Construction Company University Bridge Project
Noise Exposure Assessment

A Puget Sound road/highway/bridgework construction contractor requested that the University of Washington Field Research and Consultation Group (FRCG) conduct a noise exposure assessment at their University Bridge Seismic Retrofit Project site. Students from an Environmental Health Department class, Environmental Noise, conducted the survey under the direction of Associate Professor Mike Yost and Mary Ellen Flanagan of the FRCG.

The University Bridge Project involved a seismic upgrade of the bridge. The project began in early autumn 1997 and is scheduled for completion in late summer 1998. At the time of the survey 23 workers from six trades were working at the site. During the survey, the standard work week was four 10-hour days, beginning at 7:00 AM.

There is little published information on noise levels during construction projects, and even less specifically for bridge construction. A recent UW graduate student thesis on noise at construction sites found significant noise overexposures. Three hundred thirty-eight noise exposure samples were collected from carpenters, laborers, ironworkers, and operating engineers at 4 construction sites. Forty percent exceeded the Washington Department of Labor and Industries standard of 85 dBA for an 8 hour shift. All four trades could be overexposed, with overexposures most likely to occur during use of heavy equipment or pneumatic tools. Since it is likely that bridge construction has some similar exposures, this project is considered to be a good addendum to the work already conducted.

Bridge construction activities which may produce significant noise exposure include concrete demolition (chipping, sawing), concrete pouring, paint stripping, welding, use of air powered and electric tools including air compressors, generators, and heavy equipment. In addition, many places on the site are close to moving traffic, sometimes in adjacent traffic lanes and sometime directly beneath the bridge deck. At times workers must work in small, closed-in concrete spaces where the reverberation from any noise produced could be considerable.

Methods

Noise exposures were evaluated using data logging dosimeters on all site workers for multiple days. During two one-week periods (May 4 - 7 and May 18-21, 1998) ten dosimeters were placed on workers each day. When a worker was monitored, he/she completed a task data card for that day, recording which activities and tools were used each hour throughout the day. Task data cards were designed specifically for the activities and tools expected for each trade. Examples of these cards are found in Appendix B.

Dosimeters used included five Metrosonics db-308 dosimeters and five Quest Q-300 dosimeters. Dosimeters were pre- and post-calibrated each day. Dosimeters were set to record slow response on the A-weighted scale, with a 5 dB exchange rate, a threshold of 80 dBA, and a criterion level of 90dBA. On one day (May 19) Metrosonics db-307 dosimeters, which do not data log, were used in place of the Quest Q-300 dosimeters.

Dosimeters were placed on the worker at the start of the shift and removed at the end of the shift. They were not removed during the 30 minute lunch break. On the last day of monitoring (May 21), dosimeters were removed after five hours because workers were going off-site for training for the remainder of the day. At the end of each shift, workers were each told their time-weighted average exposures.

Results

A summary of full shift sampling results is presented in Table 1. Over the course of this survey, 55 full shift samples were collected for six trades, the superintendent, and two employees whose primary work tasks were inside the site trailer (construction engineer and safety). The average time weighted average (TWA) dosimeter reading was 89.9 decibels on the A weighting network (dBA) for all 55 samples. Excluding the 5 samples from workers who are mainly in the trailers, the average TWA for workers outside was 91.2 dBA.

The Washington State occupational health standard requires that a hearing conservation program be instituted when 8 hour TWA sound levels are over 85 dBA. At this site, where shifts are 10 hours, the regulatory limit is 83.4 dBA. All workers working outside at this site should be included in a hearing conservation program.

Individual results for each sample included in the data set are listed in Appendix A. Several samples could not be reported due to problems with equipment. Broken microphone wires, loose computer cables, and out-of-tolerance post-calibration values required the removal of several samples from the data set.

Although there were some differences in average noise exposures among the trades (Table 1), the more interesting difference is in the variability within each trade. Carpenters have a much smaller range than pile bucks, laborers, and the welder. This is presumably due to the variety of tasks done especially by pile bucks and laborers, some of which produce very high noise exposure.

Table 1
Full Shift Dosimetry Summary by Trade

Trade	No. of Full Shift Samples	Range (dBA)	10 Hr.TWA (dBA)
Carpenter	15	84.3 - 97.4	89.6
Pile Buck	12	76.8 - 107.1	89.7
Laborer	13	85.0 - 107.1	94.0

Operating Engineer	4	80.5 - 93.0	87.3
Welder	4	86.4 - 107.5	92.6
Iron Worker	1	93.1	93.1
Superintendent	1	75.7 - 90.9	83.3
Construction Engineer	3	65.2 - 75.7	73.2
Safety	2	73.0 - 73.7	73.5

Greatest noise exposures **-** The highest 15% of full shift samples are shown in Table 2. It can be seen that certain activities produce higher noise levels. These include paint stripping with the LTC tool, chipping concrete, and some welding tasks. The LTC machine does paint stripping with air powered shot, and a sand blast recovery system. It is suspected that the laborer doing clean up on May 18 was probably working close to either the laborer doing LTC or the laborer doing concrete chipping.

Table 2 - Highest Full Shift Exposures

Date	10 Hr TWA (dBA)	Worker's Trade	Activity
5/7/98	107.5	Welder	welding in confined area under bridge and close to traffic
5/20/98	107.1	Pile Buck	concrete chipping
5/18/98	107.1	Laborer	paint stripping - LTC
5/4/98	104.1	Laborer	paint stripping - LTC
5/18/98	103.7	Laborer	concrete chipping
5/21/98	101.0 (5 hr)	Pile Buck	welding
5/18/98	100.4	Laborer	clean up
5/20/98	100.2	Pile Buck	paint stripping - LTC

Trade Activities **-** Each trade has a different set of major tasks. Table 3 shows the primary tasks for the major trades represented at this site. For carpenters, building forms produced the highest noise level, particularly when using a power saw. The highest interior finish day (91.9 dBA) the worker reported using hammer and power saw all day.

Concrete chipping and LTC paint stripping and some welding are most significant for pile bucks. Information from the data cards does not give enough details to clarify possible reasons for the large range of noise levels. Additional sampling on workers doing welding would be helpful to determine if certain welding tasks or locations produce different noise exposure.

For laborers, LTC paint stripping and concrete chipping are the most significant noise exposures. Another task which was not characterized during this survey but may also produce significant exposure is concrete pouring. Sound level measurements during a concrete pour showed greatest sound levels inside the plywood form (104 dBA) and standing on top of the plywood form directing hoses (97 dBA) and standing 3 feet from a

generator (95 dBA). These are all positions at which laborers appeared to work for long periods. This activity should be better characterized with full shift sampling.

Table 3 - Primary Tasks for Each Trade

Trade	Primary Daily Activity	No. Samples	TWA Range (dBA)
Carpenter	Build forms	7	86.7 - 97.4
	Lay grids	3	88.2 - 93.2
	Interior finish	2	84.3 - 91.9
Pile Buck	Welding	3	76.0 -101.0
	Tighten bolts	2	88.0 - 88.4
	Paint stripping - LTC	2	88.3 - 100.2
	Chipping concrete	2	90.2 - 107.1
	Moving boat	1	82.9
Laborer	Paint stripping - LTC	2	104.1 - 107.1
	Paint stripping - hand	2	86.6 - 87.4
	Clean up	2	85.0 - 100.4
	Unload iron	2	88.9 - 94.9
	Concrete chipping	2	97.7 - 103.7
Operating Engineer	Crane only	2	80.5 - 85.0
	Crane, loader	1	93.0
	Crane,loader,PU truck,excavator	1	90.8

Table 4 - Operating Engineer Noise Exposures

Date	Worker No.	Equipment Used	Minutes Monitored	Avg. Sound Level (dBA)
5/7/98	13	Crane	29	84.1
5/7/98	13	Crane	111	84.9
5/7/98	13	Pick up	55	75.6
5/7/98	13	Excavator	30	83.8
5/7/98	13	Loader	54	85.9
5/7/98	13	Loader	130	89.5
5/7/98	13	Loader	179	90.1
5/20/98	13	Loader	59	92.3
5/20/98	13	Crane	291	90.0
5/20/98	13	Crane	30	94.2
5/20/98	13	Crane	59	89.6
5/20/98	21	Crane	616	84.9
5/21/98	21	Crane	269	80.5

For the operating engineer, noise exposure may be significantly affected by whether the enclosure doors and windows are open or closed. The crane, loader, and excavator at this

site all have enclosed cabs, but no air conditioning. The data card did not record the door and window open/close status. Crane averages varied from 80.5 to 94.2 dBA (Table 4). It is likely that some of those measurements were made with doors open and others with doors closed. There was also significant variability with the loader. Although it may not be reasonable to expect doors and windows to be closed on a hot day, this information would be useful when making decisions about future purchases of equipment.

Office Trailer Workers - Three employees were sampled who tend to spend significant periods of the workday inside the office trailer, including the superintendent, the construction engineer, and the safety specialist. The superintendent's exposure varied widely depending on how much time he spent outside (see Appendix A), but on May 7 he was outside for 7 hours and his TWA that day was 90.9 dBA. Since the superintendent may spend a large portion of his time outside, he should be included in the hearing conservation program. The construction engineer and safety specialist spent shorter portions of their monitored days outside and were below the 10 hour legal limit of 83.4 dBA on all days.

Daily Site Noise Variability - There were no days on this site where the average outside TWA was below 83.4. The range of daily average site TWAs was 87.3 - 93.3 dBA (Table 5). On 5/4, 5/5, 5/18, and 5/19 carpenters and laborers were monitored. On other days, all other site personnel were monitored. Differences between days may be due to differences in the trades/activities monitored that day or it may be due to actual differences in the noise level at the site that day.

Table 5
Daily Site Noise* Variability

Date	No. of Samples	Avg. 10 Hr TWA (dBA)	High Noise Activity
5/4/98	5	92.9	LTC
5/5/98	6	90.5	
5/6/98	5	87.8	
5/7/98	7	90.7	weld
5/18/98	10	93.0	LTC; concrete chipping
5/19/98	5	89.3	chip concrete
5/20/98	8	93.3	chip concrete; LTC
5/21/98	5	87.3	weld

* Does not include office trailer staff

This study did not assess the impact of traffic noise on the background noise level at the site. The Washington State hearing conservation standard requires that engineering controls be implemented when TWAs are over 90 dBA for an 8 hour day (88.4 dBA for a 10 hour day), if feasible. Engineering controls which could reduce noise levels may include mufflers for electric motors and air compressor intakes, placement of compressors, generators, and other loud equipment away from reverberating surfaces

whenever possible, and enclosures for heavy equipment operators. Regular maintenance of equipment can also reduce noise levels from some equipment.

Recommendations

All workers at this site are potentially exposed to sounds levels over the Washington State occupational limits over the course of a day. All outside workers on site should be included in a hearing conservation program. The elements of a Hearing Conservation Program include:

- Mandatory audiometric testing
- Hearing protectors to be worn by all workers while working outside
- Hearing protection training
- Warning signs for high noise areas (115 dBA or greater)
- Record keeping for audiometry, training, and noise monitoring
- Employee access to records.

The details of these requirements are found in Washington Administrative Code 296-62-09041. In addition, engineering controls should be implemented where feasible.

Some tasks at the site produce significantly greater sound levels, including paint stripping with LTC, concrete chipping, some welding tasks, and potentially some concrete pouring tasks. Those tasks which can produce sound levels over 100 dBA, should be conducted while wearing double hearing protectors, e.g., plugs and muffs. Since the welding and concrete pouring full shift samples are not complete regarding which specific tasks to include in this recommendation, additional monitoring is recommended for those activities.

At the end of each shift, monitored workers were asked if they had worn hearing protectors that day. In almost all cases they reported that they had worn plugs all day. It was also observed that workers were wearing ear plugs.

Appendix A

Dosimetry Results

Worker No.	Trade	Date	TWA (dBA)	Activities	Avg. Trade TWA (dBA)
1	Carpenter	5/4/98	91.2	build forms; clean up	
		5/5/98	97.4	build forms	
		5/18/98	87.7	build forms	
4	Carpenter	5/4/98	85.9	clean up; build forms; pressure wash	
		5/5/98	91.6	build forms	
		5/18/98	86.8	build forms; drilling	

		5/19/98	88.2	build forms	
5	Carpenter	5/4/98	88.2	lay grids	
		5/5/98	88.4	lay grids	
		5/18/98	91.9	interior finish	
		5/19/98	84.3	interior finish; build forms	
10	Carpenter	5/18/98	89.0	hammer, power saw	
20	Carpenter	5/6/98	95.0	placing grate; beneath road; removed at 3:30 but still logging	
		5/7/98	88.5	placing grate	
		5/18/98	86.7	build forms	89.6
11	Pile Buck	5/6/98	87.4	not known - incomplete record	
		5/7/98	76.8	welding - weld torch, slag hammer	
		5/20/98	82.9	moving boats	
		5/21/98	101.0(5hr)	welding - weld torch,weld stick	
15	Pile Buck	5/6/98	88.0	tighten bolts, cut wood, manlift	
		5/7/98	91.0	welding, roto hammer	
		5/20/98	90.2	burn, chip concrete	
		5/21/98	80.1(5hr)	hang scaffolding, boat, manlift	
17	Pile Buck	5/6/98	88.4	boat, manlift, tighten bolts, pour concrete	
		5/7/98	84.7	manlift, boat, clean up	
		5/20/98	107.1	boat, chip concrete, rigging near crane	
7	Pile Buck	5/20/98	100.2	LTC	
		5/21/98	88.3(5hr)	LTC	89.7

Appendix A (cont.)
Dosimetry Results

Worker No.	Trade	Date	TWA (dBA)	Activities	Avg. Trade TWA (dBA)
2	Laborer	5/4/98	94.9	unload iron; shore hole	
		5/5/98	88.9	unload iron; grade footing; chipping gun	
		5/18/98	103.7	chip concrete, rigging, drive PU	
		5/19/89	97.7	chipping gun, drilling	

3	Laborer	5/4/98	104.1	LTC	
		5/5/98	85.2	hand chipping	
		5/18/98	107.1	LTC	
		5/19/98	89.9	hand chipping	
6	Laborer	5/18/98	87.4	stripping	
		5/19/98	86.6	stripping	
8	Laborer	5/5/98	91.3	drill/remove temp barrier	
		5/18/98	85.0	clean up	
9	Laborer	5/18/98	100.4	clean up	94.0
13	Oper.Eng.	5/7/98	90.8	crane boom truck, loader, PU truck, excavator	
		5/20/98	93.0	crane, back hoe	
21	Oper.Eng.	5/20/98	84.9	crane	
		5/21/98	80.5(5hr)	crane	87.3
18	Welder	5/6/98	86.6	remove machinery - 1 ft below traffic	
		5/7/98	107.5	welding; prep for jacking	
		5/20/98	89.9	remove f/w; weld	
		5/21/98	86.4(5hr)	erect f/w; weld	92.6
16	Iron Worker	5/20/98	93.1	bolt up, cars above, boat	93.1
19	Superintendent	5/7/98	90.9	concrete pour; field inspect, in office 2-5:30	
		5/20/98	75.7	field inspect- 3.5hrs, office-3hrs, left site w/o monitor-2.5hrs	83.3
12	Construction Eng.	5/6/98	73.8	driving 2 hrs, superbent 1.5 hrs; barge 0.5 hrs	
		5/7/98	80.5	superbent 1.5 hrs	
		5/20/98	65.2	superbent 1 hr	73.2
14	Safety	5/6/98	73.7	jobsite 1.5 hrs, drive PU 0.5 hr	
		5/7/98	73.0	jobsite 0.5 hr, drive 0.75 hr	73.5