inter•noise 96
25th Anniversary Congress – Liverpool

INCE: 52

ALTERNATIVE MEASURES TO MITIGATE LONG TERM CONSTRUCTION NOISE

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1. INTRODUCTION

As part of the Westside Light Rail Transit Project through the Goose Hollow community Tri-Met has been granted a noise variance by the City of Portland to construct during the nighttime hours of 10 PM and 7 AM. One of the many conditions of the noise variance is a program to retrofit impacted homes with additional sound insulation. This program, known as the Sound Insulation Program (SIP), is based on treating those homes that are expected to be exposed to nighttime construction noise of 50 dBA or more. A total of 26 homes were determined to be eligible for this program. The purpose of the Sound Insulation Program (SIP) is to provide relief to a community of single family homes that are in close proximity to a construction site where operations will continue over a five year period. The construction site is the East Portal of a 3 miles of twin bore tunnels 19 feet in diameter, being mined as part of the transit project (Figure 1). The Program is intended to improve the noise reduction of all sleeping quarters and a living space up to the budgeted amount of $30,000 for each eligible home. The homeowner will be able to establish a priority list of the spaces to be treated. The budgeted moneys are spent on a room by room basis until depleted. Partial treatment of a room will not be considered.

2. PROGRAM ELIGIBILITY

The eligibility for the SIP is based on the requirements of the Portland Noise Ordinance which limits the noise from stationary sources adjoining residential land uses to 50 dBA. If the Tri-Met nighttime (10 pm to 7 am) construction activities do not exceed the City Noise Ordinance nighttime requirements then there is no impact to the homes in the East Portal area.

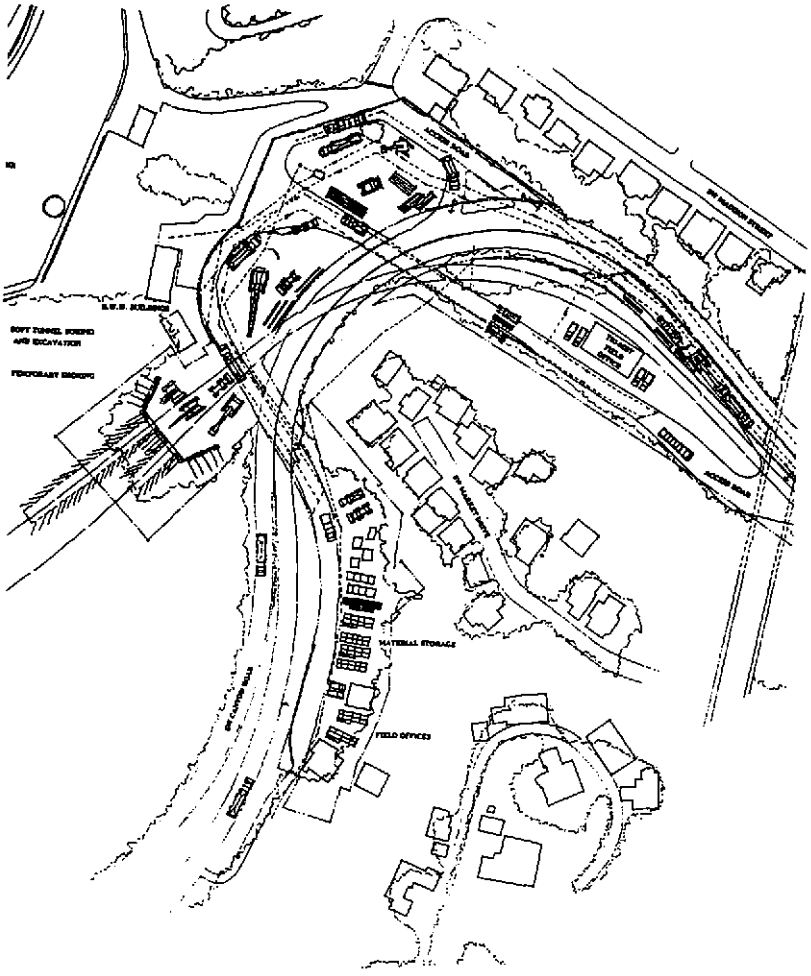

Figure 1 East Portal Construction Site

Where the levels are above 50 dBA there is the potential for noise impact. This eligibility criteria would be subject to the level of ambient nighttime noise from other sources such as traffic. At locations where the ambient nighttime noise levels (L_5) from traffic movements are higher than 50 dBA the noise impact from construction activities would have to be considered on a case by case to determine eligibility.

Determination of eligibility was be based on actual field tests where a construction noise source was generated at different locations on the construction site. The noise source generated a maximum level of L_5= 65 dBA, as permitted by the Portland Noise Variance, at the nearest property line. Measurements were made to determine the locations where the noise levels were 50 dBA or less.

Selection of Eligible Homes

A construction noise simulation test was conducted at the East Portal construction site to finalize the selection of homes in the Goose Hollow neighborhood that are eligible for the Tri-Met Sound Insulation Program. The test consisted of reproducing a tape recording of construction noise at two locations on the East Portal construction site. The playback volume of the tape was set to generate a level of L_5= 65 dBA at the nearest property line, the maximum construction noise level allowed by the Portland Noise Variance during the nighttime hours of 10 pm to 7 am. The test was conducted during the hours of low ambient noise from traffic movements, 10 pm to 12 midnight.

Noise measurements were made on the A-Scale of a Type I precision sound level meter. The levels were directly read from the meter's digital display using the sound pressure level and fast scale settings. This allowed us to measure the maximum level that was generated by the test signal as measured at each residence and to differentiate between the test signal and traffic noise which was at much higher level. Measurements were made at each of the 10 houses along Madison Street. Using this procedure we were able to determine the location on Madison Street where, at the rear yard, the prerecorded construction noise was at a level of 50 dBA or lower. The same measurement procedure was repeated for the 17 residences along Market Drive.

Simulation Test Results

Eligibility of each residence was found to be based on the following elements: (1) proximity to the construction site: (2) shielding by other

residences located closer to the construction site; and (3) elevated topography which gives some of the residences line-of-sight to the construction site.

The test results determined that 19 residence were eligible for inclusion in the sound insulation program -- 12 residences on Market Drive and 7 residences on Madison Street. Seven additional residences were later found eligible for a total of 26 homes - 3 more because of topography which allowed line-of-sight from their second floor bedrooms and 4 more because of the construction of a truck haul route that these residents overlook.

3. SOUND INSULATION PROGRAM

The Sound Insulation Program consisted of the following steps:

- Inspection of each of the eligible homes by an architect and engineer to identify the existing architectural design and the existing mechanical and electrical systems.
- Preparation of architectural, mechanical and electrical drawings of each home.
- Simultaneous interior and exterior noise measurements are conducted to determine the sound insulation provided by the existing exterior walls of the sleeping and living spaces.
- Identification of the different paths of noise intrusion through window and window frames, door and door frames, building walls. ceiling/roof construction, and other penetrations of the exterior walls.
- Recommend the needed sound insulation measures to improve the homes existing sound insulation properties.
- Conduct post-construction sound insulation measurements and architectural inspection to determine acoustical effectiveness of the sound insulation measures and to determine if the criterion of a nighttime interior level of 35 dBA will be achieved.

Sound Insulation Tests

Sound insulation tests both pre-construction and post-construction, were conducted of each residence. Prior to the pre-construction testing, an

inspection of each home was conducted to document the existing architectural, mechanical and electrical conditions and to determine the rooms to be included in the program. Rooms were selected for the sound insulation test based on their use as either sleeping or living spaces and based on the orientation of the rooms exterior wall to the construction site.

Sound insulation is the difference between the average outside noise levels and the average inside noise levels. The test was conducted by generating a pink noise test signal through two (2) loudspeakers located approximately 6 to 8 feet from the exterior building wall. Measurements were taken at the exterior and interior of each of the exterior building walls tested. The measurements were recorded on magnetic tape over a two (2) minute sampling period by moving the microphone in a 180^{o} arc in the center of each test room location. Using a hand-held sound level meter, additional noise measurements were taken at the center of each window, directly in front of the glass pane; along solid areas of the inside wall; along the door and window frames and at the ceiling and roof joints to test for sound leaks.

Recommended Sound Insulation Measures

Based on the findings of the pre-construction noise survey the following measures were used to improve the sound insulation properties of each of the tested residential structures:

- Heat pump system to heat and cool the living areas and sleeping quarters.
- To provide ventilation, the heat pump system was designed with an outside air intake with acoustical treatment (duct lining and noise control louvers) to control flanking noise transmission.
- Install replacement wood windows with insulating glass.
- Install replacement wood doors with insulating glass.
- Install or replace storm windows.
- Repair, reset and gasket exterior storm windows.
- Install new exterior wood storm doors.
- In all wall exposed to the construction site:
  - Insulate walls, roof, and attics
  - Caulk window frames, material transitions and all architectural and mechanical exterior wall penetrations.

- Refurbish deteriorated door and window sills and exterior trim.
- Weather strip all exterior doors and interior operable sash.
- Replace broken window glass and missing or loose putty

Installed Sound Insulation Measures

As part of the program, the Tri-County Metropolitan Transportation District of Oregon (Tri-Met) project manager met with each homeowner to discuss the recommended sound insulation measures. Based on the concerns of the residents and the budgetary limitations of the program the recommended sound insulation measures were modified. A letter of agreement was signed by the homeowner authorizing the installation of the sound insulation measures and agreeing to the modifications.

Post-Construction Inspection Test Results

Once the construction was completed a post-construction test was conducted to determine the acoustical effectiveness of the sound insulation measures prescribed above. Microphone and speaker locations were set up as they were during the first test program. The acoustical effectiveness of the installed sound insulation measures were analyzed for each residence.

4. CONCLUSIONS

The sound insulation measures made to the 26 homes in the SIP resulted in an interior noise level of 35 dBA or less during nighttime construction activities with windows and doors closed. In addition to the air conditioning system, which was provided to allow the sleeping and living quarters to be ventilated without opening room windows, an improvement to the sound insulation of each of the treated rooms was achieved resulting in a post-construction noise reduction in the range of 26 dBA to 42 dBA. The sound insulation measures installed on these homes were found to conform with the requirements of the City of Portland Noise Variance issued to Tri-Met to allow 24-hour construction of the Westside LRT Project.