FOLLOW UP OF INJECTED POLYURETHANE SLAB JACKING

by

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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	(F-32)/1.8	Celsius	°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
m^2	meters squared	1.196	square yards	yd^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	1.8C+32	Fahrenheit	°F

*SI is the symbol for the International System of Measurement

ACKNOWLEDGMENTS

The author thanks Steven Soltesz for providing his previous report to follow up and for being so supportive during this apprenticeship. The author also thanks ODOT Research for making work fun and enjoyable. The author appreciates all those who helped out by providing needed information in the compilation of this report.

DISCLAIMER

FOLLOW UP OF INJECTED POLYURETHANE SLAB JACKING

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1.0 INTRODUCTION

1.1 GLENN JACKSON BRIDGE FOLLOW-UP REPORT

The elevation monitoring in the report entitled Injected Polyurethane Slab Jacking (*Soltesz 2000*) is continued in this current report. The elevations of the concrete slabs are being monitored to see if polyurethane slab jacking is effective or not. The site has been monitored periodically since it was slab jacked three years ago. The current report will give a summary of the site as it is after three years.

1.2 OREGON'S EXPERIENCE WITH INJECTED POLYURETHANE SLAB JACKING

The purpose of this section is to see how successful slab jacking has been in Oregon. Information on slab jacking sites was requested from personnel in all of Oregon's maintenance districts.

2.0 TESTING METHODS

2.1 GLENN JACKSON BRIDGE FOLLOW UP REPORT

Brass survey nails were placed at twelve positions in the roadway for the first survey shortly after slab jacking. These positions were used to monitor the change in elevation of the slabs. The arrangement of the positions is shown in Figure 2.1.

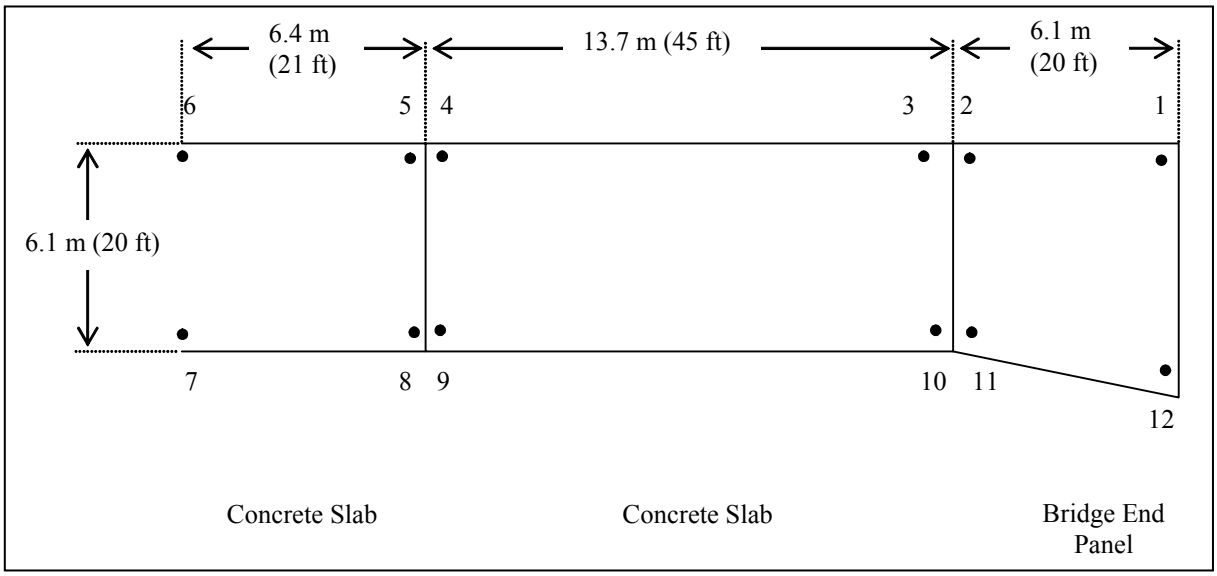


Figure 2.1: Arrangement of the brass surveying nails used to take elevation measurements

2.2 OREGON'S EXPERIENCE WITH INJECTED POLYURETHANE SLAB JACKING

Information on the slab jacking sites was requested of each maintenance district. Below are the different points of information gathered for each site:

- date of slab jacking
- exact road location of site
- cost of project
- current status of the road
- sub grade/ base material

- ADT (average daily traffic)
- pavement material
- original problem (water drainage, unstable sub grade)
- effort to fix the original problem
- injection target
- drilling depth
- amount of polyurethane injected
- dimensions of slabs (if concrete)
- number of slabs (if concrete)
- contractor
- reason for using polyurethane
- time to complete slab jacking

These data were used to compile a spreadsheet comparing different elements of each site.

3.0 RESULTS

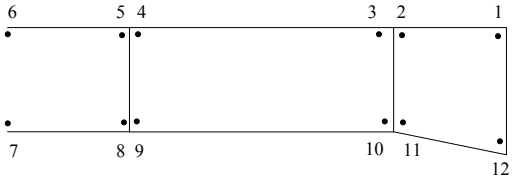
3.1 GLENN JACKSON BRIDGE FOLLOW-UP REPORT

After three years, ten of the twelve positions show continued settling. The rate of settling (change in elevation of the slab) has decreased but has not stopped altogether. The results are shown in Table 3.1 and Figure 3.1.

Table 3.1: Relative change in elevation over time with respect to the first, post-injection survey on 6/14/2000. All measurements are in millimeters. Position locations are shown in the diagram.

Positions	9/14/2000	12/14/2000	6/14/2001	12/17/2001	6/17/2002	7/07/2003
12	-2.4	-3.6	-1.6	-2.0	-2.7	-1.8
11	-7.2	-7.7	-8.1	-8.5	-10.5	-11.5
10	-6.0	-6.7	-7.0	-8.0	-9.7	-10.3
9	-4.8	-5.4	-5.1	-6.1	-6.8	-7.7
8	-5.3	-4.8	-6.1	-6.3	-7.3	-8.5
7	-3.4	-4.4	-4.8	-4.2	-5.3	-5.9
6	-3.1	-4.1	-4.5	-4.9	-5.3	-5.7
5	-4.5	-4.5	-5.3	-6.6	-6.9	-7.5
4	-4.7	-5.5	-5.8	-7.6	-7.9	-7.9
3	-5.3	-5.5	-6.7	-9.0	-9.7	-10.2
2	-4.6	-6.0	-6.6	-8.8	-9.8	-11.0
1	-1.5	-1.1	-0.9	-1.9	-2.1	-0.8

Position Locations:



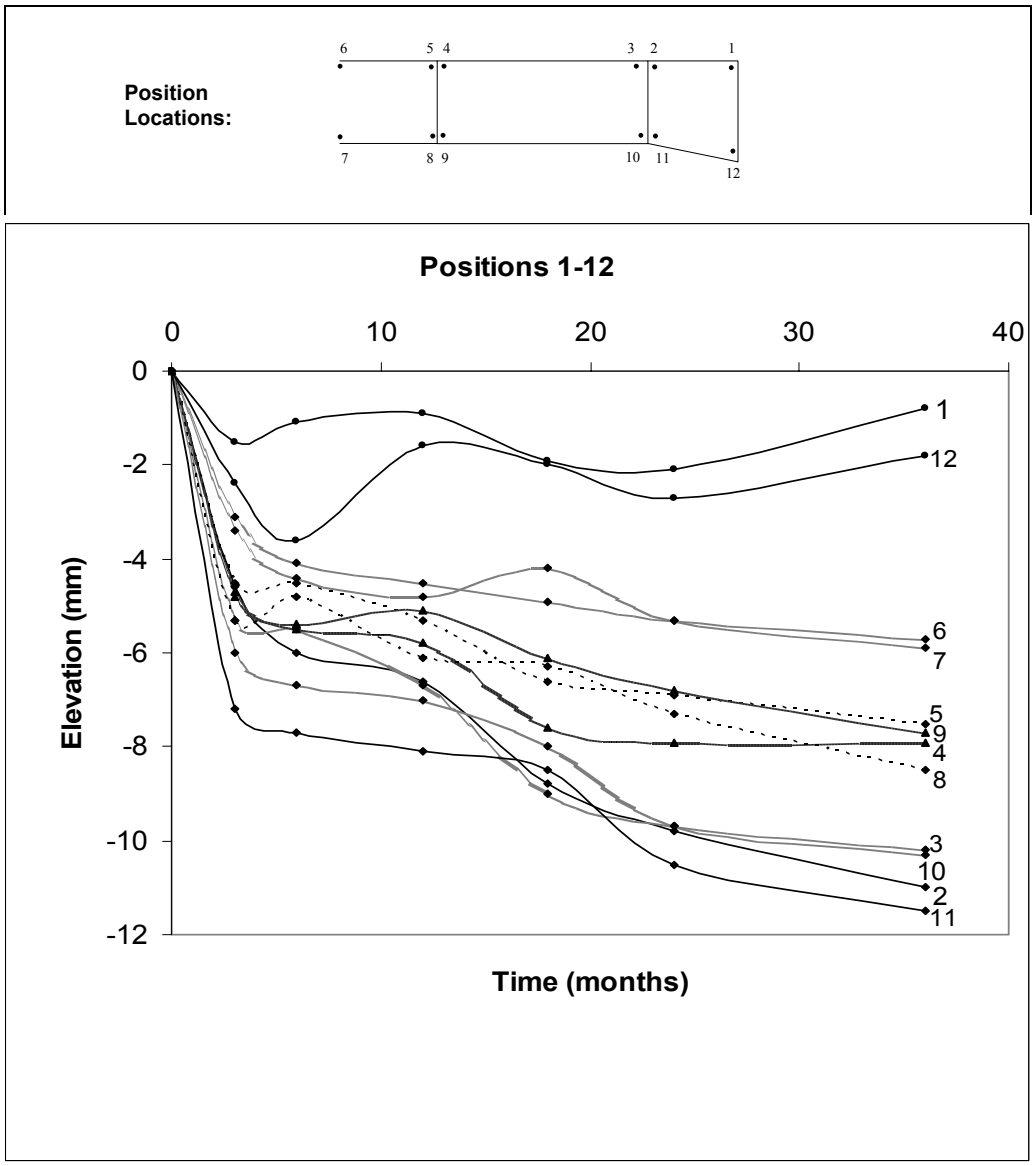


Figure 3.1: All twelve positions graphed by change in elevation (mm) over time (months)

The twelve curves in Figure 3.1 showed a natural separation into four groups: 1 and 12; 2, 3, 10, and 11; 4, 5, 8, and 9; and 6 and 7. The positions within these groups happen to be within relatively close proximity to each other on the roadway.

Graphs of the four position groupings showing elevation change over time relative to the first survey are shown in Figures 3.2 - 3.5. Positions 1 and 12 fluctuate over time, but they have an approximate slope of zero. The remaining ten positions all show settling.

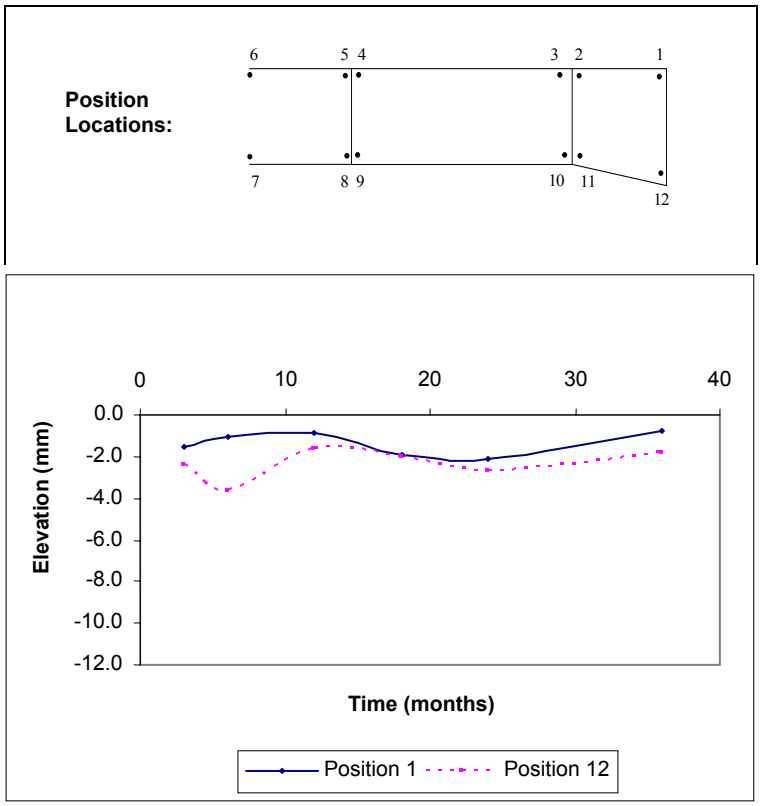


Figure 3.2: Elevation change over time of Positions 1 and 12

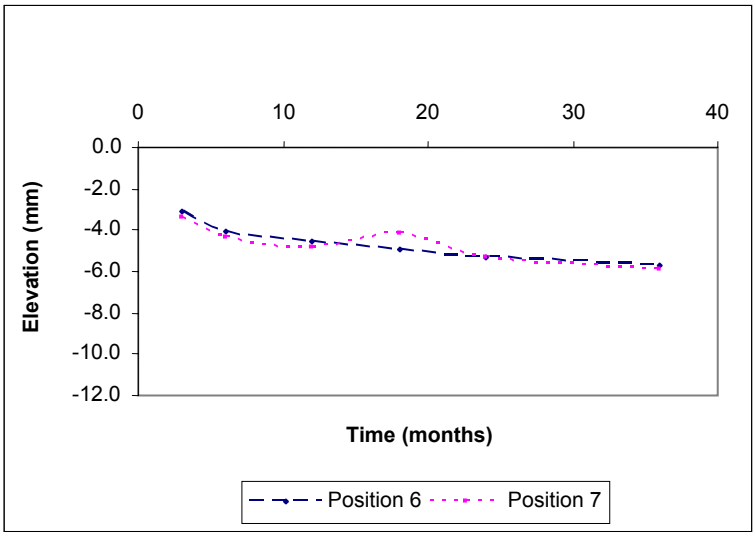


Figure 3.3: Elevation change over time of Positions 6 and 7

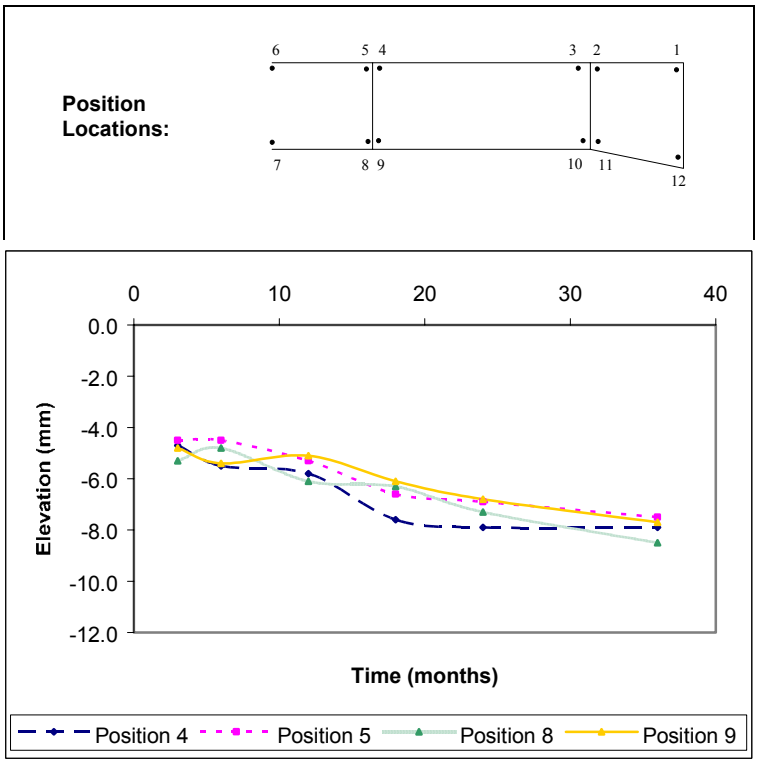


Figure 3.4: Elevation change over time of Positions 4, 5, 8, and 9

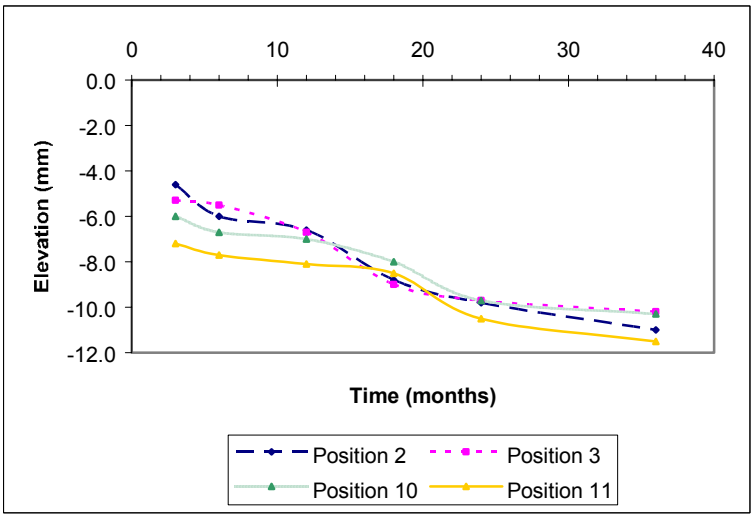


Figure 3.5: Elevation change over time of Positions 2, 3, 10, and 11

Linear regression was used to determine the line of best fit for Positions 2 through 11 as shown in Table 3.2. The slopes of the lines provide an estimate of the rate of settling at each position. The average rate of settling was calculated for the three groups containing Positions 6 and 7,

Positions 4, 5, 8, and 9, and Positions 2, 3, 10, and 11. The group of Positions 2, 3, 10, and 11 had the largest settling rate over the past three years with an average rate of elevation loss of 1.9 millimeters per year.

Table 3.2: Results of linear regression for each position and the average settling rate for groups of positions calculated from the slopes

Position	Equation	Correlation Coefficient (R^2)
1	slope is approx. 0	
2	y=-0.1948x-4.5856	0.95
3	y=-0.1673x-4.9735	0.89
4	y=-0.103x-4.8673	0.81
5	y=-0.1012x-4.2136	0.92
6	y=-0.0707x-3.4341	0.87
7	y=-0.0631x-3.6259	0.78
8	y=-0.1072z-4.6148	0.95
9	y=-0.0876x-4.5375	0.94
10	y=-0.1367x-5.694	0.95
11	y=-0.1347x-6.6936	0.94
12	slope is approx. 0	

Positions by Groupings	Average Settling Rate mm/mo (mm/yr)
1 and 12	approx. 0
6 and 7	-0.067 (-0.80)
4, 5, 8, and 9	-0.10 (-1.2)
2, 3, 10, and 11	-0.16 (-1.9)

Position Locations:

3.2 OREGON'S EXPERIENCE WITH INJECTED POLYURETHANE SLAB JACKING

According to maintenance personnel, Oregon's experience with injected polyurethane slab jacking has been successful. Table 3.3 includes the information gathered on some of the slab jacking sites in Oregon.

Table 3.3: Site evaluation spreadsheet

Information Requested	Site								
	Corvallis #1	**Corvallis #2**	**GJ Bridge**	**Boyer Hill**	**I-5 Eugene**	**Iowa St Slide**	**hw20 Toledo**	**hw 101**	**I-5 Azalea**
Date	1999	1999	Jun-00	Oct-01	Spring 2001		Jul-03	2001-2003	1999 - pres.
Road location	NW Walnut Blvd. between King Blvd. and Rolling Green Dr.	NW Walnut Blvd. between Rolling Green Dr. + NW Garry-anna Dr.	I-5 south bound off-ramp to the Portland airport	Highway 18 between McMinnville and Lincoln City, 14 miles from the coast	I-5 impact panels on 8 bridges be-tween mile post 174.41 and 179.64 12 miles s of Eugene	Mile point 298.4 on I-5 near Terwill-iger Curves right hand lanenorth bound	Highway 20 Toledo business loop, filled in an old ODOT weigh scale site	Highway101 from New-port to Cape Foulweather inject where landslides begin, more than 1 site	20-30 sites through mile posts 87-81 on I-5 south bound between Azalea and Glendale
Cost	$24,000	warranty item, no cost to city	$42,260	$3,250	$55,000	$3,500	$1,756	$15,000	
Current status	partly replaced	good	good	good	good		good stable	good, greatly reduced annual soil move-ment	road in poor shape but urethane is helping to keep it together until project in 2007
Sub grade/base material	lime-treated base	lime-treated base	sand	sand dirt 2ft rock wood chip	bar run-river rock, sand, dirt	silt, sand, and clay	1 foot gravel then dirt	sand	clay and rock
ADT	10,000	10,000	132,200	17,300	40,000		17,000	18,000	16,000
Pavement material	PCC	PCC	PCC	AC	PCC	PCC w/ AC on top	AC	AC	30 yr. old PCC
Original Problem	not sure	not sure	leaky pipe	landslide	sub grade	slide movement	void from old weigh scale	landslide	drainage + subgrade

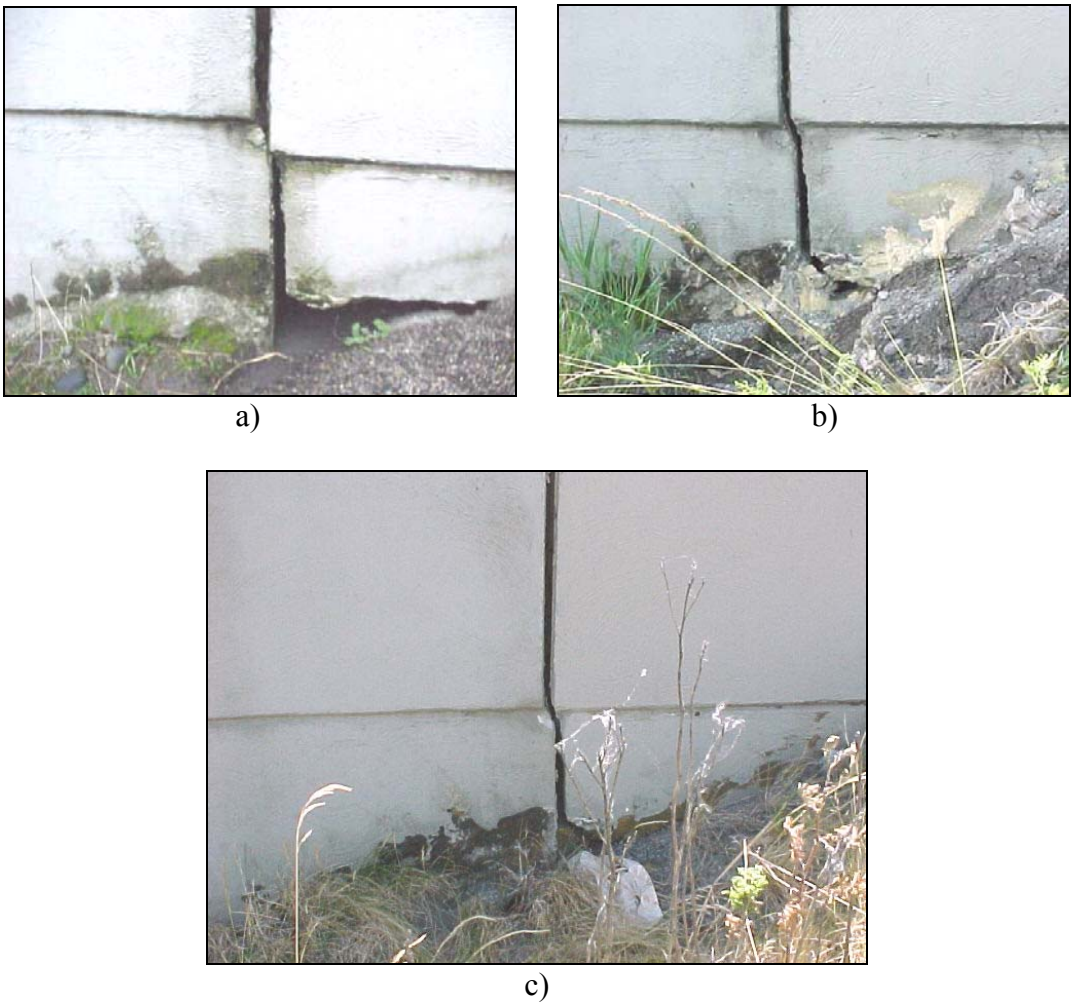
Information Requested	Site								
	Corvallis #1	**Corvallis #2**	**GJ Bridge**	**Boyer Hill**	**I-5 Eugene**	**Iowa St Slide**	**hw20 Toledo**	**hw 101**	**I-5 Azalea**
Effort to fix original problem	nothing	nothing	fixed pipe	woodchips to support road after landslide, polyurethane to protect from water damage	nothing	stabilize sub grade by drilling down past the base in to the sub grade	injected urethane to bring road bed up	inject ure-thane into cracks to prevent fur-ther sliding	had replaced road but that was expensive, also asphalt overlays and cement grout
Injection target	under concrete	into sub grade	into sub grade	between sub Grade and wood chips	under concrete+ base matter	into sub grade	into sub grade	deep into sub grade	under concrete
Drilling depth	6-8 inches	36 inches	20 inches	4 feet	12 inches		3 feet	up to 30 ft	10 inches
How much polyurethane was injected?	4,800 lbs.	not sure	4649 lbs.	650 lbs.	9,100 lbs.	585 lbs.	290 lbs.		
Dimensions of slabs (if PCC)	12' x 15'	12' x 15'	45' x 20'	doesn't apply	24' x 20'	doesn't apply	8' x 8' void	too many sites	too many sites
Number of slabs (if PCC)	30	20-25	1	doesn't apply	not sure diff. sites	doesn't apply	doesn't apply	too many sites	too many sites
Contractor	URETEK	URETEK	URETEK	Spray Foam, Inc. Albany,OR	URETEK	URETEK	Spray Foam, Inc. Albany,OR	Spray Foam, Inc. Albany,OR	URETEK
Reason for using polyurethane	wanted to try new product, lower intrusion into concrete panels, easy clean-up after process is completed		wanted to try something new, confi-dent in URETEK's abilities	prevent combustion of wood Chips light weight cost effective Wouldn't cause another landslide	liked the idea of this method better than the old methods (cement grout, asphalt pave-over)	lightweight material would not cause any more slide movement in the area	lightweight material that would fill in void caused by old weigh scale, would not cause any more sinking	lightweight material that won't cause future sliding, better than cement grout(heavy)	don't want to dig up road yet, don't like cement grout, using urethane to temporarily stabilize the road bed
Time to complete project	4 days	4 days	6 hrs	1 1/2 hrs	4 days	1 night	2 hrs	8 hrs each	1-3 slabs/dy

Information Requested	Site								
	Corvallis #1	**Corvallis #2**	**GJ Bridge**	**Boyer Hill**	**I-5 Eugene**	**Iowa St Slide**	**hw20 Toledo**	**hw 101**	**I-5 Azalea**
Other site notes	will have finish replacement of the road	had to grate road in order to make it smooth	used as Steve's test site (elevation)	used poly. to fix a previous landslide	1 panel did not work, rebar stuck, URETEK responsible				have done many sites to keep road ok until repair proj. in 2007
Contact information	Scott Dickinson (541) 766-6916	Scott Dickinson (541) 766-6916	Steve Soltesz (503) 986-2851	Jerry Stokes (541) 563-6400	Donald Angermayer (541) 686-7642	Ron Kroop (503) 229-5266	Jerry Stokes (541) 563-6400	Jerry Stokes (541) 563-6400	Darrin Neavoll (541) 957-3666

4.0 CONCLUSIONS

4.1 GLENN JACKSON BRIDGE FOLLOW UP REPORT

Because this slab jacking site has only been tested for three years, it is hard to make any conclusions about whether or not injected polyurethane has been a good solution to the original problem. The settling of the position groupings ranged from 0 to 1.9 mm/yr. However, to the naked eye, this site has not changed since slab jacking was done, as shown in Figure 4.1.



a) b)

c)

Figure 4.1: Side view of joint between bridge end panel and the adjacent slab (between Positions 2 and 3): a) before slab jacking; b) four days after slab jacking; c) three years after slab jacking

4.2 OREGON'S EXPERIENCE WITH INJECTED POLYURETHANE SLAB JACKING

Based on the slab jacking sites investigated, Oregon's experience with injected polyurethane slab jacking has been successful. Slab jacking was used for fixing road problems caused by water drainage and unstable subgrades and for fixing/preventing landslides in wet areas such as coastal regions. It was used successfully for both asphalt and concrete pavement. However, using polyurethane slab jacking does not guarantee success, as illustrated by the site in Corvallis. The roadway owner should define the cause of the settling and determine what action is appropriate to solve the problem.

5.0 REFERENCES

Soltesz, S. “Injected Polyurethane Slab Jacking – Final Report.” Report FHWA-OR-RD-02-19, Oregon Department of Transportation. June 2002.