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ROPLAN - SOFTWARE FOR MODELLING NOISE FROM ROAD SCHEMES

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INTRODUCTION

Whilst highway engineers and planners are conscious of their professional responsibilities to minimise the environmental impact of roads schemes, and particularly the noise effects, they have often found themselves hampered by the difficulties of making the necessary assessments. This paper describes the ROPLAN traffic noise modelling system, which is designed to apply the statutory calculation procedure (1) in a way which is sufficiently flexible for planning and design purposes and yet sufficiently accurate for detailed assessments under the Noise Insulation Regulations (2).

Quite apart from the public obligation to optimise the design of road schemes (which is usually "policed" through the Public Inquiry system) there are good economic reasons for doing so, in particular the possible cost of providing statutory noise insulation or so-called Part One compensation for loss of value under the Land Compensation Act 1973(3).

Under the Department of Transport's Standards (4), when a trunk road proposal progresses to its Public Inquiry stage, an assessment framework must be completed for the preferred route, for the "do-nothing" case and possibly for Objectors' routes. The framework is essentially a tabular presentation of relevant data, in which noise effects are expressed as the number of properties undergoing a change of noise level, classified into 5 dB(A) bands. Whilst the framework method is by-and-large satisfactory, there are indications that highway authorities are increasingly concerned at the time and cost involved in their preparation.

A further cost of traffic noise arises from the sterilisation of extensive areas alongside major roads by planning policies which prevent development within a theoretical noise contour, whereas the wastage of land can be minimised by well-designed noise barriers and housing layouts.

The ROPLAN suite has been developed over a number of years to meet these varied demands, encountered over many projects. The programs are written in Fortran IV/Fortran 77, originally for a mainframe machine, but they have been successfully ported to mini- and micro-systems, although on the latter the cost of the graphics peripherals needed to make the fullest use of the software can be several times the cost of the computer itself.

THE STATUTORY CALCULATION PROCEDURE

The statutory calculation procedure, set out in "Calculation of Road Traffic Noise" (CRTN) (1), is mandatory for assessments under the Noise Insulation Regulations 1975 and is also appropriate for highway design and location, environmental planning, etc. It provides a number of prediction formulae and

a flow chart which lends itself to computer evaluation, but the user must first divide the road into straight-line segments and then measure and enter all the necessary distances, heights and angles of view of the reception point to each segment, taking account of intervening barriers, reflecting surfaces, the type of ground cover and the average height of propagation if this is over undulating, absorptive ground. Except in the simplest of cases, the work is slow, tedious and error-prone, yet requires skill and experience, discouraging the evaluation of design changes and optimisation of ameliorative treatment.

THE ROPLAN APPROACH

ROPLAN, whilst using the CRTN prediction formulae and procedure, derives all the necessary data from a 3-dimensional computer model of the road and its surroundings. Because the model consists of commonsense and intuitive features - the road, barriers, ground contours and receiver locations - it is easier to build a ROPLAN model than to learn the intricacies of the statutory calculation method. Furthermore, by using computer graphics it is possible to view the model in plan, profile or perspective, enabling any modelling errors to be picked out by eye far more readily than if the data were only in numerical form.

The system can deal with multi-level junctions and roads through undulating ground. The ability to define areas of hard and soft ground cover, together with full ground-contour modelling enables calculation of both absorptive and screening effects of the ground, allowing both urban and rural schemes to be represented accurately.

The suite of programs is in four main parts: ROTAB, which drives a digitising tablet for generation of the model; ROPLOT, which allows the model to be viewed; ROPLAN, which undertakes the calculations; and ROPORT, which manipulates the results to produce information such as assessment framework data or lists of properties qualifying for insulation.

BUILDING THE COMPUTER MODEL

The model is most conveniently derived directly from scheme plans or Ordnance Survey maps by using a digitising tablet, although hand digitisation (by measuring co-ordinates with an overlay or scale rule) is a practical procedure. Indeed, the data format was specifically designed for this, and yields a readily-understood, compact data file coded in mnemonic form for easy editing, which does not require a special editor program.

Features such as road segments, ground contours, barriers and receivers can be derived from separate drawings and at different scales, if necessary. The details can be held in separate files, enabling different combinations of schemes, junction configurations, barriers and so forth to be assembled and run without having to build a separate model for each combination.

When using ROTAB, the user is prompted by an initialisation procedure which allows the map scale and grid location to be determined, and for a file onto which the model will be saved. From a menu, the user selects the type of

feature to be digitised and the program prompts for the action required. Eastings and Northings are determined from the position of the tablet cursor, but heights must be keyed in. Descriptive comments may be added ad lib; these serve to aid editing and act as descriptors and titles in the calculation procedure. Road segments, barriers, ground data (contours, profiles and ground cover) and receiver locations are entered in this way: a complete model also requires traffic flow data and results selection data, but this is usually keyed in at an ordinary terminal.

VIEWING THE MODEL

Once entered into the computer, any part of the model can be viewed on a graphics terminal in plan, profile or perspective or, with a suitable plotter, a copy can be made on tracing paper which can be overlaid on the original drawings to permit verification. It was also originally intended to draw the model as an aid during digitisation, but this has proved to be unnecessary.

The noise calculation procedure is very sensitive to errors in height data, particularly where barriers are involved, and the profile and perspective views are essential in checking this. The profile view (which is strictly an elevation on any selected plane) lends only a limited degree of verification as scheme plans rarely show more than the road long-section with a limited number of cross-sections which rarely extend beyond the limits of the engineering works.

Perspective views, however, can be compared with photographs of the area and can thus be used to check the modelling of features not shown in detail on maps or plans, including the heights of buildings and topographical features. The present version of ROPLOT presents features as transparent frames, so that foreground features do not hide those in the background. This limits the realism, but because any part of the model can be viewed separately, it is possible to avoid the problem of too much clutter.

THE ROPLAN PROCEDURE

ROPLAN uses the model to determine the values of parameters necessary to apply the CRTN procedure. For each road segment, the distance of the reception point, the angle of view and the presence of intervening barriers is determined. The program utilises the most effective barrier over each part of the angle of view, unless the soft ground excess is greater. This is determined by considering the intervening ground contours and type of ground cover to calculate the average height of propagation, and to include any screening afforded by the ground contours themselves.

CRTN does not define the procedure to be adopted where a barrier is not parallel to a road. ROPLAN assumes that the effective barrier distance is given by the intersection with the barrier of the bisector of the angle of view over the barrier.

By applying gradient, angle of view, hard ground, barrier or soft ground excess, retained cut and reflection corrections to the Basic noise level, the

program obtains the contribution to the segment, which is added to a specified category. When all segments have been assessed, the category totals are combined and displayed in the manner specified by the Results selection data. For example, the contributions from various roads could be shown, and these could be combined to give the total unaltered, altered and new road contributions, with a final grand total.

PROCESSING OF RESULTS

Output can be displayed at the terminal, printed or stored on disk for further processing. The amount of detail can range from a concise list of results to a full breakdown of all distances, heights, angles of view and the resultant noise level corrections. The level of detail can be varied for each receiver, allowing critical locations to be studied in greater depth and to assist in the design of remedial measures. The ROPORT post-processor can produce detailed reports of properties qualifying for insulation, environmental framework data, etc, from the stored disk file.

EXPERIENCE WITH THE SOFTWARE

The software has been in continual development and use since 1979, although based on programs developed in 1975 and earlier. It has been applied to a wide range of projects, from route selection through detailed design to noise insulation assessments and appeals. It has also been used in design of housing layouts alongside motorways, and has been used for Public Inquiry work over a wide range of rural and urban schemes.

It is accurate, reliable and quick, and novices readily adapt to it, although some users are tempted to over-analyse schemes by including unnecessary detail, which reduces some of the cost and time savings which can be expected. It is difficult to quantify these savings, as it becomes possible to analyse schemes with an accuracy and detail which cannot be contemplated for manual calculations, allowing design improvements with concomitant savings which would not otherwise be possible.

A recent scheme approximately 1½ km long with two grade-separated junctions took about a day to digitise, and having done so the results are obtainable immediately, but this excludes the often time-consuming phase of assembling the necessary mapping and making site visits, which is necessary whatever calculation method is employed.

FUTURE DEVELOPMENTS

One development currently in use allows digital data from the MOSS highway modelling system to be used as input to ROPLAN. Typically the MOSS model covers only the narrow strip of interest to the highway engineers, but at a high level of detail and software is required to convert the data into the necessary format. A spin-off from this will enable roads to be segmented automatically during the digitisation process, giving a more accurate and efficient model.

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To improve graphic presentation, "solid" perspective projections are being developed. This could also assist with assessment of the visual effects of noise barriers, etc. The post-processor is being improved to provide further assistance with barrier and highway environmental design.

Other possibilities include the addition of an air pollution screening-test module. Construction noise is dealt with by a separate suite of programs not discussed here, but a linkage to allow a shared data-base would be an additional advantage.

REFERENCES

[1] Calculation of Road Traffic Noise, Department of the Environment, 1975.

[2] Building and Buildings. The Noise Insulation Regulations 1975. Statutory Instrument 1975 No. 1763.

[3] The Land Compensation Act 1973.

[4] Frameworks for Trunk Road Appraisal. Departmental Standard TD/12/83. Department of Transport, 1983.