COMPARISON OF VIBRATION MEASUREMENTS AT TWO STONEMASONS

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INTRODUCTION

The use of powered hand tools in the stonemasonry industry has now become widespread due to the increase in productivity so achieved. The penalty this has brought is the increased risk of contracting VWF. Although hand working is still evident in the industry, it is limited to intricate carving, the use of pneumatic and electric powered hand tools accounting for the majority of work done.

This paper describes sets of measurements made at two stonemasons' sites by the Noise and Vibration Section of the Research and Laboratory Services Division. The measurements were initially undertaken at the request of the local Specialist Inspector who was concerned at the high reported incidence of VWF among the workforce at Site A. This was inconsistent with the incidence at Site B where the workforce were ostensibly doing the same work. Details of the measurement techniques used are given together with comparisons of the daily vibration doses and the incidences of VWF ascertained from medical questionnaires.

The diversity of skills required for architectural restoration and building work means that the tasks of an individual stonemason changes from day to day. The results presented here can only reflect a particular days work and cannot be said to be representative of all stonemasonry.

WORKING PRACTICES

A variety of powered hand tools were used to work the stone by the stonemasons at both sites. The tools and the processes for which they are used are shown in Table 1. The stone worked at both sites was Clipsham limestone which is a soft material and cuts readily. At the time of the site visit during which the measurements were taken, both sites were engaged on fashioning replacement cornice stones. The work was carried out under cover in well lit and heated workrooms. Gloves were not worn by the operatives as these were said to impair the 'feel' of the process.

At both sites the method of working the cornice stones was similar. This involved removing most of the large volumes of waste, prior to carving, using electric angle grinders (tools 6, 7 and 8, Table 1). These were fitted with 125mm and 230mm dia. stone cutting discs. At site B it was noticed that occasionally a large chipping hammer (tool 4, Table 1) was used for these roughing cuts. This was possibly to avoid the large volume of dust which emanated from the disc cutting process. The smaller angle grinders (tools 7 and 8, Table 1) were used to cut fine detail on the finished stone, as well as for removal of small amounts of waste. The majority of the shaping of the stone block was done with chipping hammers. These have largely replaced the traditional stonemasons mallet, although this is still used for detail work. The chipping hammers could be fitted with different types and widths of chisel.

Flat chisels were used to remove most of the stone; gouges and vee chisels being used for detail work. Disc sanders were used to finish off the faces of completed cornice stones (tools 9 and 10, Table 1). These were fitted with resin bonded stone grade sanding sheets.

Two designs of pneumatic chipping hammer were encountered in the study. One, the 'industry standard' (tools 1, 2 and 3, Table 1) used at both sites, employs a loose round shank chisel which is hand held into the hammer body whilst in use. The operators showed a preference for this tool as the chisel could be rotated independently of the chipping hammer body, making carving detail easier. A valve was provided for turning off the tool although this was inconveniently situated about one metre away on the supply line. The chipping hammer exhaust was used to blow away the dust and chippings from the workpiece. During this process the tool was invariably left operating in the hand. The tool also exhausts over the hand whilst in use.

The second type of chipping hammer (tools 4 and 5, Table 1) used at Site B employs a hexagonal shank chisel which is held captive into the tool body. This enables the operator to keep both hands on the tool body which has a somewhat lower vibration amplitude than the chisel. The supply of compressed air to the chisel can be coarsely controlled by a lever on the tool body which, when released, turns the air off. This facility enables the operator to match the power produced by the tool to the task.

MEASUREMENT METHOD

The range of tools used by the stonemasons was assembled for one person to use at each site. In this way uniformity of operation would be achieved and the daily vibration dose for this person evaluated. A video recording of the uninterrupted working of one face of a cornice stone was taken showing the full range of tools used (Table 1). From this the timings for each tool could be obtained. The time taken to complete the whole cornice stone, allowing for breaks, marking out, handling etc, was taken from time sheets.

Acceleration amplitude measurements were made on each tool in the range at both sites. Short sample periods were used (30-150 seconds) so that the work wasn't disrupted unnecessarily and all the recordings could be made in the time available. Three piezoelectric accelerometers were mounted on mechanical filters and arranged orthogonally on a mounting block. This was fastened to the tool under consideration as close as possible to the operators' hands. The stonemason was asked to work as normally as possible whilst the measurements were taken. A simultaneous video recording was made of the measurement procedure. It has been found that this technique helps to establish the actual contact time of the tool, this being achieved by the use of a time code recorded on both the video recording and the data recording. A further feature of this technique is that any spurious data arising from accidental contact of the accelerometers, say, with the workpiece can be easily noticed and discounted. The signals, after conditioning, were recorded on a multi-track cassette data recorder for later analysis [1] [2].

RESULTS

Figure 1 shows the estimated daily acceleration doses for the various tools and tool combinations used on each site. These are normalised to an eight hour day

[2] [4]. Also shown is the change in the overall daily dose when one of the chipping hammers is replaced by one of different design.

For each vibration recording the rms vibration acceleration amplitude in the octave bands from 8Hz to 1kHz and the weighted acceleration for each axis were determined [3]. The vector sums of the weighted acceleration amplitudes for each tool have been combined to give the overall daily dose (Table 2). This approach was adopted as the operators alter their hand orientation during the work cycle.

Table 3 shows the results from the medical questionnaires which were produced before the measurements were taken.

The typical estimated overall weighted daily acceleration dose at site A for the right hand was 66 ms^{-2}. There is no data for the left hand due to overloads in the signal conditioning system. At site B using chipping hammers 4 and 5 together with the range of tools shown in Figure 1, an overall weighted daily acceleration dose of 27 ms^{-2} for the right hand and 26 ms^{-2} for the left was calculated.

DISCUSSION

Table 1 shows the tools used at both sites and gives a brief description of the tasks on which each was used. It can be seen that, although the makes of tool are different at both sites, the same types of tools are used to work the stone in a similar fashion. This would tend to imply that the stonemasons at both sites were exposed to similar vibration doses. This is only the case however when the grinder and sander are used. Use of the various types of pneumatic chipping hammer exposes the stonemasons to very different acceleration amplitudes. These differences are illustrated in Fig. 1. At site A similar types of chipping hammer were used to undertake roughing cuts and also to finish off the detail work, (tools 1 and 2, Fig. 1).

Some operators at the second site utilised captive chisel chipping hammers, which exposed them to less severe acceleration amplitudes (tools 4 and 5, Fig. 1). It can be seen that an operator using a combination of tools which includes the captive chisel chipping hammers (tools 4, 5, 8, 10, Fig. 1) receives a lower overall acceleration dose than a combination including non-captive chisels (tools 3, 4, 8, 10, Fig. 1).

Although this survey was conducted on a small sample of stonemasons, results from the earlier medical questionnaires are borne out by the typical daily vibration doses at both sites.

The high acceleration amplitudes encountered when attempting measurements on the non-captive chipping hammer chisels produced overloads in the signal conditioners. From this it is evident that the peak vibration amplitudes for the left hand holding the chisel are much higher than those for the right hand which was holding the tool body.

CONCLUSIONS

The overall daily acceleration dose is considerably affected by the stonemasons' choice of chipping hammers. Careful selection and use of alternative tools, such as angle grinders to remove waste, can reduce the daily acceleration dose. However, even if the acceleration amplitude of the chipping hammers could be reduced to that of the angle grinders, the doses received would still result in a 10% incidence of stage 1 VWF after an exposure of one year [3].

The use of a chipping hammer equipped with an air control valve and a captive chisel was observed to produce lower vibration amplitudes than the more basic hammer with a loose chisel. It is essential that proper consideration should be given to the choice of hand tools designed to produce low vibration amplitudes if the incidence of VWF is to be reduced.

Use of automated processes to trim the stone block and remove waste is the only sure way to reduce the stonemasons' vibration dose.

REFERENCES

[1] Pitts P M, "A method for the on-site recording and subsequent analysis of hand-transmitted vibration" Paper presented at UK Informal Group, HRV, Derby. (1985)

[2] Price I R, Pitts P M, Hodges J P, "Measurements of Hand-transmitted Vibration Exposure - Problems and Results" Paper presented at 12th International Congress of Acoustics, Toronto, Canada. (1986)

[3] International Organization for Standardisation "Guidelines for the measurement and assessment of human response to hand-transmitted vibration" ISO 5349 (1986)

[4] British Standards Institution "British Standard Guide to the measurement of human exposure to vibration transmitted to the hand" BS 6842 (1987).

Table 1. Tools and processes

Site	Tool No.	Tool	Process
A	1, 2	Chipping hammer 25mm & 12mm loose chisels	Roughing and finishing cuts on stone face
	6	230mm dia. angle grinder	Plunge cuts to remove large volumes of waste
	7	125mm dia. angle grinder	Plunge cuts to cut grooves and remove small volumes of waste
	9	180mm dia. disc sander	Finish sanding of worked face
B	3	Chipping hammer 25mm loose chisel	Roughing and finishing cuts on stone face
	4	Chipping hammer 50mm captive chisel	Roughing cuts on stone face
	5	Chipping hammer 25mm captive chisel	Finishing cuts on stone face
	8	125mm dia. angle grinder	Plunge cuts to cut grooves and remove small volumes of waste
	10	180mm dia. disc sander	Finish sanding of worked face.

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Table 2. Estimated daily acceleration doses

Tool	$(a_{h,w})eq(8)$ (ms^{-2}) Left hand	Right hand	Site
1. Chipping hammer 25mm loose chisel	N/A	82	A
2. Chipping hammer 12mm loose chisel	N/A	72	A
3. Chipping hammer 25mm loose chisel	N/A	87	B
4. Chipping hammer 50mm captive chisel	41	48	B
5. Chipping hammer 25mm captive chisel	25	25	B
6. Angle grinder 230mm dia. disc	38	31	A
7. Angle grinder 125mm dia. disc	37	21	A
8. Angle grinder 125mm dia. disc	26	11	B
9. Disc sander 180mm dia. disc	13	13	A
10. Disc sander 180mm dia. disc	7	13	B
Total typical daily doses due to tool combinations:			
1+6+7+9	N/A	66	A
2+6+7+9	N/A	57	A
3+4+8+10	N/A	71	B
4+5+8+10	26	27	B

Table 3. Results from the medical questionnaires

	Site A	Site B
No. Returns (%)	100	58
Reported prevelence of VWF in total workforce (%)	67	50
Reported average time to give VWF symptoms (mths)	10	N/A
Predicted time for resulting VWF prevelence (mths)	11	19
assuming typical daily vibration dose (ms^{-2})	60	30

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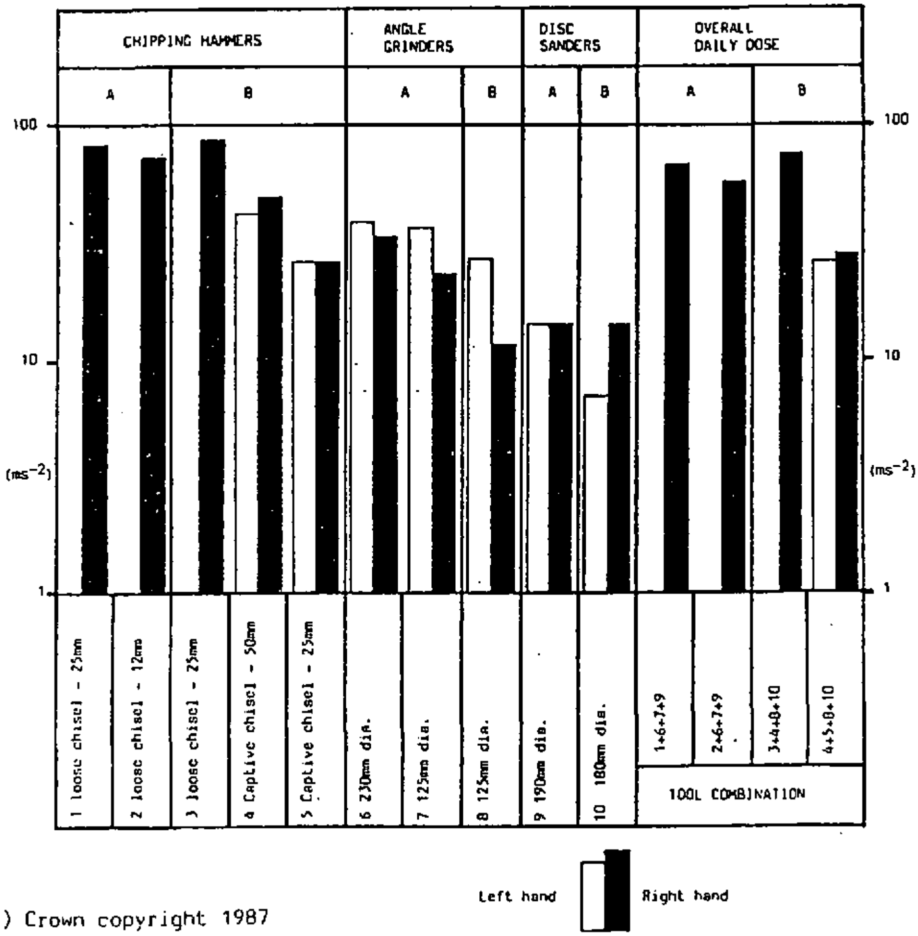
FIGURE 1

Estimated daily doses $(a_{hw})eq(8)$, for the various tools and tool combinations used at sites A and B



THE ASSESSMENT OF SITES FOR RESIDENTIAL DEVELOPMENT

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The conflict between:-

a) rating noise at the planning stage

<u>and</u>

b) the assessment of subsequent noise complaints

SUMMARY

SRL have recently been involved in advising on a planning application for a residential development, near to an industrial site, within a mainly rural area.

The acoustic assessment of the site was carried out using the rating method detailed in Circular 10/73 - "Planning and Noise". Based on this assessment, the site would be considered acceptable for development.

In the event of future noise complaints, however, an assessment would be made using the rating method detailed in BS.4142 - Method of Rating Industrial Noise Affecting Mixed Residential and Industrial Areas. On this basis the noise from the industrial site would be considered 'a nuisance'.

The conflict between the conclusions drawn from the two widely accepted documents lies in the fundamental difference in the rating method -

i.e. 10/73 - based on a 'fixed, acceptance sound level'
BS.4142 - based on 'relative to background, acceptance sound level'

This difference in approach means that problems will inevitably occur when planning residential development, close to an industrial activity in rural areas with low background sound levels.

This situation is illustrated in an SRL case study.