Bending Strength of Timber Beams Rehabilitated with Reinforced Epoxy Mortar Plates

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Abstract: The need for restoration of the built heritage increases the demand for new strengthening and rehabilitation techniques of structures. This paper discusses a rehabilitation system for timber beams, consisting of the replacement of the decayed parts by new ones of nearly the same material, connected to the sound parts by reinforced epoxy mortar plates. The use of this technique allows for lighter and less intrusive works, compatible with the normal building occupation during the rehabilitation process. The experimental analysis undertaken focused on the flexural bonding behavior with stainless steel, reinforcement steel, and glass fiber reinforced plastic bars being used as alternatives. A simple analytical model, based on the usual assumptions of the bending theory, is proposed, leading to a reasonable agreement with the experimental results. In spite of a reduction of strength when compared to the original elements, the safety level of the rehabilitated elements is high enough to comply with the Eurocode 5 requirements and is, therefore, suitable for actual works.

DOI: 10.1061/(ASCE)0733-9445(2008)134:5(792)

CE Database subject headings: Rehabilitation; Reinforcement; Epoxy resins; Steel; Glass reinforced plastics; Bending; Beams; Plates.

Introduction

Until the middle of the 20th century, structural building systems often included timber floors and roofs, generally supported by walls, arches, vaults, or columns made of stone or ceramic masonry. Many rehabilitation works in old buildings use inappropriate techniques, which require indiscriminate removal of the whole or part of the timber structure and its replacement by reinforced concrete structures, not suitable to the building original conception and "spirit." This procedure affects the global building behavior, being especially harmful in the case of recovery of historical heritage construction.

The retrofitting and recovery needs of the built heritage demand the development of structural strengthening and reinforcement techniques. The scientific work aimed at timber structures in this domain is scarce, and further developments are thus needed, especially if such improvements lead to less intrusive and less visible works.

This paper presents a rehabilitation technique for the recovery of timber structural elements. The system consists of the removal of the decayed timber parts and its replacement by new segments of the same material, connected to the sound original parts by reinforced epoxy mortar plates. Different reinforcement materials were tested, namely, hot rolled steel A400NR (S275 to EN10025) ribbed rebars, stainless steel threaded rods, and glass fiber reinforced plastic (GFRP) rods.

The proposed technique is moderately intrusive and is especially suited to the rehabilitation of timber structures affected by decay or other biological agents such as termites. This problem is frequent in ancient buildings and occurs mainly in the beam ends, whereas the inner part of the element remains in good conservation condition. The application of this technique can be done in a number of ways, all sharing some basic procedures (Freas 1982). However, there is not yet a generally accepted knowledge about it. Calculation methods are still limited and the design is often based on rules of thumb or is not even done (Gemert and Bosch 1987). The research work described in this paper was thus focused on issues concerning the experimental behavior and the analytical procedure for the design of bending splices made up of reinforced epoxy plates. A procedure for the reinforcement design is proposed and its forecast for the ultimate load is compared to that determined by tests. The constitutive laws for the different materials were established from tests described later on in this paper. The adhesion between the timber and the epoxy resin was also investigated, given the importance of this issue for the reliability of the system.

This study has an exploratory nature, aiming to investigate the feasibility of this rehabilitation system. The general conclusions and results will be used as guidelines for a more comprehensive test program to be started soon.

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Note. Associate Editor: Rakesh Gupta. Discussion open until October 1, 2008. Separate discussions must be submitted for individual papers. To extend the closing date by one month, a written request must be filed with the ASCE Managing Editor. The manuscript for this paper was submitted for review and possible publication on February 6, 2007; approved on October 8, 2007. This paper is part of the ***Journal of Structural Engineering***, Vol. 134, No. 5, May 1, 2008. ©ASCE, ISSN 0733-9445/2008/5-792–800/$25.00.