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TechNote

Fire Resistance of FRP-Strengthened Concrete Members—TechNote

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Introduction

The use of fiber-reinforced polymer (FRP) materials to strengthen concrete members is an accepted technology. In many applications, performance of FRP-strengthened members during exposure to fire remains a significant concern to design professionals, building officials, and owners. The objective of this TechNote is to provide a brief overview of key concepts, code provisions, and industry guidelines relating to the structural performance of FRP-strengthened members during a fire event.

Research findings regarding the performance of FRP-strengthened members during exposure to fire have been published by Williams et al. (2008). However, design examples and guidance regarding the performance of externally bonded FRP during exposure to fire are not widely available. In addition, differences in the design approaches and load combinations used by the steel and concrete industries, combined with the relatively recent emergence of FRP fire protection systems, have created challenges for practicing engineers tasked with assessing the structural fire resistance of FRP-strengthened members.

Questions

Under what circumstances does an FRP-strengthened member need to be protected from the detrimental effects of fire? If protection is warranted, what fire protection options are available?

Answers

The need for FRP-strengthened members to be protected from fire depends on project-specific factors, including building code requirements, structural parameters, member type, fire risk, fire severity, and method of evaluation. The design professional should evaluate these factors to determine if an unprotected member possesses sufficient strength during (and potentially after) the fire event to resist anticipated demands. Calculations can be performed based on material properties that have been adjusted to account for the detrimental effects of fire while using appropriate load and strength-reduction factors. If the analysis determines that the unprotected member does not possess sufficient strength, then fire protection may be required to enhance performance of the strengthened member. Options include mortars, coatings, boards, or other materials that have been specifically tested for use with the FRP system. As discussed in this TechNote, these insulating materials protect the embedded reinforcing steel and concrete, rather than the FRP system.

Discussion

Building codes establish minimum requirements for structures to resist detrimental effects of a standard fire as defined by test standards such as ASTM E119, UL 263, and ISO 834. In the United States, the code applicable to new construction is typically the International Building Code (IBC). The IBC sets forth required fire-resistance ratings (referred to hereinafter as fire rating) in terms of duration based on occupancy, size, separation, construction materials, and other factors. The required fire rating usually ranges from 1 to 3 hours. Certain low-fire-risk buildings, such as open parking garages sufficiently separated from adjacent occupancies, may not require a fire rating depending on size, construction material, and other factors.

For new construction, the fire rating is typically determined by an architect. Many FRP-strengthening projects do not include an architect on the design team, and even when they do, the architect may have little experience with FRP. In these instances, the building official and architect may require evidence from the structural engineer that the FRP-strengthening complies with fire resistance provisions of the code. If the structural engineer does not possess fundamental knowledge of fire protection concepts or is unfamiliar with interpreting code provisions related to fire, then assistance from an experienced fire protection design professional should be obtained.