ASBESTOS EXPOSURE AMONG CONSTRUCTION WORKERS

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INTRODUCTION

During the past two decades, construction materials containing asbestos have occupied an important place in Japanese construction industry. At present, of total asbestos consumed per year, 199,000 tons (77.8%) are used for the construction materials[1] and there are approximately 4,800,000 construction workers in Japan.[2] It is presumed that a large percentage of the construction workers is exposed to asbestos and recently the health hazards by asbestos have caused concern. However, there are few reports about the asbestos exposure at construction work sites.[3,4]

The objective of this study is to make clear the type of asbestos used in construction materials, the ambient asbestos concentration at construction work site and the working condition of workers handling asbestos-containing construction materials.

METHODS AND MATERIALS

Identification of Type of Asbestos

Asbestos-containing construction materials were randomly collected from construction work sites. Dust fractions for electron microscopic inspection were produced by scratching these construction materials with tweezers. Asbestos fibers of these samples were identified by transmission electron microscopy equipped with an energy dispersive X-ray analyzer.

Measurement of Ambient Asbestos Concentration

In order to evaluate the asbestos exposure level to the workers, dust concentrations in construction work sites were measured by the membrane filter method using phase contrast microscopy, according to the standard techniques of the Japan Association of Industrial Health for asbestos sampling and analysis. Particles $> 5\ \mu m$ in length, $< 3\ \mu m$ in diameter with an aspect ratio $>3:1$ were counted.

Questionnaire Survey

The working conditions were surveyed by use of a self-completion questionnaire on all the 10,922 members of All Kyoto Construction Worker's Union in Kyoto prefecture, Japan. The questionnaire included questions concerning sex, age, occupational category, duration of engagement in the present occupational category, use of asbestos-containing construction materials, asbestos dust exposure, protective and preventive measures, smoking history and respiratory subjective symptoms.

RESULTS

Type of Asbestos

Twenty four samples of asbestos-containing construction materials including 20 wall boards, two roofing materials, one vinyl asbestos floor tile and one sprayed wall material were collected from 22 construction work sites. Among 20 wall boards, chrysotile alone, amosite alone, and both were respectively detected from six, one, and 13 samples. From the remaining materials, only chrysotile was detected.

Asbestos Exposure Level

The asbestos concentrations in 59 spots of 17 construction work sites were measured during a variety of operations, e.g., sawing, screwing, drilling, nailing, cutting, filing of asbestos-containing construction materials. Electric hand tools were used in sawing, screwing and drilling. Airborne asbestos concentrations are shown in Table I. The personal exposure levels were measured in the breathing zone of the workers using personal dust sampler. The ambient asbestos-concentrations were measured in the center of the room. Fifty four dust measurements were made indoors and five were made outdoors. Neither local exhaust ventilation equipments nor general ventilation equipments were provided in any work sites where we visited.

Concerning the results of the indoor measurements, air samples taken in the breathing zone of the workers reached more than 100 f/ml during sawing of asbestos cement board with electric circular saw (Figure 1). The ceiling limit of threshold limit value of asbestos is 10 f/ml in Japan. The ambient asbestos concentrations during screwing (Figure 2), drilling, or nailing often exceeded the value, because sawing is sometimes done during these works. If not so, the ambient asbestos concentrations were relatively low ranging from 0.3 to 14.1 f/ml. Table I also showed that the workers near the ones handling asbestos-containing materials are exposed to

Table I

Ambient Asbestos Concentrations in Construction Work Sites

Operations	Number of samples	Sampling time (min) Range	Mean[1]	Concentrations (f/ml) Range	Mean[2]	Median
[Indoor Work]						
Sawing[a]	4	2.5-5	3.8	125-787	214	147
1.5-2m from the above work[a]	3	2.5-5	3.5	103-630	245	232
Screwing or drilling or nailing[a] (partly include sawing)	8	10-120	48	1.3-131	11.0	12.3
1-10m from the above work[a]	7	10-119	56	0.9-48.1	5.4	3.0
Screwing or drilling or nailing[a] (not include sawing)	8	2.6-110	48	0.3-14.1	2.0	2.5
1-4m from the above work[a]	15	15-171	87	0.1-4.6	1.3	1.6
Cutting and filing[a]	1	1.0	-	12.1	-	-
Inspecting work site[a] (5-30m from the work operating asbestos board)	2	68-93	-	0.04-0.12	-	-
Finishing or cleaning[a] (1 to 7 days after the work using asbestos board)	5	15-93	45	0.1-0.5	0.3	0.3
Center of room[b] (a day after the work using asbestos board)	1	110	-	0.01	-	-
[Outdoor Work]						
Sawing[a]	1	124	-	0.14	-	-
Roofing[a]	1	115	-	0.13	-	-
1-2m from the above work[a]	1	115	-	0.05	-	-
Nailing on exterior wall board[a]	1	117	-	0.13	-	-
Plumbing[a] (a day after the work using asbestos board)	1	160	-	0.05	-	-

1: arithmetic mean, 2: geometric mean

a: Personal samples were collected. b: Area sample was collected Sawing: with an electric circular saw, Screwing: with an electric screw driver, Drilling: with an electric drill, Nailing: with a hammer, Cutting: with a knife,

asbestos. The cleaning of the work sites was insufficient that ambient asbestos concentrations were from 0.1 to 0.5 f/ml after the use of asbestos wall board (Figure 3).

The outdoor ambient asbestos concentrations ranged from 0.05 to 0.14 f/ml.

Working Conditions

6549 (60.0%) out of 10,922 workers belonging to All Kyoto Construction Worker's Union completed the questionnaire. Among them, male and female workers were 6500 (99.3%) and 49 (0.3%), respectively. In the following analysis, female workers were excluded because the number was very small.

The age of male respondents ranged from 17 to 84 years (mean 44.6, SD 11.0).

The distribution of the present occupational categories is shown in Table II. More than 40 kinds of trade categories were reported. Carpenters held a majority (40.8%) followed by plasterers (8.3%), electricians (4.4%), painters (4.1%) and plumbers (3.3%). The mean duration of engagement was 22.8 years (SD 11.4, range 0.2-65).

The number of workers who *often* handled asbestos-containing construction materials were 1360 (20.9%) and who handled *sometimes* were 2449 (37.7%). The distribution of the construction materials used by these workers is shown in Table III. Asbestos slate board was the most popular material, asbestos silicate-calcium board the next. Table IV illustrates the distribution of duration of handling asbestos-containing construction materials. The duration of handling ranged from less than one to 52 years (mean 14.1, SD 8.0). The distribution of mean number of days of handling asbestos-containing materials per month in the last one year is shown in Table V. Median value was 3 days per month.

Since construction workers have been not only directly exposed but also indirectly exposed to asbestos dust emitted by other workers in the work sites, the frequency of asbestos exposure either directly and indirectly was surveyed. The results are shown by main construction trade categories in Table VI. The frequency was varied by trade categories. Among them

Figure 1. Sawing asbestos-containing wall board with electric circular saw without local exhaust ventilation equipment. Ambient air was highly contaminated by asbestos.

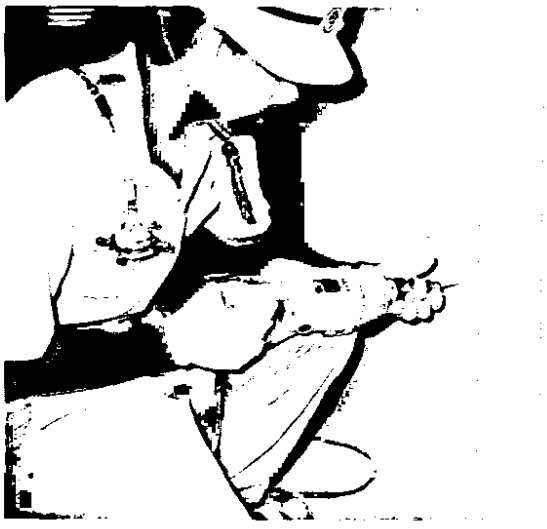

Figure 2. Fixing wall board to metal studs with screws by electric screw driver.

Figure 3. A: Floor contaminated by asbestos-containing dust after sawing wall board. B: Sweeping floor with a broom. One can see the secondary asbestos dust emission.

Table II

Distribution of Occupational Categories

	Number of workers	
carpenter	2608	(40.8%)
plasterer	531	(8.3%)
electrician	280	(4.4%)
painter	261	(4.1%)
plumber	220	(3.4%)
navvy	209	(3.3%)
sheet metal worker	197	(3.1%)
interior finish worker	147	(2.3%)
steel-frame worker	129	(2.0%)
cabinet maker	126	(2.0%)
helper	118	(1.8%)
tiler	104	(1.6%)
others	1466	(22.6%)
no answer	104	(1.6%)
total	6500	(100.0%)

Table IV

Distribution of Duration of Handling Asbestos-containing Construction Materials (N=2501)

Duration (years)	Number of workers	
0< - 4	258	(10.1%)
5- 9	492	(19.7%)
10- 14	705	(28.3%)
15- 19	416	(16.7%)
20- 24	383	(15.4%)
25- 29	124	(5.0%)
30- 34	91	(3.6%)
35- 39	24	(1.9%)
40- 52	8	(0.3%)

Table III

Distribution of Numbers of Workers Using Asbestos-containing Construction Materials (N=3782)

	Number of workers	
[Materials containing asbestos]		
asbestos slate board	2431	(64.3%)
asbestos silicate-calcium board	1747	(46.2%)
heat insulating asbestos pad	697	(18.4%)
asbestos roofing materials	639	(16.9%)
asbestos cement parlite board	600	(15.9%)
sprayed asbestos	478	(12.6%)
parlite board	429	(11.3%)
asbestos felt	336	(8.9%)
asbestos pipe	312	(8.2%)
asbestos paper laminated plywood	266	(7.0%)
asbestos packing	255	(6.7%)
asbestos cloth and yarn	230	(6.1%)
rubber asbestos sheet	184	(4.9%)
asbestos gasket	119	(3.1%)
asbestos tape	118	(3.1%)
asbestos rope	89	(2.4%)
asbestos-containing paint	72	(1.9%)
[Materials which contain asbestos or do not varies with the kind of productions]		
wood wool cement board	1438	(38.8%)
vinyl asbestos floor tile	1173	(31.0%)

carpenters were most frequently exposed to asbestos.

As for the use of protective mask, 28 (0.8%) workers out of 3710 workers who have an experience in using asbestos-containing construction materials responded to use it *everytime* and 216 (6.6%) answered *sometimes*.

There were 2491 smokers (66.4%), 670 ex-smokers (17.9%) and 588 non-smokers (15.7%) among the workers who have an experience in using asbestos-containing materials.

The relationship between the mean days of handling asbestos-containing construction materials per month in the last one year and the prevalence of respiratory subjective symptoms (palpitation, shortness of breath, cough and sputum) is shown in Table VII. The prevalence of the symptoms increased with the mean asbestos-handling days per month. The correlation coefficients between the rank of mean days per month and the prevalence of the symptoms ranged from 0.080 to 0.206 ($p<0.0001$, Kendall's tau-C), while the correlation coefficients between the rank of mean days per month and smoking habit or age were not significant.

DISCUSSION

The present study resulted in the following:

1. Not only chrysotile but also amosite are frequently used for the construction materials.
2. Ambient asbestos concentrations in the worker's breathing zone widely ranged from 0.04 to 787 f/ml depending on the kinds of work and the ventilatory conditions. Indoor sawing with electric circular saw was considered as one of the most hazardous operations.
3. A great number of construction workers are exposed to asbestos without appropriate countermeasures.
4. Of the workers handling asbestos-containing materials, 66.4% were the co-exposed to asbestos and smoking.
5. The prevalence of the respiratory subjective symptoms increased as the frequency of handling asbestos-containing materials increased.

There has been a paucity of literature dealing with the actual conditions of asbestos exposure among construction workers.

Fischbein et al. surveyed the asbestos exposure in the drywall construction trade in the United States. Of 15 industrial drywall taping and spackling compounds, they found chrysotile in nine, tremolite in one, and both in three, respectively. They showed that asbestos concentrations in the breathing zone of drywall tapers ranged 1.2-19.3 f/ml during pole sanding, 1.3-16.9 f/ml during hand sanding and 35.4-59.0 f/ml during dry mixing of taping compounds, respectively.[3]

Verma and Middleton investigated the asbestos concentrations in various operations of the drywall taping process in the province of Alberta, Canada. They showed that the asbestos concentrations in the breathing zone of workers ranged 1.2-12.4 f/ml during mixing, 1.2-24.2 f/ml during sanding and 4.0-26.5 f/ml during sweeping, respectively.[4]

Table V

Distribution of Mean Number of Days of Handling Asbestos-containing Construction Materials per Month in the Last One Year (N=1708)

day/month	Number of workers	
0<-<1	47	(2.4%)
1- 2	710	(36.6%)
3- 4	399	(20.6%)
5- 6	279	(14.4%)
7-10	314	(16.2%)
11-15	116	(6.0%)
16-30	76	(3.9%)

Table VI

Asbestos Exposure by Occupational Categories

	Number of workers	Asbestos exposure often	sometimes
carpenter	2608	15.0%	43.4%
sheet metal worker	197	5.6	32.5
plumber	220	8.2	26.8
electrician	280	7.5	27.5
plasterer	531	4.1	27.5
helper	118	5.0	21.0
interior finish worker	147	6.1	17.7
steel-frame worker	129	3.1	20.9
painter	261	3.8	19.2
cabinet maker	126	0.8	13.5
navvy	209	2.4	11.5
tiler	104	1.9	11.5
total	6500	8.9	29.1

Table VII

Relationship Between Mean Days of Handling Asbestos-Containing Materials per Month in the Last One Year and Prevalence of Respiratory Subjective Symptoms

		palpitation			shortness of breath		
day/month	number	often	sometimes	total	often	sometimes	total
0	1141	0.8%	16.5%	17.3%	2.2%	16.7%	18.9%
0<-<1	42	2.4	16.7	19.1	0	19.0	19.0
1- 2	642	2.8	19.2	22.0	3.7	19.5	23.2
3- 4	366	2.2	21.9	24.1	2.5	27.0	29.5
5- 6	254	3.5	24.0	27.5	4.7	24.0	28.7
7-10	296	3.4	24.3	27.7	5.7	24.3	30.0
11-15	108	4.6	23.1	27.7	5.6	23.1	28.7
16-30	69	7.2	31.9	39.1	8.7	30.4	39.1

		cough			sputum		
day/month	number	often	sometimes	total	often	sometimes	total
0	1141	3.3%	24.4%	27.7%	7.8%	25.6%	33.4%
0<-<1	42	2.4	31.0	33.4	4.8	38.1	42.9
1- 2	642	5.8	37.7	43.5	10.9	39.3	50.2
3- 4	366	7.4	41.5	48.9	13.4	42.1	55.5
5- 6	254	15.0	40.7	55.7	20.5	39.4	59.9
7-10	296	11.8	40.5	52.3	17.9	39.2	57.1
11-15	108	14.8	46.3	61.1	19.4	42.6	62.0
16-30	69	13.0	50.7	63.7	23.2	40.6	63.8

In Japan, no data on the asbestos exposure among workers during handling asbestos-containing boards at construction work sites has been reported in the literature. According to the present study, it was considered that the asbestos dust emission during indoor sawing with electric circular saw was larger than that of drywall taping process.

There are several reports on the health effect of asbestos exposure among the construction workers.[3,5-7] Fischbein et al. reported that pleural thickening was found in 8% of the 109 drywall tapers.[3] Hedenstierna et al. reported that 62% of the 423 construction workers who had been registered as exposed to asbestos had radiological evidence of pleural plaques in Sweden.[5] Ebihara et al. described that 1.27% of 3613 construction workers of over 40 years old had evidence of pleural plaques on chest X-ray, while none of 845 office workers had such evidence.[6] Nicholson et al. estimated that 2143 asbestos-related cancer deaths occurred in 1982 and these would rise to about 3400 annual deaths by the year 2000 among construction workers in USA.[7] The present study suggested that the prevalence of respiratory subjective symptoms elevated dose-dependently. The medical surveillance of workers who participated in the present study is now ongoing.

SUMMARY

The actual condition of asbestos exposure among construction workers were surveyed. It was made clear that workers were exposed to high concentrations of asbestos without local exhaust ventilation equipment and respiratory protective equipment. On the basis of this study, there is urgent need to work out a sufficient countermeasure minimizing asbestos exposure in construction work sites.

REFERENCES

1. According to the data of Japanese association of Asbestos. (1986).
2. *1986 Establishment Census of Japan*, Vol. 1, Results for Japan, Part 1, Division 1, pp 2-3, Statistics Bureau, Management and Coordination Agency, Tokyo (1987).
3. Fischbein, A., Rohl, A.N., Langer, A.M., Selikoff, I.J.: Drywall Construction and Asbestos Exposure. *Am. Ind. Hyg. Assoc. J.* 40:402-407 (1979).
4. Verma, D.K., Middleton, C.G.: Occupational Exposure to asbestos in the drywall taping process. *Am. Ind. Hyg. Assoc. J.* 41:264-269 (1980).
5. Hedenstierna, G., Alexanderson, R., Kolmodin-Hedman, B., Szamosi, A., Tollqvist, J.: Pleural Plaques and Lung Function in Construction Workers exposed to Asbestos. *Eur. J. Respir. Dis.* 62:111-122 (1981).
6. Ebihara, I., Kawami, S.: Pleural Plaques among Construction Workers. Presented at the 61st Annual Meeting of Japan Association of Industrial Health, held on 11-14 April, 1988, in Kanazawa, Japan.
7. Nicholson, W.J., Perkel, J., Selikoff, I.J.: Occupational Exposure to Asbestos: Population at Risk and Projected Mortality-1980-2030. *Am. J. Ind. Med.* 3:259-311 (1982).

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