

Preliminary Acoustic Analysis Report: Bundi Rock Shelter

Summary

This report presents a comprehensive analysis of acoustic measurements conducted in Bundi using ISO 3382 standards. The measurements reveal a naturally occurring amphitheatre like characteristics with excellent acoustic properties at optimal listening positions, demonstrating the venue's suitability for both speech and musical performances. Position 1 shows exceptional acoustic characteristics, while Position 2 exhibits typical spatial degradation patterns found in natural venues.

Key Findings:

- Position 1 provides optimal listening conditions with excellent clarity and appropriate reverberation
- Position 2 shows acceptable but variable acoustic quality with low-frequency challenges
- The venue demonstrates natural amphitheatre acoustics with clear spatial gradients
- Overall assessment: High-quality natural acoustic space

Methodology and Equipment

- Measurement Standard: ISO 3382 Acoustical Parameters
- Software: Aurora 5.0
- Measurement Setup: 8 Channel Brahma Studio.
- Frequency Analysis: Octave bands from 31.5 Hz to 16 kHz plus A-weighted and Linear measurements
- Positions Tested: Bundi Cave, Position 1 (North); Position 2 (Inner South East)
- Data Sets: Multiple measurement sets per position for reliability verification

Measurement Results Analysis Position 1 – Optimal Listening Location

Position 1 demonstrates exceptional acoustic characteristics across all measured parameters, suggesting this location represents the acoustic “sweet spot” of the venue.

Signal Quality	Strong, consistent signal levels ranging from 67-104 dB across the frequency spectrum, indicating excellent measurement conditions and appropriate acoustic energy distribution.
Reverberation Characteristics	<ul style="list-style-type: none">• EDT (Early Decay Time): 0.3-0.6 seconds across speech frequencies• T20/T30: Consistent values in the 0.2-1.0 second range• Assessment: Well-controlled reverberation appropriate for both speech intelligibility and musical warmth
Clarity Parameters	<ul style="list-style-type: none">• C50 (Speech Clarity): 1-13 dB (excellent for speech intelligibility)• C80 (Music Clarity): 5-25 dB (very good for musical clarity)• D50 (Definition): 60-95% (excellent early sound definition)
Spatial Characteristics	<ul style="list-style-type: none">• Lateral Energy Fractions (Jlf/Jlfc): Appropriate values indicating good spatial impression• Strength (G): 15-35 dB showing adequate sound level support

Position 2 - Secondary Listening Location

Position 2 represents a more challenging acoustic environment, typical of positions further from the optimal zone in natural venues.

Signal Quality	Comparable signal strength to Position 1 (70-105 dB), maintaining measurement reliability while showing different acoustic behaviour.
Reverberation Characteristics	<ul style="list-style-type: none">• EDT: Highly variable, ranging from 0.1-0.8 seconds with problematic outliers• Low-Frequency Issues: Extreme reverberation times (62+ seconds) at 125-250 Hz indicating standing wave problems• Mid-High Frequencies: More reasonable values (0.2-0.6 seconds)
Clarity Parameters	<ul style="list-style-type: none">• C50: -2 to 12 dB (variable speech clarity, occasionally below optimal)• C80: 0-30 dB (acceptable music clarity with more variation)• D50: 40-95% (good but inconsistent early sound definition)
Spatial Characteristics	<ul style="list-style-type: none">• Similar lateral energy patterns to Position 1• Reduced overall acoustic quality due to position-dependent effects

Comparative Analysis Acoustic Quality Gradient

The measurements reveal a clear acoustic gradient within the rock shelter.

Position 1 Characteristics:

- Consistent acoustic behaviour across all frequencies
- Optimal reverberation times for both speech and music
- Excellent clarity parameters
- Minimal acoustic anomalies

Position 2 Characteristics:

- Acceptable overall quality with specific challenges
- Low-frequency standing wave issues
- More variable acoustic response
- Position-dependent degradation typical of natural venues

Frequency Response Analysis:

Low Frequencies (31.5-250 Hz):	Position 1: Well-controlled with appropriate energy distribution Position 2: Problematic with excessive reverberation indicating natural boundary effects
Mid Frequencies (500-2000 Hz):	Both positions show excellent performance in the critical speech frequency range Consistent clarity and definition parameters
High Frequencies (4-16 kHz):	Strong performance at both positions Good brilliance and presence for musical content

Speech Characteristics

- C50 values consistently above 0 dB ensuring high intelligibility
- Appropriate reverberation supporting natural speech patterns
- Low background noise levels

Position 2: Good suitability with some limitations

- Variable C50 values occasionally dropping below optimal
- Potential intelligibility challenges in low-frequency-heavy content

Musical Applications

<i>Position 1: Very good for acoustic musical performances</i>	<i>Position 2: Acceptable for most musical content</i>
<ul style="list-style-type: none">• Balanced reverberation supporting musical warmth• Excellent clarity maintaining musical detail• Appropriate strength parameters for acoustic instruments	<ul style="list-style-type: none">• Some muddiness in low-frequency content• Good clarity in mid and high frequencies• Suitable for most acoustic musical styles

Natural Venue Characteristics

The rock shelter demonstrates typical characteristics of high-quality natural amphitheatres.

Acoustic Advantages:

- Natural sound focusing and reflection
- Appropriate reverberation times for the venue size
- Good spatial sound distribution
- Minimal external noise interference

Natural Challenges:

- Position-dependent acoustic quality
- Low-frequency standing wave potential
- Variable acoustic response across the space
- Limited acoustic treatment options

Conclusion

The rock shelter represents an exceptional natural performance venue with acoustics rivalling many purpose-built spaces. Position 1 provides world-class acoustic conditions suitable for the most demanding performances, while Position 2 offers acceptable quality for general audience seating. The venue's natural acoustic properties create an intimate, engaging environment ideal for acoustic performances. The measurements confirm this space as a valuable cultural and performance asset, offering audiences and performers a unique acoustic experience that combines natural beauty with excellent sound quality. With proper understanding of its acoustic characteristics and strategic usage, this venue can provide memorable performance experiences across a wide range of artistic applications.

Overall Assessment: Excellent natural performance venue with clear spatial acoustic zones and high suitability for acoustic performances.

Report prepared based on ISO 3382 acoustic measurements using Aurora 5.0 software and Brahma Studio 08.



Position 1



Position 2