SERB GUARDRAIL
SOUTH ASHLAND INTERCHANGE CALIFORNIA STATE LINE SECTION PACIFIC HIGHWAY (INTERSTATE 5) JACKSON COUNTY, OREGON

Final Report

Oregon Experimental Features
Project Number or 88-02

by

Eric W. Brooks
Research Specialist

Prepared for

Oregon Department of Transportation
Research Unit
Salem, Oregon 97310

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Federal Highway Administration
Washington, D.C. 20560

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16. Abstract

The Self Restoring Barrier (SERB) is a proprietary guardrail unit comprised of a single tubular thrie beam held outward from the supporting wooden posts by pivoting metal arms, its height above the ground secured by short cables attached to the top of the wooden posts.

Two SERB guardrail systems were installed on the Pacific Highway (Interstate 5) in southern Oregon as part of an Experimental Features Project for the Oregon Department of Transportation (ODOT). The SERB guardrails were placed along the same alignment as the previous standard guardrail. The SERB guardrails were placed along the same alignment as the previous standard guardrail. The SERB guardrail is designed to redirect vehicles (including larger vehicles) when struck, yet require little or no maintenance after being struck by smaller vehicles.

During the three years of in-service performance, the SERB guardrails had experienced some damage to the rail, and were not repaired. A problem with the lag screw that connects the support cable to the guardrail post has been found: the lag screw has been slipping from the weight of the thrie beam, allowing the guardrails to sag. However, the guardrails were still functional in 90% of the length of installation. The local maintenance district opted to remove the SERB in July of 1993. Reasons cited for renewal included, high costs, man-power, and traffic control in a dangerous work zone.

This final report covers the three evaluation and removals of the SERB guardrails.

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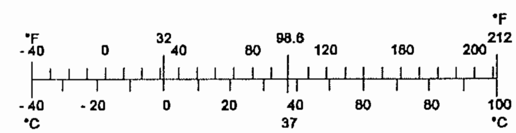
SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	millimeters squared	mm^2
ft^2	square feet	0.093	meters squared	m^2
yd^2	square yards	0.836	meters squared	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	kilometers squared	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	meters cubed	m^3
yd^3	cubic yards	0.765	meters 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	Celsius temperature	°C

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	millimeters squared	0.0016	square inches	in^2
m^2	meters squared	10.764	square feet	ft^2
ha	hectares	2.47	acres	ac
km^2	kilometers squared	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	meters cubed	35.315	cubic feet	ft^3
m^3	meters 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	Celsius temperature	1.8 + 32	Fahrenheit	°F



* SI is the symbol for the International System of Measurement

(4-7-94 jbp)

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SERB GUARDRAIL - SOUTH ASHLAND INTERCHANGE CALIFORNIA STATE LINE SECTION PACIFIC HIGHWAY (INTERSTATE 5)

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1.0 INTRODUCTION

Although standard steel-rail guardrails perform satisfactorily when struck by an automobile, no standard guardrail consistently redirects heavier vehicles. Also, with the exception of concrete barriers, most guardrail systems require at least some maintenance after moderate to severe impacts.

A possible solution to this problem is the Self Restoring Barrier (SERB) guardrail. The SERB guardrail was developed to redirect vehicles (including large vehicles), while requiring little or no maintenance after being struck by smaller vehicles. The SERB guardrail is best suited for areas which have a high frequency of vehicle/guardrail collisions, where heavy vehicle containment and minimal maintenance is desired, and where a concrete barrier might be subjected to high angle hits and perform poorly (*Traffic Barrier Systems,*).

To evaluate the system, the Oregon Department of Transportation (ODOT) installed the SERB guardrails on two sections of the Pacific Highway (Interstate 5) in Jackson County (*Rusnak and Scholl, 1990*). The SERB guardrails were evaluated as part of a Federal Highway Administration (FHWA) Experimental Features Project.

2.0 DESIGN

Figure 2.1 shows the design of the SERB guardrail. The rail itself consists of two 12-gauge thrie beams fastened together back-to-back forming three hollow tubes. The rail is attached to the pivot bar with two 10-gauge beam mounting straps, which allows the rail to hang freely when the pivot bar is mounted. The pivot bar-rail assembly is anchored to the 8"x 8" (nominal) wood post by fastening 1/4" diameter x 3" long lag screws through the 10 gauge mounting brackets, allowing the assembly to pivot about the bottom of the pivot bar.

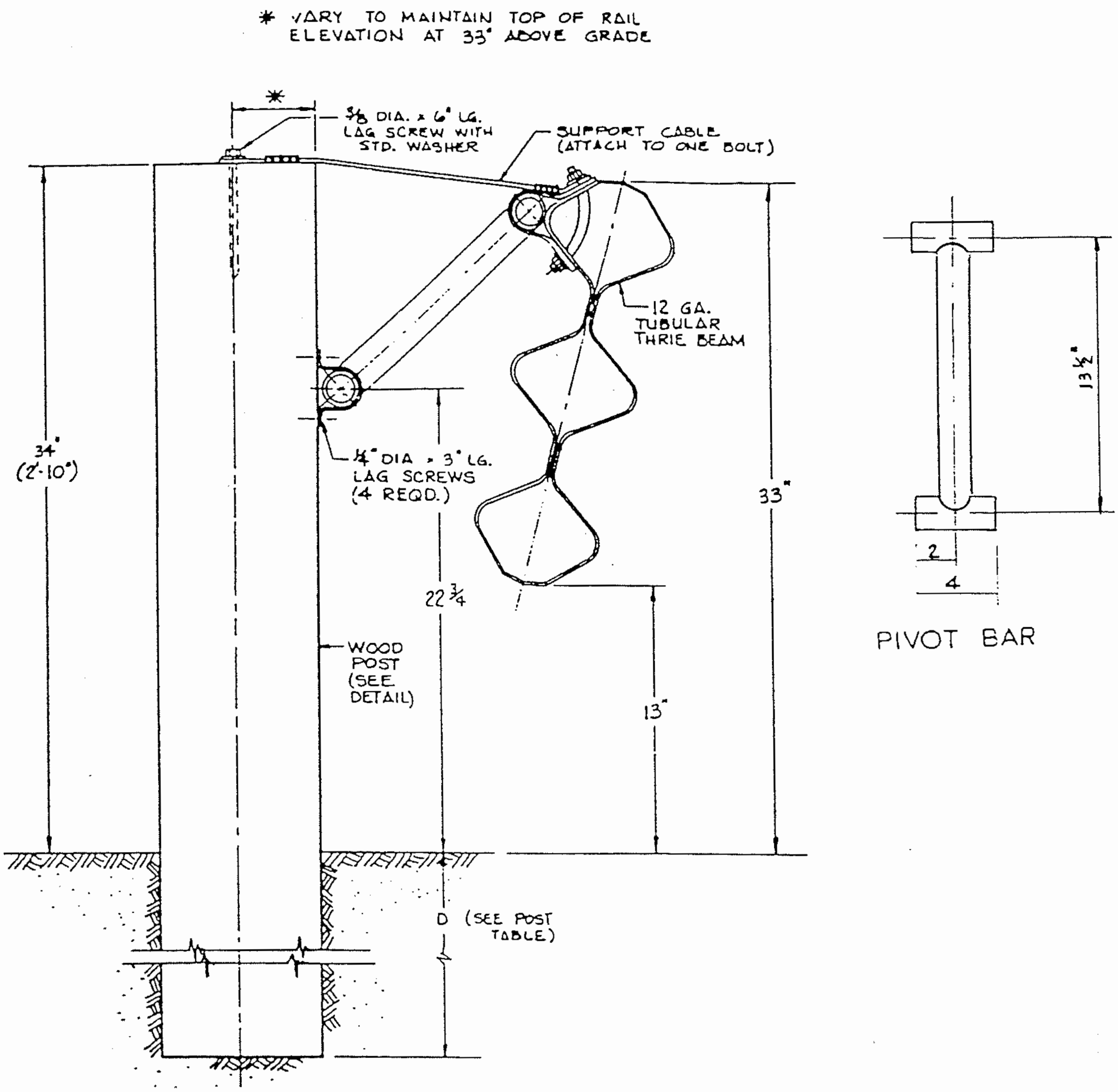

Figure 2.1 SERB Guardrail Design

The assembly is held up by 18 1/2" long x 3/16" diameter steel support cable connecting the rail to the top of the wooden post as shown in Figure 2.2. This type of connection is used on every other post. The remaining posts are placed in line, and serve to support the guardrail against horizontal forces when it is pushed up against the Posts.

Figure 2.2: Pivot bar and support cable.

The SERB guardrail is held together longitudinally by an internal splice, as shown in Figure 2.3. This splice plate slides into the ends of two adjoining rails. Six 3/4" diameter x 2" long bolts are used to fasten the internal splice to the end of the rail.

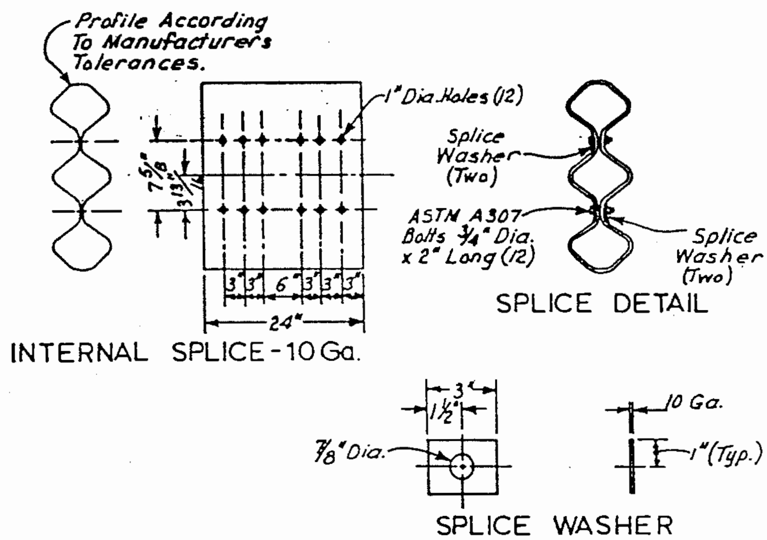

Figure 2.3: Internal splice used in the SERB guardrail

When assembled, the SERB guardrail hangs with the bottom of the rail 13" above the ground and the top of the rail 33" above the ground. The support cable is always in tension, except when the SERB guardrail is hit.

If the SERB guardrail is hit, the pivot bar allows the rail to deflect upward and outward, and then return to its original position, as shown in Figure 2.4. This allows the guardrail to follow the upward motion of the vehicle, and makes the redirection of the vehicle smoother.

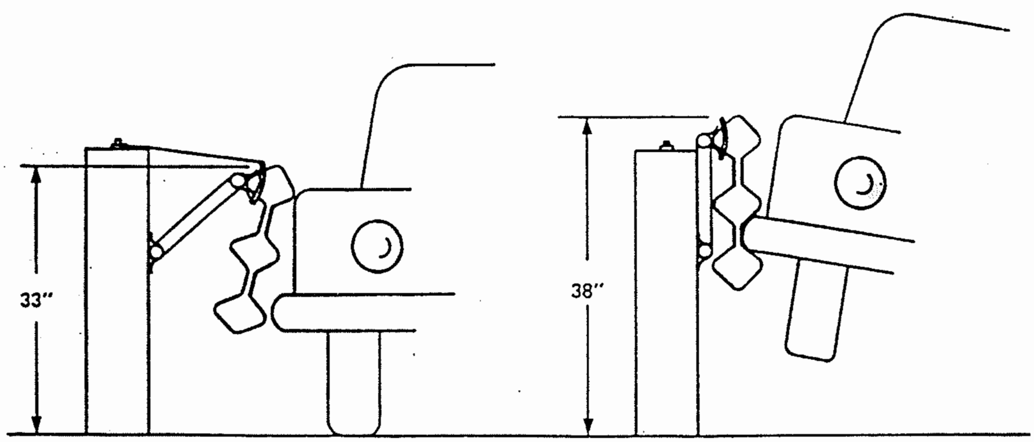

Figure 2.4 SERB reaction to a small angle collision.

In a series of full scale tests performed by Southwest Research, the SERB guardrail functioned as intended when struck by an 1800-lb automobile at 55 mph and a 17° impact angle, and by a 40,000-lb. intercity bus at 57 mph and a 16° impact angle (*Traffic Barrier Systems, 1986*).

3.0 INSTALLATION

3.1 SITE LOCATIONS

Two sites were chosen for the installation of the SERB guardrails. The first SERB guardrail was installed along the shoulder of the northbound lanes of Interstate 5 (I-5) between mileposts 5.99 and 6.23 in Jackson County. It was installed in October, 1988. The second SERB guardrail installation was on the same stretch of highway between mileposts 5.19 and 5.28. It was installed in June, 1989. Both of these installations were included in the South Ashland Interchange - California State Line Section Paving Project (Rusnak and Scholl, 1990). These sites were selected because of their higher than average frequency of vehicle-guardrail collisions and, resulting maintenance.

3.2 INSTALLATION

To keep the same alignments for the wider SERB guardrails as the existing guardrails, the wooden guardrail posts had to be installed an extra 6" away from the travel lane. The SERB guardrail posts required a spacing of 4'2", compared to 6'3" for the standard type 2A guardrail. Since each SERB tubular thrie beam section is 24' 11 1/2" long, with a 1/2"gap allowance for the splice, each section required seven posts for support (center-to-center). The posts were installed using the standard machine driving method.

The size and weight of the guardrails made it very difficult to work with them. The tubular thrie beam sections had to be moved with a fork lift truck and suspended from chains during installation. Due to the large size of the tubular thrie beam and the area required to maneuver the machinery, two lanes of traffic needed to be closed.

Probably the most difficult task in working with the SERB guardrails was the installation of the splice plates. The thrie beams were very stiff and it was often impossible to slide the splice pates between the thrie beams. To install the splice plate, the thrie beams had to be wedged apart and the splice plate then inserted. Sometimes the splice plate had to be hammered into place. However, extra care was given to preserve the galvanized coating. Once the splice plate was in place, it was fastened to the ends of each rail section with six 3/4" diameter x 2" long bolts, each with a pair of 2" x 3" 10-gauge splice washers (Figure 3.1).

Figure 3.1 Splice plate used in the SERB guardrail construction.

3.2.1 1988 INSTALLATION

The SERB guardrail was installed in October, 1988 on a descending mountain pass with a 5 1/2 percent grade. The north end of the SERB guardrail was fastened to the south end of a special barrier built for a truck escape ramp. The lane configuration and location of the guardrail are the same as the previously installed conventional guardrail. Alignment ranged from a straight line to a 7° curve. Super elevation rates ranged from 0.02 to 0.1 ft/FT. A typical cross section of the northbound lanes include a paved 6'median, two 12' travel lanes, and a 10' paved shoulder.

3.2.2 1989 INSTALLATION

An additional 500' of the SERB guardrail was installed in June, 1989. It was placed less than 1 mile south of the SERB guardrail installed in 1988. The guardrail is on a straight section of the highway with the same cross section and grade as the 1988 installation.

4.0 COST INFORMATION

4.1 INSTALLATION COSTS

A contract for the South Ashland Interchange - California State Line Section project was awarded to Ball, Ball, and Brosamer. The contract included SERB, type 2A, and type 3 guardrails. The guardrail lengths, unit bid prices, and total bid prices are listed in Table 4.1.

Table 4.1: Cost Information for Different Guardrail Types Used in South Ashland Interchange - California State Line Section

Guardrail	Length (Feet)	Unit Bid Price (Per linear foot)	Total Bid Price
SERB	1,850	$54.00	$99,990.00
2A	73,114	7.00	511,798.00
3	104	18.00	1,872.00

The 1988 SERB guardrail installation was recorded with a video camera. The Project Manager used this video tape to make an estimate, based on the run time of the video and the number of laborers, of the actual construction costs for that section of SERB guardrail. The estimated actual costs were broken down as follows:

Labor	$ 7,240.40
Equipment	6,923.29
Materials	34,830.00
TOTAL	**$48,993.69/1290 L.F. = $37.98/L.F.**

If this figure is compared to the bid price of $54.00/L.F., it appears that costs can be lowered when future sections of SERB guardrail are installed.

4.2 MAINTENANCE COSTS

It would have been beneficial to compare the maintenance costs of the SERB guardrails to the original conventional barrier which it replaced. However, maintenance information for the original barrier is not available.

Since there has been no damage requiring maintenance, no maintenance costs have incurred. In the event that a section of the SERB guardrail would require replacement, the cost to repair the guardrail would be dependent on the distance from the ends of the guardrail to the location of the damaged section. With the design of the splice the way it is, to replace a section of the guardrail requires ODOT Maintenance staff start at one end of the guardrail system and remove one section at a time until the target segment is reached. At this point, the damaged section can be replaced, and the guardrail may be reassembled. Unless the damaged section was near an end, the labor costs of the repair potentially could be very high.

5.0 EVALUATION

5.1 ACCIDENT FREQUENCY AND TYPE

The accident frequency of the previous guardrail was less than that of the SERB guardrail. In the four years prior to the SERB installation, two guardrail hit accidents were reported. Three accidents with guardrail hits were reported in the four years after the installation of the SERB as shown in Table 5.1.

Table 5.1: Reported Accidents in test zone.

YEAR	HIT RAIL	MILEPOINT 5.2	SURFACE	SEVERITY	COMMENTS
1984	NO	5.22	ICE	INJURY	CAR, SPEED
1984	YES	6.13	ICE	PDO	CAR
1985	NO	6.00	ICE	PDO	CAR
1985	YES	6.08	DRY	PDO	TRUCK, SLEEP
1988	NO	6.00	ICE	PDO	2 CARS
1989	NO	5.20	SNOW	KILL	CAR, DRUNK
1990	NO	6.00	ICE	INJURY	3 CARS, 1 TRUCK
1990	NO	6.00	ICE	PDO	1 CAR, 2 TRUCK
1990	YES	6.13	ICE	PDO	2 CAR, 2 TRUCK
1990	YES	6.22	DRY	INJURY	1 CAR, SPEED
1990	NO	6.13	ICE	PDO	2 CAR
1991	NO	6.00	ICE	PDO	1 CAR, 1 TRUCK
1991	YES	6.00	SNOW	INJURY	3 CARS
1991	NO	6.00	DRY	PDO	1 CAR, DEER
1992	NO	6.00	ICE	PDO	1 CAR, 1 TRUCK

Most of the reported accidents were confined to a section at milepost six. This is a curve to the left with super elevation and on a grade. (See Figure 5.1) Collisions in this area were typically multi-vehicle and involved ice or snow on the road surface. There were as many reported collisions with the median barrier on the left as there were collisions with the guardrail on the right.

Figure 5.1 Many accidents are reported at milepost six.
Also note lane closure for SERB removal.

Not all collisions with the guardrails are reported: If the motorist can drive away, they do often without reporting the accident. ODOT Maintenance does not have an exact number of impacts, but they do recall more hits than those reported.

5.2 ACCIDENT DAMAGE TO SERB GUARDRAIL

Major damage to the SERB Guardrail was done by an out of control tractor-trailer truck in early 1993. This accident was not reported to the DMV but details were deducted from skid marks and damage to the SERB installation . Several posts were split and 2 cables were broken. One section of the thrie-beam was bent severely. One of the support arms came loose when the arm connecting bolts were sheared by the impact. (See Figures 5.2 and 5.3).

Figure 5.2 Top left - Top of posts damaged
Bottom left - Broken cable; cable cutting into post
Top right - Dent from impact..
Bottom right - Snow plow guage.

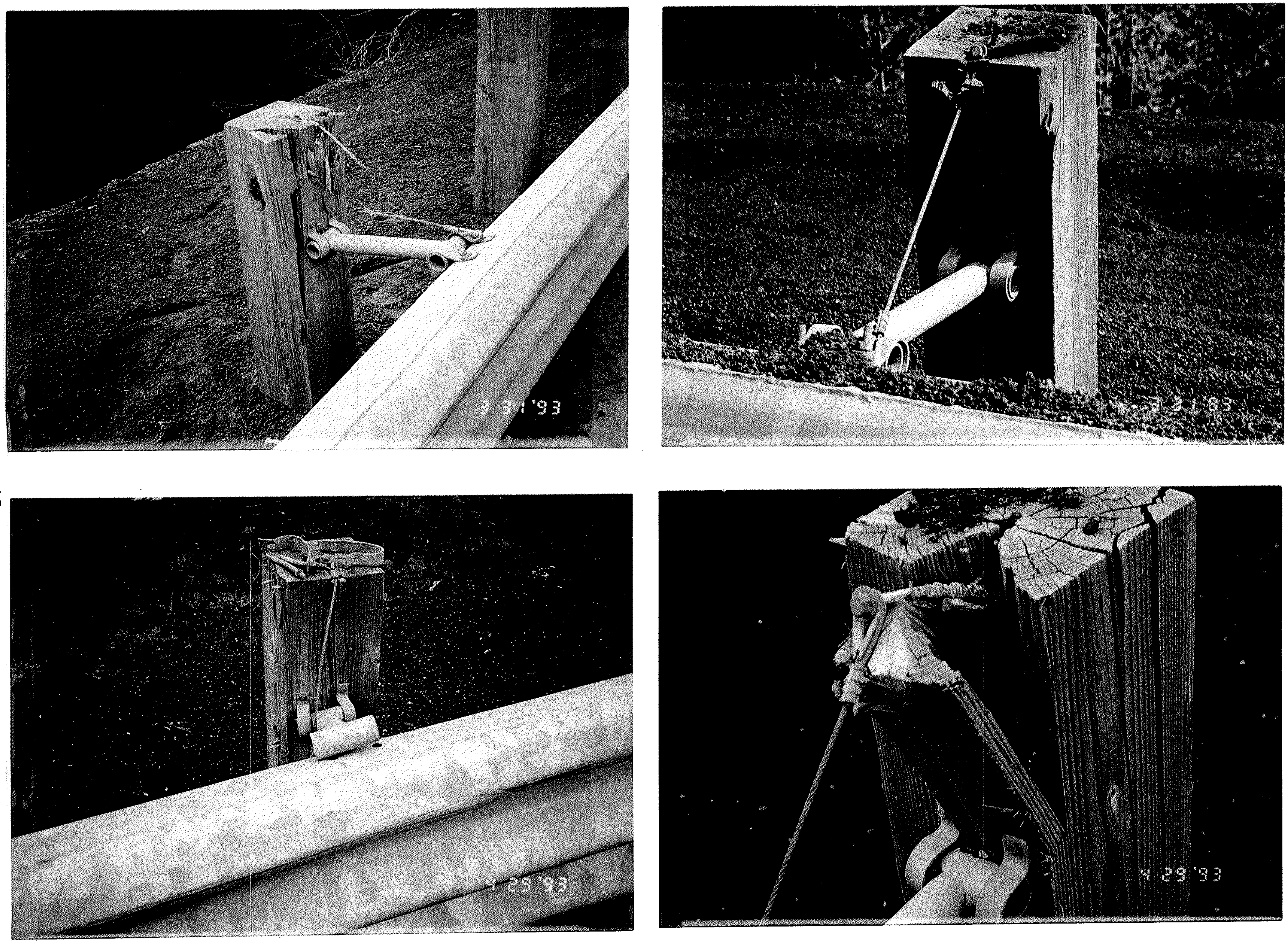

Figure 5.3 Typical damage to SERB Components

Top left - Post split and cable broke by impact   Top right - Post splayed by cable, lag bolt pulled to side.

Bottom Left - Sheared not clamp bolts sheared from pivot arm   Bottom right - Post split, lag bolt pulled to side and bent. Not corded threads..

The broken arm allowed the thrie-beam to rest on the asphalt shoulder. The height of the top of the rail was only 23 inches at this section. The recommended minimum is 28 inches to prevent vaulting on a vehicle impact.

5.3 SERB CONDITION REPORT

The SERB rail was reported to be sagging in 1991. A field check indicated that it was sagging. The average height was about 30 inches or about 3 inches lower than the design height. This was still above the minimum recommended height of 28 inches.

In April of 1993 the rail height was checked again. Several hundred feet were found to be below the 28 inch required height. The posts were checked for height and found to be close to the design standards of 33 inches. The posts were also plumbed and aligned. Thus rail height was controlled by the support cables length. The length of the cables had not changed significantly (See Table 5.2)

Table 5.2 Top of rail measured from the Asphalt shoulder.

SERB GUARDRAIL INSTALLATION	**FROM MP 5.19 TO MP 5.22 SOUTHBOUND**	
STATION	**HEIGHT**	
	1991	1993
0+00	31	30
1+00	30	26
2+00	29	26
3+00	29	27
4+00	30	27
5+00	31	28

SERB GUARDRAIL INSTALLATION	**FROM MP 5.99 TO MP 6.23 SOUTHBOUND**	
STATION	**HEIGHT**	
	1991	1993
0+00	33	31
1+00	32	27
2+00	30	28
3+00	30	28
4+00	30	29
5+00	32	31
6+00	31	30
7+00	32	30
8+00	32	23
9+00	30	23
10+00	30	28
11+00	31	31
12+00	30	31
13+00	36	33

The main cause of the sag was found to be movement of the lag bolts in the post. Some bolts were partially pulled out the from post top and leaned toward the rail top. In other cases the posts split, allowing the bolt to move toward the rail top. A few bolts were sheared off at the post top.

Snow plow operators observed that the action of snowplowing caused the SERB to activate. After the plow passed, the SERB would return to its rest position very abruptly. This jarring is believed to be the cause for the lag bolt shift in the post (See Figure 5.3).

5.4 FINAL SOLUTION: SERB REMOVAL

The damaged section of the SERB which was resting on the shoulder needed quick repair. Also, many sections of sagging rail needed to be raised. Several solutions were suggested. One was to jack the rail up and attach the cables by placing the lag bolts on the back of the post. Another was to place a steel plate on the post top to prevent the cable from cutting into the post. The damaged rail could be cut with a torch and a new section welded into place (See Figure 5.5).

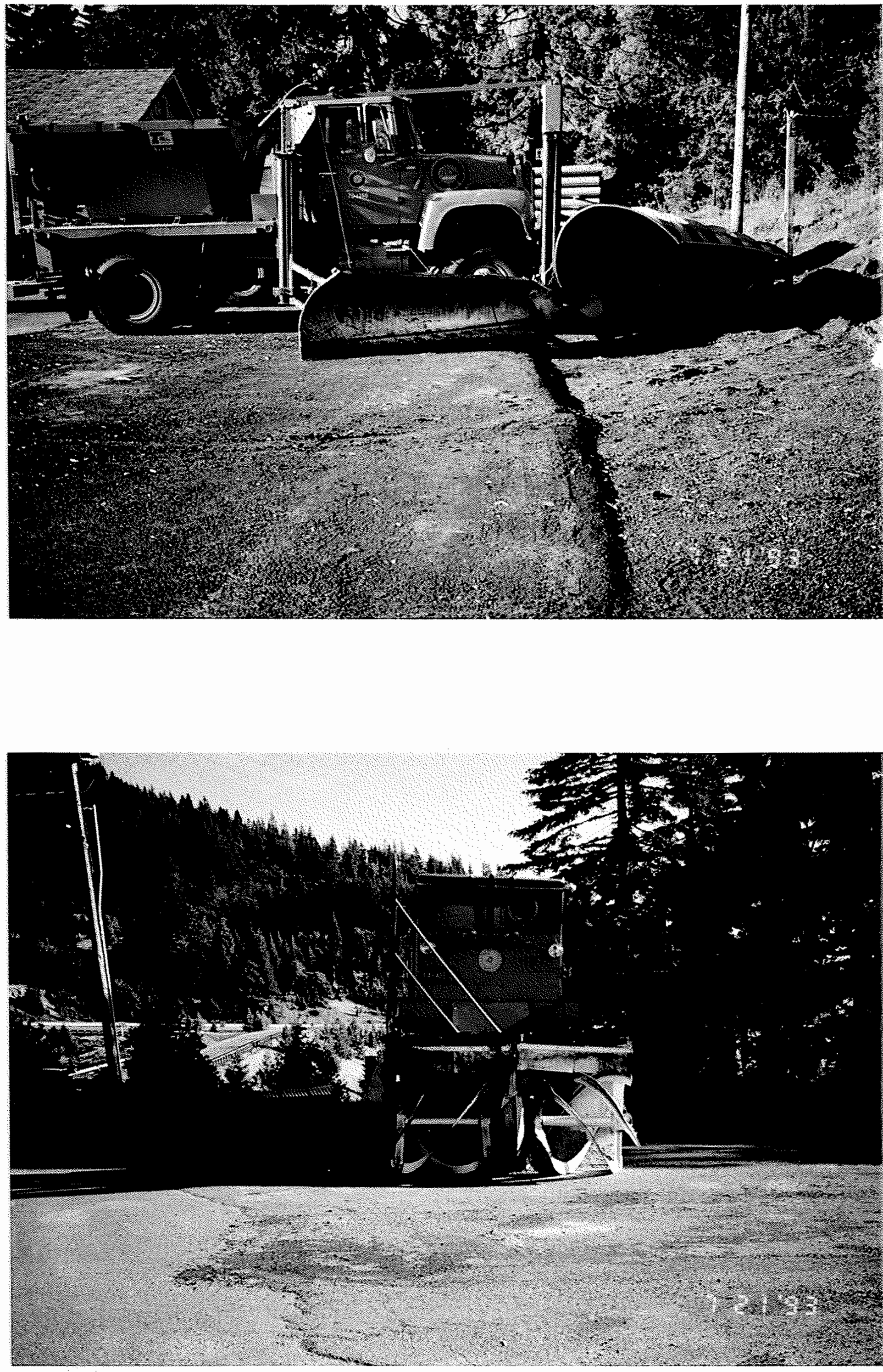

Figure 5.4 Snow removal equipment used on Syskiyou grade.
Truck mounted snowplow(top). Snow blower (bottom).

Much of the sagging problem was caused by snow plow operations. Snow plows impact on standard guardrails is only minor. Since this section receives several snow storms each year, it is important to keep the roadway plowed. Keeping the plows from hitting the SERB was not practical.(Figs. 5.4)

ODOT maintenance forces decided to remove the SERB installation rather than experiment with repair methods. Standard repair methods had not been established and were believed to be costly(see section 4.2).

The entire installation was removed in July of 1993. Removal called for one lane of traffic to be closed, in order for the equipment to maneuver. The rails were unbolted at the splice plates and removed by a front end loader. A special hydraulic lift attachment for the front end loader had to be rented for this job. The operator lifted the SERB sections by balancing the beam as a counter lever. A chain connected near the hoisted end secured the section. This was a slow process and required a great deal of skill by the loader operator.(See Figure 5.6) This same method was used to load the SERB onto a trailer.

Posts were pulled with a hydraulic scoop. A chain was wrapped around the post and hooked over the bucket. The bucket was then raised to pull the post out of the ground. This method is used often by field crews.

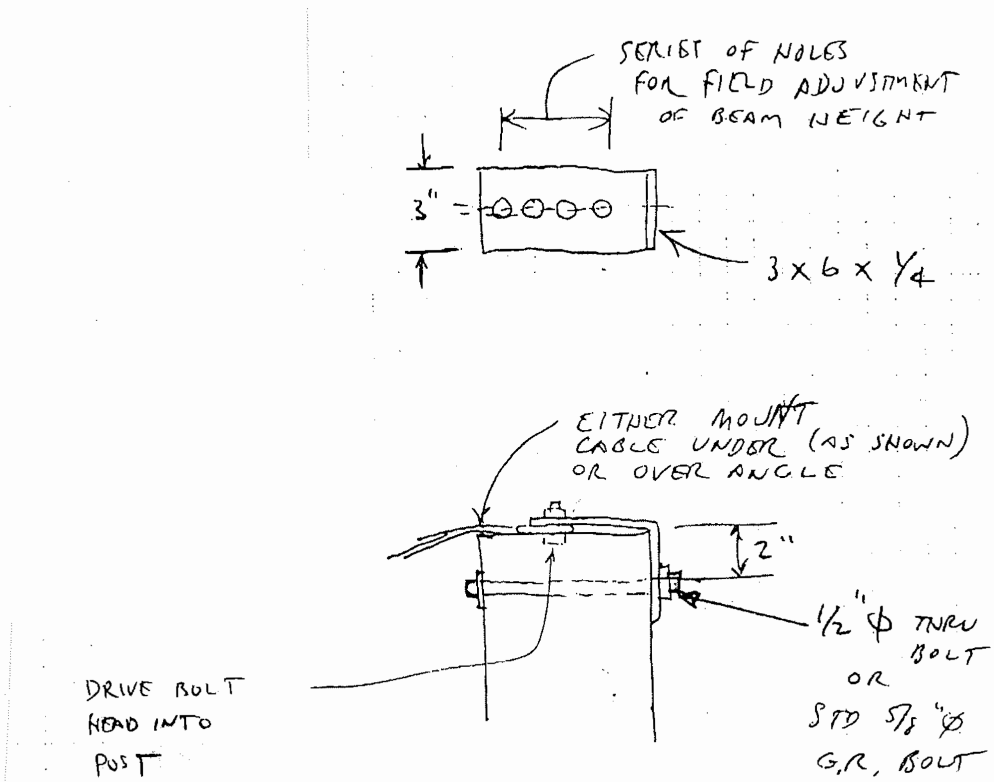

Figure 5.5 Drawing of suggested improvement for cable mounting.

Figure 5.6 A special attachment for the front end loader was rented to move SERB sections.

6.0 CONCLUSIONS AND RECOMMENDATIONS

1. The SERB guardrail was effective in redirecting larger vehicles back to the travel lane.
2. More damage was done to the rail and hardware then suggested by the manufacture.
3. Repairs to the rail are expensive, based on the removal experience of ODOT maintenance forces.
4. The SERB may not work well in snow zones due to snow encasing the rail.
5. Because the SERB rails are damaged by snowplow operations, they should not be installed in snow zones.

7.0 REFERENCES

Rusnak, J.S., and Scholl, L.G., "SERB Guardrail In-Service Evaluation," Construction Report, FHWA Experimental Feature Project No. OR 88-02, Oregon Department of Transportation, Salem, Oregon, March 1990.

Traffic Barrier Systems, Federal Highway Administration, Office of Highway Operations, Washington D.C. Project No. 64, Supplement No. 5 May, 1986.