FLEXURAL STRENGTH AND HARDNESS OF CLAY REINFORCED WITH NATURAL POLYMER

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Abstract

Clay-based materials reinforced with natural polymer were prepared by blending clay with an aqueous solution of natural polymer. The flexural strength in term of characteristic strength was investigated as a function of natural polymer content, aging temperature and aging time. It was found that characteristic strength of materials increased with increasing polymer content and aging temperature. Vickers hardness test was also performed in order to observe the load dependence of the hardness. The critical indentation load for the materials was 0.5 kgf and Vickers hardness number was approximately 9 – 11 MPa.

Keywords: clay-based materials, flexural strength, hardness

Introduction

Clay-based materials reinforced with polymer is an alternative eco-friendly building materials [1-2]. The appropriate polymers should have an excellent adhesion to clay particles in order to provide suitable mechanical strength. Aqueous-based polymers such as polyvinyl alcohol (PVA), polyvinyl pyrrolidone (PVP), carboxymethyl cellulose (CMC) are known to be eco-friendly polymer. However, the flexural strength of clay-based materials strengthened with the mentioned polymers showed relatively low values, i.e., 10 - 30 kgf/cm^2 [1]. In this study, natural polymer extracted from Hevea Brasiliensis was selected. The effect of natural polymer content including aging temperature and aging time on flexural strength and hardness were investigated.

Methodology

Commercially available clay consists of kaolinite, microcline and quartz was used in this study. Average particle size of clay was 4 - 8 micron. The clay suspension was prepared to a solid loading of 65 wt%. Natural polymer extracted from Hevea Brasiliensis and other additives, e.g., sulphur, zinc diethyldithiocarbamate and ZnO were then added to the suspension. The proportion of additives is available elsewhere [3]. Homogenization process was carried out by mechanical mixing prior to forming the test specimen. The test specimens were naturally dried then oven dried (aging) at 110 - 150^{o}C for 12 and 24 hours. Twenty specimens of each condition were carried out for flexural strength test using three point bending technique. Flexural strength distributions were evaluated using Weibull analysis. Vickers hardness measurements were performed using indentation loads: 0.1, 0.2, 0.5 and 1 kgf with dwell times of 15 seconds. Data from 10 measurements were collected.

Results, Discussion and Conclusion

The results for the effect of natural polymer on strength distribution are shown in figure.1 - 3. In case of specimens aging at 110°C with holding time for 12 hours (Fig.1), the characteristic strength of a clay specimens was 34 kgf/cm^2, whereas the characteristic strength of specimens containing natural polymer of 3, 5, 7 and 9 wt% were 80, 159, 163 and 76 kgf/cm^2, respectively. Specimens with high amount of natural polymer obviously show poor strength distribution as presented by a low Weibull modulus (m). This result is possibly due to poor dispersion of natural polymer phase in clay suspension during the homogenizing process. Case of specimen aging at 150°C with holding time for 12 hours (Fig.2), the characteristic strength has increased to the values of 134, 171, 213 and 259 kgf/cm^2. At the holding time of 24 hours (Fig.3), the characteristic strength has reduced to 121, 151, 195 and 235 kgf/cm^2 for specimen containing natural polymer of 3, 5, 7 and 9 wt%, respectively. The deterioration of the characteristic strength is attributed to the degradation of natural polymer. However, it is obvious that the characteristic strength increases with an increase amount of natural polymer and aging temperature.

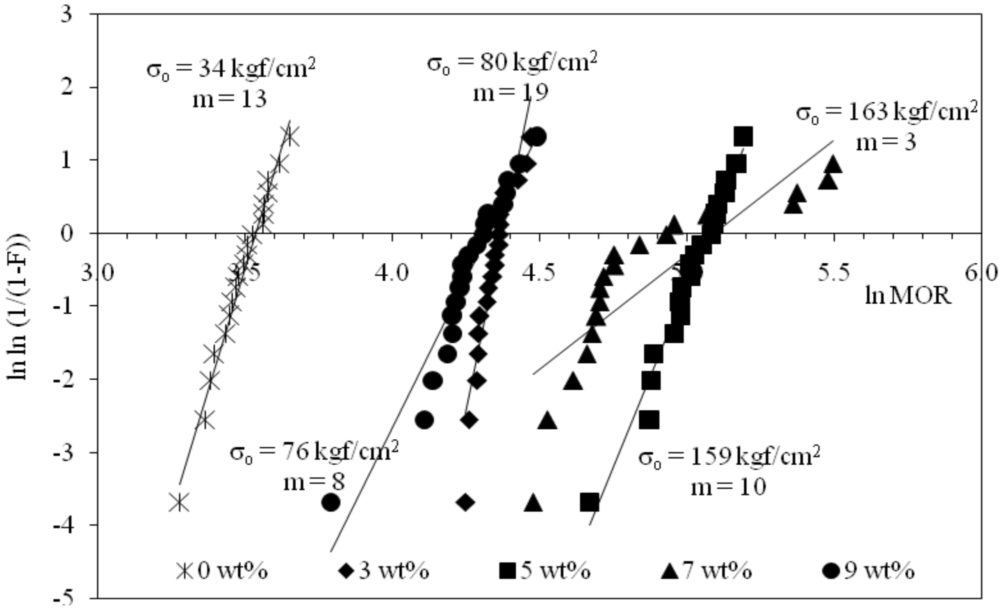

Figure 1 Weibull plots of materials with five different proportion of natural polymer. (110°C - 12 hours)

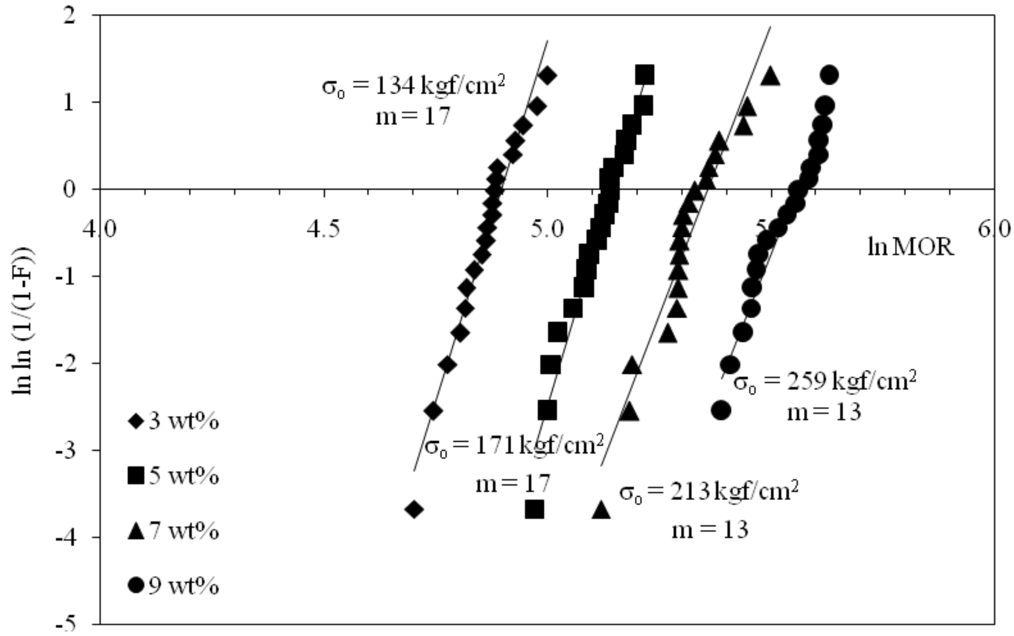

Figure 2 Weibull plots of materials with four different proportion of natural polymer. (150^{o}C - 12 hours)

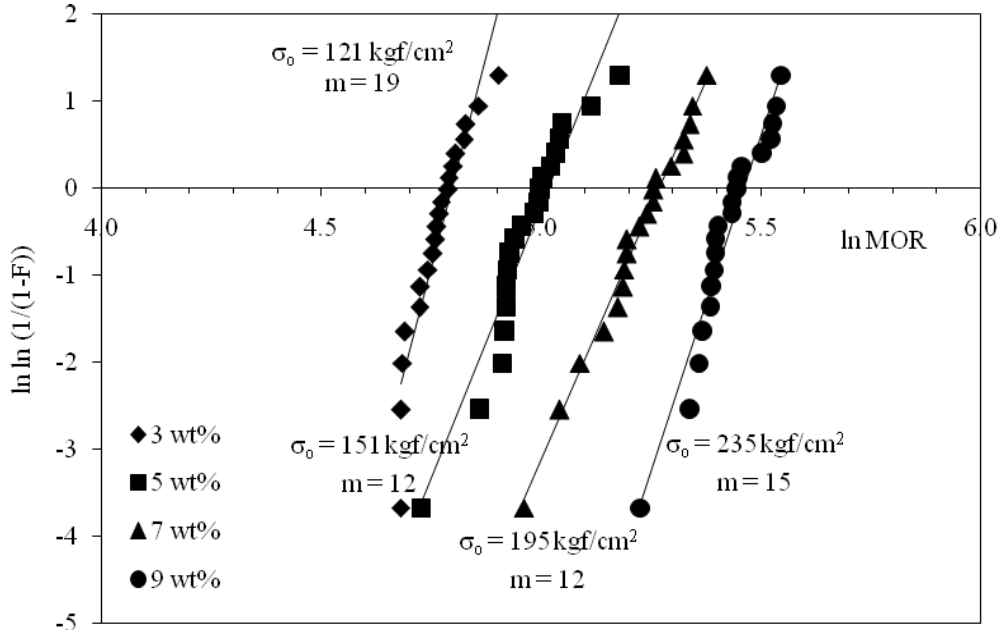

Figure 3 Weibull plots of materials with four different proportion of natural polymer. (150^{o}C - 24 hours)

Vickers hardness test was performed on the specimen that containing natural polymer of 9 wt% and aging at 150^{o}C with holding time for 12 hours. The apparent hardness, HV was calculated using the formula, $HV = 1.8544\,P/d^2$, where P is the applied load (kgf) and d is the average length of the two diagonals of the indentation (mm). The variation of hardness number with indentation load has been observed (Fig.4). Optical photographs of Vickers indentation with load were compared in Fig.5.

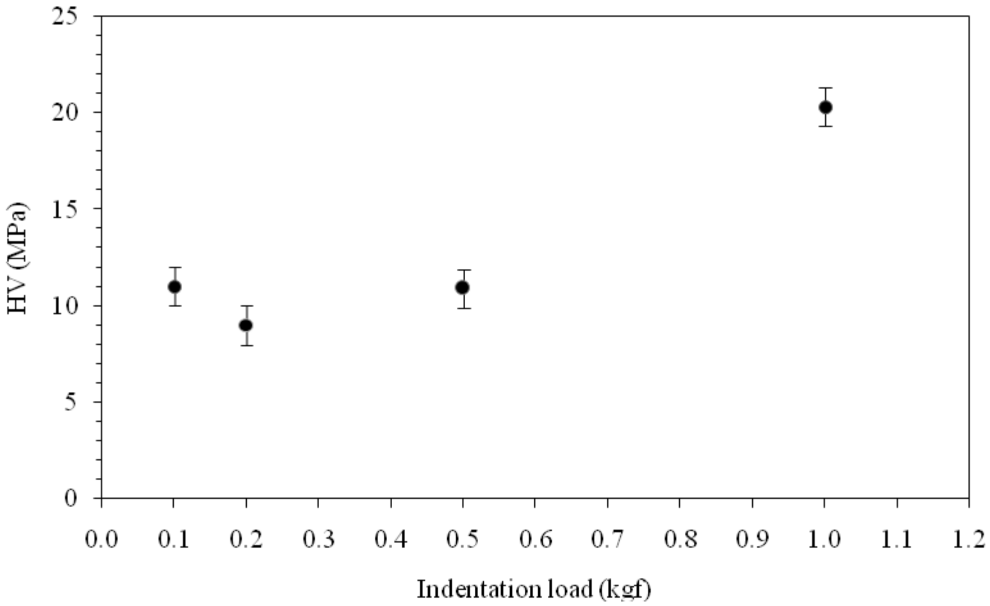

Figure 4 Vickers hardness as a function of indentation load

For the load of 0.1, 0.2 and 0.5 kgf, the hardness number was in the range of 9 – 11 MPa. At a 1 kgf load, however, the hardness number suddenly increased to 20 MPa. This indicated that the critical indentation load was 0.5 kgf. Moreover, the hardness of the specimens used in this study increases with the increasing test load, while others [4-6] has reported the tendency of hardness of materials decreases with the increasing test load. So, it should be studied over a relatively wider range of the applied load in order to obtain a complete understanding of the phenomenon.

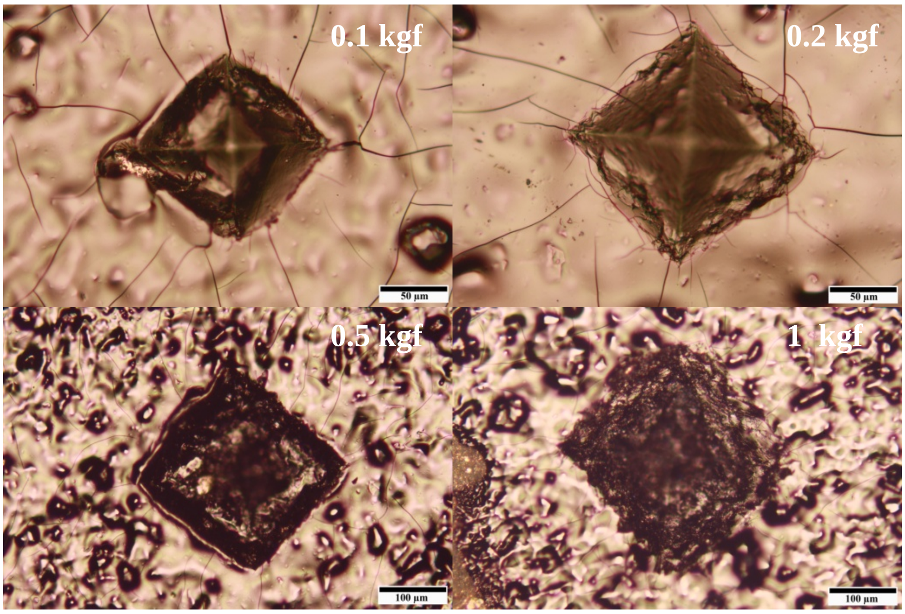

Figure 5 Vickers indentation at difference loads (0.1, 0.2, 0.5 and 1 kgf)

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