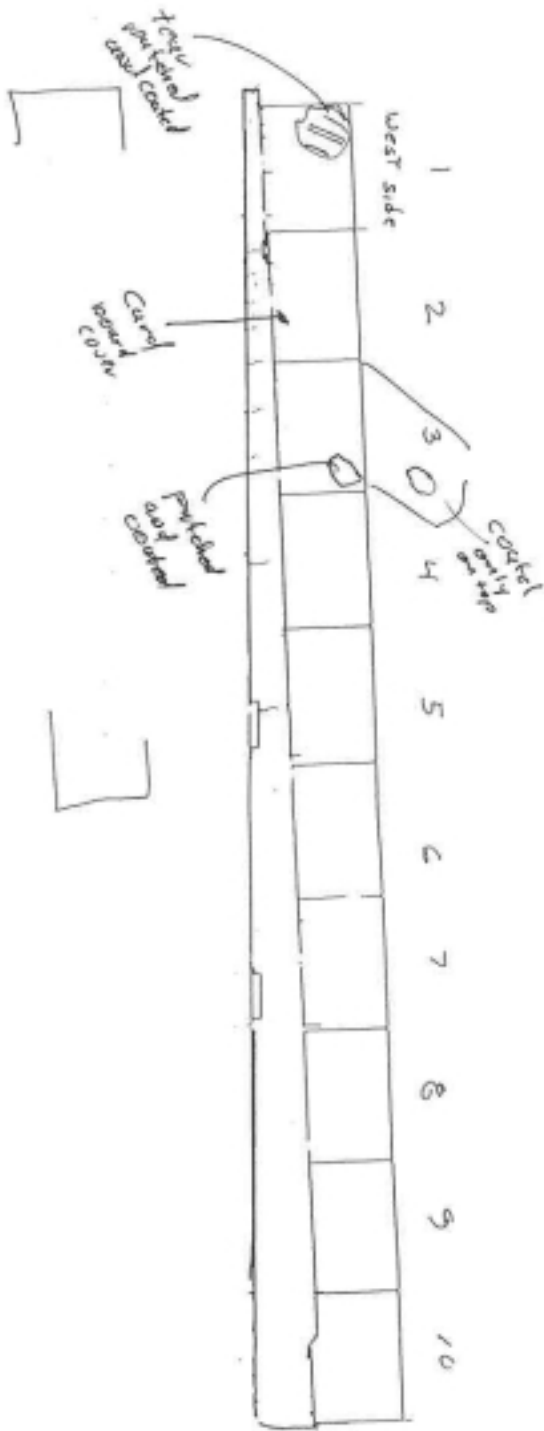
One other protective device was installed on one block of the southbound installation. This was a waterproof cardboard cover that was placed over the crushable block. The installation was difficult because of no clearance between the blocks. A complete installation would call for the removal of one block from the base. This would allow space enough to fit the covers over the blocks, then the removed block could be placed back on the base with its cover installed.

Don started working about 9 A.M. and was completed by noon. The ODOT Research Unit set up the required signs and cones for the shoulder work.

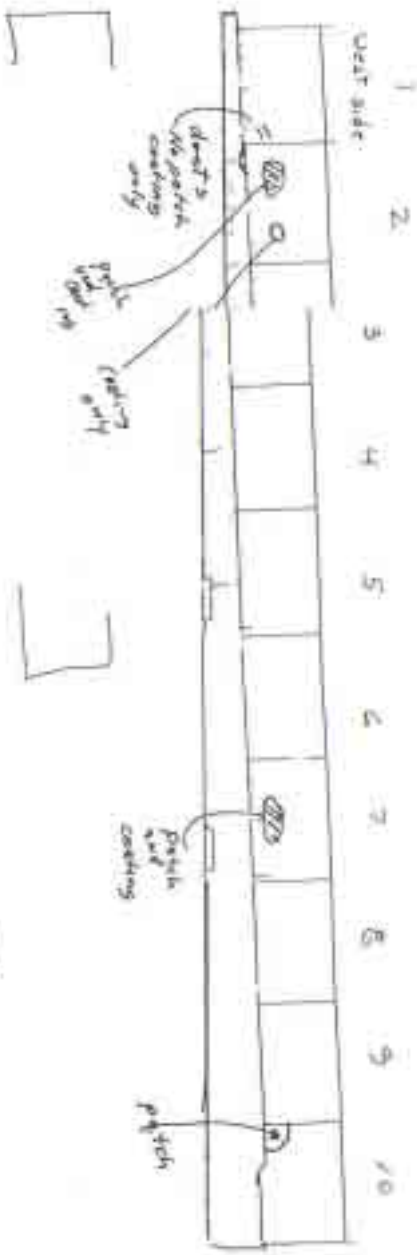
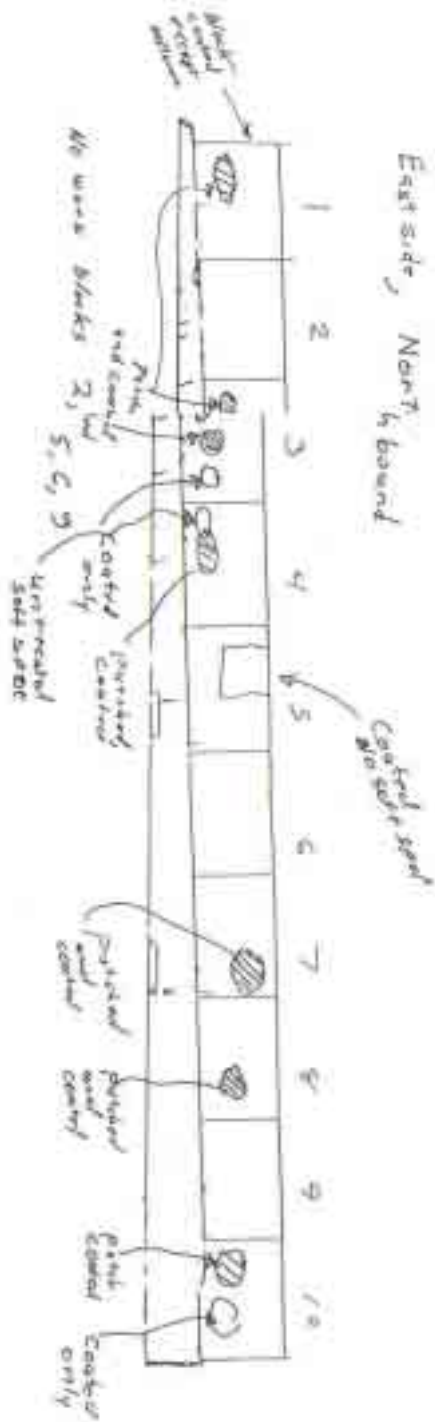
East side, South bound



Scale 1" = 40'



East side, North bound



Scale 1" = 10'

NO repair blocks 3, 4, 5, 6, 8, 9

repaired areas SEPT 9, 1998

APPENDIX C
1999 INSPECTIONS



Oregon Department of Transportation
RESEARCH UNIT 986-2700

INTEROFFICE MEMO

DATE: April 28, 1999

RES 6 #96-01

TO: File

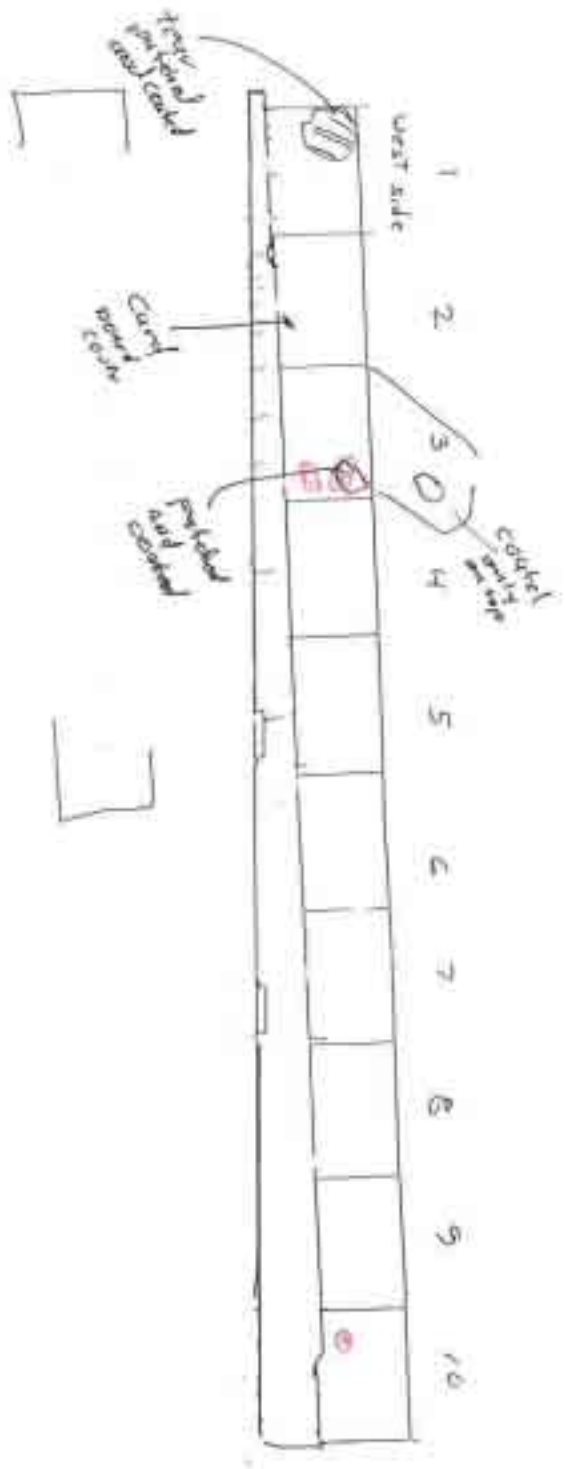
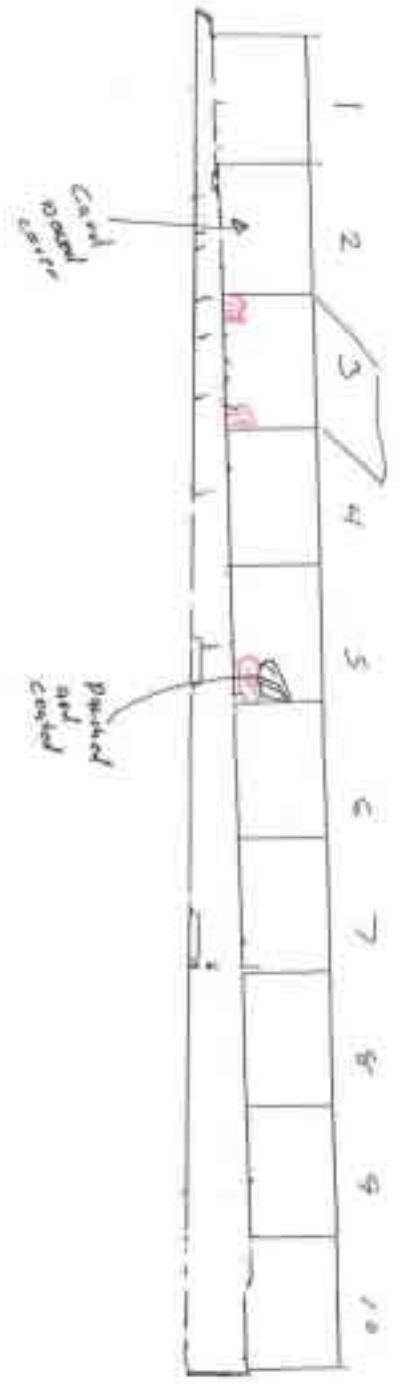
FROM: Eric W. Brooks
Research Specialist

**SUBJECT: Site visit for ADIEM II END TERMINAL
I-5 , Milepost 247.9, (Near the Delany Road Oxing)**

On April 22, an inspection was made on both the northbound and southbound ADIEM II units on the above project. Several soft spots were found in the northbound unit while the southbound unit, which was installed in August of 1998, only had a few soft spots. Some of these spots were in the same general area as the ones found in 1998. A few new ones were also found. The general appearance of the blocks was only fair because some were stained. The cardboard covered block on the southbound unit was still in tact and looked good. The base still looked the same as on previous inspections. See attached drawings for details.

CC: Mike Dunning

East side, South bound



Scale 1" = 10'



DATE: October 14, 1999

RES 6 #96-01

TO: File

FROM: Eric W. Brooks
Research Specialist

**SUBJECT: Site visit for ADIEM II END TERMINAL
I-5 , Milepost 247.9, (Near the Delany Road Oxing)**

On October 5, 1999 new crushable concrete modules were installed on the Northbound ADIEM II installation at Delany Road. Don Gripne, a consultant for SRYO, was on hand to oversee the installation. Two ODOT maintenance workers removed the exiting blocks and installed the new blocks. I was there also taking pictures and notes.

The new blocks arrived at the Salem maintenance yard about 9 AM. They were loaded onto an ODOT one-ton truck and arrived at Delany Road about 9:30 AM. The old blocks were removed by breaking the Acrylink bond between blocks and then pushing them one at time down the track. The concrete bases on two of the blocks were crumbled. The pieces of concrete filled the track and made pushing the blocks difficult. All ten blocks finally were removed and stacked.

The new blocks were unloaded from the truck with the help of the lift-gate. Even though the blocks weigh about 180 lbs, the two maintenance workers could easily lift and slide the blocks up the rail. After some motor oil was placed on the base, the blocks slide on quite easily.

After the blocks were in-place I checked them for soft spots and found none. Don Gripney recoated a few spots where the new coating had been rubbed off during handling. The entire operation took less than two hours.

The new blocks are constructed the same as the existing blocks had been. A different coating which is silver rather than white was used. The new block coating is called Garna-Thane. It like Acrylink is a roofing material.

CC: Mike Dunning

APPENDIX D

GARNA-THANE PRODUCT INFORMATION



SYRO, INC.
A SUBSIDIARY OF TRINITY INDUSTRIES, INC.

Adiem 350
Don J. Gripne
5216 Brassfield Dr.
Olympia, WA 98501
360-943-9559
Fax No. 360-943-9559

(P1663)

July 7, 1999

RECEIVED
JUL 13 1999
2nd FLOOR
TECHNICAL SERVICES
BRANCH

Mr. Dan MacDonald
Standards Section
Oregon Department of Transportation
222 Transportation Bldg.
Salem, OR 97310

Dear Dan

This last year Trinity Industries has been testing different coating material for the ADIEM modules to improve its durability. A product that has proved to be better than the Acrylink that is current being used is Garna-Thane. It like Acrylink is a roofing material and has been used as such since 1978.

I have enclosed for your review a copy of the Garna-Thane Product Information Sheet and a copy of the Material Safety Data Sheet. It is requested that the Garan-Thane be approved as an acceptable coating for the ADIEM modules.

If you have any questions, please give me a call.

Very truly yours,
Don J. Gripne
Don J. Gripne
SYRO, Inc.

Enclosures

Garna-Thane® PRODUCT INFORMATION

Type	Moisture Cure Poly/Glycol™
Color	Silver
Hardness Shore A	ASTM D-2240, A60 +/-5
Elongation	ASTM D-412, 240%
Memory of Elongation	100
Moisture Vapor Transmission	ASTM E96, 2.0
Solid Contents	70%
Flammability	Class A Fire rated on non-combustible surfaces*
Recommended Solvent	Xylene
Low Temperature Flexibility	ASTM 413, Excellent
Abrasion Resistance	ASTM C-501, Excellent
Adhesion Characteristics	ASTM 413, Excellent
Coverage Rate (per gallon)	100 square feet; 11 dry mils
Drying Rate	2 hours, 24 hour cure
Aluminum Content	28.73%

Product Description: Garna-Thane® is a fluid-applied, single component, poly/glycol elastomeric topcoat which protects roofing and wall systems monolithically.

Product Application: Protects roofing and wall systems from weather, ultraviolet light, and airborne corrosion. Stops rust and inhibits further oxidation. Waterproofs and seals. Resists effects of mold, mildew, fungus, and other parasites.

Precautionary Data:

1. Garna-Thane® contains solvents which require normal precautions in handling materials of this type. Keep out of the reach of children.
2. A particulate respirator is required for spray application. Avoid skin contact.
3. Casual or recreational foot traffic should be avoided when applied as roofing system topcoat.
4. Protect stored material from freezing.

*UL 790 and Factory Mutual rating may be acquired when applied per system specification.

Revised 1/94

gpa/tc/bhs/PID



MATERIAL SAFETY DATA SHEET

RoofMart International, Inc., P.O. Box 502, 2020 Industrial Rd., Chapman, KS 67431

GARNA-THANE

Manufacturer's Name: RoofMart International, Inc.
Address: 2020 Industrial Rd., Box 502
Chapman, KS 67431

Emergency Telephone: 800-451-8348 (3E Company)
Information Telephone: 785-922-8544
Date Prepared: January 8, 1999

Section II - Hazardous Ingredients / Identity Information

Specific Chemical Identity:

Common Name(s)	OSHA PEL	ACGIH TLLV	%(opt.)
Polyether Polyol			22
Solvent - Xylol		100	22
Diphenylmethane Diisocyanate Based Adduct			26
Polymethylene Polyphenyl Isocyanate			

Section III - Physical / Chemical Characteristics

Boiling Point:	281 F
Vapor Pressure (mm Hg.):	6.6
Vapor Density (AIR=1):	1
Evaporation Rate (butyl Acetate=1):	.8
Specific Gravity (H ₂ O=1):	.87 at 60 F
Appearance and Odor:	Slight odor
V.O.C lbs/gal:	1.85

Section IV - Fire and Explosion Hazard Data

Flash Point (Method Used)	79 F TCC	Flammable Limits - in air	LEL- 1.9	UEL- 12.3
Extinguishing Media -	CO ₂	Foam	Dry Chemical	
Special Fire and Explosion Hazards -	None			
Special Fire Fighting Procedures -	Treat as flammable liquid			

Section V - Reactivity Data

Stability: Stable

Conditions to Avoid: Source of ignition or strong oxidizing agents.

Hazardous Polymerization: Will Not Occur

Section VI - Health Hazard Data

Route(s) of Entry: Inhalation - Yes Skin - no Ingestion - yes
Signs and Symptoms of Exposure - Headache; Light-headedness
Emergency and First Aid Procedures - Move to well ventilated area. Call Physician.

Section VII - Precautions for Safe Handling and Use

Steps to be taken in Case Material is Released or Spilled -

Small Spills - absorb with activated clay absorbents.

Large Spills - dike up and pump into appropriate containers.

Waste Disposal Method: Waste material may be incinerated under conditions which meet Federal, State and Local environmental control regulations.

Other Precautions - Keep containers tightly closed in a cool, dry place Store away from open flame

Section VIII - Control Measures

Respiratory Protection (Specify Type) - Enclosed breathing apparatus or organic filter mask.

Ventilation - Use in well ventilated area, or in open air situation.

Protective Wear - As required for good industrial hygiene.

Section IX - Physical and Chemical Properties

Alternate Name(s): Single Component Polyurethane Elastomeric

Chemical Name: N/A - Mixture

Chemical Family: N/A - Mixture

Molecular Formula: N/A - Mixture

Appearance: Silver liquid

Odor: Sweet

Odor threshold (ppm): 0.4 (Hydrocarbons)

pH: N/A

GARNA-THANE

Flash Point: 79 F
Vapor Pressure (mm Hg at 25°C): 14 at 60 F
Vapor Density (Air =1): 6.6 approx.
Boiling Point: 262 to 286 °F
Melting Point: N/A
Solubility (water): 0.02 at 77 F Calculated
Solubility (other): Soluble in most organic solvents.
Specific Gravity: .87 at 60 F
Evaporation Rate: .8 approx.

Section X - Stability and Reactivity

Hazardous Decomposition Products: Highly unlikely under normal industrial use.
Chemical Stability: Stable at room temperature
Conditions to avoid: High humidity, Moisture, and temperatures above 375°F
Incompatibility with other Substances: This product will react with any materials containing water.
Hazardous Polymerization: Not applicable

Section XI - Toxicological Information

Toxicological Data:

Oral LD50 (rat) > 5,000 mg/kg
Dermal LD50 (rabbit) > 5,000 mg/kg
Inhalation LC50 (rat) = 480 mg/m³/4H (respirable aerosol)

Potential Health Effects:

Inhalation: This product is a respiratory irritant and potential respiratory sensitizer. Repeated inhalation of vapor or aerosol at levels above the occupational exposure limit could cause respiratory sensitization.

Skin Contact: Moderate irritant. Repeated contact may cause skin sensitization.

Eye Contact: The aerosol, vapor or liquid will irritate human eyes following contact.

Ingestion: Ingestion may cause irritation to the gastrointestinal tract. This product is considered non-toxic by ingestion.

Chronic Effects: A study where groups of rats were exposed for 6hrs/day, 5 days/wk for a lifetime to atmospheres of respirable aerosol. Overall, the tumor incidence, both benign and malignant, and the number of animals with tumors were not different from controls. Only at the top level (5 mg/m³), there was a significant incidence of a benign tumor of the lung (adenoma) and one malignant tumor (adenocarcinoma). There were no lung tumors at 1 mg/m³ and no effects at 0.2 mg/m³. The increased incidence of lung tumors is associated with prolonged respiratory irritation and the concurrent accumulation of yellow material in the lung, which occurred throughout the study. In the absence of prolonged exposure to high concentrations leading to chronic irritation and lung damage, it is highly unlikely that tumor formation will occur.

There are no reports that chronic exposure may result in permanent decrease in lung function.

Carcinogenicity: The ingredients of this product are not classified as carcinogenic by ACGIH or IARC, not regulated as carcinogens by OSHA, and not listed as carcinogens by NTP.

Mutagenicity: There is no evidence of mutagenic potential.

Reproductive Effects: No adverse reproductive effects are anticipated.

Teratogenicity and Fetotoxicity: No information is available and no adverse teratogenic/embryotoxic effects are anticipated.

Section XII - Ecological Information

Environmental Fate and Distribution: It is unlikely that significant environmental exposure in the air or water will arise, based on consideration of the production and use of the substance. Also factoring the pot life once exposed to the environment.

Persistence and Degradation: Immiscible with water, but will react with water to produce inert and non-biodegradable solids.

Toxicity: Not Regulated

Section XIII - Disposal Considerations

The generation of waste should be avoided or minimized whenever possible.

Disposal should be in accordance with local, state, provincial or national regulations. This material is not a hazardous waste under RCRA 40 CFR 261. Small quantities, should be treated with a decontaminant solution (See Section 6). The treated waste is not a hazardous material under RCRA 40 CFR 261.

Chemical waste even small quantities should never be poured down drains, sewers or waterways.

Empty containers should be decontaminated and either passed to an approved drum Recycler or destroyed.