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CONSTRUCTION NOISE IN SINGAPORE AND THE USE OF THE LEQ (5 MIN) IN ITS PREDICTION, MEASUREMENT AND CONTROL.

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Summary

With the present construction boom in Singapore and further massive construction and demolition programmes anticipated for the proposed new Mass Transit system, construction noise is expected to be a major problem there in the near future. This paper looks into the investigations carried out leading to the development of a Code of Practice for control of construction noise in Singapore.

Studies for the proposed Code commenced in 1978 when a survey of the local construction methods and equipment was undertaken to look into noise caused at the sites. The effects of the noise on personnel employed on the construction site as well as that on other people in the neighbourhood were examined. The criteria upon which the new Code was to be established was determined from a social survey carried out in different parts of the country and each was zoned according to varying local requirements and sensitivities. Laboratory studies were also carried out into the subjective response of the local population to construction noise. Considerable thought was also given to establishing acceptable noise levels which continue to be economically realistic for the survival of the industry.

A review into existing legislation carried out at the same time revealed that the BS 5228:1975 was the most suitable standard on construction noise in existence at that time but also had its shortcomings. Adaptation was necessary to suit conditions in the Singapore construction scene. Other literature of interest were the 1963 Final Report on Noise, Chapter 10 on Construction Noise and the BS 4142AMD 1975 which dealt with industrial noise and mixed industrial-residential areas. Reference was also made to the Japanese and American standards of practice.

Of interest especially were the ways in which the local authority would be able to specify, monitor and control noise levels from the construction sites. The final approach was the eventual emphasis on the possible advantages of the issue of a set of guidelines whereby public approval could be brought to bear rather than through enforcement by legislation. Also in the Code is the use of a short time average descriptor, the L_{Aeq} (5 min) which is unique to the Singapore Code at present. The studies leading to its use in the Code is described.

Some of the problems encountered in the compilation of the Singapore Code of Practice for Noise Control on Construction and Demolition sites are reviewed and the steps taken to ensure that practicable measures exist to achieve the desired noise levels is discussed.

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The Proposed Construction Noise Code

A Code of Practice for the Control of Noise from Construction and Demolition Sites in Singapore has been proposed (1). Originally based on the British Standard of the same name (2) but with some significant diviations, the Code has been proposed by the technical committee under the direction of the Building and Construction Industry Standards Committee of the Singapore Institute of Standards and Industrial Research in response to growing public concern over the noise problem caused at construction and demolition sites springing up all over the country. The warm weather necessitating open windows and the generally built up nature of the country has contributed to the seriousness of the situation.

Background Construction Noise Studies

The studies carried out since 1978 looked mainly into construction noise, but also considers the masking effect of background noise in the neighbourhood. A survey carried out on eleven different areas in Singapore has found that nearly 18% of all noise complaints obtained are directly related to noise from construction work. This is despite a generally high background noise level due mainly to dense road traffic. It was also noted that the often assumed nature of construction noise being temporary is not applicable. In many other countries construction work in any particular vicinity occurs once in a fairly long period of time. In Singapore much construction work is going on and being a very small country in terms of size, no sooner does one project end than another commences. A particularly massive construction project on the partly underground mass rapid transit system is also about to begin. Construction noise in Singapore therefore can not be treated as isolated events as often done in many other countries.

Small though it is, Singapore does have differing neighbourhoods which may tolerate different levels of construction noise based on existing background noise levels and the predominant buildings in the area. An earlier survey (3) has also found that the public residential apartments which form 80% of the Singapore homes can be divided into two categories with different background noise levels based roughly on the gross floor area density of the apartment. These are accounted for in the type of district ranging from the quiet rural areas right up to the noisy industrial areas and the instances of empty land where no nearby populated buildings are likely to be disturbed.

The other area of concern is over personnel employed on construction sites who may be exposed to high noise levels over long periods of time. The normal hours worked in Singapore is often longer than the 35 or 40 hours weekly that many other countries work. It was found that although employers are required to provide hearing protectors, over 80% of over 400 persons on construction sites who were surveyed did not use the protectors (4). No long term effects have been studied to date in Singapore regarding such exposure, but evidence from other countries show cause for concern. Of those who use them 16% were found to use ear plugs and ear muffs, less than 2%. This is mainly because of the hot and humid weather which makes the use of ear muffs rather uncomfortable. The approach which is taken is to consider these as temporary relief only and every opportunity should be taken to reduce noise at the source. The use of modern noise-reduced and noise-labelled equipment in the construction industry is encouraged in the attempt to reduce noise from construction sites. Although there is at present no restriction on the use of noisy equipment the recommended noise levels specified in the Code is expected to result in the demise of machines such as the diesel pile driver. It is interesting to note that diesel hammer pile driving is banned in Tokyo and several other cities in Japan. Alternative less noisy methods are actively being sought after in all aspects of construction.

The approach taken in the Code to minimise noise from construction and demolition sites is to educate rather than penalise. It follows the British Code in presenting sets of noise data for the various equipment used on construction sites so that consideration of the noise factors may be taken at the earliest stages of the works. Similarly, the control of propagation of noise by the use of barriers, distance or good site management is highlighted. The Code emphasises noise control at the earliest design stages and the owner and his agents, i.e. architects or engineers are to specify at the design stage the working methods or machinery expected to be used. At the tendering stage the builder should know the noise control requirements and is expected to tender according to the most appropriate method and equipment available. The Code, however, is a guideline to good practice only and no legislation has been planned for the immediate future.

Noise Exposure Descriptor

The unit chosen for specifying and measuring noise in the Code is the time equivalent sound energy level (Leq in dBA). This is in keeping with previous findings, and also with the widespread use in general in most countries. One significant deviation here is in the use of a very short period of consideration. Whereas common practice in other countries is to use 24 hr, 12 hr, and 1 hr, the use of the L_{Aeq}(5 mins) is at present unique to the Singapore code. This was originally proposed in anticipation of difficulties in practice which would be experienced at the site of monitoring say L_{Aeq}(12 hrs), as suggested in the U.K. Construction Code. However, further work carried out indicated that no available literature has reported on noise complaints from construction noise being related to the eight or twelve hour time energy equivalent noise level. Moreover the existing work on subjective response to noise is generally based on shorter periods of exposure for practical reasons. Again bearing in mind the attempt in establishing an ideal in a code of good practice, it was anticipated that subjection to noise levels in excess of 80 dBA for one hour, as permissible and equivalent to L_{Aeq} (12 hour) 70 dB, is not acceptable. Taking the concept further, the 70 dBA Leq (12 hour) would also allow a level of 90 dBA to be exceeded for a period of 5 minutes, provided the rest of the 12 hours would have to be silent.

Much of the work reported in BS 5228 was based on the 1963 UK Wilson Report (5). The chapter on construction noise there quite clearly suggests a continuous noise level limit of 70 dBA, not Leq, at the closed window of the nearest building in rural, suburban and urban areas away from main road traffic and industrial noise. An additional 5 dBA is allowed where the latter is evident. It is also interesting to note that in 1975 it was reported that community reaction to construction noise in the UK was more adverse than to road traffic noise (6) even though the opposite was often assumed.

Recently completed subjective response studies in Singapore indicates that 70 dB

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L_{Aeq} (5 min) is a more acceptable limiting descriptor of construction noise annoyance, than 70 dB L_{Aeq} (12 hour) and continues to take into account the various impulsive type noises commonly experienced in construction work (7), without allowing objectionable high noise levels to be reached. Coupled to this, a long term descriptor such as the LLeq series which could take into account the duration of the whole construction works may be applicable.

Subjective studies on Annoyance using L_{Aeq} (5 min).

The work carried out was based on 5 minute L_{Aeq} exposures and included field surveys as well as laboratory studies on subjective response to construction noise. Recordings of construction noise was made during the five typical stages of construction:

(i) Site preparation - including demolition, excavation, levelling and delivery of materials and equipment

(ii) foundation work - excavation, earth auger and piling

(iii) building erection

(iv) inside fabrication - partition walls, metal work and ducting

(v) final installation and equipment testing.

The recordings were taken from a new site where the background noise was as low as possible. Recordings of various background noises, road traffic, aircraft, community and industrial were also taken to determine their masking effect on the construction noise in addition to their own annoyance effects. Studies were then carried out to investigate:

(a) acceptability level of the various 'background' noises on their own

(b) acceptability level of the noise at the five different stages, including a comparison of the impulsive piling noise and the continuous compressor noise

(c) the effect of different levels of (a) masking (b).

The individual recordings were edited, normalised and mixed into different master tapes which were used to investigate the three areas of interest. Subjects were selected for the laboratory investigations from undergraduate students based on audiological screening and these were then exposed to the noise for the five minute intervals in an audiological test booth.

Results and Conclusions

There was a small difference between field tests and laboratory studies. In general the results on a five point scale were found to be fairly consistent and were taken to be:

Subjective Judgement	L_{Aeq} (5 min)	
Very acceptable	50 dB	(indoor)
Barely acceptable	55	
Disturbed	60	
Annoyed	65	
Highly annoyed	70	

There was little or no detectable difference between the annoyance effect of construction noise and that of other noises. There was also no difference in the annoyance due to the same levels of noise of different types of construction noise, impulsive or otherwise. The masking effect of background noise becomes noticeable only if within 5 dB of the main (construction) noise.

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