Design Development
Phase II
Design Development Phase II

Design Development Phase II is concerned with further development of the design but it is concentrated to include only a selected part or parts of the building as opposed to the further development of the entire project. This will allow for a more in-depth analysis of the building details which will allow the final product to be produced as envisioned by the architect.

The area in which this project will receive its concentration will be the interior space of the auditorium. The development will include the analysis of the space for its acoustical properties, the reinvestigations of the house entries, the selection of materials and the layout of appropriate details. A secondary area which will also be considered is the method by which the run off water from the house roof is handled.

Through this procedure it is realized that this same in-depth design process must be done for all design aspects of the building.
### SEATING
- **Fabric**: microtexture, A1312-69 midnight
- **Paint**: standard

### FLOOR
- **Flooring**: carpet, acrylic, 7016 caviare

### WALLS
- **Fabric**: jute, sisal, wave 13a
- **Paint**: calibrated 2012 document gray
- **Wood**: self-harwood, red oak

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**ig auditorium seating**
LIGHTING
a. House Ceiling
b. Wall Wash
c. House Entry
d. Curtain Wash
Acoustics

Even though there are many unknowns which enter into the acoustical design of an auditorium space, there are some definite areas which must be taken into account if you want to avoid situations which are known to cause serious acoustical problems.

The following are the major design parameters which were considered in the development of the auditorium space. In addition to this list were the mathematical tables used for the various calculations.

1. The interior space should evolve from acoustical requirements.

2. The ideal capacity is from 600 to 800 seats for legitimate drama.

3. The sound sending end should be hard and reflective as well as the ceiling and the side walls. The receiving end should be absorptive.

4. The ceiling is the principle distribution surface. It is designed to distribute sound evenly by reflection to all the audience. It should also be a hard and smooth surface.

5. The wall configuration is shaped to avoid flutter and focusing. It should also be a sound absorbent surface where necessary to achieve the desired reverberation.

6. Seats should absorb the same amount of sound empty as occupied if the reverberation time is to be independent of audience size.

7. In sound reflection the angle of incident equals the angle of reflection.

Sound absorption is found by multiplying the surface area times the absorption coefficient of the selected material
(x square feet) (absorption coefficient) = surface absorption (sq. ft. sabins)

8. Hearing conditions in the house are affected by the house shape, dimensions, volume, seating arrangements, audience capacity, surface treatments and decorative materials.

9. Reverberation is the prolongation of sound after the source of the sound has stopped.

10. Reverberation time is the length of time in seconds that it takes for the sound pressure level in a room to decrease 60 decibels after the sound stops.

\[
\text{Reverberation Time} = \frac{0.05\ V}{A}
\]

\(V\) = volume of room in cu. ft.
\(A\) = total room absorption sq. ft. sabins

11. Reverberation time increases in direct proportion to the cubic volume and in inverse proportion to the total area of sound absorbing surfaces.

12. Calculate reverberation times for 250 Hz, 500 Hz, 1000 Hz, and 2000 Hz.

13. For the auditorium being used for legitimate drama, the 1000 Hz calculation is the most critical.

14. The optimum reverberation time for legitimate drama is one second or less.

15. The speed of sound is 1130 feet per second.

16. Order of acoustical treatment to correct reverberation times.
   1. rear wall
   2. rear side wall
   3. ceiling

17. Reflected sound beneficially reinforces the direct sound if the time delay between them is relatively short—a maximum of 30 msec. or a measured difference in distance of 65 feet.
\[ \frac{R_1 + R_2 - D}{1.13} = X \text{ msec.} \]

or

\[ R_1 + R_2 - D \text{ less than 65 feet} \]

The following is an analysis of the interior space of the auditorium which was developed during Design Development Phase I. The sound reflection, sound absorption and reverberation times of this particular space were the main areas of investigation. The comments and conclusions made from this analysis will serve as a starting point for the redevelopment of the space during Design Development Phase II.

AUDITORIUM ANALYSIS

Sound Reflection—Diffusion

No problem with difference in length of path between direct and reflected sound—all less than 65 feet maximum.

Minor spots where sound diffusion is weak—especially at mid and rear house seats.

Rear wall must have a slant and sound absorption material—bounce back if rear wall is straight.

More flat ceiling surface at stage opening to serve the first 30'--0" of seats.

Sound Absorption

Sound absorption priorities
1. People and chairs
2. Floor carpet
3. Decor hangings
4. Wall surface materials
Chairs empty or occupied should have the same absorption coefficient.

Ceiling is hard with minor absorption.

Receiving maximum absorption from seats and carpet--walls are secondary. At 500 Hz and 1000 Hz the reverberation times are correct.

When mineral wool is added to side walls the reverberation times drop considerably for 500, 1000, and 2000 Hz--all well under the one second optimum.

The rear wall must become absorptive or slanted to eliminate bounce back to source.

Reverberation

For legitimate drama with the house volume at 114,000 cubic feet the desired reverberation time is approximately .9 seconds to 1.1 seconds.

The most important readings are taken at 500 Hz and 1000 Hz.
REVERBERATION TIME CALCULATIONS

1.0 seconds optimum reverberation time
house volume = 114,000 cubic feet
calculations with mineral wool in wall

\[ \text{RT} = \frac{(.05) (V)}{A} \]

250 Hz \[ \text{RT} = \frac{.05 (114000)}{4054} = 1.4 \text{ sec.} \]

500 Hz \[ \text{RT} = \frac{.05 (114000)}{6631} = .85 \text{ sec.} \]

1000 Hz \[ \text{RT} = \frac{.05 (114000)}{7934} = .72 \text{ sec.} \]

2000 Hz \[ \text{RT} = \frac{.05 (114000)}{7269} = .79 \text{ sec.} \]

(The mineral wool is giving too much absorption to the space.)

calculations without mineral wool in wall

250 Hz \[ \text{RT} = \frac{.05 (114000)}{3973} = 1.4 \text{ sec.} \]

500 Hz \[ \text{RT} = \frac{.05 (114000)}{5378} = 1.04 \text{ sec.} \]

1000 Hz \[ \text{RT} = \frac{.05 (114000)}{6142} = .91 \text{ sec.} \]

2000 Hz \[ \text{RT} = \frac{.05 (114000)}{5335} = 1.05 \text{ sec.} \]
| HOUSE MATERIALS | AREA SQ.FT. | | | FREQUENCY | | | | | | | | 125 | 250 | 500 | 1000 | 2000 |
|-----------------|------------|---|---|------------|---|---|---|---|---|---|---|---|
| CEILING         | 5075       | .01 | .01 | .01         | .01 | .02 | .02 | .02 | 101 | 101 | | |
| Concrete (Smooth) |           |    |    |            |    |    |    |    |    |    |    |    |
| WALLS           |            |    |    |            |    |    |    |    |    |    |    |    |
| Wood 3/4"      | 2036       | .10 | .11 | .10         | .10 | .08 | .08 | .08 | 163 | 163 | | |
| Concrete        | 2204       | .01 | .01 | .01         | .01 | .02 | .02 | .02 | 44  | 44  | | |
| Mineral Wool (30 mm thick) | 2036 | .08 | .04 | .04         | .64 | .89 | .95 | .95 | 1934 | | |
| FLOOR           |            |    |    |            |    |    |    |    |    |    |    |    |
| Carpet (3 cm on felt) | 4545 | .11 | .14 | .37         | .43 | 1954 | .27 | 1227 | | | | |
| SEATS           |            |    |    |            |    |    |    |    |    |    |    |    |
| 760 Seats       |            | 3.5 | 4.0 | 4.5         | 5.0 | 3800 | 5.0 | 3800 | | | | |
| ABSORPTION A#   | 15896      | 3548 | 4054 | 6681       | 7954 | 7691 | | | | | | |
| w/o MINERAL WOOL | 1512      | 3973 | 5378 | 6142       | 5335 | | | | | | |
The house as it exists at this point is very acceptable when analyzed for its basic properties. The interior materials used give the proper absorption coefficients for the desired reverberation time which is also acceptable. The house dimensions are good and should be maintained as much as possible but the ceiling height can be flexible. The major problem which must be corrected is the sound distribution problem which the irregular ceiling treatment creates. Due to this the rear seats do not receive nearly enough reflected sound. There is also a definite need to develop a more well integrated interior, especially where the interior planes intersect.