ICSV13 - Vienna
The Thirteenth International Congress on Sound and Vibration
Vienna, Austria, July 2-6, 2006

THE CHALLENGE OF HEAVY REHABILITATION PROJECTS: CASE STUDIES

Marc Asselineau[1]

[1]Peutz & Associates acoustical consultants
34 rue de Paradis, F75010 Paris, France
m.asselineau@peutz.fr

Abstract

In European cities, where urban historical assets are highly regarded, heavy rehabilitation has proved popular so as to optimize the effective floor area and the function of buildings without hampering the architectural and urban development trend. Such a move also aims to comply with the urban bylaws as regards maximal admissible values of building height and capacity. This paper aims at giving a picture of the noise control engineering aspects of such operations through a few case studies. This will entail a brief look at applicable regulations, as well as a sobering look at diagnosis difficulties. Prescriptions and eventual commissioning will then be examined. One of the key conclusions drawn from experience is that the diagnosis and the prescriptions should never be carried out by the sole noise control engineer, as they often constitute a compromise between the various constraints.

INTRODUCTION

Over the years, the rehabilitation of buildings has become quite popular in Europe. Several factors have been contributing to this trend: first of all, such a move will often prevent the complicated administrative process of requesting a full demolition permit followed by a building permit. Also, whenever the building is located in an area close to a historical place or a monument, the building permit specifications are quite stringent, which means that it really is much simpler to try and keep the existing façade and build a new structure behind. Next, quite a few townships now try to reduce the admissible floor area per ground area for new construction, which makes older buildings with a higher ratio an attractive proposition. Lastly, old prestigious buildings often feature high ceilings, and that means that one may add some more floor surface provided a new floor layout is built.

It is also not uncommon for a building considered an historical landmark to be allocated a new lease of life with most of the envelope being kept while a totally new interior scheme is developed inside.

On the negative side, rehabilitation can be quite tricky: one has to make sure that the building can really cope with all the legal constraints that will be in force in the project (e.g. eliminating asbestos and lead, upgrading the fire and safety issues, the later often calling for more stairways and emergency exits). More to the point, one also has to make sure that the structure of the rehabilitated building will be able to cope with the new setup. Therefore, prior to the design phase, it is of uttermost importance that a proper diagnosis of the building earmarked for rehabilitation should be performed.

REGULATIONS

Various regulations are in force regarding the rehabilitation of buildings. First of all, urban planning does set limits regarding the height of the buildings, as well as their occupancy. For example, it is usually not permitted to turn dwellings into offices, though it might be possible to introduce offices in such a building provided that the floor area allocated to dwellings is not reduced in the process. Next, some specific urban factors (e.g. a historical monument close by) may complicate the construction of the façades (e.g. the building permit inspector will not have any piece of technical equipment visible on the roofs or terraces, more to the point he will not tolerate any change in the appearance of the windows either).

As concerns the noise issues, while the usual community noise control are in force, the sound insulation values are dependent on whether the destination of the premises has been changed or new floor surface has been introduced (e.g. while old dwellings can stay put with the former sound insulation values, new additions must comply with the latest regulations in force [1]). A significant feature, though, is that the acoustical performance of a refurbished dwelling must not be inferior to the one that existed prior to rehabilitation [2].

DIAGNOSIS

The diagnosis must be planned with care, as most members of the design team have an interest in it, yet their respective procedures are not always fully compatible. For example, the noise control engineer will look forward to measure the sound insulation and the impact noise between rooms (which calls for closed rooms), and especially between floors. On the other hand, the structural engineer will usually be quite anxious to learn about the nature of floors and walls by drilling significant holes in them! Therefore, one must make sure of the order followed by the various performers.

Another complication often comes from the occupants of the building prior to refurbishment, as the rather tight schedules seldom allow for such niceties as leaving the building unattended for months. This means that the available time span for the diagnosis (i.e. between the building being vacated and the actual beginning of construction work) is quite short!

In addition, in order to be really effective, a diagnosis has better be performed knowing the future layout of the project. This means that, based on actual experience and educated guesses, a first draft of the project is actually made without actually knowing for sure whether the building performances are really up to it. The diagnosis will later confirm or infirm the validity of the hypotheses that were retained.

A sore point is the presence of neighbours: in order to avoid future conflicts with them, it is quite necessary to perform sound insulation and impact noise measurements with regards to their premises. This can be quite noisy and due to the high background noise in daytime, it is often desirable to perform such measurements late in the evening, which seldom is a good way to make friends. It also is necessary to try and measure the background noise in the neighbours' premises, which can prove quite difficult due to the various local sounds such as the refrigerator starting up, the dog walking on tiles, etc. It is not totally unknown for such measurements to be performed in another dwelling or even in the building project, with the results suitably adapted on the basis of experience to cope with the situation encountered.

In addition, if the façade of the building is to be kept, façade sound measurements are quite necessary too. This means that a sound source will have to be used outside, and such a measurement too is not that popular with the neighbourhood.

Even worse, there are quite a few projects in which the user stays in part of the building while the construction (and partial demolition too) work is carried out in other parts of the building. It is then necessary to find out the noise and vibration attenuation between the occupied area and the work area in order to assess the restrictions (with regards to technique and schedule) to be applied.

DEVELOPMENT

The project design and development actually starts prior to the diagnosis, as the architect needs to be sure that the building, once refurbished, will be able to answer all the user's wishes: this means that enough space must be found for the various office or dwelling spaces, but also for the various technical spaces (e.g. boiler room, cooler room, etc.). From then on, it is a constant struggle between the various specialists: the architect will try and enhance (or at least preserve) the majesty of the building, the structural engineer will look forward to try and reduce the weight of the walls and partitions as well as the allowable weight of the technical equipment, while the noise control engineer will usually try and preach for a significant increase of thickness of walls and floor-ceiling assemblies. More to the point, there often are some awkward questions to be answered regarding the location of technical equipment, as it needs a significant amount of ventilation (which points to a location on a terrace or under the roof), but has to be hidden away while complying with all the relevant safety regulations.

This goes on till the diagnosis is performed. Then, either luckily the tenders document can be drafted, or part of the project has to be redesigned in a hurry, taking into account the limitations of the existing building and environment. Basically, the design frequently relies on rather thick (as compared to concrete) gypsumboard walls and ceilings, as those can simultaneously be used for sound insulation and fire safety purposes without adding undue weight.

COMMISSIONING

The commissioning measurements typically call for the usual sound insulation, impact noise, and background noise level measurements.

In case of dwellings, one of the typical features of such measurements is to check whether the acoustical performances are at least equal (or preferably better!) to those measured prior to the rehabilitation project.

Another typical feature is the measurement of the noise emitted by the technical equipment. Due to the fact that the existing equipment was switched off during the construction, its start may be noticed by neighbours. In addition, significant new equipment (e.g. coolers being installed at the last level prior to the roof being constructed) may have been spotted by the neighbours during construction, therefore it is important to make sure that all the community noise criteria are safely met [3] as any visible feature is likely to be suspected of noisiness.

CASE STUDIES

Case 1: a building with dwellings and offices downtown

This particular building was located on the Champs Elysées in Paris, and was earmarked for rehabilitation in order to increase its value. It featured a luxury shop at ground level, which was to keep operating during the construction work and a mixture of offices and dwellings. One of the neighbours happened to be a hotel. Due to the location of the building, technical equipment outside or on the roof was ruled out at once. More to the point, the windows both on the main façade and on the courtyard façade had to be kept, which meant that a double window system had to be implemented on the main façade.

The preliminary concrete based design, as initially envisioned by the noise control engineer, was not compatible with the structure as devised by the structural engineer. Another preliminary design, based on the extensive use of gypsumboard ceilings and partitions, eventually looked promising.

When the diagnosis was eventually performed, it was found out that the sound insulation performances of some walls did not match the expectations. Later examination by both the structural engineer and the noise control engineer eventually showed that some existing partitions (that were supposed to be kept in the project) were actually built from the wooden floor on (with a resulting noise bypass underneath), while some others were actually much lighter than they appeared. The design was modified accordingly (with a somewhat disgruntled user who saw his usable floor surface slowly shrinking away). In addition, it was found necessary to reinforce the structure of the last floor, as technical equipment was to be installed under the roof (with suitably looking louvers hidden there) and while both the structural engineer and the noise control engineer were eager to go for it, weight restrictions eventually compelled them into using a rigid steel structure and a thick gypsumboard ceiling.

The construction planning had to be scheduled very carefully, as several points had to be taken into account: first, on this famous street it is not permitted to either get deliveries or get rid of waste material after 8 am, second the neighbouring hotel would not accept any construction noise before 10 am or after 8 pm, and lastly the shop would not accept noise after 2 pm. This sure was quite a limitation.

In order to reduce the risk of noise annoyance to the hotel next door, the site supervision called for the noise control engineer to come and perform measurements in some hotel rooms without warning the contractor first. The hotel was quite satisfied with the results as such a move did limit unduly noisy behaviour of the contractor.

The commissioning measurements eventually showed that the acoustical objectives had successfully been met.

Case 2: an opera theatre

The Capitole Theatre in Toulouse is a well known 17th century theatre that serves as the local opera. While the performance hall had earlier twice been heavily refurbished, the stage tower had not been touched for years as any change would have resulted in a request for new harsher safety requirements. Eventually, the township and the ministry of Culture decided to refurbish and heighten the tower and planned a complete modernization of the equipment and the safety systems.

The preliminary design was performed on the basis of available data. Due to the old age of the facility, as well as various reconstructions over the years, the available information was rather scarce and quite conflicting (e.g. some walls were labelled as brick on some documents and as concrete on others, while their thickness would vary from simple to twice).

When the diagnosis was eventually performed, it was found out that the sound insulation performances of the walls met the expectations, but the sound insulation with regards to the outside was much smaller than anticipated due to the old windows. The reverberation time and background noise levels were carefully recorded to be used as future reference in the project. Interviews of key personnel were also carried out in order to try and discover either potential flaws or wishes in both the existing structure and the design project.

The construction planning was drafted so as to comply with the rather tight schedule (namely the closure of the theatre for 18 months). Due to the location downtown, night work was not allowed. After demolition of the roof and floor, it was found out that some structural elements needed some strengthening. Once those structural elements were built in, the work was able to proceed. In addition, it was found out that there were quite a few tight spots in the construction that prompted the redesign of several partitions and ceiling assembly. The layout of the new ventilation system had to be redesigned too, as there were a few tight corners in which the original design just would not fit.

The commissioning measurements were performed in between periods of intensive use by the users, as the schedule was rather short. They eventually showed that most of the acoustical objectives had successfully been met, with the others (mainly ventilation noise) initially failing due to last minute changes in the design, but to follow suit after minor corrective actions.

Case 3: a building with offices downtown

One of the earliest elevated parking in Paris was located close to the Champs Elysées, close to dwellings and offices. By the late thirties, it had already been turned into offices. A new rehabilitation scheme was planned in the mid nineties, as the available floor surface was extremely interesting as compared to nowadays standards.

The preliminary design was performed on the basis of available data. Once again, due to the age of the building, as well as numerous local modifications and reconstructions over the years, the available information was rather scarce and quite conflicting (e.g. some walls were labelled as concrete on some documents and as plasterwork on others, while their thickness was simply not reliable).

When the diagnosis was eventually performed, it was found out that the sound insulation performances of the walls usually met the expectations, with the noticeable exception of a few walls in which uncharted chimney ducts were found. Meanwhile, the sound insulation of the floors was found to be much smaller than anticipated; this was eventually traced to the floors being less thick than anticipated. The floor and ceiling assembly, as well as the location of archives and technical rooms in the project, were consequently redesigned so as to cope with those limitations. More to the point, the background noise level in the courtyard of the building proved to be rather low, which meant than extra provisions had to be made in order to reduce the sound levels that would be generated by the technical equipment.

Due to the location downtown next to dwellings, night work was not allowed. Actually, the neighbours were quite quick to complain about the noise from building activities and site supervision had to be implemented in order to keep the annoyance down. More to the point, it was found out that there were quite a few tight spots in the construction that prompted the redesign of the layout of the new ventilation system.

The commissioning measurements eventually showed that the acoustical objectives had successfully been met.

Case 4: a cinema in an old building

The only remaining cinema in downtown Bordeaux had been heavily refurbished in the beginning of the nineties. Being the only one such facility downtown, it was enjoying a good frequentation. However, closer scrutiny showed that there was a potentially good demand for art films. It was then decided to add three mode screens in the facility, but safety regulations then requested that a new emergency exit be built on a different side of the building. The only way to expand while solving this issue was to build these screens inside the shell of an existing building next street (one per floor). However, this particular building, dating back to the beginning of the 20^{th} century, was flanked by dwellings on each side and heavy external modifications of the facades were not allowed.

A preliminary examination of the building showed that an expansion joint was supposed to be on each side of the building. Consequently, the preliminary design assumed that the community noise issue could be solved. In order to create the three projection rooms, the existing floors had to be demolished and new stepped floors created. However, the initial design performed by the noise control engineer called for 25 cm concrete floors; this was not deemed feasible by the structural engineer, as one wanted to keep the original foundations of the building in order to control the final cost of the project. So, a newer preliminary design, based on floors made of concrete poured on a metal deck associated to a heavy gypsumboard ceiling, was developed, while partitions called for gypsumboard walls.

The diagnosis was limited to background noise measurements, as it was no longer possible to perform sound insulation measurements due to missing windows and holes in the existing floors. The sound insulation of the side walls was eventually estimated on the basis of the explorations made by the structural engineer, which fortunately showed that the expansion joint actually seemed to be free of obstructions.

Technical equipment was installed under the roof (with suitably looking louvers hidden there); weight restrictions prompted the use of a rigid steel structure under the equipment and a thick gypsumboard ceiling.

The construction planning had to be scheduled very carefully, as there was no possibility of stopping for a long time a truck in the narrow street. More to the point, due to the tight schedule (6 months between the beginning of the demolitions and the commissioning), there was no margin for error.

The commissioning measurements eventually showed that the acoustical objectives had successfully been met.

Case 5: a cinema in a commercial mall

In the seventies, several buildings had been built in the new business suburb La Defense close to Paris. The automobile museum, which featured an Imax theatre, was not considered viable enough and eventually closed down in 2000. This large available space was quite tempting to a cinema operator who quickly saw that 15 projection rooms could be accommodated there.

During the preliminary design, it was decided to include the former Imax in order to have a grand total of 16 screens in the facility. Meanwhile, existing documents showed that the concrete structure was not that thick at all! In order to cope with the weight restrictions and also to keep some flexibility in the project, it was decided to use gypsumboard walls with a steel reinforcement structure at bottom.

The diagnosis showed that the sound insulation of the main facades and roof was rather poor, and the impact noise of the floor system was rather high. However, there was nothing a suitable floor covering and ceiling assembly could not manage. One of the problems that were intently studied was that of the unusual height of the premises: for some time it was wondered whether the partitions should not be erected to ceiling height only (so as to try and save on weight and cost) but eventually high partitions (12 to 15 m high) were used; a steel structure was necessary on the bottom in order to help the building structure support them. As concerns the former Imax, while a new floor had to be built in order to provide a decent sloped floor, it was deemed possible to use most of the existing shell.

In this very busy spot, the construction planning had to be scheduled very carefully, as several points had to be taken into account: first of all, the road was much lower than the building site but no crane was allowed due to the presence of the highway close by. More to the point, there was parking space for one truck only, and due to the weight restrictions the dispatching of materials on site had to be performed with great care.

The commissioning measurements eventually showed that the acoustical objectives had successfully been met.

CONCLUSIONS

Many factors can determine the extent of the rehabilitation work. To start with, the general aspect of the building must be accepted as suitable by the authorities. This often implies keeping some old roof and windows elements (with subsequent rebuilding work behind). Next, the structural integrity of the building has to be achieved. This often means that light constructive solutions have to be implemented. Safety issues may also complicate the matter, with more emergency exits required or more stringent fire protection applied. No wonder that the final project can be quite different from the initial idea.

Ideally, much of the difficulties should be timely detected through the diagnosis. However, it is not unheard of to find such situations in which the structural engineer has gone first and opened quite a few apertures in the walls and floors n order to check their composition, thus preventing the possibility of performing sound insulation measurements.

More to the point, rehabilitation projects are often located in populated areas, and this means that provisions have to be taken in order first to reduce the potential annoyance from building work, and then the potential annoyance from the future activities in the refurbished building.

While rehabilitation is a tempting way to make projects, and often achieves its goals, it can really be tricky and must be carried out with a real team.

REFERENCES

[1] "Arrêté du 30 juin 1999 relatif aux performances acoustiques des bâtiments à usage d'habitation", Journal Officiel (1999).

[2] " Cour de Cassation, 3ème chambre civile", n° 95-10928 (1997) DDE 92 (1993)

[3] "Arrêté du 18 avril 1995 relatif à la lutte contre les bruits de voisinage", J. Officiel (1995).