THE RELATIONSHIP BETWEEN ENERGY CONSIDERATIONS AND NOISE CONTROL IN NEW RESIDENTIAL DEVELOPMENTS

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ABSTRACT

The Province of Ontario has taken a leading position with regard to the control of both indoor and outdoor noise levels on new residential developments. Some of the noise control methods in use offer definite possibilities for both energy conservation and solar energy collection. Other methods have opposite effects and increase energy consumption. This interdisciplinary paper examines both areas, pointing out where energy conservation can be very easily accomplished simultaneously with noise control, and also examining methods of handling both concerns even when they have opposing influences.

INTRODUCTION

In recent years man has shown increasing respect for the effect his activities may have on the natural environment. The emissions of industrial operations have come under governmental surveillance with the result that standards now exist to restrict air, water and noise pollution. These standards have been in existence for several years and definite inroads are being made in the reduction of pollution levels to acceptable values.

Against this background of environmental awareness a new factor has emerged, the realization that most of the presently popular forms of energy are finite and that the time when they will be exhausted could well be in sight. In some cases it seems that measures to conserve our natural resources (rivers, lakes, woodland, etc.) need only be extended to include energy conservation. In other cases environmental and energy concerns seem to run in opposing directions (nuclear power stations, etc.).

It is the purpose of this paper to investigate the relationship between one environmental concern, noise control, and energy conservation. Here common areas of interest appear and these need to be highlighted. Where noise control and energy conservation are synergistic, possibilities for their mutual application should be emphasized. In areas where noise control and energy conservation are contradictory influences, solutions to the impasse must be sought to the benefit of both.

Two major areas of noise control exist - industrial and environmental. This paper is mainly concerned with the control of environmental noise as it affects new residential developments. In-plant noise is usually dealt with at the source, whereas noise impinging on a new residential development is abated either along the path of the noise or at the receiving point, the residence itself.

The main sources of environmental noise are road traffic, trains and aircraft - all transportation services and all prime users of energy. The ultimate situation "no fuel therefore no transportation noise" will not be examined here as our civilization would be so drastically affected that energy conservation could be considered to have failed if such a situation arose.

THE CONTROL OF OUTDOOR NOISE

If noise reductions cannot be achieved at the source in a reasonable time frame, then timely noise control can be achieved by interposing a sound barrier between the source and the receiver to deflect the path of the noise. In both Canada and the U.S., the concept of sound barriers has been widely used to reduce the effects of noise. A barrier is any object (a building, wall, solid fence or berm, etc.) long enough, heavy enough and high enough to oblige sound waves to travel away from a receiver at ground level. People who regularly travel Highway 401 in Toronto will have noticed light green steel barriers about 10 feet high along many sections of that highway.

Such barriers present the possibility of energy conservation if instead of steel panels, etc., solar collectors are used. Problems would need to be solved, of course. Dust and film collection along the solar collector barriers could degrade their performance. Light reflection into the eyes of motorists may be a problem. Finally, piping would have to be laid from the collector acting as a rear-yard fence to dwellings with an associated loss of efficiency. However, 15 ft. high solar panels along miles and miles of highway represent a formidable source of energy with noise reduction as an added benefit.

In areas of very high noise level a simple barrier may not provide sufficient noise reduction and a whole building row can be used as a noise barrier. For such a barrier building row to the north of east/west running highways or rail tracks solar panels would be used to form the southerly building facade, replacing the 'blank wall' building which has been used in Ontario to protect against highway and train noise. Rooms with a requirement for natural light (living rooms, bedrooms, etc.) would be oriented to the north, away from the highway, and rooms with less requirement for natural light (kitchens, washrooms, entrances, garages) oriented towards the solar panel side of the building. These north facing windows should, of course, be designed with a view to reducing infiltration and heat loss to a minimum, although acoustically no requirements would exist.

The building barrier in the form of either a townhouse row, stacked townhouse row or low rise apartment block row allows strong possibilities of noise control and energy conservation along highways and rail tracks. Larger areas for placement of solar panels exist than for simple noise barriers. However, only one side of the noise source could be utilized for solar collection. A second problem is that not all highways or rail tracks run east/west. To overcome this problem to a certain extent, staggered unit angles up to 45% to the source of noise could be used to allow the panels to have a more southerly aspect.

Two minor additional considerations for building barriers apply. Row townhouses or apartment blocks are more energy efficient designs than detached residences and hence provide a second-order energy saving. Also in the case of long building rows it may be possible to utilize wind-channeling effects to drive electrical energy generating devices such as windmills, turbines and paddle wheels.

It is felt that the combination of solar panels with both barriers and barrier buildings affords strong possibilities of energy conservation through the use of renewable resources. These possibilities should be investigated by engineers and architects alike. The possibly lower marketability of property close to noisy highways and railroads could well be considerably offset by the solar collection possibilities which exist.

CONTROL OF INDOOR NOISE

Building Envelope Considerations

In many respects, factors allowing the influx of sound into a building will also allow an efflux of heat energy. Poor workmanship resulting in badly filled components will result in small gaps which will allow sound to enter and heat to escape. Consequently a basic factor in providing a building which is well-insulated for sound and heat is that of maintaining a high standard of workmanship. Doors, windows, etc., should be fitted tightly into other building components to minimize sound penetration, heat loss and infiltration.

Windows represent the weakest link in the building envelope with regard to both heat loss and sound insulation. Minimization of sound ingress and heat egress is achieved using similar if not identical measures. Use of double and triple glazing is a well known method of improving heat loss through windows. Such methods will also reduce sound ingress, but greater air space is required between panes to achieve the potential noise reduction. Acoustically air spaces of 2" or 4" are not unknown whereas thermal glazing often only has an airspace of 1/2" or less. Thus double glazing designed for thermal insulation may have to be modified when a certain sound transmission is required.

A further commonality between heat loss and sound insulation is the degree of sealing around the glazing. Openable windows allow greater infiltration of cold air in winter (particularly in north-facing windows) and also have a slightly reduced sound transmission loss performance. Acoustically, only windows facing (or at right angles to) a noise source are considered for improved sound insulation. In consideration of energy conservation, however, north-facing windows (which may face away from a noise source) will also have to be investigated and suitably designed and installed to reduce heat loss and infiltration.

It may be thought that additional heat insulating materials in walls would also increase the ability of the building facade to reduce sound. The wall itself will have an increased performance, but improvement in the sound transmission characteristics of the wall will not have a very great effect as the predominant path for sound ingress is provided by the windows. Reduction of heat loss through a building envelope by upgrading the glazing is often an expensive task and addition of insulation to the walls and roof is preferable. However, in noisy situations the extra gain in sound reduction may make the fitting of double glazing more appropriate.

Ventilation and Air Conditioning

In order for special glazing to achieve its full noise reduction potential, the windows must remain fully closed. Even slightly opened windows will have greatly reduced acoustical performance. The occupants of a residence protected with special double glazing are thus faced with a dilemma; either they close the windows and suffer the heat in summer or they open the windows and suffer the noise. Clearly for the special glazing to reach its full potential in reducing noise levels some form of ventilation must be provided. If mechanical ventilation or air conditioning is provided to allow special windows to remain closed during the summer months, then an energy penalty will have to be paid. In this instance energy conservation and noise control are opposing influences and solutions are required which satisfy the demands of each.

The basic problem is to adequately cool the residence with windows on the noisy side closed. Windows on the quiet side can be opened allowing some exchange of air but not a cross-flow of air from one side of the building to the other. Apartments are faced with a similar problem as they usually only have windows facing in one direction. However, apartment dwellers often attempt to solve the problem by purchasing large fans and this invokes an energy penalty.

Site layout and landscaping considerations can, in some cases, reduce the problem, though not solve it completely. If possible, residences should have openable windows facing north, the coolest side of the building. These windows however should not be large so as to avoid too great a heat loss in winter. Unfortunately many highways and railways do not run east/west and also the demand for serviced land necessitates building on both sides of these noise sources. Hence, a northerly aspect for openable windows cannot always be achieved.

South-facing windows can be protected from the summer sun by suitable shading devices or even deciduous shade trees. In both instances the winter sun would penetrate the residence to allow some solar heat gain. East and west facing windows are more difficult to shade. With low sun elevations, even in summer shading is difficult to achieve. Windows facing east however are exposed to morning sun and hence lower outdoor temperatures. West-facing windows pose a more difficult problem as they are exposed to the evening sun and high outdoor temperatures. Thus residences to the west of a north/south oriented noise source with openable windows facing west pose the most difficult problem.

Apartment blocks offer greater possibilities for solutions to the contradiction between energy conservation and noise control. A single-aspect apartment building - a corridor close to one building face with apartments leading off to the other building face only - offers definite possibilities. The corridor side can be enclosed by a solid wall, but this can look rather ugly and also requires lighting even during the day. Installation of sealed windows to reduce lighting and improve the esthetics of the building leads to the possibility of overheated corridors and hence heating of the apartments themselves.

In Europe apartment buildings are often single-aspect but with an external corridor or walkway to allow access to apartments on each floor. This system has advantages in the present context. The entrance walkways would face the noise source necessitating adequate door design, but also allow windows on the noisy side to light the unit. These windows (if facing south) would be shaded from the high summer sun by the walkway above. If north, east or west-facing, they need only be small (such as over the kitchen sink) and thus minimize either heat loss or solar heat gain as appropriate. Placing the kitchen and washroom close to the entrance on the noise side is reasonable as these rooms are less sensitive to noise than living rooms and bedrooms.

Although the architectural features so far discussed to provide definite possibilities to achieve satisfactory solutions to the problems of noise reduction and energy conservation, they often utilize non-traditional methods which may adversely affect the marketability of the units themselves. It is worthwhile therefore to investigate means of ventilating units of traditional design without using electrical energy.

A number of devices exist which allow air flow but restrict noise transmission. Acoustic louvres are one possibility. These, however, are limited in the amount of sound attenuation they provide, although they are easily installed and are readily available. They can be expensive if a large area is required for ventilation. Cross-talk (Z-shaped) silencers afford a second possibility. These can provide as much attenuation as a dwelling wall itself and are reasonably priced. Such silencers should be designed to fit into the building wall itself to avoid ugly protrusions on the outer building facade.

A further possibility exists utilizing thermo-siphoning (as in the Trombe Wall) as a means of both heating and cooling interior spaces of units. In noisy environments these systems when cooling only need to exclude noise on the noisy side while allowing warm air to escape. Here again acoustical louvres or cross-talk silencers may be used. Alternatively, it may be possible to merely line the internal passages of the system with sound absorbent material to obtain the required sound reduction.

CONCLUSIONS

This paper indicates that considerations of noise control and energy conservation run parallel in many cases. Often the two concerns are complementary and mutually advantageous solutions apparent. In other cases they are opposing influences but means can be found of solving the contradictions which arise. As energy conservation becomes of greater importance in residential construction other concerns such as noise control should not be neglected but rather considered in conjunction with it. In this way energy conservation can be added to other longer-standing environmental considerations in an effort to maintain the quality of life so far achieved by mankind.