



Failure and impact behavior of facade panels made of glass fiber reinforced cement(GRC)

A. Enfedaque ^{a,*}, D. Cendón ^b, F. Gálvez ^b, V. Sánchez-Gálvez ^b

^a Departamento de Ingeniería Civil: Construcción, ETSI Caminos, Canales y Puertos, Universidad Politécnica de Madrid, 28040 Madrid, Spain.

^b Departamento de Ciencia de materiales, Universidad Politécnica de Madrid, Spain

ARTICLE INFO

Article history:

Received 14 July 2010

Received in revised form 12 January 2011

Accepted 14 January 2011

Available online 25 January 2011

Keywords:

GRC

Impact behavior

Gas gun

Numerical simulation

ABSTRACT

GRC is a cementitious composite material made up of a cement mortar matrix and chopped glass fibers. Due to its outstanding mechanical properties, GRC has been widely used to produce cladding panels and some civil engineering elements. Impact failure of cladding panels made of GRC may occur during production if some tool falls onto the panel, due to stone or other objects impacting at low velocities or caused by debris projected after a blast. Impact failure of a front panel of a building may have not only an important economic value but also human lives may be at risk if broken pieces of the panel fall from the building to the pavement. Therefore, knowing GRC impact strength is necessary to prevent economic costs and putting human lives at risk.

One-stage light gas gun is an impact test machine capable of testing different materials subjected to impact loads. An experimental program was carried out, testing GRC samples of five different formulations, commonly used in building industry. Steel spheres were shot at different velocities on square GRC samples. The residual velocity of the projectiles was obtained both using a high speed camera with multiframe exposure and measuring the projectile's penetration depth in molding clay blocks. Tests were performed on young and artificially aged GRC samples to compare GRC's behavior when subjected to high strain rates. Numerical simulations using a hydrocode were made to analyze which parameters are most important during an impact event.

GRC impact strength was obtained from test results. Also, GRC's embrittlement, caused by GRC aging, has no influence on GRC impact behavior due to the small size of the projectile. Also, glass fibers used in GRC production only maintain GRC panels' integrity but have no influence on GRC's impact strength. Numerical models have reproduced accurately impact tests.

© 2011 Elsevier Ltd. All rights reserved.

1. Introduction

Glass fiber reinforced cement (GRC) is a composite material produced by mixing cement mortar and AR (Alkali Resistant) glass fibers. Cement mortar has good compressive strength, although it is a brittle material with very low tensile strength and ductility. Glass fibers enhance cement mortar's mechanical properties by improving its toughness and its flexural and tensile strength without decreasing its compressive strength [1].

Due to its excellent mechanical properties, fire resistance, easy moldability and high corrosion resistance GRC is a highly competitive material in applications such as permanent formwork, pipes, refurbishment of buildings, sewer liners, tunnel cladding, river bank protection and acoustic barriers [2,3]. More recently it has been proposed as a candidate for producing

* Corresponding author. Tel.: +34 91 336 6722; fax: +34 91 336 6680.

E-mail address: alejandro.enfedaque@upm.es (A. Enfedaque).