

The Crack Propagation Mechanism In Layered Materials

M. R. V. Sereshk¹, L. Bratasz¹, H. Rushmeier¹

¹Yale University, New Haven, CT, USA

Abstract

In this paper, vertical and delamination crack propagation is studied in practical case of panel painting as the representative of layered materials. Panel paintings frequently exhibit pronounced craquelure pattern generated by drying of the paint, mechanical impacts and environmental variations. Relative humidity (RH) variations are main cause of the mechanical damage to works of art. The environmental standards were determined by mechanical research using new or artificially aged materials, and crack initiation in uncracked, virgin paint layer served as a selection criterion. However, mechanism of mechanical damage development in historic works of art with their accumulated damages and long environmental history can only be partially understood studying undamaged mockups.

Presented paper analyzes process of cracks saturation fundamental to understand why panel paintings survived remarkably well several centuries in uncontrolled environment of historic houses or places of worship. The process of cracks saturation was analyzed using simulation with COMSOL software. Critical separation between vertical cracks was determined and compared with patterns observed in real paintings. In addition, generation and propagation of horizontal interlaminar cracks was studied to understand the effect of their propagation on saturation distance of vertical cracks as well as load carrying ability of paint layer. The contributing modes of crack propagation and their significance are also discussed for these two types of cracks. The result demonstrates that opening and shearing fracture modes both contribute in delamination of layers with similar magnitude. The impact of crack saturation on allowable range of relative humidity variation is also discussed.