Table 2. Indoor Formaldehyde Concentrations during Construction with Varying Ventilation Conditions

Variables	No. of samples	Max. (ppm)	Min. (ppm)	Med. (ppm)	Mean ± S.E. (ppm)	ANOVA	Multiple comparisons by Bonferroni t-test			
							excellent ventilation	good ventilation	moderate ventilation	fair ventilation
excellent ventilation	4	0.605	0.243	0.357	0.390 ±0.082					
good ventilation	6	0.624	0.530	0.195	0.287 ±0.104		t = 0.72			
moderate ventilation	11	0.593	0.045	0.342	0.306 ±0.045	$p < 0.05$	t = 0.88	t = -0.73		
fair ventilation	9	0.481	0.025	0.258	0.264 ±0.06		t = 1.21	t = 0.21	t = 1.25	
poor ventilation	5	1.941	0.398	1.394	1.149 ±0.308		t = -2.13	t = -4.02*	t = -5.34*	t = -5.21*

* $p < 0.05$.

ranged from < 0.10 to 2.84 ppm, with a median exposure concentration of 0.39 ppm. Concentrations exhibited an inverse relationship with the age of the construction materials. Puhakka and Karkkainen[15] also found that the age of the construction materials was an important factor affecting indoor formaldehyde concentrations. The author reported that indoor formaldehyde concentrations of new 1-to 2-year-old buildings in Helsinki exceeded the guideline value for Finland (0.12 ppm), although the chipboard used complied with the Class E1 specification. Because emission guidelines have not been established yet in Taiwan, the domestic market does not widely use low-formaldehyde-emission products. And higher levels of formaldehyde concentrations should be expected in newly decorated buildings. In one plywood formaldehyde-emission decay experiment in other research of ours, lower (only 1/10) formaldehyde concentrations were detected in imported compared to domestic products. However, because the home owners disliked being disturbed, many follow-up samples were lost and only three samples were obtained in the final sample period. Because of the small sample size, we are unable to exactly determine the severity of the indoor formaldehyde problem.

Formaldehyde concentration is closely related to ventilation; Lin and Yao[17] demonstrated a negative relationship between windows being open and formaldehyde concentrations. Puhakka and Karkkainen[15] and Salthammer[10] also indicated that the lower the air exchange rate, the higher the formaldehyde concentration. Air exchange rates were not measured in this survey, although the air velocity and types of ventilation were well documented by the sampling personnel and were ranked as excellent, good, moderate, fair, or poor. For those houses with poor ventilation during construction, the mean/median concentration was over 1 ppm, which is significantly higher than any values of the better-ventilated groups (Table 2 and Fig. 2). Formaldehyde concentrations depend to a great extent on the amount of chipboard used. In this study, we tried to estimate the amount of chipboard at each sampling site, but it was too difficult to estimate. This may partly explain the non-significant differences among different ventilation conditions except for sites with the worst ventilation.

Other factors which affect indoor formaldehyde

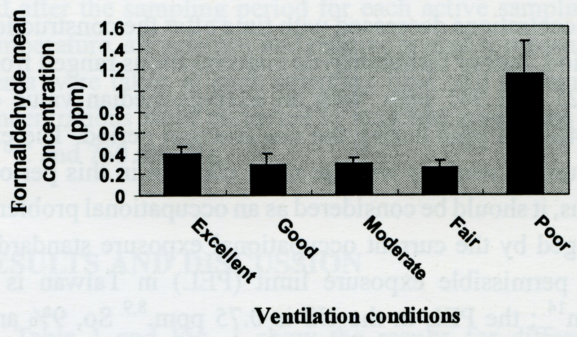

Fig. 2. Formadehyde concentration and standard error vs. ventilation conditions during construction.