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NSM Rebar and CFRP laminate strengthening for RC columns subjected to cyclic loading

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HIGHLIGHTS

- An experimental program is achieved to investigate the benefit gained from strengthening cracked RC columns for seismic loads.
- The two strengthening techniques used are NSM rebar and CFRP laminates.
- Deflection response curve, yield and ultimate load capacities, dissipated energy, initial stiffness degradation, and ductility ratio are denoted and examined for each test column specimen.
- Visualized Crack patterns and fracture modes are enhanced for the strengthened columns.

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ABSTRACT

An experimental program is achieved in this study conducted of three reinforced concrete column-stub specimens tested under increased cyclic lateral load to show the enhancement gained from using two well-known external strengthening techniques, which are NSM rebar and CFRP laminate, applied to partially cracked columns. Test data indicates that both of these strengthening techniques are efficient to enhance the overall behavior of the retrofitted columns like crack pattern, yield and ultimate cyclic load capacities, ductility ratio, dissipated energy capacity, initial stiffness degradation, and fracture mode. Strengthening Using CFRP laminates showed better enhancement in crack formation and propagation, while using MSN rebar showed better enhancement in load capacities, ductility ratio, and dissipated energy. Therefore, using NSM rebar may be a better choice for retrofitting and strengthening such cracked reinforced concrete columns that may be subjected to seismic event conditions.

1. Introduction

A large number of existing reinforced concrete buildings and bridges are built prior to or not designed in accordance with modern seismic design codes and may have suffered severe damage or complete collapse during earthquake due to inadequate shear strength, flexural strength, and ductility of old columns [1]. These old columns are vulnerable during extreme cyclic loading and need to be retrofitted and strengthened to meet the modern codes and standards [2]. Concrete and steel jacketing was the columns' most popular traditional retrofitting technique for decades [3,4]. This method was time consuming and labor intensive, and was increasing the cross-sectional area of the structural column members [5].

In addition to jacketing, the steel reinforcement can be inserted into grooves cut through the reinforced concrete columns in an application called generally "Near Surface Mounting" (NSM) [6], which was developed in Europe in early 1940's [7]. In 1948, a reinforced concrete bridge deck in Sweden needed to be upgraded in its negative moment region by inserting steel reinforcement bars in grooves made in the concrete surface and filling it with cement mortar [8]. Employing externally steel plates to reinforced concrete structures also was a conventional technique to improve flexural performance [9], and shear resistance [10]. In particular, fasteners have been proven to be useful for enhancing the ductility of these structures [11], but steel plates are heavy and need many anchor bolts for attachment, and require a steady maintenance to prevent corrosion. This has led to a reduction in use of this technique at recent years. Since the 1990's, Fiber Reinforced Polymers (FRP) have replaced steel plates as the preferred method of external bonded reinforcement for several reasons; easy to handle, high

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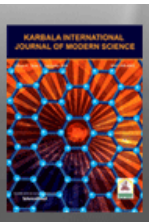

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Design of Reinforced Concrete Deep Beams using Particle Swarm Optimization Technique

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DESIGN REQUIREMENTS FOR THE FIREFIGHTING WATER AMOUNT NEEDED IN INDUSTRIAL BUILDINGS AND THEIR RELATIONSHIP TO GEOGRAPHIC INFORMATION SYSTEMS: A REVIEW PAPER

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Abstract

Industrial fires are the most costly compared to other fires. Water is the most common fire extinguishing agent because it has a set of physical and chemical properties that make it a very effective means of extinguishing, as it is applied either manually or automatically. The theoretical amounts of water needed for actual extinguishing are very low when calculated and provided in an effective manner. Therefore, it was necessary to propose several numerical models to estimate the amount of water that must be available in these buildings to extinguish fires if they occur or until support arrives from fire departments to complete the extinguishing process with the least possible loss of life and property that occurs in burning industrial buildings and nearby buildings that are exposed to fire. This research seeks to determine the relationship between firefighting water requirements and building design by reviewing current methods found in the literature for calculating firefighting water requirements and flow rates and discussing the extent to which they can be applied in the context of fire service procedures in industrial buildings. These flow rates can then be compared to the total capacity available at these buildings to determine if the available resources are sufficient. Some of these methods are designed to be interactive, so that the user can immediately see the effects of different parameters on the desired water flow rate. The ISO method and the Fire Risk Management Program method of the National Research Center of Canada are the most detailed and effective methods in taking into account many different factors, specifically related to the structure of the building and its relationship to neighboring buildings. Given that many fire service tasks depend on location, the importance of utilizing Geographic Information Systems to support fire service institutions has emerged, and by storing spatial data and making effective use of it, dynamic fire maps can produced and utilized in analyzing industrial building fires and predicting the effective ways to suppress them.

Keywords: Water Flow, Firefighting, Industrial Constructions, Geographic Information Systems..

Introduction

Thermal conductivity and compressive strength of carbon fiber concrete

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ABSTRACT

This research includes an experimental study to find out the possibility of benefiting from the addition of Carbon Fiber Reinforced Polymers (CFRP) to the concrete mix in reducing the thermal conductivity of concrete and thereby reducing the heat transferred through the structures and elements of buildings, which leads to increased thermal insulation and reduce the electrical energy consumed to operate air conditioners. Eight rectangular concrete specimens are prepared and poured for thermal conductivity testing, in addition to 12 standard concrete cubes for compressive strength testing. CFRP strips cut in different proportions are added to find out the effect of the amount of these fibers on the thermal insulation of concrete and compare it with their effect on compression resistance. The results of the thermal conductivity tests for a test time of 390 minutes for each model showed that there is an increase in the insulation of concrete with added percentage of CFRP strips. The concrete specimens and cubes are classified into four groups according to the percentage of addition of CFRP, which was (0 %, 0.45 %, 1.1 %, and 1.6 %) by the weight of the cement allocated for the mixture. Despite the increase in insulation with the presence of fibers, there was a decrease in the compressive strength of concrete with an increase in the amount of fibers, where this decrease ranged between (6.4 - 28.5) % relative to the compressive strength of the reference concrete.

Keywords: CFRP, concrete, thermal conductivity, compressive strength.

1. Introduction

Heat is defined as a type of energy that moves from warm regions to cold regions and its transmission is by conduction, transmission, and radiation. The amount of heat transfer depends on several factors, including: the temperature difference between the two surfaces of the element, the thickness of the element, the area of surfaces exposed to heat, and the rate of thermal conductivity of the material (or thermal insulation of the material) [1].

The percentage of electrical energy consumed in summer to cool buildings is estimated at about 66 % of the total electrical energy, and the heat that penetrates walls and ceilings on

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Finite Element Analysis of Self-Compacted Concrete Filled Steel Tube Columns Exposed to High Temperatures

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Abstract: To represent the structural behavior of self-compacted concrete filled steel tube composite columns under axial compression loading after high temperatures exposure, a nonlinear three-dimensional finite element analysis model has been achieved to analyze these columns using ANSYS R-15 software. An eight-node solid brick element (Solid65) is used to represent the concrete, while a four-node isoparametric shell element (Shell63) is used to represent the steel tube for the analyzed composite columns. A Newton-Raphson incremental-iterative approach is used to simulate the nonlinear solution technique. The finite element method results indicated that the predicted ultimate loads and axial deformations for the analyzed four column specimens agree well with the experimental results for normal strength and high strength concrete in static loading up to failure, and therefore, it is sufficient to model how these columns behave. The reduction in the analytical ultimate loads compared to the experimental values ranged from 11% and 16%, while the reduction in the total axial deformation values ranged from 3% to 7%. The yield patterns obtained from the analyzed composite columns under axial compressive stress are comparable to the yield patterns determined from the experimental study.

Keywords: self-compacted, composite column, steel tube, finite element, ANSYS.

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1. Introduction

Concrete Filled Steel Tube (CFST) composite columns are widely used in structures due to their excellent attitude, including superior fire resistance compared to plain steel columns, resistance to seismic loads, efficient use of materials, better strength, higher stiffness, larger ductility, and a noticeably shorter construction time. Composite concrete-steel structural elements are frequently used in modern bridge and building construction [1]. When a steel part, such as a steel tube, is enclosed in concrete or when a steel I-section is filled with concrete, a composite member here is produced. In a CFST like this, the high compression concrete strength matches the high-tension steel strength. Concrete that self-compacts (SCC) is fluid and is cast without vibration [2]. This building material is increasingly employed in flat buildings like slabs or industrial floors because of its self-leveling qualities. However, when concrete is uncovered to hot and/or windy circumstances, this form of construction is particularly susceptible to plastic shrinkage cracking [3]. Investigations were made for the behavior of steel tubular SCC filled stub columns and exposed to a protocoled fire at the same time [4]. The temperature distribution, axial deformation, steel's limiting temperature, and fire resistance of the SCC filled steel tubular stub columns were all measured through a series of experiments. A Finite Element Method (F.E.M) analysis model was also suggested and utilized to simulate the columns' fire behavior.

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Research Article

Evaluation of Ultra-High-Performance Fiber-Impregnated Reinforced Concrete Beam Elements

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Abstract: Ultra-High- Performance- Fiber Reinforced -Concrete (U-H-P-FR-C) seismic elements are constructed very differently from traditional concrete. However, as the U-H-P-FR-C seismic members are expensive, much information in the literature about how they behave dynamically. The requirements for the experimental work (design guidelines for large-scale seismic elements) can be reduced using limited element programs. Analytical models, which validated can be employee to examine the modifications in geometry, loading configurations, and reinforcement ratios, which will affect seismic behavior. For simulating the U-H-P-FR-C beam under dynamic stress and evaluate the numerical model's prediction precision, this study used a restricted element program, ABAQUS. Tensile and uniaxial pressure tests have used to establish the parameters of the material model. The results obtained from the numerical models show that the dynamic behavior of U-H-P-FR-C beams can be well predicted by the analytical model.

Keywords: impact, U-H-P-FR-C, ABAQUS, limited element analysis.

I. INTRODUCTION

The novel composite building material (U-H-P-FR-C) has replaced steel and synthetic materials. The ductility, fatigue resistance, and fracture toughness of this composite material are all good. Fibers that have a normal compressive strength from 150 to 250 MPa and a tensile strength from 10 to 15 MPaare used to strengthen it [1-4]. The lower water/cement ratio of about 2%, additives that increase density and offer uniformity, curing, and influence of steel fibers are responsible for these outstanding qualities [5]. Apart from these characteristics, U-H-P-FR-C could be a new good material for reinforced concrete constructions that are subject to dynamic loads, including military structures and nuclear power plants, transit networks, and coastal structures. This is related to its strong resilience for sudden or repeated loadings. Few studies have investigated the dynamic behavior of U-H-P-FR-C reinforced concrete parts. Słomka-Słupik et al., has conducted experimental investigation on the dynamic behavior of U-H-P-FR-C beam, which revealed that the bending fracture occurred in the beam in the absence of stirrup reinforcement [1]. The impact of fiber content, stiffening ratio, and concrete type on the dynamic behavior of U-H-P-FR-C panels has investigated using experimental work in another study under the same dynamic stress [6]. It has shown that an increase in reinforcement ratio and fiber content introduce less peaks and permanent displacements. A study by [7] observed how the reinforcement ratio affected the U-H-P-FR-C beams bent when subjected to dynamic loads. It is found that the maximum fracture width lowers with less permanent displacement as the reinforcement ratio rises. According to another study [8], damage levels in U-H-P-FR-C beams under dynamic loading can be reduced by using 2% of the volume of steel fibers. As a result, the permanent and maximum displacements show a significant drop in their values. The behaviour of seismic elements created with U-H-P-FR-C under impact loads has been the subject of very few investigations in the literature.This outcome could also be caused by factors like not fully understanding the design process for such features and the high expense of the materials and test apparatus needed for the experimental investigation. The quickly advancing of computer technology, it is now possible to conduct these tests in a computer environment and quickly

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Analysis of Reinforced Concrete Beam Elements Impregnated with Ultra-High-Performance Fibers

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Abstract: The manner of seismic elements made of Ultra-High Performance Fiber Reinforced Concrete (UHPFRC) differs significantly from conventional concrete. However, limited research exists in the literature on the dynamic manner of UHPFRC seismic members due to their high cost. Limited element programs can reduce the need for experimental studies to develop design procedures for large-scale seismic elements. Validated analytical models can be utilised to investigate the impact of geometric changes, loading schemes, and reinforcement ratios on the seismic behaviour. This research employed a limited element program, specifically ABAQUS, to model a UHPFRC beam subjected to dynamic loading and evaluate the predictive accuracy of the numerical model. The material model parameters were determined based on uniaxial pressure and tensile tests. The findings from the numerical models demonstrate that the analytical model effectively predicts the dynamic behaviour of UHPFRC beams.

Keywords: Limited element analysis, impact, UHPFRC, ABAQUS.

1. Introduction

Ultra High Performance Fiber Concrete (UYPLB) (Unknown Yield Point Low Bond) emerged as a new composite building material; steel, synthetic, etc. This composite material has good ductility, fatigue resistance, and fracture toughness. It is reinforced with fibers, with characteristic compressive strength of 150-250 MPa and tensile strength of around 10-15 MPa [1-4]. These superior properties are provided by the low water/cement ratio (approximately 2%), very fine additives that maximize grain density and provide homogeneity, steam curing and the contribution of micro steel fibers [5]. In addition to these properties of UYPLB, it can be a suitable material for reinforced concrete structures that may be exposed to dynamic loading such as nuclear power plants, military structures, transportation infrastructure, coastal structures, due to its high resistance to sudden or repeated loadings [1]. However, there is a limited number of studies in the literature on the dynamic behavior of UYPLB reinforced concrete elements. In a related study, UYPLB dynamic behavior of the beam was investigated experimentally and reported that bending fracture occurred in the beam without stirrup reinforcement [1]. In another research [6], the effect of concrete type, fiber content, and stiffening ratio on the dynamic behavior of UYPLB panels was studied experimentally. It was observed that the increase in fiber content and reinforcement ratio resulted in fewer peaks and permanent displacements under the same dynamic load. A research [7] has studied the effect of the reinforcement ratio on the bending behavior of UYPLB beams under dynamic loading. It is determined that as the reinforcement ratio increases, less permanent displacement occurs and the maximum crack width decreases. In other research [8], it was proved that if 2% of the volume of steel fibers was used in UYPLB beams under dynamic loading, the level of damage decreases and thus the permanent and maximum displacements reported that there was a significant decrease in their values. In the literature, it is seen that there are a limited number of studies examining the behavior of seismic elements produced with UYPLB under impact loads. Reasons such as not knowing the design procedure of such temple elements very well and the high

Impact of Rapid Corrosion of Steel Bars on the Flexural Behavior of Reinforced Concrete Beams with Different Mix Proportions

Khamees N. Abdulhaleem , Waleed Khalid Mohammed, Shwan H. Said and Qais F. Hasan*

Abstract--- *The presented study is an experimental program to cast and test twelve small-scale reinforced concrete beams with three different mix proportions to determine the impact of rapid corrosion of bottom tension steel bars, using an electric corrosion cell, on the flexural behavior and ultimate capacity of the beams with variable corrosion degree. Using Faraday's Law and the amount of time spent to keep the samples inside the corrosion cell, the degree of corrosion (slight, moderate, and severe) is determined. The corrosion-related cracking pattern was the same for all beams and visually, did not indicate any loss in ultimate capabilities. Despite the significant degree of steel corrosion and the obvious spalling of the concrete cover, the highest corrosion-related fracture width was less than 1 mm. The ultimate flexural capacities and mid-span deflections decreased as an effect of the corrosion process in direct proportion to the degree of corrosion; the maximum loss in ultimate flexural capacity was for beam R2D which was 36%, and the maximum loss in mid-span deflection was for beam R1D which was 54%.*

Keywords--- *Reinforced Concrete, Rapid Corrosion, Tension Bars, Flexural Capacity.*

I. INTRODUCTION

Corrosion is defined as the disintegration resulting from the interaction of two or more materials or their components in the presence of an auxiliary medium such as heat, moisture, and salts [1]. It is also a corruption of the material or its properties as a result of its interaction with external or internal influences, so the material loses its design specifications and the purpose of its use. Corrosion occurs in real life very slowly and quietly, but the losses it causes are beyond imagination. Some of these losses are material and economic, and some are related to human health and directly affect him in addition to their impact on the surrounding environment [2].

One of the important structural elements that corrosion affects directly and negatively and significantly is the reinforced concrete beams. Despite the recommendations of the American Concrete Code [3] to provide a concrete cover to ensure that chloride salts do not penetrate and corrode the reinforcing steel, the cracks that occur in the concrete in the various stages of loading, especially the tensile area, cause a weakening of the concrete cover in protecting the reinforcing steel [4]. In many cases, it is needed to rehabilitate a specific beam or bridge due to the presence of an increase in the expected loads on it. Therefore, one of the first rehabilitation steps is to know the degree of corrosion in the reinforcing steel and its impact and try to reduce the resulting structural damage. The reinforcing

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Optimal design of public transport networks (lines) in Kirkuk City using GIS-based AHP

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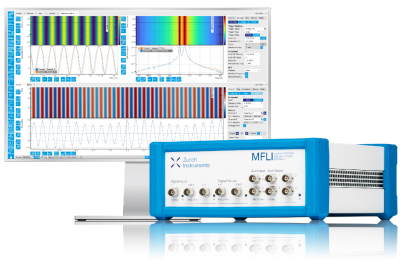

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Green Concrete: Ferrock Applicability and Cost- Benefit Effective Analysis

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ABSTRACT

This research aims to assess the viability and suitability of Ferrock as an alternative to concrete for constructing foundations. The study evaluates the performance of Ferrock in foundation applications, compares its costs with traditional concrete, and examines the benefits of using Ferrock for foundations. To achieve these objectives, the utilization of Staad Pro and Foundation software is done to analyze the performance of Ferrock foundations. A cost-benefit analysis, considering factors like material costs, construction techniques, and maintenance requirements to determine the economic feasibility of Ferrock as a substitute for concrete and the potential to reduce carbon emissions, and promote environmentally friendly construction practices is also done. The research findings indicate that Ferrock exhibits promising performance characteristics for building foundations. It demonstrates comparable strength to traditional concrete while offering potential environmental benefits. Although implementing Ferrock may require an initial investment, the long-term advantages of reduced maintenance costs and improved sustainability contribute to its overall value proposition.

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