Influence of environmental service conditions in Portugal on structural timber bonded connections

João Custódio
PhD, Departamento de Materiais,
Laboratório Nacional de Engenharia Civil
(Lisboa, Portugal)
jcustodio@lnec.pt

Helena Cruz
PhD, Departamento de Estruturas,
Laboratório Nacional de Engenharia Civil
(Lisboa, Portugal)
helenacruz@lnec.pt

Pedro Palma
MSc, Departamento de Estruturas,
Laboratório Nacional de Engenharia Civil
(Lisboa, Portugal)
ppalma@lnec.pt

Keywords – Timber structures, bonded connections, adhesives, environmental exposure, durability.

ABSTRACT

A set of experiments was conducted to investigate how effective the insulating properties of timber were against excessive heating of a bonded connection located inside a structural element. The exterior and interior environmental conditions were monitored in several buildings (new glulam structures, historic timber roof trusses, common timber roof structures), with different uses (swimming pools, shopping centres, theatres, residential) and in different Portuguese climatic regions. These measurements were then used in a numerical model to predict the temperatures reached at several depths of timber members, in order to evaluate the temperatures that bond-lines are exposed to. This was then complemented with mechanical tests at high temperatures of fifteen adhesives frequently used, mostly in association with steel or composite rods, in the repair and strengthening of timber structures. It was found that bonded-in rod connections may be exposed, in service conditions, to ambient air temperature up to 50 ºC and to relative humidity up to 80 % for long periods. The service temperature to which timber elements were exposed dictated the temperature reached at the bond-line placed well inside the bonded element, despite the insulation provided by the timber cover, which delayed and damped the ambient conditions. The results showed that the polyurethane (PUR) and epoxy (EP) adhesives tested display significantly different viscoelastic responses over the temperature ranges normally reached in the summer. All adhesives showed a pronounced decrease in their strength and stiffness for temperatures in the range of the expected maximum service temperatures. Both EP and PUR adhesives had formulations which performed quite well at lower temperatures, however, the polyurethane tended to give lower stiffnesses at standard temperature (20 ºC) than the best epoxies, but enough to match and even exceed their performance at higher temperatures.

1. Introduction

Structural adhesives have been used for several years in the repair and strengthening of timber structures, mostly with steel or composite (fibre reinforced polymer) rods. However, the use of these strengthening systems is still frequently limited by the lack of information related with their performance under high service temperatures.

Today's prevailing belief is that whenever the bond-lines in a structural bonded connection are hidden inside the timber element, they experience considerably lower temperatures compared to