

OVERHEAD CANOPY DESIGN



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This issue launches a bi-weekly serialized presentation of RPG's research on the design and acoustical performance of overhead stage

and audience canopies. We will address the most frequently asked questions concerning overhead canopies, their design and arraying for uniform coverage. We will focus on the physics of canopy design, beginning with traditional geometric approximations and conclude with a description of what is now possible using a combination of boundary element and multi-dimensional optimization methods, which we have incorporated into a powerful software tool called the Shape Optimizer.

INTRODUCTION

The purpose of an overhead reflector is to blend direct and reflected sound to either enhance intelligibility or musical clarity. Typically speech ceilings are low to provide early supporting reflections. In music rooms, clouds/reflectors can be used to increase clarity while not compromising the reverberance. Basically, canopies fall into two categories, which are determined by the amount of open area in the canopy. Sometimes canopies completely cover the stage (virtually no open area). For example, these are common where the canopy is being used to block sound entering the fly tower. Other canopies over the stage and audience use elements sparsely, with plenty of open area between the canopy diffusers or reflectors. **Solid ceilings** provide complete specular coverage, i.e. there is a specular reflection point

from all sources to all observers. However, the strong directional reflections may cause the specular effects of comb filtering and image shifting, because the specular reflections contain the same frequency content as the direct sound and are displaced in time. **Canopy arrays** have the potential of not providing complete coverage due to the gaps between elements. This can result in loud and soft areas, if the shape and orientation of the panels are not optimized. In the past, poor choice of canopy shape, size and array patterns were the primary cause of uneven coverage in performance spaces.

PLANE SURFACES

We begin by examining the scattering from a simple planar surface, because an understanding of scattering from finite sized plane surfaces is fundamental to an understanding of diffraction and diffuse reflection. With no surface roughness, any scattering generated is by edge scattering. Consequently, understanding plane surfaces enables finite size effects from more complex surfaces to be partly or fully explained. Whether by accident or design, plane surfaces are probably the most common architectural surface. Consider the geometry shown in Figure 1, where a source and receiver are near a finite sized plane surface. The surface is assumed rigid, hard and non-absorbing. If the source and receiver are chosen so that the geometric reflection point, the point at which the angle of incidence equals the angles of reflection, lies on the panel, then the scattered pressure as a function of frequency, as shown in the top line in Figure 2, resembles an approximate high pass filter. At very low frequencies, when the wavelength is very large compared to panel size, little or no sound is scattered from the surface. At very high frequency, when the wavelength is small compared to the surface size, strong specular reflection results. Figure 2 also shows predictions for the scattering at two oblique reflection angles. This shows that repre-

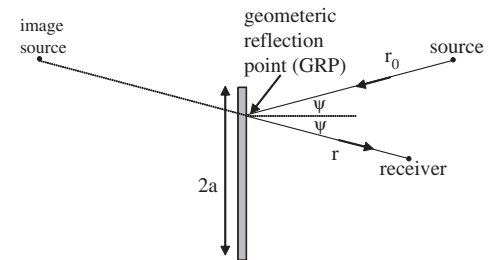


Figure 1. Geometry of scattering from a plane surface.

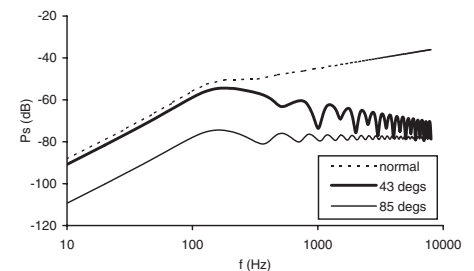


Figure 2. Scattered pressure from a plane surface for normal incidence sound, for three different receiver angles as shown in the legend.

sented the scattered pressure by a simple high pass filter does not work for every direction. In this case, there is often a complicated pattern of minima and maxima. When the geometric point of reflection lies on the surface of the panel, it is reasonable to assume that the scattered pressure at high frequencies is going to be dominated by specular type reflection. When the geometric reflection point does not lie on the panel, however, the scattered pressure is entirely due to diffraction. In this case, the diffracted energy reaching the receiver will not be constant with frequency increases. Consequently, the frequency response for these receivers is more likely to follow something closer to a band pass filter response. This is illustrated by the 43° receiver in Figure 2. This is not always true, however, as shown at the grazing reflection angle case of 85°. In dB Volume 1, Issue 2, we will discuss the cutoff frequency approximation. A rough guide to the region over which the cut-off frequency representation works is therefore the region over which the geometric reflection point lies on the panel.

