



Acoustical Breadth



Acoustical Breadth Study

The Woolly Mammoth Theatre is a live performance theatre. It is about 6000 SQ FT with 265 seats. The seating includes 187 orchestra seats and 78 balcony seats. Acoustics play a very important role in the function of the theatre. The theatre has been designed as a courtyard configuration to connect the audience with the actors in a close setting. The theatre company's goal is to produce live productions for the community. They value the connection between the actor and the audience, and therefore expect the theatre to be a very intimate atmosphere. Their goal is to produce intimate performances where the audience will forget they are in a large public atmosphere.

Reverberation time is defined as the time required for sound to decay 60 dB after the source has stopped. The recommended reverberation time for small theaters is between 1.2 to 1.4 seconds. Yet because of the theatre company's goal, the theater will be designed to have a reverberation time between small theaters and intimate drama. The reverberation time for intimate drama is between 0.9 and 1.1. Therefore the goal reverberation time for the Woolly Mammoth Theatre is 1.15 seconds.

Many different types of sound absorbing materials can be used to control reverberation to the ideal level. The larger a volume is, the longer the reverberation time will be. This is because sound waves will have to travel farther to hit room surfaces, than in a small room. Sound absorption is a great asset because the sound can be made to seem like it is coming directly from the actual source, rather than from all around the room.

The Sabine formula for reverberation will be used in this analysis:

$$T = 0.05 V/a$$

T = reverberation time (s)

V = room volume (CU FT)

a = total SQ FT of room absorption (sabins)

The Existing Design

Materials

The existing design has many materials to be taken into account when doing a reverberation time calculation. The floors in the theatre are concrete in the seating areas, and the rest is heavy carpet on concrete. The stage is wood. There are many different wall materials throughout the space. The side walls are concrete block wall. The back wall of the first floor is a gypsum board wall, and the back wall of the balcony level is perforated metal acoustical wall baffles, with a control room window. The ceiling in the theatre is a concrete slab ceiling. The balcony railings and catwalks must also be taken into account. The railings of the balconies are wood paneled, and the catwalks are metal.

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WOOLLY MAMMOTH THEATRE
WASHINGTON, DC**



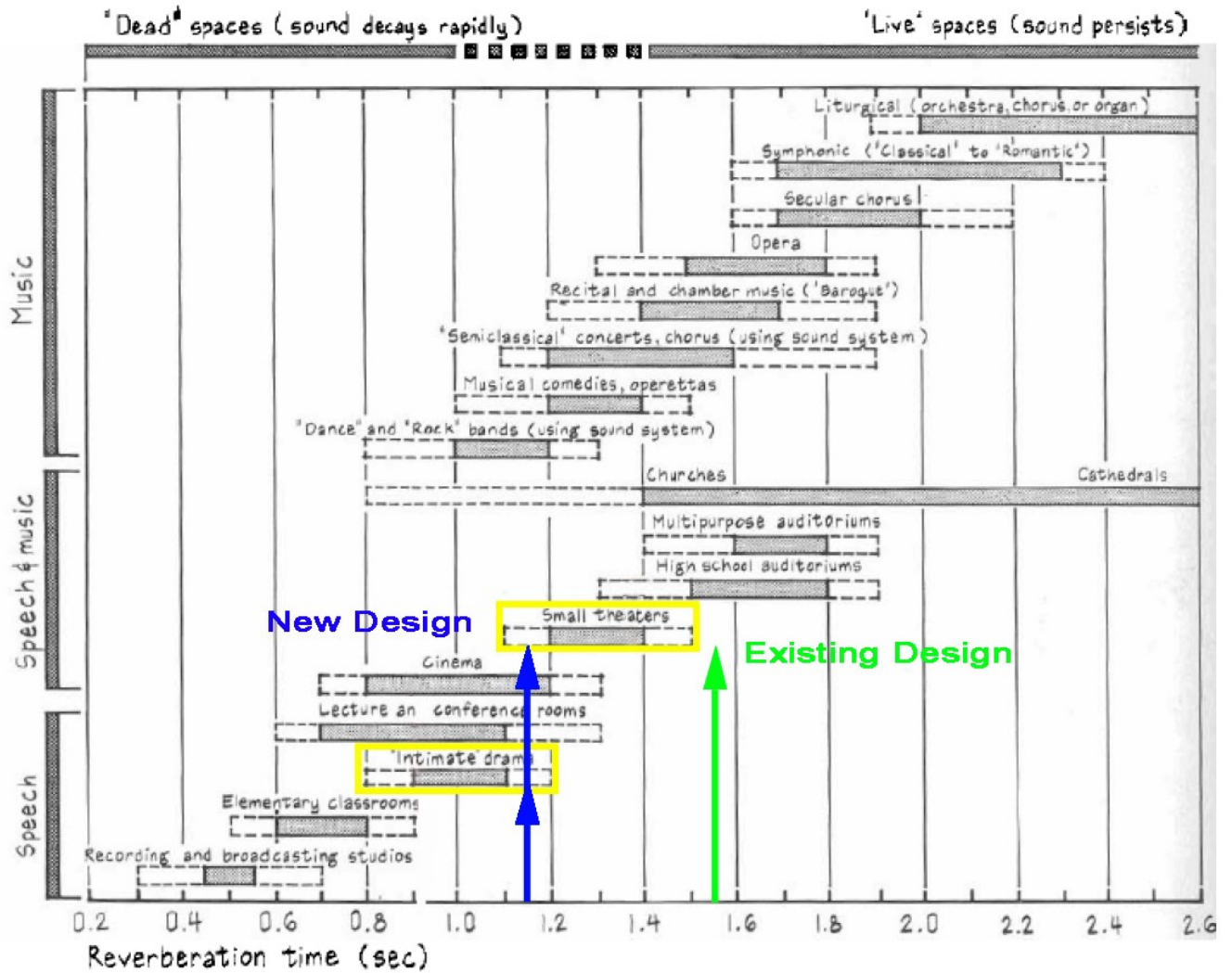
Acoustic Calculations

Sound Absorption Data For Materials														
Surface Type	Material Description	Surface Area (SF)	125 Hertz		250 Hertz		500 Hertz		1000 Hertz		2000 Hertz		4000 Hertz	
			alpha	sabins	alpha	sabins	alpha	sabins	alpha	sabins	alpha	sabins	alpha	sabins
Floor	Concrete slab floor-clear satin finish	1105	0.010	11.05	0.010	11.05	0.015	16.58	0.020	22.10	0.020	22.10	0.020	22.10
	Wood	921	0.150	138.15	0.110	101.31	0.100	92.10	0.070	64.47	0.060	55.26	0.070	64.47
	Heavy carpet on concrete	2089	0.020	41.78	0.060	125.34	0.140	292.46	0.370	772.93	0.600	1253.40	0.650	1357.85
Walls	Painted gypsum board	900	0.100	90.00	0.080	72.00	0.050	45.00	0.030	27.00	0.030	27.00	0.030	27.00
	Concrete block wall painted	3000	0.100	300.00	0.050	150.00	0.060	180.00	0.070	210.00	0.090	270.00	0.080	240.00
	Control room window	110	0.180	19.80	0.060	6.60	0.040	4.40	0.030	3.30	0.020	2.20	0.020	2.20
	Satin silver perforated metal accoustical wall baffles	682	0.700	477.40	0.860	586.52	0.740	504.68	0.880	600.16	0.950	647.90	0.860	586.52
Balcony Railing Fronts	Wood	286	0.150	42.90	0.110	31.46	0.100	28.60	0.070	20.02	0.060	17.16	0.070	20.02
Catwalks	Metal	400	0.050	20.00	0.100	40.00	0.100	40.00	0.100	40.00	0.070	28.00	0.020	8.00
Ceiling	Concrete slab ceiling-clear finish	2849	0.010	28.49	0.010	28.49	0.015	42.74	0.020	56.98	0.020	56.98	0.020	56.98
Audience	Audience in upholstered seats, per SF of floor area	1865	0.600	1119.00	0.740	1380.10	0.880	1641.20	0.960	1790.40	0.930	1734.45	0.850	1585.25
			Total Sabins	2289		2533		2888		3607		4114		3970

Reverberation Time Calculation						
	125 Hertz	250 Hertz	500 Hertz	1000 Hertz	2000 Hertz	4000 Hertz
Alpha Total Absorption (Sabins)	2288	2533	2888	3607	4114	3970
V Volume (CU FT)	100000	100000	100000	100000	100000	100000
T Reverberation Time (sec)	2.18	1.97	1.73	1.39	1.22	1.26

The average reverberation time between 500 and 1000 Hertz in the existing theater is 1.56 seconds. This is above the ideal reverberation time of the theater. Therefore, added absorptive material should be used in the space.

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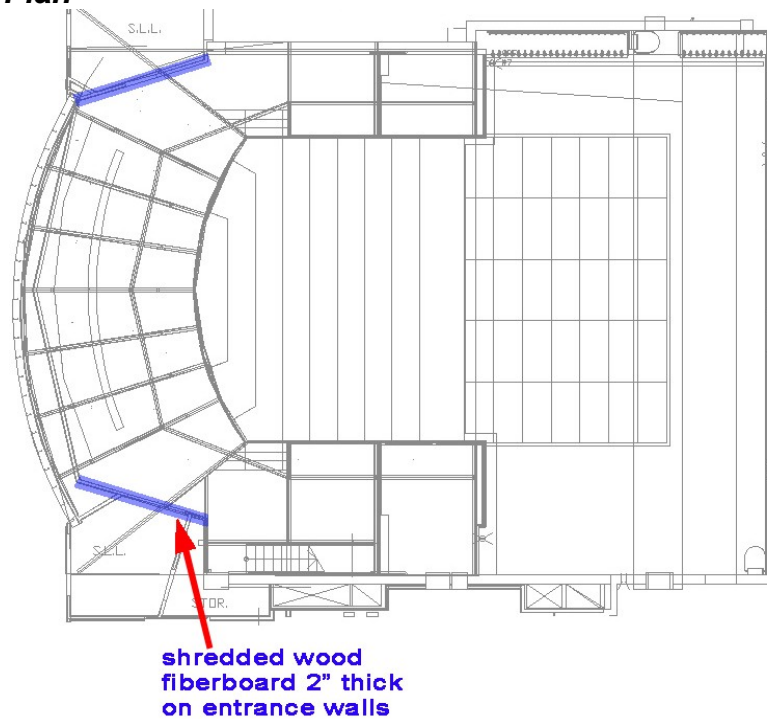




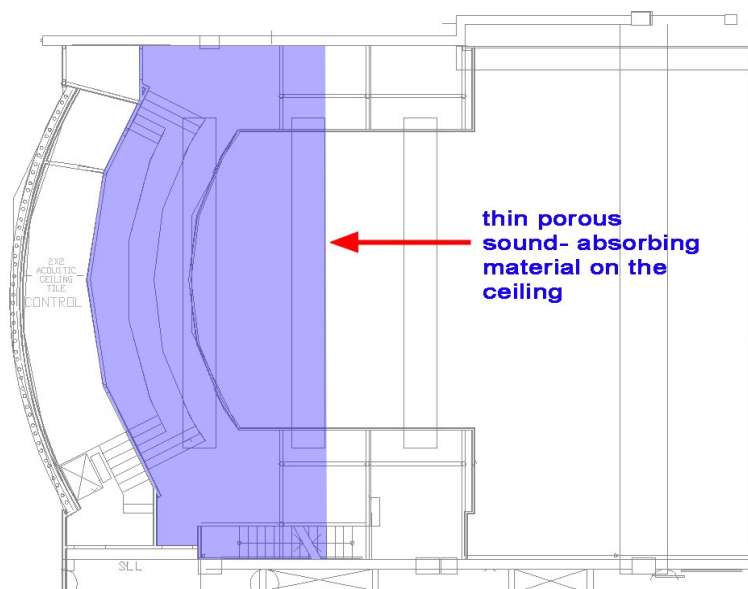
The New Design Materials

The new acoustic design for the theatre has incorporated two new absorbing acoustical materials. In the new acoustic design for the theatre, two new sound-absorbing materials were incorporated to the existing design. On the orchestra level, the north and south entrance walls were covered with 2" thick fiberboard. Also a thin porous sound absorbing material was added to the back half of the theater's ceiling.

Orchestra Level Plan



Balcony Level



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Sound Absorption Data For New Design Materials														
Surface Type	Material Description	Surface Area (SF)	125 Hertz		250 Hertz		500 Hertz		1000 Hertz		2000 Hertz		4000 Hertz	
			alpha	sabins	alpha	sabins	alpha	sabins	alpha	sabins	alpha	sabins	alpha	sabins
Floor	Concrete slab floor-clear satin finish	1105	0.010	11.05	0.010	11.05	0.015	16.58	0.020	22.10	0.020	22.10	0.020	22.10
	Wood	921	0.150	138.15	0.110	101.31	0.100	92.10	0.070	64.47	0.060	55.26	0.070	64.47
	Heavy carpet on concrete	2089	0.020	41.78	0.060	125.34	0.140	292.46	0.370	772.93	0.600	1253.40	0.650	1357.85
Walls	Painted gypsum board	900	0.100	90.00	0.080	72.00	0.050	45.00	0.030	27.00	0.030	27.00	0.030	27.00
	Concrete block wall painted	3000	0.100	300.00	0.050	150.00	0.060	180.00	0.070	210.00	0.090	270.00	0.080	240.00
	Control room window	110	0.180	19.80	0.060	6.60	0.040	4.40	0.030	3.30	0.020	2.20	0.020	2.20
	Satin silver perforated metal acoustical wall baffles	682	0.700	477.40	0.860	586.52	0.740	504.68	0.880	600.16	0.950	647.90	0.860	586.52
	Shredded Wood Fiberboard, 2in thick on concrete	340	0.150	51.00	0.260	88.40	0.620	210.80	0.940	319.60	0.640	217.60	0.920	312.80
Balcony Railing Fronts	Wood	286	0.150	42.90	0.110	31.46	0.100	28.60	0.070	20.02	0.060	17.16	0.070	20.02
Catwalks	Metal	400	0.050	20.00	0.100	40.00	0.100	40.00	0.100	40.00	0.070	28.00	0.020	8.00
Ceiling	Thin porous sound absorbing material 3/4" thick	1100	0.10	110.00	0.60	660.00	0.80	880.00	0.82	902.00	0.78	858.00	0.60	660.00
	Concrete slab ceiling clear finish	1749	0.010	17.49	0.010	17.49	0.015	26.24	0.020	34.98	0.020	34.98	0.020	34.98
Audience	Audience in upholstered seats, per SF of floor area	1865	0.600	1119.00	0.740	1380.10	0.880	1641.20	0.960	1790.40	0.930	1734.45	0.850	1585.25
Total Sabins			2439		3270		3962		4807		5168		4921	

Reverberation Time Calculation						
	125 Hertz	250 Hertz	500 Hertz	1000 Hertz	2000 Hertz	4000 Hertz
Alpha Total Absorption (Sabins)	2439	3270	3962	4807	5168	4921
$\frac{V}{T}$ Volume (CU FT)	100000	100000	100000	100000	100000	100000
Reverberation Time (sec)	2.05	1.53	1.26	1.04	0.97	1.02

The average reverberation time between 500 and 1000 Hertz of the new design is 1.15 seconds. This is the ideal reverberation time for the Woolly Mammoth Theatre.

Conclusion

The primary concern in the theater is to have an ideal reverberation time, while keeping the aesthetic concept of an “unfinished” edgy space. The absorbent material was added to the ceiling, which is not in the main line of view in the theatre. Fiberboard was also added on the entrance walls in the back of the first floor. The absorbent materials were placed very carefully to not disturb the architectural concept of the theatre. The ceiling and the back entrance walls are inconspicuous places to add absorbent material. The added material lowered the reverberation time the ideal time of 1.15. This reverberation time falls in the high end of the RT for intimate drama and on the low end of the RT for small theatres.