# BRIDGECLIMB SYDNEY – REDUCING TONAL NOISE FROM SAFETY LATCHES

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## Abstract

Each year, thousands of Sydneysiders and visitors climb Sydney's most prominent icon, the Sydney Harbour Bridge. To ensure a safe journey, each Climber is required to wear a safety harness, which attaches to a static line on the bridge. When the first Climbs commenced in October 1998, the latches, which form part of the safety harness, emitted a bell-like noise at every static line connection point. These tonal emissions were audible in a nearby residential area. Over a period of 4 years, various engineering noise control measures were implemented on the latches and static line connection points to significantly reduce the tonal characteristics and overall noise emissions. As a result, BridgeClimb is now able to offer Climbs during night-time periods without creating excessive noise. This paper describes some of the noise controls that have been implemented and the resulting noise reductions.

## Introduction

BridgeClimb Sydney offers the public an opportunity to take a guided tour of the Sydney Harbour Bridge. The venture was officially opened on 1 October 1998 and since then, has had more than one million paying customers.

Figure 1 shows a schematic of the BridgeClimb route. The walking tour commences with a briefing and safety demonstration (locations 1 and 2), before accessing the southern approach span of the bridge (location 3). The tour groups, consisting of approximately 10 to 12 Climbers, are led along the eastern side of the approach span below road level (location 4) to the southern pylon (location 5). The Climb then proceeds to roadway level and to the top of the arch where Climb groups traverse to the western side of the bridge (locations 6 to 8). The Climb then returns via the southern pylon and the western side of the approach span (locations 9 and 10).

The nearest noise sensitive receivers are residential terraces located in Lower Fort Street, approximately 30 m from the western side of the southern approach span.

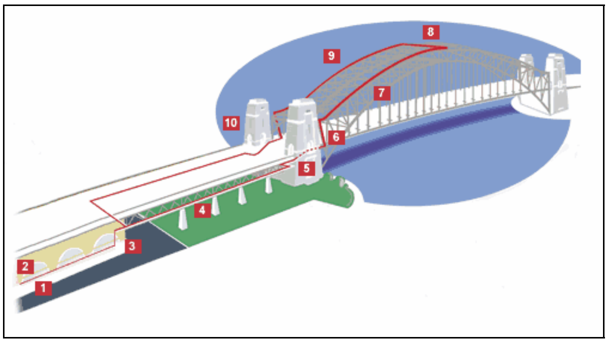


Figure 1. BridgeClimb Route [1].

## Noise Source Characteristics

To ensure a safe tour of the Sydney Harbour Bridge, each Climber is required to wear a safety harness and latch, which connects the Climber to a static line on the bridge.

The static line is a wire cable, fixed at regular intervals to structural support members of the bridge. The safety latches are designed such that they can move freely over the fixings without having to be disconnected from the static line. This is achieved by a twin star-wheel arrangement with an engaged tongue, which slides along the static line while the two star-wheels rotate over the fixings. The star-wheels are fixed to a common shaft and have two end caps.

As Climbers move along the eastern and western sides of the southern approach span, noise is generated as the safety latch passes through the static line fixing points. The noise results from the metal-to-metal contact, causing structure-borne noise from the bridge members and bell-like "ringing" of the latch. The noise emission from the latch is negligible between static line fixing locations.

When noise measurements were initially undertaken by Heggies in December 1998, noise emissions from the safety latches were found to be clearly audible outside residential dwellings in Lower Fort Street during the daytime period. The overall A-weighted noise levels during a Climb group passby event were comparable with ambient noise levels, but in the higher frequency octave bands (approximately 4 kHz and above), noise emissions were higher than the corresponding ambient noise levels.

Follow-up measurements were undertaken in January 1999 (in the near field) to confirm the noise emission characteristics of the safety latches. The measurement results confirmed that the dominant source of noise emission occurred in the 4 kHz third octave frequency band.

In the two adjacent frequency bands, the measured noise levels were 5 dBA to 8 dBA lower, indicating that the noise emissions were inherently tonal. Both Australian Standard AS 1055.1 [2] and the Department of Environment and Conservation's Industrial Noise Policy [3] recommend a 5 dBA noise penalty when assessing noise emissions with tonal characteristics. This is because tonal noise sources are judged by most people to be more intrusive than broad band sources of a similar magnitude.

During community consultation meetings in 1998-99, residents in Lower Fort Street expressed concerns that noise emissions from Climb groups (from the safety latches in particular) were excessive and would be unacceptable during night-time periods. At this time, the management of BridgeClimb decided to take a proactive approach in seeking to minimise noise emissions. Prior to seeking approval from Sydney City Council for extended operating hours, it would be necessary to demonstrate a significant reduction in the audible character of safety latch noise emissions.

## Measurement Results

In January 2001, noise measurements were undertaken outside one of the residential dwellings in Lower Fort Street during an early morning period. The noise levels were recorded on digital audio tape to allow the noise characteristics to be analysed in more detail. A typical 15-minute noise profile is provided in Figure 2, showing significant events such as train passbys, road traffic passing over bridge expansion joints and the period when a Climb group accessed the eastern side of the approach span.

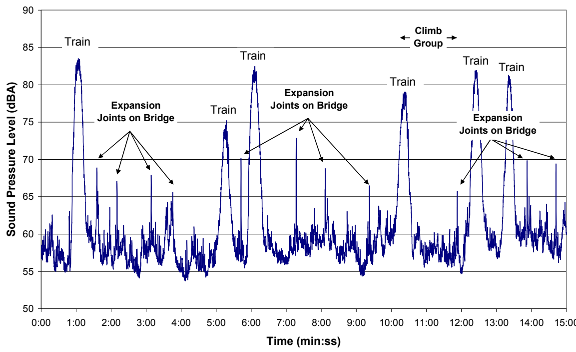


Figure 2. Typical 15-minute noise profile.

A zoomed view of the same measurement is provided in Figure 3, showing the overall A-weighted noise level and the A-weighted noise level in the 8 kHz octave frequency band. The 8 kHz band was adopted for display purposes due to its prominence over the background noise (as indicated in Figure 4).

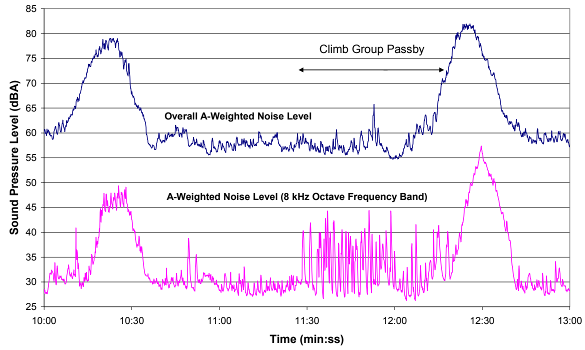


Figure 3. Zoomed noise profile.

In Figure 3, the Climb group accessed the eastern side of the approach span during the period 11:30 to 12:15 Minutes. During this 45 second interval, the maximum A-weighted noise level was unaffected by the Climb group noise emissions as the overall noise levels are controlled by other ambient sources such as road traffic on the Sydney Harbour Bridge and mechanical plant at the nearby Hyatt Hotel. When the same measurement is pass-band filtered to include only emissions in the 8 kHz octave frequency band, Figure 3 shows that the filtered levels during the Climb group event were up to 14 dBA higher than the equivalent ambient level of 30 dBA.

By analysing the recorded noise levels in this fashion, it was possible to listen to the pass-band noise in each octave band and determine whether noise emissions from the safety latches were audible above the ambient noise environment. In octave frequency bands where safety latch noise emissions were audible, it was possible to determine the A-weighted noise level contribution of the safety latches.

Thus from the measurement results, the overall A-weighted noise level from the Climb group was estimated to be 49 dBA, compared with a measured background noise level of 55 dBA. Although 6 dBA quieter than the background noise level, noise emissions from the safety latches were still audible, resulting from the octave band levels above 4 kHz being higher than the background noise levels in these bands. This is illustrated in Figure 4.

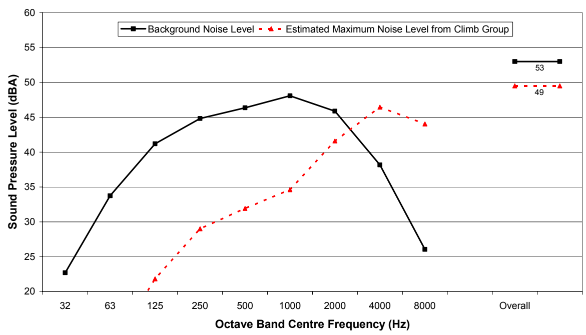


Figure 4. Octave band noise levels (Jan 01).

In Figure 4, the background noise level of 53 dBA is representative of the repeatable background noise level during the night-time period. The safety latch noise emissions in octave frequency bands below 4 kHz were estimated by near-field noise measurements.

## Noise Control Options

The following sections describe the noise control options that were implemented between 1998 and 2002 to substantially reduce the overall noise level and tonal character of the safety latch noise emissions, when measured outside the residential dwellings in Lower Fort Street.

Bies and Hansen observed that *"Any noise problem is described in terms of a source, a transmission path and a receiver, and noise control may take the form or altering any one or all of these elements."* [4]

In the following discussion, the noise reductions achieved by modifying the source, transmission path and receiver are addressed separately.

**Modification of the Source Noise Levels**

When measurements of the safety latches were initially undertaken in 1998, the character of the noise emissions was highly tonal, described as a bell-like "ringing" noise. The ringing noise was emitted each time a safety latch was passed over one of the static line connection points on the bridge. For a group of 12 Climbers, 12 such noise events would occur as each person passed a given connection point.

As previously discussed, the dominant frequency of the safety latch noise emissions occurred in the 4 kHz third octave frequency band. The major focus of the noise control program was therefore to reduce the tonal character of the source by providing some damping in the latch mechanism, so as to reduce the vibration response (and hence noise) in the region of resonance.

BridgeClimb staff worked closely with the latch manufacturer, Latchways, to explore methods of reducing the tonal emissions. A number of options were implemented to introduce some damping into the latch mechanism and reduce the bell-like characteristics.

The first option involved the installation of nylon gaskets between each star-wheel and its corresponding end cap. Measurements confirmed that a modest noise reduction of 2 dBA to 3 dBA was achieved in both the overall measured level and in the dominant 4 kHz third octave frequency band.

Subsequent to these measurements, BridgeClimb staff modified one of the safety latches by spot welding the star-wheels to their corresponding end caps at each contact point. This resulted in a further source level reduction of approximately 6 dBA, attributable to damping provided by interaction between the spot welded components.

Further reductions of up to 3 dBA were achieved by covering the existing end caps with rubber-like covers.

The soft covers provided some further damping, and because of their large diameter, cover the entire surfaces of the noise radiating end caps. Photos of the original and modified latches are provided in Figure 5.

Overall, a source noise level reduction of approximately 10 dBA to 12 dBA was achieved by modifying the design of the safety latches. Perhaps of greater significance, the tonal bell-like characteristics of the original safety latches are no longer present in the source noise emissions. The 5 dBA noise penalty, normally applied for tonal sources is therefore no longer applicable.

Figure 5. Pictures of Original (left) and Modified (right) Latches.

**Modification of the Transmission Path**

Modification of the transmission path usually includes such measures as relocating noise sources, using partial or full enclosures to shield noise emissions, providing reverberation control by adding sound absorbing materials and vibration-isolating equipment to reduce structure-borne noise.

A number of such measures were implemented to reduce the overall noise emissions from Climb groups.

In addition to the airborne noise emissions from the safety latches, structure-borne noise was also found to be a contributing factor to the overall source noise levels. The impact of the safety latch on the static line connection point caused the structural support members to vibrate and hence radiate structure-borne noise. In order to reduce the structure-borne noise emissions, rubber grommets were provided between the connection points and the support members to reduce the amount of vibration transmitted to the structural support members. The noise levels in the frequency range (315 Hz to 2 kHz) were reduced by approximately 2 dBA.

Initially, static line connection points were provided at each bridge support member adjacent to the walkways on both sides of the approach span. A single static line connection point was provided at the vertical support member locations. Two connection points were provided at the angled support member locations. Two-thirds of these fixing locations were redundant and have since been removed on both sides of the approach span.

As a result, the number of noise sources has been reduced by two thirds, representing a significant improvement.

The construction of noise barriers and partial enclosures in the vicinity of the static line connection points was investigated, but ruled out due to engineering and aesthetic reasons. Instead, it was decided to make use of the existing shielding provided by the angular support members by strategically placing the static line connection points in a position offering maximum shielding to the adjacent dwellings.

For the static line connection points on the western side of the approach span (closest to the residential dwellings), the static line connection points were located on the angular support members to provide optimum shielding (see Figure 6). For the static line connection points on the eastern side of the approach span, the static line connection points were located on the vertical support members in order to reduce the reflected noise emissions in the direction of the residential dwellings (see Figure 7).

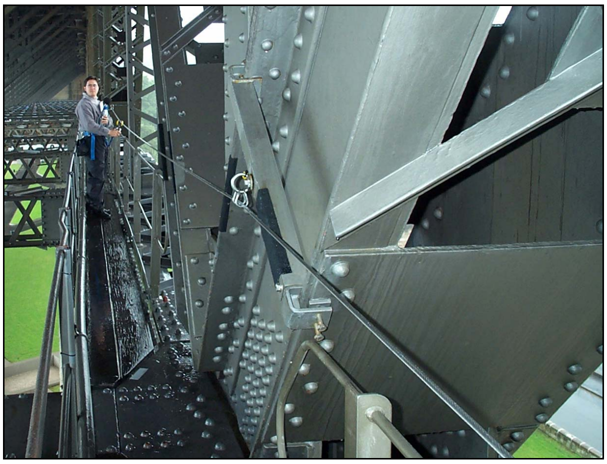

Figure 6. Angular support member fixing location.

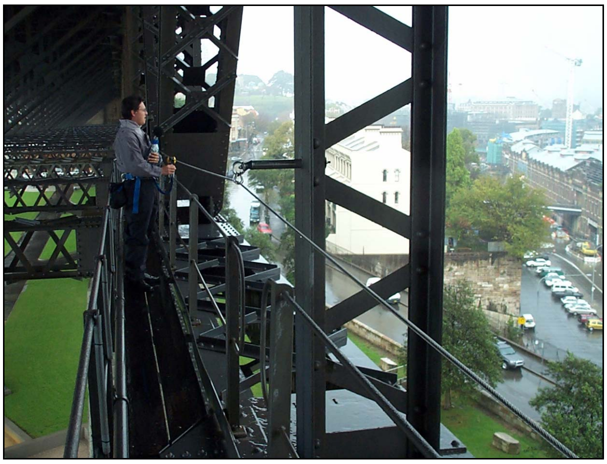

Figure 7. Vertical support member fixing location.

By strategically placing the static line connection points in these positions, noise level reductions of 5 dBA to 10 dBA were achieved for Climb groups on the western (near) side of the approach span and no increase in noise emissions (due to reflected noise) occurred for Climb groups on the eastern side of the approach span.

**Modification of the Transmission Path**

Noise control at the receiver (in this case, the residential dwellings in Lower Fort Street) was not a desirable outcome and was considered unnecessary as a result of the significant noise reductions achieved by the other two methods. A possible noise control treatment at receivers would have been upgraded windows and seals on exposed facades.

## Outcome of Noise Control Measures

After implementation of the noise control measures discussed in the previous section, additional noise measurements were undertaken outside a residential dwelling in Lower Fort Street in June 2002 in order to verify the overall noise reductions achieved. The results of this study are presented in Figure 8, together with the measured noise levels from the January 2001 study. Although comparable measurements were not undertaken in December 1998 (prior to the implementation of initial noise control measures), it is anticipated from the near-field measurement results and subjective observations, that the overall A-weighted noise level would have been in the order of 53 dBA.

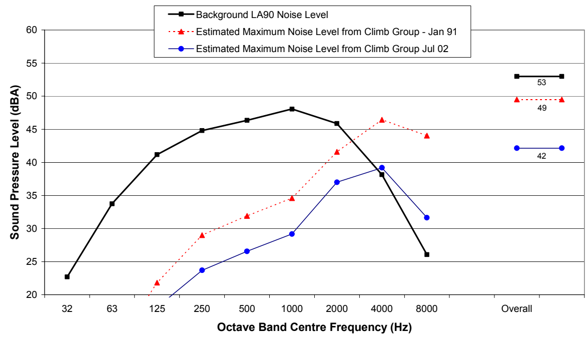


Figure 8. Octave Band Noise Levels (Jul 02).

The overall A-weighed noise level in June 2002 was estimated to be 42 dBA outside the residential dwelling in Lower Fort Street, compared with the minimum background noise level of 53 dBA. During the attended noise measurements, it was difficult to distinguish the Climb group noise emissions in the presence of other ambient sources.

## Conclusions

When the first Sydney Harbour Bridge climbs commenced in October 1998, noise emissions from the safety latches were highly tonal in character, emitting a bell-like noise each time a latch passed over a static line connection point on the bridge. Because of the tonal characteristics of the original safety latches, noise emissions would have been considered intrusive at residential dwellings in Lower Fort Street during night-time periods.

Over a period of 4 years, a series of engineering noise control measures were designed in collaboration between BridgeClimb, Latchways and Heggies. These changes were successfully implemented on the latches and static line connection points to significantly reduce the tonal characteristics and overall noise emissions. These measures included design modifications to the safety latches, strategic relocation of the static line connection points and minimising the number of static line connection points.

As a result of these noise control measures, the overall noise emissions from the safety latches was reduced by approximately 10 dBA to 12 dBA. Perhaps of greater significance is the fact that the tonal bell-like characteristics of the original safety latches are no longer present in the source noise emissions.

Following the implementation of the noise controls described in this paper, Sydney City Council has granted approval for BridgeClimb to operate on a 24-hour per day basis.

## References

[1] BridgeClimb Sydney, *Public Website*, http://www.bridgeclimb.com.au, 2004.
[2] Australian Standards AS1055.1-1997. "Acoustics – Description and measurement of Environmental Noise Part 1: General Procedures."
[3] Department of Environment and Conservation, *NSW Industrial Noise Policy,* January 2000
[4] Bies D, Hansen C, *Engineering Noise Control*, E&FN Spon Publishers, London, pg4, 1996