Novel Noise Prediction Technique for Demolition Saves Time and Money

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Many construction projects require the demolition of existing structures that are no longer needed or obstruct new building work. Where these structures are close to other buildings – for example, in a city center – the noise generated by the demolition process can cause significant disturbances and potential health and safety issues for people working or living nearby. A novel technique for predicting the sound levels generated during demolition has been devised. This enables informed decisions to be made about an effective demolition strategy to minimize potential disturbances without compromising operational speed and efficiency. In the case study described here, it is estimated that applying this technique saved hundreds of thousands of dollars and many weeks of construction time.

The redevelopment of a subway station in central London required the removal of a thick concrete slab, approximately 66 × 56 ft, that had previously been the basement of a bank, where the safe had been situated (see Figure 1). There were concerns that using normal mechanical breaking techniques would generate a considerable noise nuisance at a nearby foreign embassy and might also prevent passenger announcements being heard in the existing subway station. This would present a potential health and safety hazard if an emergency occurred and passengers were unable to hear safety instructions. To minimize the potential disruption, it was necessary to estimate the noise that would be generated by mechanical breaking.

The obvious solution was to perform some test runs with a mechanical breaker to measure the extent of the problem. Unfortunately, it was impossible to get a demolition machine into the area until other surrounding structures were demolished, at which point it was desirable to start breaking up the slab. Waiting until then to conduct tests and devise an appropriate strategy would incur unacceptable delays: it was important to know in advance the extent to which mechanical breaking could be used and whether other, more costly, procedures might be necessary.

Noise estimates using techniques such as modelling or energy transfer calculations were considered to be unsuitable for the situation. Alternative, quiet methods of demolition, such as chemical cracking, were deemed to be too time consuming and costly.

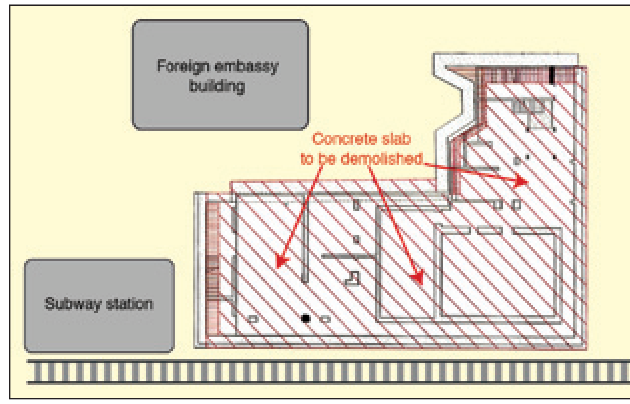

Figure 1. Location of slab showing nearby structures.

Figure 2. Mechanical breaker at off-site location.

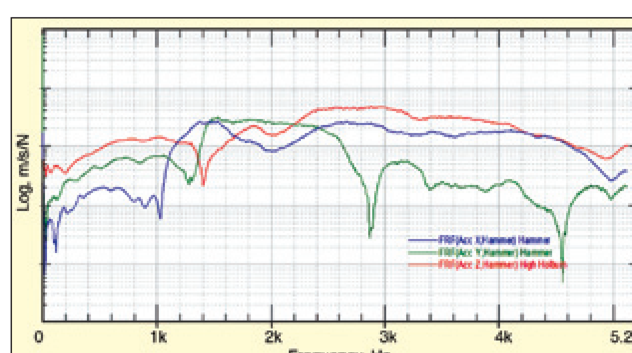

Figure 3. Plot of test slab sensitivity.

Novel Solution

The solution devised by JoTech Ltd. consisted of two parts. In the first, an estimate of the forces imposed on the slab by a mechanical breaker was made using a similar concrete slab located elsewhere in London. In the second part, the noise transfer function (NTF) from the slab to the critical areas (the embassy and the subway station platform) were measured. This was then combined with the breaker force measurements to estimate the levels of noise that would be generated during demolition operations. With that information, an appropriate demolition strategy was devised.

Breaker Force Measurement

Although it is theoretically possible to directly measure the forces imposed by a breaking machine, the magnitude of the forces and the rugged environment make this very difficult, particularly over the frequency range required (up to 4 kHz). JoTech, using the m+p international measurement and analysis system, devised an alternative method.

At the off-site concrete slab (at a remote location where noise nuisance was not a problem) the demolition machine shown in Figure 2 was operated and the velocity of the breaking tool during normal operation was measured using accelerometers connected to a laptop computer running m+p international's SO Analyzer software. It derives velocity data by averaging and integrating the real-time acceleration measurements.

Next, the sensitivity of the slab (velocity/force) was measured in three dimensions using a calibrated impact hammer (which measures force) with accelerometers attached to the slab (see Figure 3). By combining the breaker velocity measurements with the measured sensitivity of the slab, a spectrum of the forces exerted

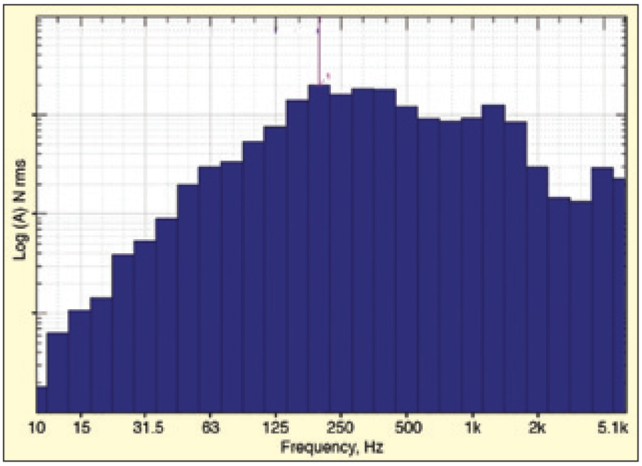

Figure 4. Calculated force spectrum for breaker tool.

Figure 5. Location of measurement points on slab.

Figure 6. Mechanical tamper used during noise measurements.

during demolition could be calculated (see Figure 4).

Noise Transfer Function Measurement

At the target concrete slab, four separate measurement points (Points A, B, C, D in Figure 5) were identified. These were selected by taking into account the structure of the slab and underlying features, including a large sewer pipe that ran under one area of the slab. At each of these points, an impact hammer was used to measure the sensitivity of the slab (velocity/force), as had been done at the remote site. Measurements were taken at two points equidistant from each hammer position (with the exception of position D, where physical limitations prevented this).

A mechanical tamper (see Figure 6) was operated, and the noise caused by it was measured on the subway platform as shown in Figure 7 and in the embassy. These measurements were carried out during the night to avoid any disturbance to staff or passengers. For comparison purposes, ambient noise measurements were also taken on the platform with no trains in the station, a train entering the station, and a train leaving the station.

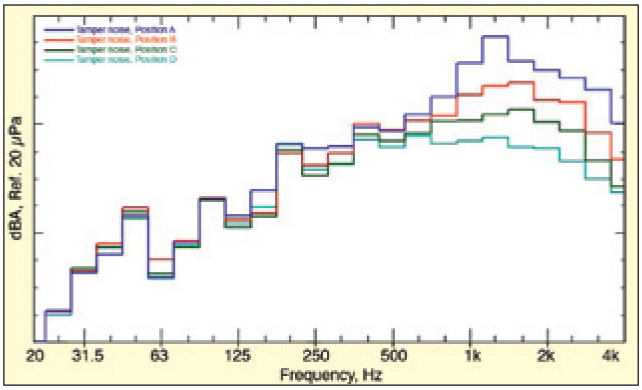

Figure 7. Noise measurements on station platform from each test point on slab.

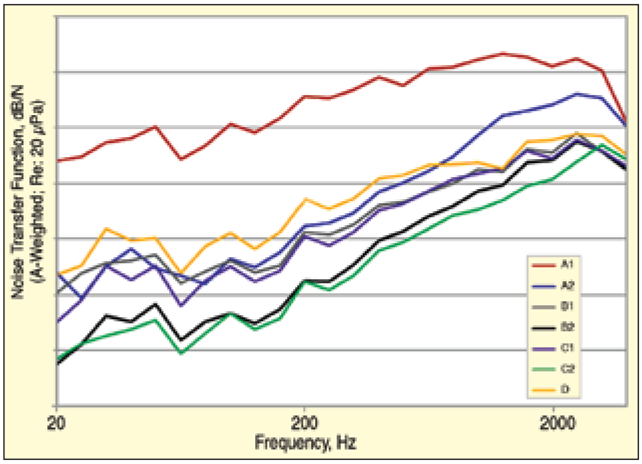

Figure 8. Location of measurement points on slab.

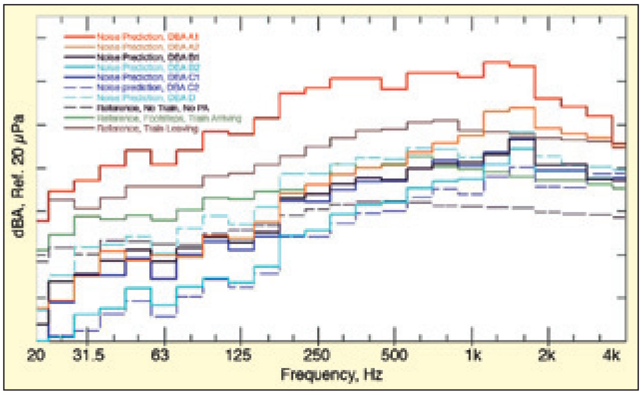

Figure 9. Predicted noise plot.

Once again these measurements were taken using m+p's SO Analyzer software running on a laptop computer, with a four-channel portable USB data acquisition module. The lightweight, easily transportable kit and the flexibility of the software, including integrated narrowband and third-octave calculations, are ideally suited to such on-site investigations. Results were available immediately, which enabled JoTech to check their validity and allow for adjustments. By combining measurements of slab sensitivity with the noise readings, it was possible to calculate the NTF from the seven points around the slab (see Figure 8).

Results

Noise = Force × NTF. Multiplying the NTF by the estimated force spectrum gave the predicted noise levels on the platform for demolition work at each of the seven points on the slab, shown in Figure 9. From these results, it was clear that the noise likely to be generated by mechanical breaking in Area 3 (A1 and A2 in Figure 5), was considerably higher than the noise level when a train was leaving the station, and this was unacceptable. However, mechanical breaking in Area 1 (Plot D) would generate noise levels

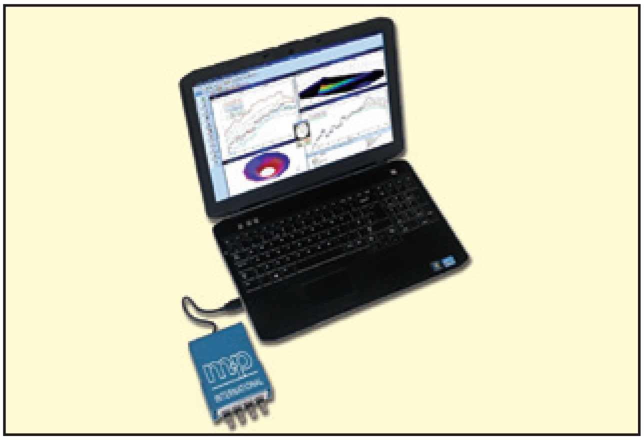

Figure 10. Portable equipment used for site tests.

somewhat lower than those experienced when a train left the station, and was thus acceptable.

Area 2, represented by Plots C1, C2, B1 and B2, was also deemed suitable for breaking, provided that a slit trench was dug to isolate it from the more sensitive Area 3. It was recommended that mechanical demolition for Areas 1 and 2 take place outside office hours to minimize disturbance within the embassy, while chemical cracking was utilized to demolish Area 3 of the slab.

Cost and Time Saved

This technique for predicting noise levels during demolition enabled the contractors to restrict costly chemical cracking to one area of the slab while still maintaining the safety and comfort of embassy staff and subway commuters. It is estimated that this saved many weeks on the project and several hundreds of thousands of dollars.

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