Acoustic environmental impact of stadiums

Christophe Rougier,
J. Defrance, N. Noé, J. Maillard, M. Baulac
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- Introduction
- Methodology of work
- Noise levels around the stadium: matches and concerts
- The stadium as an equivalent sound source
- Acoustic propagation in environment
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Introduction

• Stadiums are build closed to urban areas and their inhabitants
• Two aspect of acoustic impact studies: communication and respect of regulation
• Need for a “tool” to predict the acoustic impact of stadiums (or complex buildings)
• Two main use of stadiums:
  - football matches
  - amplified concerts
• Work done for an hypothetic, but representative stadium
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Methodology of work

Living, urban environment
{Topography, Buildings, Roads, …}

Acoustic propagation
MITHRA

Stadium
Equivalent sound source

ICARE (Beam tracing)

Stadium
{Geometry, Materials, Sound sources}

Concert Match

Absolute future noise levels

Difference with existing site
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Predicting noise levels around the stadium

- Non existing, but representative stadium
- Pitch: 100m x 50m
- Two stands
- Opening between the top of the highest stand and the roof
Predicting noise levels around the stadium
Match (1/5)

• During a football match, the noise comes mainly from the crowd into the arena

• Need to have a good knowledge of a typical “crowd” sound source, or “supporter” sound source
  – Sound power level ($L_w$ in dB)
  – Frequency response (Hz)
Predicting noise levels around the stadium
Match (2/5)

- Characterization of a “supporter” sound source in the Gerland stadium, Lyon, France (existing stadium)
- Measurements at 3 points around the stadium
- Simulation in the ICARE tool (beam tracing) to get the sound levels emitted by the crowd, and its frequency response
Predicting noise levels around the stadium
Match (3/5)

• “Typical supporter” source characteristic

<table>
<thead>
<tr>
<th>Octave band</th>
<th>L_p(dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>63</td>
<td>86,7</td>
</tr>
<tr>
<td>125</td>
<td>82,6</td>
</tr>
<tr>
<td>250</td>
<td>83,7</td>
</tr>
<tr>
<td>500</td>
<td>89,2</td>
</tr>
<tr>
<td>1000</td>
<td>85,9</td>
</tr>
<tr>
<td>2000</td>
<td>79,5</td>
</tr>
<tr>
<td>4000</td>
<td>74,2</td>
</tr>
<tr>
<td>8000</td>
<td>67,0</td>
</tr>
<tr>
<td>dB(A)</td>
<td>89,8</td>
</tr>
</tbody>
</table>
**Predicting noise levels around the stadium**
**Match (4/5)**

- Variations of sound power regarding supporter location, and match period

<table>
<thead>
<tr>
<th>Octave Band</th>
<th>Normal period</th>
<th>Goal period</th>
<th>Normal period</th>
<th>Goal period</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&quot;kop&quot; stands</td>
<td>other stands</td>
<td>&quot;kop&quot; stands</td>
<td>other stands</td>
</tr>
<tr>
<td>63</td>
<td>74.3 dB</td>
<td>65.8 dB</td>
<td>66.0 dB</td>
<td>73.4 dB</td>
</tr>
<tr>
<td>125</td>
<td>81.9 dB</td>
<td>73.4 dB</td>
<td>76.1 dB</td>
<td>80.3 dB</td>
</tr>
<tr>
<td>250</td>
<td>86.1 dB</td>
<td>77.6 dB</td>
<td>82.5 dB</td>
<td>85.0 dB</td>
</tr>
<tr>
<td>500</td>
<td>89.9 dB</td>
<td>81.4 dB</td>
<td>93.1 dB</td>
<td>93.7 dB</td>
</tr>
<tr>
<td>1000</td>
<td>89.1 dB</td>
<td>80.6 dB</td>
<td>97.2 dB</td>
<td>99.3 dB</td>
</tr>
<tr>
<td>2000</td>
<td>84.5 dB</td>
<td>76.0 dB</td>
<td>91.2 dB</td>
<td>93.1 dB</td>
</tr>
<tr>
<td>4000</td>
<td>77.1 dB</td>
<td>68.6 dB</td>
<td>81.4 dB</td>
<td>82.3 dB</td>
</tr>
<tr>
<td>8000</td>
<td>63.4 dB</td>
<td>54.9 dB</td>
<td>69.9 dB</td>
<td>69.3 dB</td>
</tr>
<tr>
<td><strong>Global Level</strong></td>
<td><strong>92.4 dB(A)</strong></td>
<td><strong>83.9 dB</strong></td>
<td><strong>99.1 dB</strong></td>
<td><strong>101.0 dB</strong></td>
</tr>
</tbody>
</table>

[www.internoise2010.org](http://www.internoise2010.org)
Predicting noise levels around the stadium
Match (5/5)

- Calculation of sound pressure levels around the stadium
  - Ring of 36 point receivers ring at 200m around the stadium
  - “Normal period” directivity, and “Goal” directivity
Predicting noise levels around the stadium: 
Concerts

- Main sound source: “line arrays”
- $L_w \rightarrow 105 \text{ dB on the pitch in average (1m70 above the floor)}$
- Loudspeaker spectrum $\rightarrow$ used of audio recordings in a similar sport arena
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The stadium as an equivalent sound source

- The stadium is described with a directivity
- SPL values at receivers R1-8 are known (local averages of the 36 receivers)
- Identification of $L_w$ for the 8 point sources S1-8 with a mean square method
- Stadium represented with its surrounding facade
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Acoustic propagation in environment (1/4)

- Hypothetical site in the MITHRA software
  - Road: 400m from the stadium, 1000 vehicles/hour
  - Some houses: 700 to 900m far from the stadium
  - Small hill
Acoustic propagation in environment (2/4)

- Noise levels when the stadium is not used (with any background noise)

- The stadium do not have a masking effect for the houses on the west side (too far)
Acoustic propagation in environment (3/4)

- Noise levels when the stadium is used for a football match
  - House on the west side: +9 dB(A)
  - House on the east side: +5 dB(A)

- Masking effect of the road traffic

- Major sound increase for houses without any noise barrier (natural or artificial)
Acoustic propagation in environment (4/4)

• Importance of the presentations of results

• Presented in LAeq to consider the duration of the noises

• Especially important for sport games, or discontinuous events
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Conclusions

• A methodology has been build to simulate the acoustic environmental impact of complex buildings such as stadiums, thanks to a junction between 2 different acoustic software's (ICARE and MITHRA).
• Complex geometry of the stadium taken into account.
• The topography, road traffic, etc, have an important influence on the sound increase due to the stadium exploitation.

• Very basic example used here to illustrate the methodology. The diffraction effects and curve surfaces can also be considered in ICARE computations, and meteorological effects can be considered in MITHRA computations.
• Further developments : optimization of the “equivalent sound source” identification
Thank you for your attention!

Any questions?

christophe.rougier@cstb.fr