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Flexure behavior of a hybrid reinforced concrete beam. Strain correlation between mechanical gauges and optical measurement

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Abstract

Civil engineering is a professional engineering field that deals with the design, construction, and maintenance of the physical and naturally built environment. There are several disciplines that can apply in civil engineering like mathematics and physics. Failure in flexure will occur when the bending moment is sufficient to induce tensile stresses greater than the yield stress of the material throughout the entire cross-section. In structural analysis, this bending failure is called a plastic hinge, since the full load carrying ability of the structural element is not reached until the full cross-section is past the yield stress. In order to prevent the failure of a reinforced concrete element at bending moment it is important to know the maximum bending moment capable to sustain the force being placed. Experimental methods are used specifically for elements with irregular form. Therefore obtaining the bending moment resistance, for a hybrid beam, by experimental methods is a more accurate method.

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Keywords: flexure behavior; hybrid beam; high strength concrete; digital image correlation; mechanical gauges.

1. Introduction

High-strength concrete is typically used for high-rise structures. It has been used in components such as beams, columns (especially on lower floors where the loads will be greatest), shear walls, and foundations. High strength concrete is also occasionally used in bridge applications as well.

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An important fact of this type concrete represents the costs, which are very high. Normal concrete stations are reluctant to provide high strength concrete. There mix of the high strength concrete cannot always be achieved routinely using conventional constituents like for normal Concrete. It can be only found at specialized concrete stations. This is a reason why studies are made to reduce the amount of high strength concrete in structural elements required to sustain high loads.

Nomenclature

HSC	high strength concrete
DIC	digital image correlation
MG	mechanical gauges
ε	strain measured in the experimental methods ($^{o}/_{oo}$)
b	width of beam cross-section (mm)
h	height of beam cross-section (mm)
L	beam length (mm)
f_{cm}	mean value of experimental concrete cylinder compressive strength (MPa)
f_{yk}	characteristic yield strength of reinforcement (MPa)
E_{cm}	secant modulus of elasticity of concrete (MPa)

1.1. Theoretical background

Concrete is defined as “High Strength Concrete” (H.S.C) on the basis of its compressive strength measured at a given age. High-strength concrete is required in engineering projects that have concrete components that must resist at high compressive loads [1].

A bending moment is the reaction induced in a structural element when an external force or moment is applied to the element causing the element to bend. The most common or simplest structural element subjected to bending moments is the beam [2].

Strain measurements are very important in mechanical sciences. A strain in any material can be defined as the coefficient of the change in length and the initial length. Strains are involved in many important material properties and parameters (i.e. Stress-Strain Curve, Young, Poisson, Ratio, etc.). Recently, new and more complex investigations are requiring strain measurements at any point inside an area of interest to improve the study of the behavior of materials and structural components [3].

1.2. Purpose of the paper

The current paper studies the correlation of two different measurement systems for a reinforced concrete beam, subjected to flexure, which are based on mathematics and physics. This paper presents an overview of the research on flexural behavior of a two layer high strength reinforced concrete beam compared with a single layer high strength reinforced concrete beam.

2. Materials and methods

2.1. Materials

2.1.1. Concrete

The concrete classes are C80/95 and C110/115, tested on cubes of 150 mm, with a mean compressive strength f_{cm}=92.55MPa and 115.48MPa. [1] The secant elasticity modulus was also determined at date of testing, E_{cm}=38299MPa and 46277MPa. [1] The two concrete compositions are detailed in Table 1.