ACOUSTICAL BREADTH

The Black-Box Theater of Cal IT^2 is a multi-functional space. It will be used for small student theatrical performances, small live music ensembles, guest speakers, video/audio presentations, and as a classroom for theater based students. Acoustics plays a large role in the comfort level of this space. Without the proper materials, the theater can sound rather dead and life-less. In this theater, I will be adding in acoustical materials to the walls, floor, and ceiling. I will then be calculating the acoustical properties by determining absorption coefficients of the materials and the reverberation times of the various frequencies.

Materials – Existing Conditions

Floor – Dark grey carpeting
Walls – Fiberglass fabric drapery on top gypsum board
Ceiling – Plywood custom shaped to reflect sound into crowd
Seats – Fabric, well-upholstered seats with perforated seat pans (audience seated)

Acoustical Method – Existing Conditions

Reverberation time is the time required for sound to decay 60 dB (decibels) after the source has stopped. This is important for live music and theatrical performances to be pronounced and lively as well as guest and audio speakers.

I will be using the Sabine formula as given: $T = 0.05 * (V / A)$

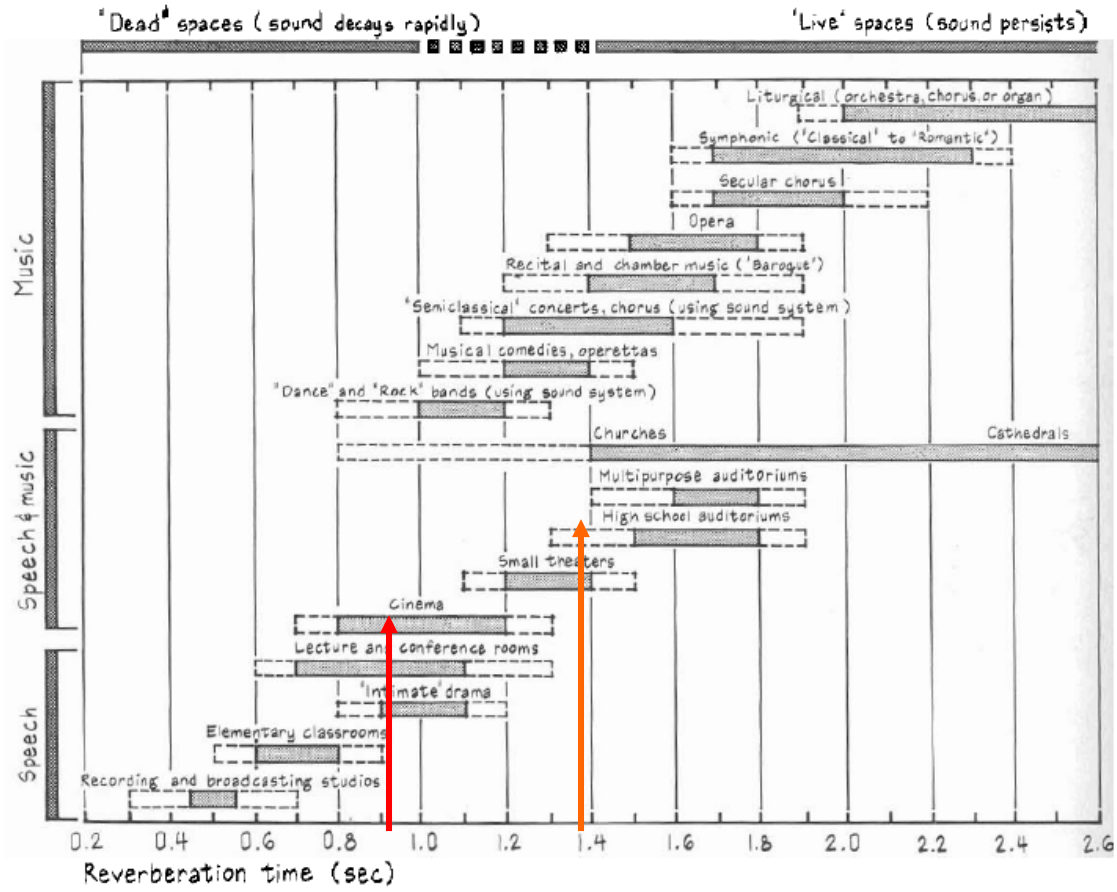
V = Room Volume
A = total square feet of room absorption
T = reverberation time

Sound Absorption Data for Materials and Furnishings

Room Part	Material	Surface Area (sq ft)	Absorption Coefficient					
			125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
Walls	Fiberglass fabric curtain with small airspace between curtain and gyp board	3926	0.09	0.32	0.68	0.83	0.39	0.76
Floors	Carpet, heavy, on concrete	2095	0.02	0.06	0.14	0.37	0.6	0.65
Ceilings	Metal Mesh Grid	1452	0.15	0.22	0.29	0.36	0.43	0.5
	Plywood, 3/8" thick	400	0.28	0.22	0.17	0.09	0.1	0.11
Seating Area	Audience, seated in upholstered seats with perforated pans	900	0.39	0.57	0.8	0.94	0.92	0.87

Reverberation Times						
Room Part	Room Absorption					
	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
Walls	353.34	1256.32	2669.68	3258.58	1531.14	2983.76
Floors	41.90	125.70	293.30	775.15	1257.00	1361.75
Ceilings	217.80	319.44	421.08	522.72	624.36	726.00
	112.00	88.00	68.00	36.00	40.00	44.00
Seating Area	351.00	513.00	720.00	846.00	828.00	783.00
Total sq. ft	1076.04	2302.46	4172.06	5438.45	4280.50	5898.51
Volume (Cu. Ft)	85500	85500	85500	85500	85500	85500
T (sec)	3.973	1.857	1.025	0.786	0.999	0.725

The average reverberation time (which is taken between the 500 and 1000 Hz levels) is about **0.9055 sec**. I will be using different materials on the walls and floor to provide a longer reverberation time as recommended by the chart below. I am treating the space as a small theatre with multiple uses.



Materials – Redesigned Conditions

Floor – Dark grey carpeting on foam rubber
Walls – Lightweight drapery on top gypsum board
Ceiling – Plywood custom shaped to reflect sound into crowd
Seats – Fabric, well-upholstered seats with perforated seat pans (audience seated)

Acoustical Method – Redesigned Conditions

Sound Absorption Data for Materials and Furnishings

Room Part	Material	Surface Area (sq ft)	Absorption Coefficient					
			125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
Walls	Lightweight drapery	3926	0.03	0.04	0.11	0.17	0.24	0.35
Floors	Carpet, heavy, on foam rubber	2095	0.08	0.24	0.57	0.69	0.71	0.73
Ceilings	Metal Mesh Grid	1452	0.15	0.22	0.29	0.36	0.43	0.5
	Plywood, 3/8" thick	400	0.28	0.22	0.17	0.09	0.1	0.11
Seating Area	Audience, seated in upholstered seats with perforated pans	900	0.39	0.57	0.8	0.94	0.92	0.87

Reverberation Times

Room Part	Room Absorption					
	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
Walls	117.78	157.04	431.86	667.42	942.24	1374.10
Floors	167.60	502.80	1194.15	1445.55	1487.45	1529.35
Ceilings	217.80	319.44	421.08	522.72	624.36	726.00
	112.00	88.00	68.00	36.00	40.00	44.00
Seating Area	351.00	513.00	720.00	846.00	828.00	783.00
Total sq. ft	966.18	1580.28	2835.09	3517.69	3922.05	4456.45
Volume (Cu. Ft)	85500	85500	85500	85500	85500	85500
T (sec)	4.425	2.705	1.508	1.215	1.090	0.959

The new average reverberation time (which is taken between the 500 and 1000 Hz levels) is about **1.3615 sec**.

Conclusions

The primary concern with the space was keeping the aesthetics in tune with the black-box theater atmosphere as well as rising the reverberation time to adequate levels for the various uses the theater has. By using the Sabine formula, it was easy to see how the absorption coefficients really affected the sound attenuation. Adding foam rubber under the carpeting and lighter drapery on the walls, the theater sounds more like the small multi-purpose theater it was built as.