TEMPORARY THEATRES: CHALLENGES AND EXPECTATIONS

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1 INTRODUCTION

The acoustic aims for a theatre space are to provide an environment of

- High speech intelligibility to the audience
- Acoustic response back to the performers
- Control of intrusive noise
- Control of noise egress on some sites

To meet these aims, theatre designs, while differing in the scale and the detail, tend to follow a conventional and successful pattern of design which includes:

- Heavy masonry building envelope or a theatre buffered by other accommodation to control noise ingress and egress;
- Quiet ventilation, usually mechanical and extensively serviced
- Interior surfaces of predominantly sound reflective materials

In a temporary theatre, these all have to be questioned and challenged due to the inherent building constraints.

2 THE TEMPORARY THEATRE

The temporary theatre requires a different approach; usually driven by cost and acknowledging that it is extremely wasteful to build highly serviced, heavy structures, only to dismantle them after a year or two. In the two cases described here, the intention was that the theatres should be later transferred to other sites, adding the need for demountability and high speed of construction.

When acknowledging that the temporary theatre will not be as acoustically ideal as that of a permanent building (and similarly of a lower standard in terms of audience facilities and thermal comfort etc) the question is then what standards to apply to the design.

An audience for an outdoor performance is clearly conscious of the environment and appears to accept relatively poor acoustic standards, for example aircraft and traffic noise and limited acoustic support for the actors. They do this in the same way that they accept it will be hot or cold (or raining). Once inside a building, that contact with the environment is lost and unwittingly the expectation becomes much higher.

The temporary venues described here were for the National Theatre and Chichester Festival theatre, two of the foremost producing theatres in the country, where theatre must be seen as 100% professional and acoustic aims are high.

3 THE SHED, NATIONAL THEATRE

The Shed at the National Theatre was planned as a temporary theatre to replace the Cottesloe during the 18 month closure for refurbishment. It consists of the theatre auditorium for 220 people only, with some additional enclosure linking it to the main building foyers. The theatre has stalls and a single balcony of seating in a thrust / in-the-round format. The construction is of steel and timber and it is naturally ventilated. The theatre is principally for drama productions although has staged an amplified musical.

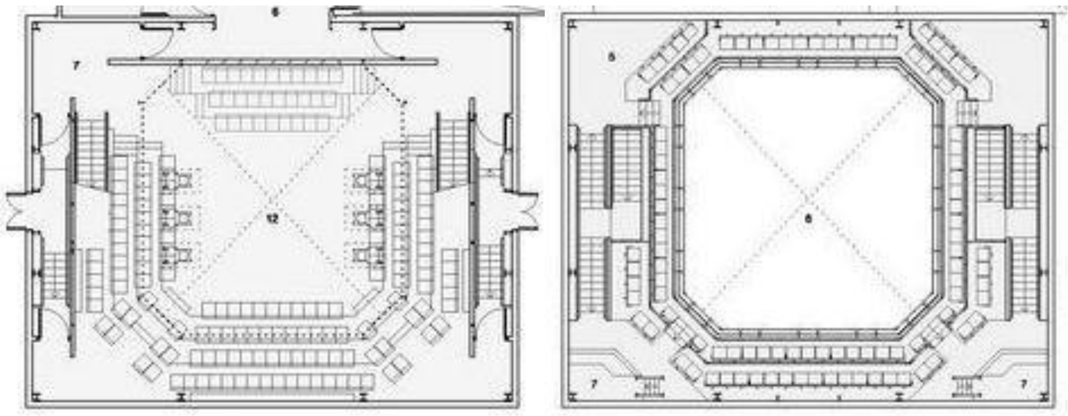

Figure 1: The Shed, stalls and balcony plan (architect Haworth Tompkins)

In a small timber clad theatre with no more than 3 or 4 rows of seating, the room acoustic design to achieve good speech intelligibility for audience and performers is as for a conventional small theatre with many sound reflecting surfaces close to the audience.

3.1 Control of Noise Ingress

The main acoustic issue at The Shed was controlling noise ingress, via the building envelope and via the natural ventilation system. Conventional criteria for theatre spaces suggest limiting intrusive noise (from ventilation or noise ingress) to around NR20 or 25dB(A). For larger spaces, where the voice has to carry over a greater distance, lower limits would be used. These limits are also usually applied to the highest level of noise ingress eg L_{A1}.

Outside The Shed, noise levels are around 61 to 64dBL_{Aeq} due to constant road and river traffic. Higher noise events occur from emergency vehicles, helicopters and occasional music or shouting close to the theatre site. It was decided that the general noise should be limited to 30dBL_{Aeq} and that occasional high noise events would be audible over this, 10dB higher. This saved a considerable amount on the sound insulation construction of the building envelope and allowed the natural ventilation and simple lobbied fire doors to be pursued.

The Shed has no foundations and sits on the basement car park of the NT. There was therefore a strict limit on the allowable mass of the whole construction. The envelope walls are based on a construction of 18mm ply / 150mm air gap including 100mm mineral wool / 2 x 18mm OSB. For ease of construction and demountability, this construction was made into timber framed modular cassette units with compriband strips sealing all the joints.

During value engineering of the design, the design noise level was questioned in order to look for savings in the envelope and natural ventilation design. Although a background noise level of 35dBL_{Aeq} would not be ideal in a theatre, for such a small venue it could be possible. However reducing the sound insulation would have also made disturbance from occasional high noise activities both more noticeable and more frequent. On this basis it was not pursued.

Noise from heavy rain was also a potential issue with there being no conventional roof void. Being aware of rain may be acceptable in a temporary venue as an occasional occurrence. However as rain lasts for some time, it raises the background noise to a level where it interferes with speech intelligibility and is therefore detrimental. The roof was designed with similar cassette units but with an additional void, ply layer and external thermal insulation. The rain screen cladding of spruce boards with open joints also helped to limit rain noise by slowing down the rain impact. The result was that the heaviest downpours were just audible as a low frequency rumble, suggesting an optimum balance was achieved.

3.2 Natural Ventilation

For successful quiet natural ventilation in a theatre, there must be sufficient space to attenuate the incoming noise through the air routes. Its feasibility usually depends on the amount of open area required at the inlets and outlets and through the system to make the ventilation work. This in turn is dependent on the size of audience. For The Shed the total open area on the inlet and outlet needed to be $7m^2$ each.

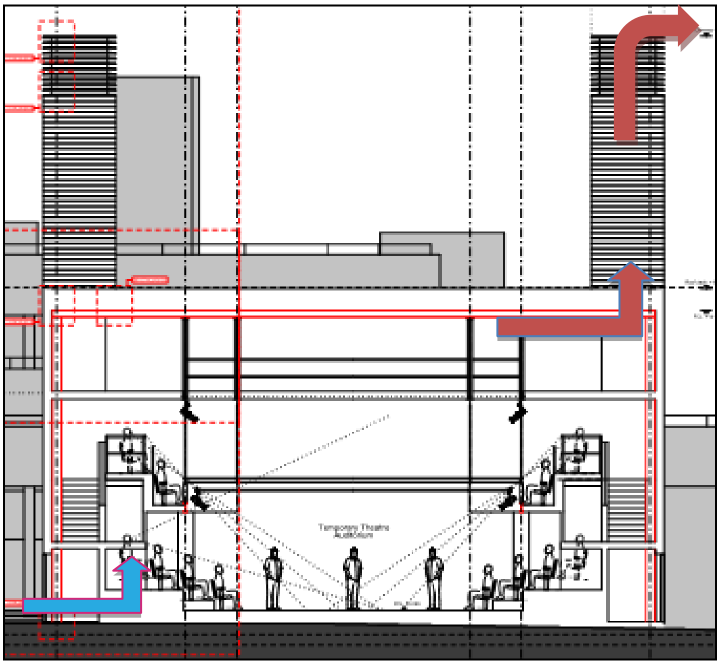

Figure 2: Natural ventilation at The Shed

Air is drawn in through a 500mm high grille around the perimeter of the building. An acoustically lined labyrinth under the stalls seating brings the air to open slots behind the seating. Four chimneys use the buoyancy of the rising warm air to draw it through the theatre and exhaust it. The chimneys are acoustically lined and have a ducted bend at the base to provide additional attenuation.

3.3 Conclusion

The Shed has worked very well as a theatre space and is very popular with both performers and audience. The general level of background noise is 25dB(A) (lower than targeted) and is not noticeable. Noise from occasional events is noticeable and, for example, staff have had to move along nearby buskers. This is as was to be expected.

During design, the available attenuation in the natural ventilation systems was expected to be the limiting factor in the overall control of noise ingress. However, by measurement and listening, the limiting factor was found to be the envelope. This is probably due to the construction of the timber cassettes, which form a very stiff module, limiting the attenuation achievable with a double wall construction, and possibly the high number of joints between panels.

4 THE PAVILION IN THE PARK, CHICHESTER

Chichester Festival Theatre has now re-opened after a major refurbishment last year. The annual summer theatre festival is an important part of Chichester's role and reputation as a major producing theatre and it was important to continue this through the building project.

The Pavilion in the Park was a temporary venue in a theatre tent designed to replicate to 1400 seat, arena-form main stage. The main show to be staged was a new Cameron Mackintosh production of Barnum; with a play, Neville's Island, following. The theatre tent housed the auditorium, stage and small foyer. All other theatre backstage and front of house facilities were housed in tents or shipping containers on the site. The tent is made of stretched fabric supported on three large external trusses. Internally the floor stage and seating are built up from the ground. The tent is mechanically ventilated and cooled.

The tent material is reflective to sound at high frequencies and mostly transparent to sound at low frequencies. Two issues drove the design acoustically:

- Stringent planning restrictions on noise egress
- Providing a suitable room acoustic for a show sound system

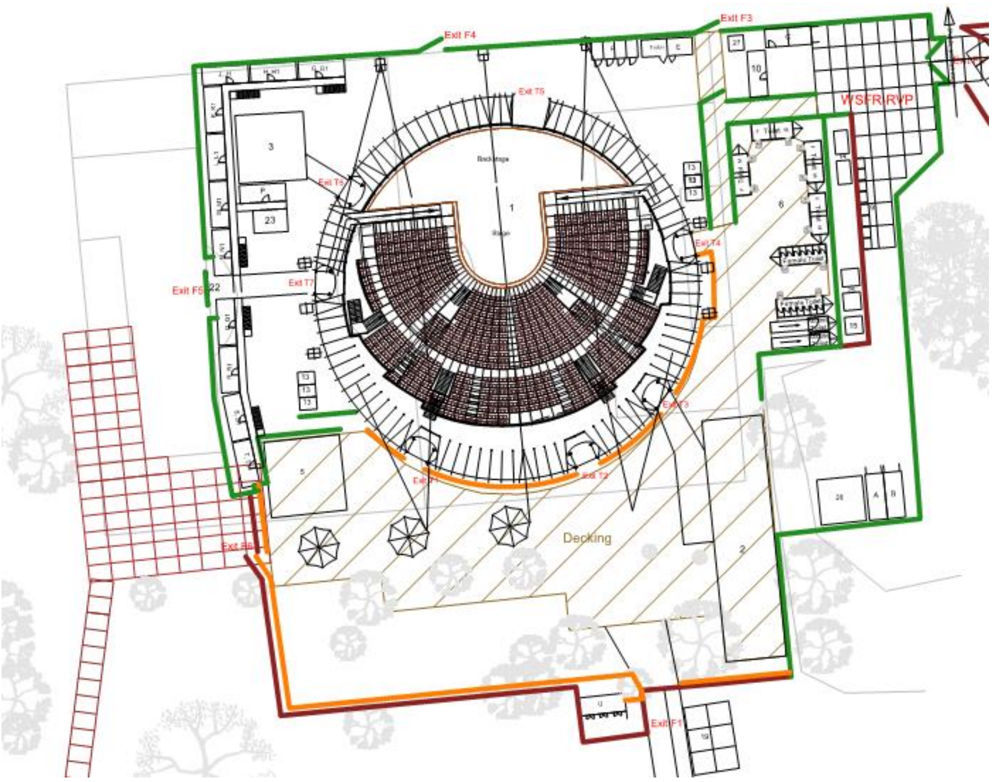

Figure 3 Plan of the Pavilion in the Park and associated facilities (architect Teresa Hoskyns)

4.1 Control of Noise Egress

The local authority wished to control noise to residents on Broyle Road, 65m from the edge of the tent on the west side of the site. The requirement was to limit noise (from music and plant) to no more than 55dB$L_{Aeq,15mins}$ and no more than 70dB in either the 63Hz or 125Hz octave frequency bands. As well as residents on Broyle Road, there were two residential properties at the north end of the park, 150m from the tent.

Noise from the show was controlled by a combination of

- Control of noise at source
- Sound insulation of the theatre tent
- Barriers around the edge of the site

As well as the show sound system, the production included a live band (a circus band including brass and woodwind) on a bandstand platform above the stage. The sound system was designed to be primarily directional with line arrays directed towards the audience. However there were also surround speakers and bass speakers, which are more omnidirectional. Room acoustic modelling of the auditorium suggested that noise levels throughout the tent and on the envelope of the tent were fairly uniform even with a directional sound system. The sound level at the mix desk was monitored and limited to 85dB$L_{Aeq,15mins}$ although in practice it was always run at a level no more than 80dB(A).

The audience seating naturally forms a barrier to noise egress at low level, but around the stage there is no natural enclosure. Placing the band on a raised platform meant there was no natural screening between them and local residents. Proposals were discussed to enclose the band on all sides other than the front. This was not pursued, partly for artistic reasons, but also because it can be counter-productive acoustically. If the band are mostly enclosed in a sound absorbing enclosure, their perception of hearing themselves and each other is impaired and they tend to react by playing louder. Screening was therefore limited to high plywood panels hung behind the band platform and covered with theatrical drapes.

The theatre tent was located roughly in the centre of the park. The back stage facilities were all housed in shipping containers, fitted out as dressing rooms, wardrobe stores and canteens. These were double stacked to form a barrier 7m high, controlling noise propagation from low level sources particularly round the stage area.

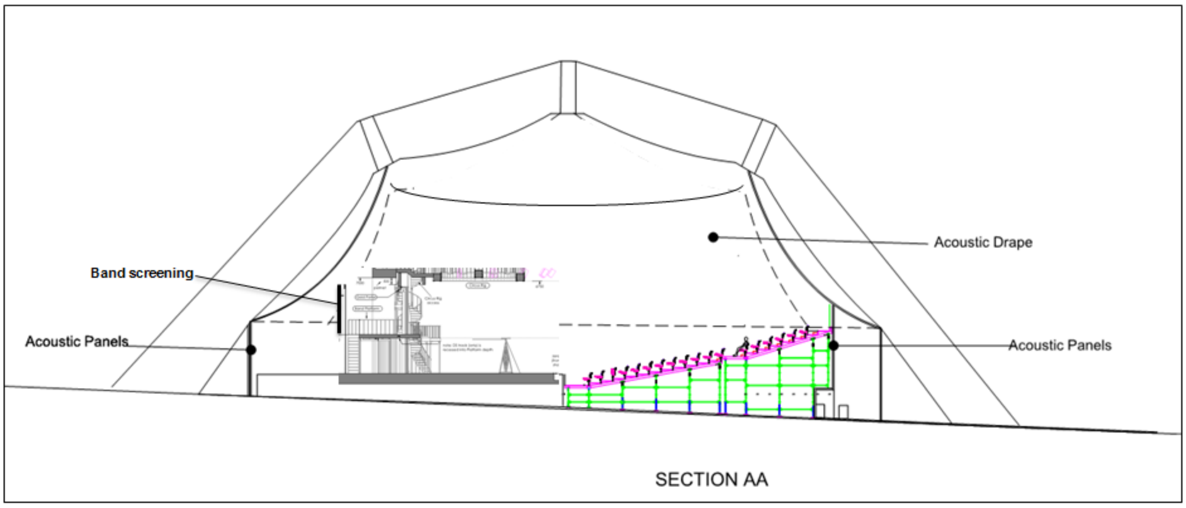

Figure 4 Section through the theatre tent

Inside the tent, the perimeter of the auditorium was enclosed with a 4m high wall of Kingspan insulated cladding panels. These were selected to be quick to erect, form a neat wall to the foyer and be reusable for future sites. The panels enclosed the seating and stage at low level to reduce noise egress from low level sources. They also provided some sound insulation between the auditorium and foyer.

Much of the sound was expected to leave the tent at high level, above all practical screening. The tent was made of Ferrari Precontraint fabric, surface weight 1.2kg/m^2. Sound insulation test data was available from another project, both for the tent fabric and with various serge linings as shown in Figure 5.

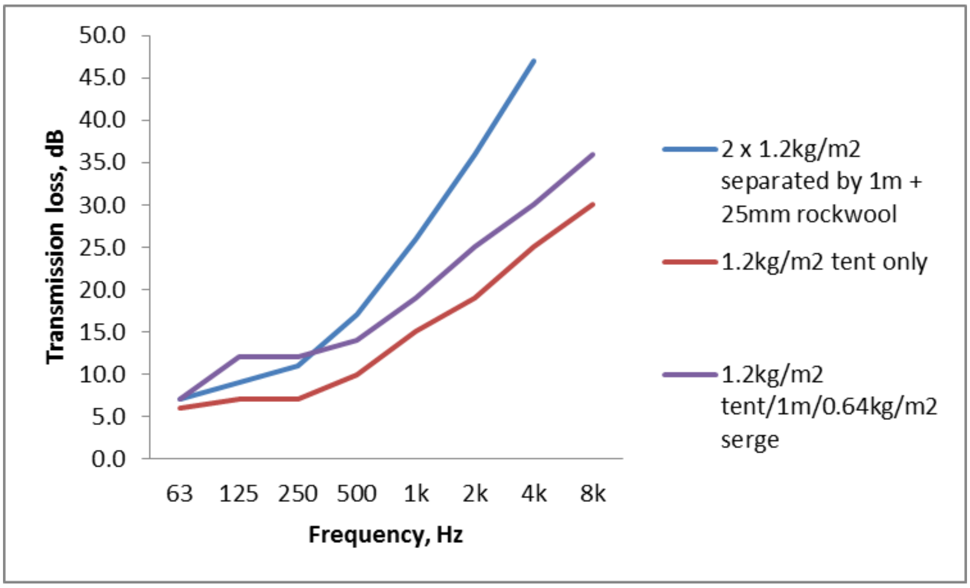

Figure 5: Transmission loss of tent and drape combinations

The sound insulation of only the tent fabric was not sufficient to control noise egress to the residents. The trusses which hold up the tent had a limited load capacity, to include the tent, ventilation and all the theatre rigging. There was therefore a limit to the amount of additional materials that could be added to the tent to increase sound insulation.

Sound insulation was maximized by hanging a sandwich of 0.6kg/m^2 serge, 0.9kg/m^2 wool felt and a second layer of 0.6kg/m^2 serge, draped from a truss, an average of 1m from the outer tent fabric; the void between the drape and tent fabric providing the sound insulation benefit. Although the gains in low frequency sound insulation are not high in absolute terms, they were needed and sufficient to provide the low frequency noise control. This heavy sandwich drape was only hung for the upper sides of the tent on the west and the north sides in order to limit cost and weight.

4.2 Room Acoustic Design

From the start, it was agreed that both productions would be sound reinforced throughout. This was due to the high audience area to be covered, the non-ideal control of background noise and the lack of acoustic support that could be gained in a tent theatre. The room acoustic analysis was still import however due to the circular form of the tent at low level.

The solid perimeter Kingspan panelling had the potential to provide a highly sound focusing ring exactly at the level of the performers. Around the seating, this was kept below the seating rake, where possible, and screened with serge drapes where not. Around the stage area, the wall was screened with the set and theatrical masking at some distance from the wall.

Odeon modelling showed a potential risk from focusing sound reflections off the lower portion of the tent fabric. This was therefore covered with a single layer of 0.6kg/m^2 serge hung in from of the tent fabric. Normally, a thin covering of serge would not provide sufficient sound absorption to correct a strongly focusing reflective surface. However the serge was hung more than 0.5m in front of the tent, greatly increasing its effectiveness.

As a result, reverberance was very low and therefore of benefit to the design of the sound system. There were two interesting outcomes of the resulting room acoustic. The deadness in the space resulted in a very theatrical stillness, very far from the impression of being in a temporary tent. This in turn does raise the expectation of the audience.

Most of the interior of the tent was lined in some weight of drape, only the top and some of the sides exposed the original tent fabric. On commissioning the sound system, late high frequency reflections were heard from an area of the roof of the tent as a slap back. In an untreated tent, these reflections would not have been distinguishable amongst all the other sound reflections. However because there were few sound reflecting surfaces left, these became distinctive. An additional small area of drape was suspended across the lighting rig to successfully interrupt this sound path.

4.3 Building Services

The building services for the tent included a generator, cooling condensers and air-handling units. These were all externally located on the site and had to meet the same noise limits at local residents as the amplified music. However limiting noise to the tent became the driving factor. The generator and cooling units were located on the east side of the site and screened from tent. The air handling units had to be located close to the tent in order to minimise the duct runs and pressure drop of the fans and therefore their duty.

The noise target set for inside the tent was 35dB(A). As the performances were sound reinforced, intelligibility of speech was not likely to be an issue. However background noise should be set at a level where the noise is not unnecessarily distracting.

This noise target meant limiting noise from the fans to 50dB(A) at 3m. Ordinarily, this may be easily achievable, however all of the equipment for the production was hired. The choice of equipment and the standards of noise control on the available equipment are poor compared with that procured for permanent installations. On site, the fans had additional enclosures built for them, but unattenuated noise from the lightweight fabric ductwork caused noise levels of over 40dB(A) in the tent in the vicinity of the fans. This was noticeable when the auditorium was unoccupied but less noticeable with the audience present and the productions underway.

4.4 Conclusions

The room acoustic conditions and the resulting internal noise level worked well for the productions staged and with sound reinforcement of speech.

Noise level measurements were made close to the nearest residents to the west and the north of the site during commissioning. In the tent, a music sound track was played at the agreed maximum level; the track containing a higher bass content than would be experienced during the show. At the monitoring positions, the noise level was up to 50dB(A), and comparable with the ambient at that time. The music was distinguishable due to its character. The low frequency content was measured at 62dB.

During the festival season, long term monitoring was reported weekly to the local authority and no complaints were received.

5 SUMMARY

Temporary theatres present new challenges in their design compared with permanent venues. It is important to understand the desired use of the venue, the likely limitations and the expectations of client, performers and audience. Commissioning a temporary venue may start out with agreed understanding that acoustic standards will be lower than that of a permanent venue. However, once inside, the audience may forget that the theatre is temporary and retain their high expectation and as a minimum the intelligibility of speech and the attention of the audience on the actor are essential.

The issues that influence the design may vary depending on the site and the form of the theatre. However the issues are likely to be driven by cost, weight and portability.

Selection of an appropriate background noise target and the client understanding that target is vital. If the highest noise events are allowed to be heard then the sound insulation can be achieved with lighter weight materials provided sufficient depth of construction can be used. With modular or demountable systems joints may be a weakness for sound insulation. Noise from rain should be considered in the design, although mitigation can be expensive.

Natural ventilation can be considered for small auditoria, where the demands on open area through the system are reasonable. If mechanical systems are used and where other building services equipment are used, the standards of noise control on hired equipment may not be sufficient to control noise to the theatre or to audience areas.

Where room acoustic design cannot naturally support the actor’s voice, sound reinforcement should be strongly considered.