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TRANSPORTATION NOISE IN CINEMA HALLS: SOME PRACTICAL WAYS OF REDUCING THE DIN

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ABSTRACT
Most standards covering the acoustics of cinema halls specify some rather stringent background level limits, ranging down to 50 Hz and lower. However, they are now often located near transportation corridors, and the quest for quality is now prompting the cinema operators to improve the sound insulation of their new halls with regards to such sources. A few case studies (covering such sources as a light rail terminal, a heavy rail line, and a high speed rail line) are submitted, looking into the context of the situation as well as into the technical solutions that were applied.

1 - INTRODUCTION
In its quest for customers, the cinema industry is locating its premises as close as possible to transportation corridors, as it is felt such a location is more attractive. Unfortunately, this also means that the cinema halls are directly exposed to the noise and vibrations from those transportation systems. Each new project is a new challenge which needs first of all an acoustical diagnosis of the site.
In France, the usual requirements for a cinema hall are standardized [1]: the background noise level is not to exceed the NR 27 limit together with a maximum sound level value of 32 dB(A). With both high sound levels and vibrations outside of the building, this means that careful designing is in order.

2 - CASE STUDIES

2.1 - A cinema close to a highway and a light rail line
A concrete cinema building was built in the seventies close to a 3 lanes highway and a light rail line terminal 25 m distant, which seemed reasonable enough as far as rail noise was considered. However, due to the nature of the ground (sandy, with water underneath, which accounted for low frequency propagation) the arrival or departure of a 5 car train resulted in a loud rumbling sound in the halls reaching a 45 dB(A) value on a 15 s span, with a predominant contribution in the 31 Hz band. A new project considered the replacement of that building by a more spacious one that developed on several floors.
The diagnosis included both noise level measurements outside and inside the building, plus some vibration measurements on the floor of the old building and on purposely built concrete rods reaching down 7 to 15 m in the ground. It pointed out that apart from the sound insulation of facades, a structural uncoupling of the halls had to be considered. Initially, a suspension of the complete concrete building was considered. However, due to the cost of that scheme, especially when taking in account the phreatic layer close by, it was decided to use a concrete and steel structure and limit the suspension to each of the cinema halls individually.
Each of the halls is designed as a box in box construction featuring a concrete floor resting on the steel structure of the building by means of springs, with gypsumboard walls and ceiling. This is easier for the structure to cope with as far as the load is concerned, but can prove tricky when dealing with the support of the ceiling, which calls for long spans. More to the point, this concept can also complicate matters as far as fire proofing is concerned, due to a possible chimney effect.
Various schemes were envisioned to provide noise control at the trackbed. However, this turned out to be impractical, as it would mean a partial closure of the line for the duration of the work. More to

the point, the reduction to be expected in the 31 Hz band ruled out most of the readily available quick solutions.

2.2 - A cinema close to a suburban rail station

A concrete cinema building is currently under construction next to a suburban rail station, with a bus lane on top of it, and also serves as the foundations for a public apron. The acoustical diagnosis of the site included vibration measurements at various distances from the track, that showed that only the halls closer to the station needed to be uncoupled form the structure. Some squealing noise, reaching 80 dB(A) on the site, could also be heard when energetic braking was applied.

The design made sure that no structural link was to be found between the station and the cinema building, which was achieved using a resilient suspension of the bridge on the cinema side. Both halls closer to the station are designed as a box in box construction featuring a concrete floor resting on the concrete structure of the building by means of resilient pads, with gypsumboard walls and ceiling. Due to the public apron overhead, a concrete building structure was used, with the other halls being treated to a gypsumboard ceiling and furring when appropriate. The apron itself is designed as a large floating slab so as to prevent the intrusion in the halls of noise generated by rollers and occasional vehicles.

2.3 - A cinema close to a main rail line

A cinema building was erected near a commercial facility and reasonably far from the rail line so that no uncoupling was necessary. However, this cinema turned out to be quite a success, so that an extension was decided, which brought the new halls uncomfortably close to the line. The diagnosis showed that unless the adequate provisions were taken the noise levels inside the halls could reach 50 dB(A) for 30 s when a main line train was running by.

The design of the extension called for a rigid connection to the existing building, but for a resilient bearing of the other extremity. This was provided using resilient pads mounted in boxes, that were set on top of the basement structure which housed the parking lot. Such a scheme was also quite practical to monitor those bearings, as they are fully accessible.

During construction, the usual problems of various concrete chunks and other waste materials squeezing themselves in the gap between the suspended structure and the basement were encountered but were eventually solved through careful site supervision. The extension is now under operation and patrons can enjoy their pictures without some unwanted rumbling noise interfering with the show.

2.4 - A cinema close to a rail line in a seismic environment

A large development project, to be built over a vacated urban area, featured a parking lot and a commercial facility topped by a cinema building. It was located in a mountain area considered as a seismic liability. More to the point, a rail line tunnel bordered the whole facility. This prompted the acoustical engineer to warn about a possibility of having to uncouple the cinema from the foundations. The diagnosis included vibration measurements on a heavy concrete block on the ground, that confirmed the need for such an uncoupling as it was estimated that a 45 dB(A) sound level over 30 s could be reached when a train was running by. More to the point, that diagnosis also included some noise level measurements during which it was discovered that helicopters could be flying over on a regular basis.

The suspension of the whole facility was ruled out due to the weight of the building and the complicated subject of sharing the cost between the commercial mall and the cinema. It was decided to build the halls as a concrete structures resting by means of resilient pads on a thick concrete structural slab. However, due to the height limit enforced in the area, accessible boxes of springs or resilient pads could not be used under some parts of the halls, which lead the acoustical engineer to accept the use of rows of resilient pads under the walls. This proved to be quite satisfactory for the acoustical requirements; however, the seismic specialists found themselves rather uncomfortable with such a scheme, as it implied a heavy moving mass on top of the building. Quite a few calculations were needed for it to be validated, and these resulted in a few additional provisions developed in close team work with the acoustical engineer, such as resilient buffers on the sides to prevent too large a movement, and extra provisions regarding the glazed facades linking the lower cinema floor (suspended) and the concrete structural slab.

2.5 - A cinema close to a high speed rail line

A cinema building was built close to a high speed train tunnel 20 m distant. The diagnosis included vibration measurements on a purposely built concrete rod reaching down 10 m in the ground. It confirmed the need for the uncoupling of the facility, as it was estimated that a 50 dB(A) sound level over 12 s could be reached when a train was running in the tunnel.

The initial design called for a suspension for the whole building on springs. Economical considerations lead to a modified design in which the halls were independently suspended. This was achieved using

concrete beams on top of the foundation pillars, on top of which were set rows of resilient pads supporting the halls. Each hall was designed as a concrete floor and wall assembly closed by a metal roof and resting of those beams.
During construction, the first serious problem was to convince both the architect and the contractor that attempting to use low cost untested resilient pads was bound to failure. This was especially hard, as there was no national standard regarding the resilient suspension of buildings, with only an ISO standard available [2]. Next, came the usual problems of various chunks of concrete and other waste materials squeezing themselves in the gap between the beams, that were solved through vigilant site supervision. The facility is now operating without patrons noticing their being seated 20 m from a speeding train.

3 - CONCLUSIONS

While it is easier to prescribe a general suspension of the building, the combination of local specificities, the requirements of safety regulations, and the economical objectives, often means that a much more tailored made solution will have to be studied − and implemented. To that effect, a serious diagnosis of the site is needed, so as to help optimize site selection and orientate the initial design of the project.
For such a solution to be successful, the acoustical engineer will have to work in close collaboration with the design team to make sure that no design flaw is incorporated. Then, a vigilant site supervision will be needed in order to make sure this design is effectively carried out.

REFERENCES

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