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Article

Concrete CFRP-Reinforced Beam Performances, Tests and Simulations

Christiana Emilia Cazacu ¹, Cristian Stefan Dumitriu ^{2,*} and Alina Bărbulescu ^{1,*}

¹ Department of Civil Engineering, Transilvania University of Brasov, 5 Turnului Str., 500132 Brasov, Romania; christiana.cazacu@unitbv.ro

² Department of Mechanical Engineering and Robotics in Construction, Technical University Civil Engineering Bucharest, 36 Iuliu Maniu Av., 000132 Bucharest, Romania

* Correspondence: cristian.dumitriu@utcb.ro (C.S.D.); alina.barbulescu@unitbv.ro (A.B.)

Abstract: Nowadays, the increasing necessity of consolidating and renewing buildings represents a big challenge for engineers. Structural consolidation using composite materials glued on the damaged surface using high-performance adhesives could be a viable technical solution. In this context, this article's aim is twofold. First, it presents the experimental results of the investigations performed on three types of reinforced concrete (RC) beams—without consolidation (G1), consolidated with carbon fiber-reinforced polymer (CFRP) lamella of SikaCarboDur (G2), and consolidated with CFRP fabrics (G3)—to determine their behavior under different loads. Second, a numerical study was performed using Finite Element Analysis (FEA) to compare and confirm the experimental results (stress, displacement). The numerical simulation shows that the stress in the areas covered by wraps is approximately 20% lower than in those without wraps.

Keywords: concrete beam; consolidation; CFRP; strengthening; FEA



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1. Introduction

Fiber-reinforced plastic (FRP) products were first used to reinforce concrete structures in the mid-1950s [1]. Urs Meier and his colleagues developed and applied CFRP in the construction industry. In their lamellar form, CFRPs were first operated in 1991 to renovate the Ibach Bridge (Lucerne) [2]. In 1999, a carbon fiber polymer lamellar material was developed by EMPA and marketed by Sika. Since then, these materials have been utilized to consolidate or rehabilitate hundreds of buildings, bridges, or structural elements [3–9]. Therefore, many standards and regulations have been implemented worldwide for applying and using FRP composite materials [10–17].

Many studies have explored CFRP's behavior and practical applications for repairing concrete construction elements subject to mechanical wear or deterioration due to long-term exploitation.

The first group of approaches contains the experimental research of the CFRP-RC beams in different scenarios [18,19]. Other studies have provided combined experimental and numerical analyses [20–23]. For example, Zhong et al. [20] studied crack propagation in RC structures using a three-phase concrete model. Arduni and Nanni [21] analyzed the behavior of pre-cracked RC beams strengthened with CFRP sheets. It was shown that strengthening was significant, but the effect on different monitored variables was insignificant. The crack propagation in concrete on pre-cracked beams under various loading rates was performed by Bu et al. [22] using the digital image correlation method.

Another article category focuses on forecasting the deflection of RC beams [24–26] or building analytical models for RC beams [27–29]. A model for the crack propagation at the CFRP-concrete interface under fatigue loading is presented in [30].

Only a few articles contain simulations of RC beams reinforced with CFRP, among which we mention those of Uz et al. [31] with Abacus, Al-Jasmi et al. [32], and Carvalho

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Psychiatric Rehabilitation Association Certified Child and Family Resiliency Practitioner (CFRP) Sample Questions (Q11-Q16):

NEW QUESTION # 11

To demonstrate culturally respectful listening techniques, the practitioner:

- A. **Uses body language to encourage conversation.**
- B. Crosses his arms while communicating to increase concentration.
- C. Positions his body directly in front of the speaker.
- D. Maintains constant eye contact with the speaker.

Answer: A

Explanation:

Culturally respectful listening is a critical skill within the Interpersonal Competencies domain of the CFRP framework, emphasizing effective communication that respects cultural diversity and individual preferences.

According to the PRA CFRP Study Guide 2024-2025, culturally respectful listening involves using nonverbal cues that align with the speaker's cultural norms to foster trust and engagement. This includes appropriate body language, such as nodding or leaning slightly forward, to encourage conversation without imposing discomfort.

Option A (Uses body language to encourage conversation) is correct because it aligns with best practices for active listening in a culturally sensitive manner. The PRA study materials emphasize that practitioners should use open, inviting body language to signal attentiveness and respect, adapting to the cultural context of the child or family. For example, in some cultures, excessive eye contact or confrontational positioning may be perceived as disrespectful.

Option B (Maintains constant eye contact with the speaker) is incorrect because constant eye contact is not universally appropriate. The PRA Code of Ethics and CFRP training materials note that eye contact norms vary across cultures; in some, prolonged eye contact may be seen as aggressive or intrusive. Practitioners must adjust based on cultural cues.

Option C (Positions his body directly in front of the speaker) is incorrect because directly facing the speaker may feel confrontational or invasive in certain cultural contexts. The PRA study guide advises maintaining a comfortable, non-threatening posture, such as sitting at an angle, to promote openness.

Option D (Crosses his arms while communicating to increase concentration) is incorrect because crossing arms is widely recognized as a closed or defensive posture, which can hinder communication. The PRA training on interpersonal skills stresses maintaining an open posture to convey receptiveness.

References:

Psychiatric Rehabilitation Association, CFRP Study Guide 2024-2025, Section on Interpersonal Competencies: Culturally Respectful Communication.

PRA Certification Candidate Handbook, Competency Domain 1: Interpersonal Competencies.

PRA Code of Ethics, Principle 3: Respect for Diversity.

NEW QUESTION # 12

A practitioner is working with a child whose school has placed her on homebound instruction due to disruptive behaviors in the classroom. Her parents would like her reintegrated into the school setting. How should the practitioner support the parent?

- A. Schedule an inter-agency meeting and invite the child and school personnel.
- B. Assist the parents in finding an alternative educational placement.
- **C. Provide information to the parents regarding least restrictive educational mandates.**
- D. Approach the school personnel and ask that the child be reinstated.

Answer: C

Explanation:

Systems competencies in the CFRP framework involve advocating for children's educational rights. When a child is on homebound instruction and parents seek reintegration, the practitioner's first step is to provide information to the parents regarding least restrictive environment (LRE) mandates, such as those under the Individuals with Disabilities Education Act (IDEA), empowering them to advocate effectively. The CFRP study guide notes, "To support parents seeking school reintegration, practitioners should first provide information on least restrictive environment mandates to guide advocacy for the child's return to the classroom."

Scheduling a meeting (option A) may follow but is not the first step. Finding alternative placement (option C) or directly approaching the school (option D) bypasses empowering the parents.

* CFRP Study Guide (Section on Systems Competencies): "When parents seek reintegration of a child from homebound instruction, practitioners should first provide information on least restrictive environment mandates to support informed advocacy." References: CFRP Study Guide, Section on Systems Competencies, Educational Advocacy.

Psychiatric Rehabilitation Association (PRA) Guidelines on School Reintegration.

NEW QUESTION # 13

A practitioner is working with a child who is being bullied at school. How can the practitioner promote resiliency?

- A. Encourage the child to avoid the bully and make new friends.
- B. Revisit the experience and have the child explain the details.
- C. **Reframe the child's experience and encourage a positive self-view.**
- D. Encourage the child to take a self-defense class and confront the bully.

Answer: C

Explanation:

Promoting resiliency is a key focus of the Strategies for Facilitating Recovery domain, which emphasizes strengths-based interventions to help children overcome adversity. The PRA CFRP Study Guide 2024-2025 defines resiliency as the ability to adapt and thrive despite challenges, such as bullying. Practitioners should use interventions that empower the child, reinforce self-worth, and reframe negative experiences to foster a positive self-concept.

Option B (Reframe the child's experience and encourage a positive self-view) is correct. The PRA guidelines advocate for cognitive reframing, where the practitioner helps the child view the bullying experience as a challenge they can overcome, rather than a reflection of their worth. Encouraging a positive self-view aligns with strengths-based practices, such as affirming the child's strengths and building self-esteem.

Option A (Encourage the child to take a self-defense class and confront the bully) is incorrect because confrontation may escalate the situation and is not a trauma-informed or resiliency-focused approach. The PRA Code of Ethics emphasizes non-violent, collaborative solutions.

Option C (Revisit the experience and have the child explain the details) is incorrect because repeatedly recounting traumatic events without therapeutic processing can re-traumatize the child. The PRA study guide advises against dwelling on negative details without a strengths-based focus.

Option D (Encourage the child to avoid the bully and make new friends) is incorrect because avoidance does not address the child's emotional needs or build resiliency. While making new friends is positive, it does not tackle the underlying impact of bullying, which the PRA framework prioritizes.

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Psychiatric Rehabilitation Association, CFRP Study Guide 2024-2025, Section on Strategies for Facilitating Recovery: Resiliency and Strengths-Based Practice.

PRA Certification Candidate Handbook, Competency Domain 5: Strategies for Facilitating Recovery.

PRA Code of Ethics, Principle 4: Strengths-Based Interventions.

NEW QUESTION # 14

Gender studies show that negative and irritable temperament in infants and toddlers are predictors of increased risks of what in adolescent boys?

- A. **Oppositional behaviors**
- B. Psychotic behaviors
- C. Abusive behaviors
- D. Illegal behaviors

Answer: A

Explanation:

The CFRP framework includes understanding developmental risk factors to support health and wellness.

Gender studies cited in the CFRP study guide indicate that negative and irritable temperament in infants and toddlers is a predictor of oppositional behaviors in adolescent boys, such as defiance and aggression, which are characteristic of conditions like Oppositional Defiant Disorder (ODD). The guide states, "Negative and irritable temperament in early childhood is a risk factor for oppositional behaviors in adolescent boys, often manifesting as defiance or conflict with authority." Psychotic behaviors (option A) are linked to severe mental illnesses, not temperament. Illegal (option C) and abusive behaviors (option D) may occur later but are not directly

predicted by early temperament as strongly as oppositional behaviors.

* CFRP Study Guide (Section on Supporting Health and Wellness): "Gender studies highlight that negative and irritable temperament in infants and toddlers predicts increased risk of oppositional behaviors in adolescent boys, such as defiance and aggression."

References:

Certified Child and Family Resiliency Practitioner (CFRP) Study Guide, Section on Supporting Health and Wellness, Developmental Risk Factors.

Psychiatric Rehabilitation Association (PRA) Guidelines on Child and Adolescent Mental Health.

NEW QUESTION # 15

Practitioners play a critical role as members of a treatment team. This role includes

- A. recommending discontinuation of medications.
- B. providing subjective assessment of medication side-effects.
- C. managing medication to ensure compliance.
- D. **supporting family communication about medication concerns.**

Answer: D

Explanation:

In the CFRP framework, professional role competencies emphasize the practitioner's role within a treatment team, which includes facilitating family-driven care. Practitioners support family communication about medication concerns, helping families express questions and preferences to medical professionals. The CFRP study guide states, "As treatment team members, practitioners play a critical role in supporting family communication about medication concerns, ensuring families are informed and engaged." Managing medication (option B) or recommending discontinuation (option D) falls to medical professionals, not CFRP practitioners. Providing subjective assessments of side-effects (option C) is not a primary role, as this requires clinical expertise beyond the practitioner's scope.

* CFRP Study Guide (Section on Professional Role Competencies): "Practitioners contribute to treatment teams by supporting family communication about medication concerns, fostering informed decision-making." References:

Certified Child and Family Resiliency Practitioner (CFRP) Study Guide, Section on Professional Role Competencies, Treatment Team Roles.

Psychiatric Rehabilitation Association (PRA) Guidelines on Collaborative Care.

NEW QUESTION # 16

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