MODELLING TRAFFIC NOISE IN HIGH DENSITY DEVELOPMENT

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INTRODUCTION

The potential of modelling to assist in evaluation of the external acoustic environment of proposed urban developments, where reliance is on the shape and layout of the buildings for protection rather than on either the building envelope or purpose-built barriers, has been recognized for a considerable time. Computer modelling and physical modelling using both acoustic and optical sources have been suggested [1,2]. However, few reports on the practical application of such procedures have appeared, at least not in the English language literature. This could be because there may be a limited number of large scale developments, where at least one building can be used to screen others, actually designed and constructed in most western countries. Of those that are, many such as schools, hospitals or office complexes would likely be either located in acoustically favourable locations in the first place or adequately protected by the building envelopes.

This paper will indicate that, by contrast, the nature and process of urban development in Hong Kong is such that modelling of the external acoustic environment there could profitably be applied on a routine basis to new developments.

THE HONG KONG ENVIRONMENT

Urban Hong Kong is characterized by a high population density housed predominantly in high-rise buildings. Some locations have population densities of up to 200,000 persons per square kilometer, though design densities in newly developed areas are considerably lower. The scarcity of suitable building land has produced vertical development of nearly all land uses and residential tower blocks of 30 storeys or more are common. Some 40% of the population is in public housing, and further new housing is provided in comprehensively developed estates, really small cities, with dwellings, shops, schools and transport termini in large,closely spaced building blocks. For example, 3,000 to 5,000 residents may be accommodated within a single tower, with a total estate population of 15,000 to 30,000 residents. These developments, and others constructed privately, are designed and built within surprisingly short periods and planning staff are under considerable pressure to produce results as quickly as possible. For example, a target of 35,000 new flats each year was reported in 1982 [3].

These high population densities are serviced by a relatively small network of roadways with consequent high traffic volumes on all roadways and high traffic noise production. Short distances between roadways and the residential towers, combined with line of sight from a very high proportion of dwellings in the towers to roadways, results in the Hong Kong population being exposed to high ambient noise levels in their homes.

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Figure 1 is a view of some of the earlier housing developments which clearly shows the high population densities referred to, and both the bulk and form of the development.

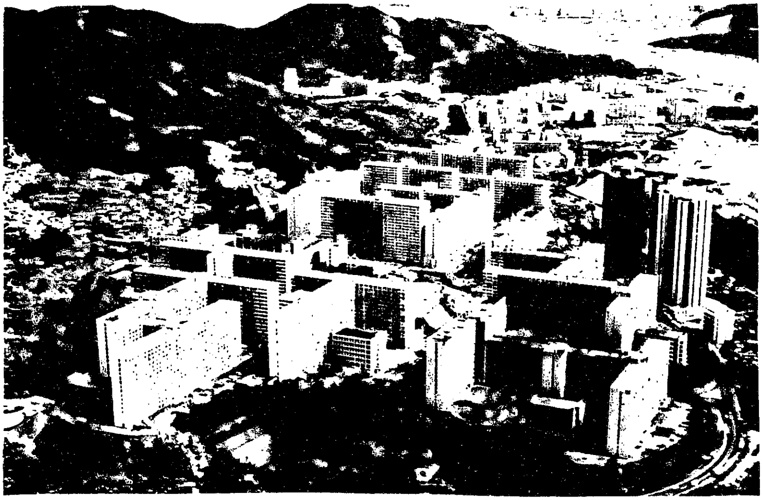

Figure 1

INADEQUACY OF CONVENTIONAL SOLUTIONS

The nature and economics of urban development in Hong Kong are such that conventional design solutions to high levels of road traffic noise are quite inappropriate. There is no possibility , even in the new developments, of increasing the separation of roadways and dwellings because of the premium on land and because of the absence of areas distant from heavily trafficked roadways. Barriers at the side of roadways are also inappropriate because shielding is generally only effective for the lowest floors, leaving the majority of dwellings in tower blocks unprotected. Further, using the building envelope for the insulation of dwellings is not feasible because of the costs involved, particularly so in public housing estates where all ventilation is through the windows. Air-conditioning would be essential if windows were to be sealed during the hot summer months.

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URBAN DESIGN SOLUTIONS

While the form of new urban development in Hong Kong renders conventional measures of noise reduction inappropriate, the paradox is that this same urban form can provide unique opportunities for noise reduction through site layout. This is for two reasons. Firstly, the bulk of the buildings within any one development site is very large and this means that considerable opportunities arise to place dwelling units and other noise-sensitive uses in acoustic shadows cast by other buildings within the development. Secondly, all residential and service buildings are designed simultaneously with the infrastructure of roadways and other transport facilities, together with landscaping and recreation areas. Comprehensive planning of this sort can always provide some flexibility in the arrangement of building units and transport facilities and could be exploited to produce a major reduction in the transport noise levels to which much of the development is exposed. In some cases, this flexibility can extend beyond the simple spatial rearrangement of building blocks to variation in the height and shape of some of the blocks, to changes in the relative elevation of roadways and platforms on which the residential towers are constructed (developments in Hong Kong often are constructed on areas of significant relief) and to covering of the roadway noise sources to some degree by incorporating them into the design of the buildings, transport terminals or landscaping works.

It is not suggested that complete protection of all noise-sensitive uses within a development can be achieved in this manner. Complete protection would only be possible if those uses not protected by shielding could be acoustically insulated. However shielding can result in a very large reduction in the number of dwellings within a development exposed to high levels of ambient noise. The essential point is that this can be achieved at little or no cost, a critical factor when the first priority is the provision of housing for as many people as quickly and as economically as possible.

THE DESIGN PROCESS

However, despite the potential benefits, there are considerable difficulties in having acoustic considerations incorporated into the design process. One reason is that designers are faced with a multitude of overriding constraints such as achieving the required residential densities and services, foundation requirements, scheduling of construction,costs etc., together with the softer architectural constraints of aspect, views and aesthetic appeal of the final built form. A quiet external environment has, in the past, not ranked highly as a design constraint in such projects. One of the difficulties is that the urban design professions have generally not been well equipped to handle the problem of high external noise; the other is that methods for estimating the noise levels throughout a complex urban form require that the geometry of roadway sources and building outlines are well established. A detailed geometry is required on which to perform computations or on which to build the scale models needed for physical modelling. However, in the trial-and-error process which is required in fitting together the jigsaw of an urban development, a fixed geometry is the very thing which is not available. Levels of external noise can be calculated when the final design is available, but this merely serves as a post-hoc evaluation and it is only reasonable to expect reluctance on the part of a designer to alter a final design even if such acoustic evaluation demonstrated high levels of noise. The first requirement is thus one of a rapid-assessment technique which can give the urban designer insight into the likely noise exposure of sensitive uses at any stage of the design and the acoustic ramifications of any changes in location and geometry. The initial need is for a design tool for coarse assessment rather than for refined analysis.

OPTICAL MODELLING

In the type of urban complexes described above, noise levels are likely to be determined by direct or reflected sound, and refracted sound, while present, is likely to be dominated by these. Further, as propagation is well above the ground surface, ground effects on propagation can be neglected. In these circumstances, crude optical modelling has potential both as an educational device for designers and as a first-stage design tool. Roadway sources can be represented by rows of small incandescent light bulbs and buildings and ground surfaces modelled from some reflective material such as white plastic, foam or cardboard. Dimensional accuracy is not critical, except for those edges of buildings and ground planes which case shadows on buildings at greater distances from the roadways. When viewed in a darkened room, building elements which are in light, in shadow or in penumbra are clearly distinguishable. In no sense can a crude model like this be used in a quantitative fashion, and this is not the intention. Its purpose is to give the urban designer an indication of the extent of high noise exposure and low noise exposure (light and dark) within the development and, of more importance, which building elements effectively act as screens and which have the potential to act as screens through design modification. With an appropriately constructed model the designer can have the hands-on experience of trying different designs. This can be by shifting the building elements, by changing slopes of roadway cuttings, or adding new building elements, merely by using hand-held sheets of modelling material, or by addition of modelling clay walls to see the potential effects of barriers. In a very short time a designer, untrained in acoustics, can become aware of the constraints and possibilities concerning the external acoustic environment and may be able to incorporate these with the other constraints in the project. This "feeling" for the noise levels throughout the development must be supplemented at a later stage by detailed calculation or perhaps by quantitative acoustic modelling, but this two-stage approach is likely to be far more productive than a simple post-hoc evaluation of a completed design.

CONCLUDING REMARKS

In the comprehensive design of high density, high rise, urban development, considerable potential exists for low-cost traffic noise reductions through building design and layout. This potential may not be realized because of the difficulty urban designers have in incorporating acoustic considerations into the early stages of a project when the necessary flexibility to alter the design to achieve lower noise exposure still exists. Non-quantitative optical modelling can be used as a first-stage design aid in these circumstances.

ACKNOWLEDGEMENT

This paper reflects on work in which the author was involved while with the Hong Kong Environmental Protection Agency.

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