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Music and outdoors: are they meant to work together?

Marc Asselineau (1), Maud Serra (1)

(1) Peutz & Associates, 10 B rue des Messageries, F75010 Paris, France

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ABSTRACT

Outdoor spaces, or very large venues for that matter, often offer a seducing way of hosting large events without undue complications regarding security and fittings. However, they usually do not provide the audience and the performers with as high a level of comfort than enclosed venues. More to the point, community noise control of such facilities can really be tricky. What can be expected of such facilities? This paper intends to submit a few hints, looking at recent projects and developments.

INTRODUCTION

When it comes to holding events and performances, one will usually aim for a suitable venue. By such a term one typically thinks of such cosy facility as a performance hall. Unfortunately, such facilities are usually a bit cramped, especially in old European mid sized towns, which eventually means that financial equilibrium of the show can only be met under such circumstances through rather stiffly priced entrance fees. This means that such costly performances as operas are ruled out. More to the point, the moment the facility is roofed over, safety measures apply (e.g. smoke exhaust) and this has a cost too.

Hosting large events is often an even trickier business, as one must cope with a fairly large attendance. The safety problems are quite similar to those of outdoors venues such as a stadium.

As things go, stadiums are often plagued with a need to make money, and any extra from the usual competitions is always welcomed. Thus it should be no surprise to anybody concerned that eventually a few large shows do find their way in outdoors sport facilities, or at least in large indoors sport facilities.

This undoubtedly has its advantages when it comes to having the star landed on stage by helicopter.

Of course, a complication is to be expected: in most performance halls the stage is quite well identified and does feature such amenities as a grill. Sport facilities are devoid of such niceties, which eventually mean that something has to be done both to stage the show and to provide the performers with the usual tools of their trade. Last but not least, a performance hall usually manages to prevent outdoor noise intruding in the show, while reducing the amount of noise radiated to the neighbourhood. With an outdoor facility, there is of course no question of such protection, which means that a few awkward problems will have to be solved.

A BRIEF HISTORY

There undoubtedly is a serious precedent regarding the use of outdoors facilities for hosting shows: both the Greeks and the Romans had consistently used their amphitheatres for such purposes. More to the point, they had actually faced the din of the city, with the noise of carts wheels clanging on the stone paving [1], while neighbours (that is, those who did not attend the show) would complain about the noise from the show as well as about the difficulties stemming from the presence of such a large number of people.

With the emergence from the Antique world, gone were the large open air amphitheatres. From now on the show would either be held inside the church for religious purposes, or on its steps. For non religious purposes, either it was a popular event and it would find its way to the market place, or it was a private affair that would either be held inside the local squire's ballroom or in his private gardens. This eventually meant that the number of performers was rather limited and the distance from stage to audience was kept within very reasonable values.

The development of shows in the 17th century prompted the construction of specific venues devoted to their hosting. Gradually, the theatre as it is known nowadays started to develop. There was a stage with lateral spaces on both sides, though for a long time there was no orchestra pit and the musicians would play on each side of the stage. Gradually the larger demand led to an increase of the capacity of the venues. Also, the improvement of wind music instruments led to an increase of the strings in order to keep the equilibrium. In turn, this still prompted a need for larger facilities, especially as one was looking forward to a larger audience to help cope with the increased cost of such large outfits.

An interesting period is that of the French Revolution. In 1791 the French Government created a National Institute for Music that was specifically directed to provide the means to stimulate the patriotic spirit of citizens using music. Of course the attention of the directors turned quickly to performances outdoors, and in order to satisfy huge crowds, both a large orchestra, especially strong in winds, and high power output, were needed. Of course, one was much more concerned by the audience being able to listen than by the possible annoyance of the neighbours!

This trend culminated in the 19^{th} century with such large works as the Grande Symphonie Funèbre et Triomphale by Berlioz [2] in 1840, or even the concert given under his conduct in 1844 after the Industrial Exhibition in Paris which featured 1022 performers [3].

Due to the fact that shows are not always subsidized, it is often desirable to pack as large an audience as possible. This quickly proved difficult in enclosed spaces, with the 4300 seats Auditorium Theatre in Chicago by Adler & Sullivan being an example [4]. However, an outdoor space such as a stadium does not offer so much complexity. So it is not surprising that the moment electro acoustics were available, shows were performed in such outdoors facilities.

Nowadays, electro acoustics have been on the rise. This means that one has steadily evolved from a somewhat tiny installation meant to improve the speech intelligibility inside the premises to a massive system capable of emitting high level signals, including in the low frequency range. Electro acoustics can even be used to try and simulate acoustic reflections on virtual walls [5,6].

The need to optimize the money earning capability of large venues such as stadiums prompts the managers to try and host shows in their facilities. Of course, this is much noisier, and either specific noise control measures must be implemented, or rather restrictive agreements must be negotiated with the local authorities.

The easy availability of powerful electro acoustic devices has led to the development of a new trend known as “rave parties”, which one might remotely consider as the inheritors of the popular festivities in the middle ages! Of course, due to the heavy low frequency content of such happenings, specific regulations have been developed and there is abundant literature on the subject [7].

A FEW LEGAL REQUIREMENTS

In France musical venues are covered by a specific law text [8] which states that the emergence (i.e. the difference between the ambient noise including the noise from the music, and the background noise level) should not exceed 3 dB(A) in the built environment.

In addition, it is quite usual to try and meet whenever possible criteria that is compulsory in the case of adjacent buildings: the emergence in each octave band from 125 to 4000 Hz should not exceed 3 dB.

Due to the difficulties of complying with such stringent regulation, it is not unusual for the local authorities to permit a limited number of occurrences (typically 4 per year) with higher emergence values (e.g. 6 to 9 dB).

An interesting feature of this text is the limitation of the sound pressure level at 0,5 m from the loudspeakers: the L_{Aeq} over the most noisy 10 minutes must not exceed 105 dB(A) while peak value must not exceed 120 dB. This is meant to try and protect both the technicians and the audience.

Unfortunately, this particular text applies to enclosed musical venues as another legal text was supposed to take care of open air facilitiesd. In its absence, the regulations in force are those of community noise control [9], in which the notion of emergence per octave band has only recently been taken into account. The emergence should not exceed 5 dB(A) in day tiome and 3 dB(A) during night time in the built environment. In addition, it should not exceed 7 dB in the 125 and 250 octave bands and 5 dB in the octave bands till 4000 Hz.

In Belgium and Luxemburg, the respective regulations [10, 11] state that the maximum sound level emitted on the dance floor should not exceed 90 dB(A) either on the dance floor [10] or at any point that people would normally access [11]. This was meant first of all as a safety for the neighbours as the sound insulation of musical venues usually was enough to guarantee a reasonable chance of reduced annoyance in the neighbour’s premises. But it was also meant to try and protect people inside the facility, especially technicians and musicians who are likely to spend much more time exposed to noise than the average audience.

OUTDOORS FACILITIES

Outdoors facilities usually provide a simple answer to the challenge of large audiences as well as to the possibility of special effects. But there may be some serious drawbacks. Here are a few significant points.

Controlling the background noise in the facility

To start with, large outdoors facilities are meant to handle huge crowds. This means that they are often located close to a major motorway so as to ease the inbound or outbound traffic flow. However, this also results in the background noise levels inside the facility being rather high, for a performance facility that is.

This means that noise barriers between the facility and the transportation corridor are needed. Those are typically provided by the walls of the facility. Yet, those walls must also feature all the necessary exits, which mean that provisions for noise reduction without hampering a hasty emergency exit have to be devised in order to avoid their radiating noise to the neighbourhood.

This noise barrier effect can be significantly upgraded using the roof over the audience. However, it is not uncommon for the architect to try and find large openings between the roof and the vertical wall for natural lighting purposes, which must be treated accordingly.

Last but not least, the facility has better be located far from any air corridor!

Reducing the noise pollution outside the facility

Basically, this is about increasing the noise barrier effect. This means that the walls of the facility and the roof over the audience will be put again to contribution.

Depending on the location of the sound system, the noise barrier effect can be enhanced. While a system using a large cluster of loudspeakers in the middle of the stadium will not benefit from the best noise barrier effect, it also is possible to use loudspeakers located under the edge of the roof over the audience for maximum efficiency. However, such a move supposes that the field is not used to receive any audience. At any rate, when it comes to low frequency sound, the noise barrier effect is pretty low and one is left with no practical solution safe reducing the emitted noise levels.

Other points to think about

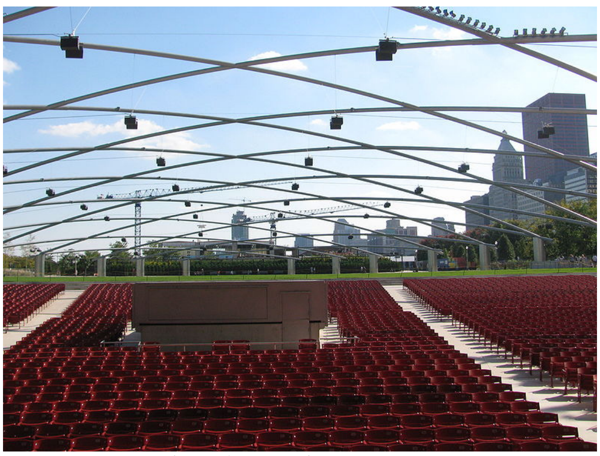
As compared to an indoor facility, an outdoor facility clearly lacks reverberation and natural reflections (not that there is no risk of echoes!).

Echoes can be prevented using the usual absorptive (or even diffusive) treatment on the relevant walls. More to the point, it is also possible to minimize their effect by judiciously positioning the loudspeakers.

While the lack of natural acoustic reflections is either not a problem for pop or rock like music, or downright unwanted, it is a serious problem when dealing with classical works. To start with, the lack of reflections on the ceiling greatly impairs the capability of musicians to behave as an ensemble, as the communication between the various pulpits is difficult. More to the point, it easily leads to a situation where the feeling of musical mass, which is typical of symphonic work, as opposed to that of individual pulpits, which is more typical of the baroque era, can be totally lost. More to the point, the experience of the audience seldom is a happy one when compared to the acoustics of any fair concert hall, as there is a definite lack of lateral reflections. It has been pointed out that "while the outdoor performance experience of may be deemed "good" for both those playing as well those listening, it is not the experience that either desire" [12]

As concerns reflections (that really are quite desirable whenever attempting to perform classical musical works), electro acoustics can come to the rescue, provided the system has been designed specifically. However, one might care to note that simulating such reflections does suppose that there are loudspeakers under a virtual ceiling over the audience as well as over the virtual lateral walls. While this is quite easily feasible around the stage in order to provide performers with indoor like acoustics (though in outdoor facility there is no grill worth speaking of over the stage and free standing structures have to be built accordingly), it is much more complicated to achieve such a feat over the whole audience the moment it is no longer located under the roof of the facility.

Acoustic enhancement was used during the 1995 Vienna Festival, which was not criticized by the musicians or the audience [13]. It was later on used in other venues, for example in the Jay Pritzker Pavilion by Frank Gehry. In this later case, due to the permanent character of the facility, the loudspeakers were installed on a grid over the facility rather than on fixed columns.



(Picture by Antonio Vernon, 2007)

Figure 1. Jay Pritzker pavilion, as seen from the stage, with the array of loudspeakers on the "ceiling"

An example of implementation of a SIAP enhancement system in the Tanglewood Music Shed outdoor venue is given in reference [14]

One should nevertheless exercise caution with such systems: while they can enhance the acoustics of a good facility, e.g. by adding reverberant energy, they cannot remove energy, e.g. from echoes, or even from background noise by mechanical systems or simply from the audience coughing. Thus, its design must be treated with as much care as the design of the whole facility.

LARGE INDOORS FACILITIES

Large indoors facilities may provide a simple answer to the requirements of noise control, that is, as long as other finer points are not yet taken into account. When enclosing the space, new problems are to be solved, namely reverberation control and fire related safety. Here are a few points to consider.

Controlling the background noise in the facility

To start with, large indoors facilities are meant to handle huge crowds. This has several consequences. First of all, they are often located close to a major motorway so as to ease the inbound or outbound traffic flow. This means that the sound insulation of the envelope will have to be treated accordingly.

Next, due to the enclosed character of the venue, suitable provisions will have to be provided in order to comply with smoke exhaust requirements as well as emergency exits that are more numerous in the case of an enclosed venue). More to the point, the sheer size of the venue will call for large ventilating systems that are potentially noisy. Apart from taking care regarding the location of the HVAC rooms, it will be necessary to make sure the necessary silencers have been included in the design, and ventilation louvers correctly selected (i.e. not noisy while properly covering the audience).

Reverberation control

Due to the sheer size of the facility, all absorptive surfaces will be welcomed, especially when taking into account the fact that the basic seating of such venues seldom is as absorptive as the upholstered seating of performance halls. The aim of such an absorptive treatment is on the one hand to prevent the reverberation time value to be too high, but it also is meant to prevent the occurrence of unwanted sound reflections on the walls and ceiling.

Nowadays, it is possible to have variable acoustics in such venues using electro acoustics systems [5,6]. Basically, one can use a couple of microphones hanging over the stage, as well as loudspeakers located over and around the audience. This readily prompts a question: the stage can be located in the middle of the facility, but it often can also be located at one end. This means that suitable provisions will have to be taken in order to allow such flexibility to occur (e.g. a grill located over the various possible locations of the stage). Next, the audience can be either frontally located (using removable seating) or around the stage area (using the regular seating capability). This means that suitable provisions have to be taken in order to allow the setting of loudspeakers in the correct locations both under the virtual ceiling and over the virtual walls; a grill over the audience cal provide a response in that case too.

Incidentally, care has to be taken regarding background noise control, as such electro acoustic systems can easily amplify any unwanted sound too.

Reducing the noise radiation of the facility

Basically, this is about the noise radiation of the envelope of the facility. Several points have to be taken into account.

To start with, due to the sheer size of the facility the roof is usually of a light structure type. This means that its performance in the low frequency range is usually rather poor, to the point where it might prove insufficient (especially when taking into account that it usually is the largest radiating surface as seen from any point in the neighbourhood). Of course, a double roof can prove interesting for acoustic purposes but one will then especially have to beware of fire protection of the building structures that are no longer visible from the floor. More to the point, the numerous smoke exhaust openings in the roof can prove troublesome and need special attention.

Next, the walls of the facility are ridden with openings. Due to the enclosed character of the venue the requirements regarding the number of exits are higher than in an outdoor facility. More to the point, the firemen may require a single set of doors to be used instead of an airlock in order to allow their easy use for emergency air intake. Also, the installation of the stage area often needs the attendance of trucks that must access inside the facility, which means that large sets of doors are required. Due to their high price, whenever possible it is highly advisable to turn them away from the neighbours so as to reduce their acoustic requirement.

Of course those provisions are only valid as long as those doors are kept closed during the show and the rehearsal!

Mechanical equipment of the facility

Due to the sheer size of the facility the mechanical equipment definitely cannot be ignored, both for indoor noise control and for outdoor noise radiation.

To start with, the mechanical equipment features intake and exhaust on the outside of the venue that can radiate noise unless the proper set of silencers has been applied. Those have to be dimensioned with regards to the sound power of the AHU but also with regards to the noise levels inside the facility.

Next, the correct ventilation of such a large venue can be carried out either using air louvers under the ceiling of the facility or air diffusion under the seating together with air displacement devices for the play area. In the first case, the amount of pressure needed in order to cover the whole audience is likely to generate rather high noise levels. In addition, such louvers will be found rather close to the microphones of the electro acoustics system and significant background noise levels may be expected this way. In the later case, air handling is limited to the areas where it is really needed with a rather low velocity which helps reduce the noise levels generated by the HVAC.

A special mention should be made of the diesel generators. While they are normally supposed to be used in case of an emergency, it is not uncommon for a show to call for their use (if need be bringing their own apparatus) in order to avoid the complications of hooking up to the network. Provisions have to be taken on that subject both as regards the noise radiated to the neighbourhood and the noise generated inside the facility.

Trying to mix the types: openable roof facility

An openable roof facility can be seen as an easy compromise between the outdoors facility and the indoor venue. This is especially true as several sports require an outdoor environment (e.g. rugby) while shows often require an enclosed venue. However, there are a couple of sore points to consider.

First of all, the dimensioning of the emergency exits has to be performed in the worst case (i.e. an enclosed venue). This means that several weak points will exist in the walls of the facility.

Next, the openable roof often is a poor performer when it comes to sound insulation, as it is light and leaky. Of course it is possible to have a double roof as, e.g. the Montreal Olympic stadium [15] but this can be quite complicated and expensive.

More to the point, the moment the facility is enclosed serious reverberation problems can occur. This means an absorptive treatment is required under the roof, which adds to the weight and the cost of the system.

Another interesting factor, at least in France, is that of applicable regulations: an outdoor facility simply has to comply with the community noise control regulations that allow for greater emergence values over short durations, while the musical venue regulation does not allow for such simplifications.

DIAGNOSIS OF EXISTING FACILITIES

The diagnosis of existing facilities is twofold: internal acoustics and outdoor noise radiation. The diagnosis of the internal acoustics can be carried out using standard methods (e.g. measurements of background noise levels, reverberation time, and strength) and usually does not involve complicated actions. The diagnosis of outdoor noise radiation is much trickier, as one has to try and find out the weak points of the envelope of the facility. This means that first of all a sound source strong enough to generate high sound levels all over the venue must be used: this typically is an electro acoustic set typical of rock performances that will be rented for the diagnosis. Next, one must access every area of the envelope so as to measure the sound reduction index or the sound power levels radiated. This implies an access all over the envelope; more to the point, the signal to noise ratio must be high enough. Last but not least, the noise levels radiated by the facility must be measured in a few reference points so as to be able to adjust the computation model that will be elaborated on the basis of the diagnosis.

An interesting diagnosis of an old sport facility turned into a music and dance facility is given in reference [16] and outlined in example 1. It shows how complicated a diagnosis can be, needing a powerful sound source capable of generating high noise levels all over the facility, as well as means to access safely the various areas of the facility, including along the envelope.

MISCELLANEOUS

Around the facility

While the aspects pertaining to community noise control of facilities is rather well covered in the relevant law texts, the noise and general annoyance from large crowds attending events at a facility are seldom taken into account in depth. That is, it is often left to the discretion of the local authorities to try and cope with the resultant mess.

When questionning the neighbours regarding the annoyance from outdoors facilities (and even from large indoor facilities), there clearly are three phases to be considered.

First, the stage elements and their associated electroacoustic systems are delivered (which incidentally implies quite a few trucks moving around); balance of the system is performed (which usually means that high noise levels are emitted to test the system) and generators are usually installed to help provide the required electric power. Next, the concert proper occurs. Last, people slowly get away, the stage elements and the electro acoustics are packed away, and the cleaning can occur. Unfortunately, this usually happens very late in the night, which does not leave much of a chance to the neighbours to try and doze off.

Low frequency sound

One often thinks of the use of low frequency sound, as often experienced in the modern musical events such as those happening in stadiums or open air performances, as a thing of the present. However, a first trial had been performed as early as 1936 when a theatre manager had asked for the help of the famous physics scientist R.W. Wood in devising a device to generate a deep rumbling sound [17]. Wood had come up with a very long organ pipe located behind the stage; however on using it during the rehearsal according to witnesses the chandellers and fixtures began to vibrate alarmingly, as during an earthquake, and people were so afraid that the manager decided the device would not be used anymore.

Even before that particular occurrence, there was a music instrument making full use of low frequency sound: the large organs that are found in cathedrals often feature long closed pipes. While those pipes are not meant to be used as solo, they help generate interesting harmonics when worked together with smaller pipes [18].

Till the introduction of electro acoustic devices, getting enough sound power level in the low frequency range often was a problem. This was acutely felt in the second half of the 19th century with the increase of the sound power level of wind instrument and the subsequent development of larger orchestras. In the large facilities, especially outdoors, some help was needed and one of the tentative answers of the time was the octobass, which looks like a gigantic double bass. It was invented by the famed violin maker Vuillaume [19] and features a lowest C at 16.25 Hz. Though Berlioz enthusiastically wrote about it [3], its gigantic size (3.48 m) and tremendous internal strain, as well as the sheer complication (due to the extraordinary size the strings could not be fingered but had to be pressed using keys) prevented its widespread use.

Care should be exercised regarding the effect of low frequency noise, both as regards occupational noise like exposure [20] and health related problems [21].

EXAMPLES

A few examples of outdoors and indoor facilities are provided in the following paragraphs.

Example 1: diagnosis of an existing facility

The following example is taken from reference [16]. A former velodrome and sport facility located in a park close to dwellings was turned into a “mega dance hall”. Due to the sheer size of the facility and its location inside the urban landscape, it was the subject of a serious acoustical diagnosis as well as a predictive study [16]. The managers were looking forward to be able to generate sound levels in excess of 100 dB(A) close to the walls of the facility though the regulations theoretically limited the sound level value at 90 dB(A) on stage [10].

The diagnosis was performed using a professional show electro acoustic system featuring sets of loudspeakers and subwoofers that managed to generate 106 dB(A) inside the facility for hours upon hours. Sound intensity measurements were performed on 120 building elements and the building in its original state was duly 3D modelled, with the results checked against sound pressure level measurements that were performed around the building. It turned out that the major contribution to the noise radiated in the environment was mainly in the 40 to 400 Hz range.

On the basis of this diagnosis, various noise mitigation measures, such as the reinforcement of the sound reduction index of selected building elements, were entered in the model and their efficiency checked.

According to [16], the main difficulties of this diagnosis were in accessing the various areas of the envelope, achieving correct stability of the sound source as well as having a correct signal to noise ratio in the environment (including on some exposed parts of the façade).

Regarding the high sound levels generated in the facility, it turns out that it is not uncommon at all: should the legal requirement of 90 dB(A) be strictly applied, every facility in the country would be caught red handed, as measurements very often lead to sound levels in excess of 94 dB(A) at a distance of 5 meters away from the dance floor.

Example 2: a small facility in an urban area

When a medium sized French town decided on creating a new park downtown, it was decided that a small open air facility for music performance would be included. This was achieved using a gazebo like structure, with individual chairs being brought by the attendance.

Due to the location of the park in an urban area close to a couple of high traffic streets, the place had first of all to be protected from traffic noise. This was achieved using a noise barrier effect by means of large earth berms around the facility.

Next, the protection of the neighbourhood also had to be considered. This was achieved on the one hand using those very same berms, and on the other hand defining maximum emitted sound levels that precluded the use of electro-acoustic music. In addition, hours of operation were defined, which ruled out any nightly use.

The facility initially met with success, as it was a good place for non professional musicians, especially students from the local school of music, to perform. However, trouble was not long coming when an irate old neighbour complained that the noise coming from the facility prevented him to listen to the birds nesting in the park (though how the birds were audible from his window over the traffic noise was best left to imagination). Next, several old ladies remarked that this part of the park was especially quiet and could the damn racket from musicians be prohibited? While the authorities pondered over suitable answers and actions, a few enterprising youngsters eventually organized a party with guitars and drums. While no electro acoustics were involved and hours of operation duly respected, such an occurrence greatly incensed the neighbours who repeatedly called the police and petitioned for closure of the facility. With the municipal elections fast approaching, the authorities decided on a temporary closure of the facility. Later on, they simply did not bother with any attempt at complementary noise control measures and kept the facility permanently closed.

Example 3: a large openable facility

In the 1990s, a large provincial French town decided to build a large facility (5000 seats plus) for pop and rock music shows. While a first considered location initially seemed ideally located close to major streets and public transportation, and even featured a large parking lot, it was soon found out that there were many houses close by and the background noise levels were really low in night time. A new search eventually turned out a suitably looking location close to a motorway and a factory. More to the point, the ground was much lower than the surrounding landscape, which promised a good noise barrier effect. A predictive feasibility study confirmed the soundness of that scheme.

On looking at the terrain, the architect in charge decided it would be fun to take advantage of the terrain by introducing in his design the possibility of an audience seated on the berm facing the stage end of the venue. Of course, this meant that the regular stage of the venue should feature large doors opening on that side. While this was likely to change a great deal the radiation pattern of the facility, the township enthusiastically agreed on that scheme.

The first warning shot came from the factory that was located close to the berm. It made it very clear that should the noise from the facility be deemed too much annoying they would pack and find themselves a quieter place, with the township left to try and figure out how to make do from the lost taxes. This meant that first of all noise annoyance at the factory had to be defined; next, proper noise control measures had to be defined. It was eventually agreed that outdoor performances would only be held during week ends when the factory was not in operation.

Next, the neighbourhood expressed worries regarding the potential noise radiation of the facility. They pointed out that outdoor performances would of course induce annoyance, and even indoors performances would induce annoyance too due to the presence of the stage doors proving to be a very weak point. Incidentally, that neighbourhood was no closer than 500 m from the facility and exposed to the road traffic noise from the nearby motorway. After a long discussion and the intervention of an expert regarding the determination of background noise levels as well as the assessment of sound propagation, further noise control measures were implemented. Those featured a limitation of the noise levels generated at the facility as well as a restriction of the operating hours. Next, a lawyer pointed out that the stage doors would really be a weak point for the facility and could their performance be upgraded? Those stage doors were eventually completed as acoustic sliding doors with pneumatic seals. Due to their sheer weight, they needed a hydraulic actuator and a fair bit of annual maintenance.

Due to the complication of the system and the animosity of the neighbourhood, the outdoors potential was eventually seldom used over the years.

Example 4: stadiums as performance facilities

Over the years, an existing stadium in a large French town has sometimes been used to host musical events. That stadium is conveniently located close to major streets but it is also ensconced in the urban landscape including a sizable part of dwellings. Looking at various acoustic reports of measurements in the vicinity during such hosting, it turns out that neighbours complain not only of the noise from the actual performance but also from the noise from the deliveries and stage preparation as well as sound system balance. Other complaints concern the noise from the generators used by the technicians of the sound system as well as the noise from the cleaning and dismantling after the show.

In order to help reduce the annoyance, plans are currently considered to implement a mobile roof over the stadium and relocate the generators and the delivery area in an underground lot located away from the dwellings. Of course, this will not solve the annoyance problem from tens of thousands of people going to and fro!

A similar facility is also under construction for a new French stadium intended for sport and music events. Its location was chosen close to a major motorway and public transportation. Unfortunately, recent housing was located nearby and residents started to prove irate regarding the potential noise annoyance from such a facility. Communication efforts had to be implemented in a hurry by the authorities, and an impact study was duly ordered to be published. However, when predictive calculations pointed out that there would be significant noise levels emerging on the façade of neighbours due to their close proximity to the new facility, the authorities nevertheless decided to go on as the project was deemed to be of public importance.

The use of stadiums as music performance facilities can lead to gigantic stage performances. For example, during concerts at the huge Stade de France in 1998, a popular singer was brought in on the roof of the stadium using a helicopter. Of course, this meant that not only did the neighbourhood suffer from the actual noise of the concert, but it also had to endure the noise from the helicopter circling around. But at any rate, in such a facility where there is no possibility of an acoustic mobile roof and where the background noise levels on site are no lower than 55 dB(A), A weighted equivalent sound level values over 70 dB(A) were reported more than 250 m away during the noisiest 30 mn of the concerts (during which the A weighted equivalent sound level value is not supposed to exceed 105 dB(A) [22]. Noise survey equipment has since then been installed at suitable locations in the environment for noise control purposes.

A rather similar concept was recently implemented in the vicinity of Amsterdam. However, right from the start the facility was devoted to sports as a regular stadium as well as to musical events. To this end, an impact study was carried out and one of the first tentative prescriptions was for the facility to feature a complete roof for musical performances. This prevented too much noise being radiated in the outside environment while keeping the background noise levels reasonably low by insulating the audience from the noise of planes and road traffic. As sport events required an open air facility, this meant that an openable roof was in order.

(Picture by Florian K, 2005)

Figure 2. Amsterdam Arena

Of course, even with an absorptive cladding of the inside face of walls and the underface of the roof, closing the roof would result in rather high reverberation, especially in the low frequency range. Therefore, special absorptive devices, made of absorptive baffles that could be easily hung for the tenure of musical events, were prescribed and have since then proved efficient at controlling the extra reverberation induced by the closed volume.

Achieving the required amount of protection of the neighbourhood in such facilities is not a simple task. To start with, the manager of the facility is seldom the boss when it comes to deciding on the settings of the sound system, which usually is brought in by the visiting artist anyway. More to the point, it is not uncommon for the artist and his aides to deny access to the acoustician in charge on the grounds that his job is solely concerned with noise measurements outside the facility while the occasional measurements inside should be made by the authorities. Next, while the technicians are aware of the noise limits that they are supposed to comply with, they can easily disregard them. For example, in France it is quite usual to hear technicians stating that complying with the rule of the L_{Aeq} not exceeding 105 dB(A) over 10 minutes really is hard enough but keeping the peak noise levels under 120 dB would simply just ruin their sound quality [23].

Example 5: a versatile sport and music facility

A French region decided on having a large facility capable of housing sports as well as hosting musical events. The key feature of this facility is a 5000 seats hall designed for all these activities.

The sound insulation with regards to the environment has been solved using either concrete walls or multiple metal panels elements.

Due to the wide range of activities to be carried out inside the hall, the location of the stage can be either in the middle of the facility, allowing full seating around, or at one end. In order to allow for all possibilities, a theatre grill has been installed all over the terrain.

Of course such a large venue needs absorptive treatment in order to reduce the reverberation. Yet, when used for music events, its audience needs an impression of lateral reflections. In order to try and solve that problem, the hall received an absorptive treatment on the walls and under the roof. For musical performances, an active system was introduced. It serves several purposes: controlling the reverberation time independently of the occupation of the hall, and creating “reflections” where needed. A Constellation system by Meyer Sound was eventually chosen. This system calls for a limited number of microphones around the stage area and a digital reverberation chamber; the loudspeakers can be located on either the ceiling or on the walls, with the relevant positions clearly defined.

Due to the variable configurations of the hall, there are no fixed wall positions of the loudspeakers. There are several pre-equipped positions on the grill where suspensions for the loudspeakers can be installed, creating if need be a kind of virtual acoustic wall. This goes for the audience as well as for the stage.

A similar system could be also used for outdoors performances, though it is not yet implemented in the project.

Example 6: such a nice place to hold outdoor concerts

A southern French city enjoyed in the core of the old city a nice old cloister dating back to the 13th century. Though during the French Revolution part of it had been sold away and dwellings bordered the cloister on one side, it still had a nice historical flavour. In such nice surroundings, it was very tempting to hold classical concerts, and the township took advantage of it for part of its annual music festival held during summer time, with emphasis on chamber music (e.g. string quartets and piano).

Due to its configuration, the cloister was well protected from the urban environmental noise by the high walls of the nearby church as well as by the surrounding buildings. More to the point, due to the rather short distances involved between the small stage and the 300 seats audience, the quality of the music was quite nice, with strong lateral reflections from the stone walls and good direct sound to the audience. This looked to be a winner.

But was it really? Actually, over the years one of the inhabitants of the neighbouring dwellings had developed an intense dislike of those musical events, and tried unsuccessfully to prevent their occurrence through legal means. When that failed, the court having concluded that those summer concerts did not happen more than five times during summer time and had actually been performed long before the neighbour inhabiting his premises, he eventually resorted to other means. A favourite trick was for him to let his window open and from 10 pm onwards a dozen clocks, suitably time spaced, would dutifully strike their due! This time it was the neighbour’s turn to laugh his head off as the court genially decided that there actually were no regulations preventing him to do so!

CONCLUSIONS

Outdoor musical venues, and even large musical venues for that matter, prove to be quite a bit of a challenge for the acoustician.

To start with, the acoustic quality of such venues can be hard to achieve: background noise control is heavily dependent on the noise sources around the site, such as highways and air traffic corridors.

Next, due to the lack of ceiling reflections and the often quite large distances between performers and audience, the acoustic quality can easily be rather poor, unless one simply looks forward to an avalanche of decibels. Of course, there are nowadays possibilities of using additional loudspeakers to artificially create the impression of such acoustic reflections. But such a move implies that a real acoustic study must be performed, and the actual performance expected from the system well defined [24].

Poor acoustics in open air facilities (or even in large roofed facilities) has often been so much of a problem that managers, especially when dealing with temporary events, tend to look forward to increase the quantity of decibels rather than the actual quality of the music.

Reducing the amount of noise annoyance in the neighbourhood is of course a real problem. But it should not occult another significant problem, which is the protection of the audience as well as that of the technicians. There are a few law texts available on the subkect, but unfortunately they are at best ignored, and at worst passively fought.

Whether an outdoor facility or a large indoor facility is concerned, there are noise control regulations to be complied with, both at the audience and in the outside environment. Unfortunately, such regulations are not always known by the managers of facilities, let alone by the performers. Even worse, it is unfortunately not unknown for the authorities to conveniently forget about some of the legal requirements in force!

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