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Single-phase and two-phase smoothed particle hydrodynamics for sloshing in the low filling ratio of the prismatic tank

Trimulyono A.[a, b]; Chrismianto D.[a]; Samuel; Aslami M.H.[c]

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[a] Department of Naval Architecture, Faculty of Engineering, Diponegoro University, Jl. Prof. Soedarto, S.H, Tembalang, Semarang, Indonesia

[b] Ship Hydrodynamics Laboratory, Departement of Naval Architecture, Diponegoro University, Indonesia

[c] Department of Mechanical, Aerospace and Civil Engineering, University of Machester, United Kingdom

Abstract

The present study is to carry out a numerical sloshing using smoothed particle hydrodynamics (SPH) in the prismatic tank. Sloshing is a violent flow caused by the resonance of fluid in the tank by external oscillation. The prismatic tank was used to resemble a membrane LNG type carrier. The sloshing experiment was carried out using three pressure sensors, a camera high resolution, and four degrees of freedom forced oscillation machine. In this study, a filling ratio of 25% was used to reproduce sloshing in a low filling ratio. Only roll motion is used in the numerical simulation. Roll motion is directly imposing from the experiment displacement, and a comparison of hydrostatic and dynamic pressure was made to validate the SPH result. The time duration of the sloshing is the same as the experiment. Single-phase and multiphase SPH are conducted to reproduce sloshing in the prismatic tank. Sloshing was done both for the 2D and 3D domain. It shows that SPH has a good agreement with analytical and experimental results. The dynamic pressure is similar to an experiment through a spurious pressure oscillation

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Single-phase and Two-phase Smoothed Particle Hydrodynamics for Sloshing in the Low Filling Ratio of the Prismatic Tank

A. Trimulyono*[a,b], D. Chrismianto[a], Samuel[a,b], M. H. Aslami[c]

[a] *Department of Naval Architecture, Faculty of Engineering, Diponegoro University, Jl. Prof. Soedarto, S.H, Tembalang, Semarang, Indonesia*
[b] *Ship Hydrodynamics Laboratory, Departement of Naval Architecture, Diponegoro University*
[c] *Department of Mechanical, Aerospace and Civil Engineering, University of Machester, UK*

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A B S T R A C T

The present study is to carry out a numerical sloshing using smoothed particle hydrodynamics (SPH) in the prismatic tank. Sloshing is a violent flow caused by the resonance of fluid in the tank by external oscillation. The prismatic tank was used to resemble a membrane LNG type carrier. The sloshing experiment was carried out using three pressure sensors, a camera high resolution, and four degrees of freedom forced oscillation machine. In this study, a filling ratio of 25% was used to reproduce sloshing in a low filling ratio. Only roll motion is used in the numerical simulation. Roll motion is directly imposing from the experiment displacement, and a comparison of hydrostatic and dynamic pressure was made to validate the SPH result. The time duration of the sloshing is the same as the experiment. Single-phase and multiphase SPH are conducted to reproduce sloshing in the prismatic tank. Sloshing was done both for the 2D and 3D domain. It shows that SPH has a good agreement with analytical and experimental results. The dynamic pressure is similar to an experiment through a spurious pressure oscillation exist. The dynamics pressure results show fairly for short time simulation and slightly decrease after that. The free surface deformation tendency is similar to experiment.

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NOMENCLATURE

F	Force	t	Time
P	Pressure	δ_φ	Delta-SPH
r	Position vector	ρ	Density
m	Mass	v	Velocity
h	Smoothing length	w	interpolation kernel
α	Coefficient of artificial viscosity	γ	Adiabatic index

1. INTRODUCTION

The sloshing phenomenon is one of the challenging event in a liquid carrier such as an LNG ship, tanker, and oil truck carrier. Sloshing can define as a resonance of fluid inside a tank caused by an external oscillation. As sloshing dealing with nonlinear behavior, numerical and experiment method is the appropriate approach to tackle this problem. Many studies have been carried out to overcome sloshing using numerical method both of mesh CFD (computational fluid dynamics) and meshless CFD. Using an open-source CFD solver OpenFOAM [1] dynamic pressure was well-validated with the experimental result. Jiang et al. [2] did a numerical simulation of the coupling effect between ship motion and liquid sloshing under wave conditions. The results revealed that sloshing impact loading has no significant coupling effect on global ship response. Sanapala et al. [3] have used OpenFOAM to simulate parametric liquid sloshing with the baffled rectangular container to get optimal baffles. The results showed optimal baffles were obtained with reference to the quiescent free surface. Xu et al. [4] perform sloshing

*Corresponding Author Institutional Email: anditrimulyono@lecturer.undip.ac.id (A. Trimulyono)

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Mechanical Properties of Ultra-high Performance Concrete Reinforced by Glass Fibers under Accelerated Aging

M. Madhkhan*, P. Saeidian

Department of Civil Engineering, Isfahan University of Engineering, Isfahan, Iran

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ABSTRACT

Ultra-High Performance Concrete (UHPC) is a cementitious composite with fine aggregates and a homogeneous matrix with high compressive strength and excellent durability against aggressive agents. It is common to use short steel fibers in the UHPC. Besides, using steel fibers considerably increases the flexural ductility, durability and energy absorption. Using glass fibers in UHPC is a novel technique which improves its mechanical properties and it has the benefit of being lighter, and cheaper than steel fibers. Furthermore, glass fibers can be used for thin concrete plates for aesthetic purposes. However, glass fibers reinforced concrete is incompatible with the hydration reaction in the alkaline environment of concrete as it can damage glass fibers, so the mechanical properties of the concrete are decreased over long periods. The mechanical properties of UHPC containing glass fibers (GF-UHPC) was investigated under three regimes of normal curing, autoclave curing, and autoclave curing plus being in hot water for 50 days (accelerated aging). Besides, the substitution of silica fume by Metakaolin in GF-UHPC was studied to understand its mechanical properties after thermal curing. The results showed that after accelerated aging, the behavior of specimens become more brittle and the modulus of rupture and toughness indices of all prismatic specimens decreased, the modulus of rupture for samples containing glass fibers was 40% lower than autoclave curing results. However, the compressive strength under accelerated aging increased at least 4% in comparison to the normal curing. Replacement of silica fume with Metakaolin slightly increased the toughness with regard to flexural strength.

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NOMENCLATURE

I_5, I_{10}, I_{20}	Toughness Indices show the flexural strength and ductility of the specimen	δ	First-crack deflection
$R_{5,10}$, $R_{10,20}$	Residual strength factors are the strength retained after the first crack		

1. INTRODUCTION

One of the substantial achievements in concrete technology in the 20th century was the advance of ultra-high performance concrete (UHPC) or reactive powder concrete (RPC), more generally recognized as UHPC [1]. Small sand particle size (less than 0.6 mm), a high volume of cement (more than 600 kg/m^3), binder (Pozzolan, Metakaolin, Silica fume, Fly ash), and a minimum water/cement ratio (w/c ≤ 0.2) with high dosage of superplasticizer creates a solid matrix with high homogeneity and considerable compressive strength [2].

Plain concrete is a brittle material with low tensile strength and strain capacity; however, this troublesome property can be improved by adding short fibers to the matrix, which forestalls or controls the initiation or spreading of cracks [3]. Adding fibers to the matrix of concrete has many benefits, such as improving durability, bearing capacity, tensile capacity and toughness compared to plain concrete [4].

The reasons for using glass fibers in the matrix of concrete are higher tensile strength compared to organic fibers, cheaper compared to steel fibers, and lack of rust stains at the concrete surface [5]. Glass fibers have many other applications, for instance Glass Fiber Reinforced

*Corresponding Author Institutional Email: *madhkhan@iut.ac.ir* (M. Madhkhan)

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Strength Capacity Cracks Propagations Deflection and Tensile Enhancement of Reinforced Concrete Beams Warped by Glass Fiber Reinforced Polymer Strips

M. M. Abbass[a], M. K. Medhlom[b]. I. F. Ali[c]

[a] *Consultant Structural Engineering Baghdad, Iraq*
[b] *Department of Civil Engineering College of Engineering Al Mustansiriyah University, Baghdad, Iraq*
[c] *Ministry of Transport and Communications, Baghdad, Iraq*

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ABSTRACT

Different approaches were adapted to strength the structural elements to increase the load capacity and reduce the deformation such as deflection. The easiest and light external strengthening of reinforced concrete members are Fiber Reinforced Polymer (FRP) family such as Armed, Carbon, Glass and Basalt, respectively. This paper presents the theoretical approach to check out the experimental tests of reinforced concrete beams strengthened by glass fiber reinforced polymer (GFRP) using finite elements method by ANSYS software in which all models are simulate the tested beams. All models have the same geometry and mechanical properties but differ in GFRP layers and width. The main objectives of present work are evaluating the strength capacity, cracks propagations, deflection and tensile enhancement of reinforced concrete beams warped by GFRP strips subject to four points static load. Analysisof results indicate that the presences of GFRP sheets enhance the capacity and ductility of reinforced concrete beams in additional to delay the post crack concrete. The delay in the formation of first crack, increase in the number of cracks and ultimate loads of the models compared with the control model. There are improvements in flexural strength based on the modulus of rupture. Also, the cracks propogation become less in case of presence of GFRP and there is improvements in tensile resistance due to flexural. Analysis results inicated that the presence of GFRP at the bottom face of reinforced concrete beam in case of two layers gave increase in ultimate load 104.3% as compared with the control model. The reduction of the deflection for same models is 10.84%. Factor of the modulus of rupture range between (0.76-1.36) that is more than with ACI code suggested as 0.6. All model results were close to the experimental tests.

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NOMENCLATURE

Symbol			
A_f	GFRP area (mm^2)	M_n	nominal flexural strength (N-mm)
c	Distance from extreme compression fiber to the neutral axis (mm)	M_u	factored moment at a section (N-mm)
d	distance from extreme compression fiber to centroid of tension reinforcement (mm)	β_1	ratio of depth of equivalent rectangular stress block to depth of the neutral axis
f_{fu}	design ultimate tensile strength of GFRP (MPa)	φ	strength reduction factor
f_s	stress in steel reinforcement (MPa)	ψ_f	GFRP strength reduction factor = 0.85 for flexure (calibrated based on design material properties)
h	overall thickness or height of a member (mm)	M_n	nominal flexural strength (N-mm)

1.INTRODUCTION

Concrete as a material is very weak to resist tensile stress that developed in tension concrete zone due to applied loads. When the internal stress in the structural members increased the cracks will increase [1]. The mechanical properties of GFRP high strength to weight ratio, lightweight and giving better solution for strengthening. Hence, adopt in structural members. Strengthening reinforced concrete beam by GFRP with orientation of fiber reinforcements along the beam

*Corresponding Author Email: mohammadmakki2003@gmail.com (M. M. Abbass)

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Experimental Investigations on Strengthened Reinforced Concrete Columns under Monotonic Axial Loading

S. Sirimontree[a], S. Keawsawasvong[a], C. Thongchom[a], P. Jongvivatsakul[b], E. Noroozinejad Farsangi*[c]

[a] *Department of Civil Engineering, Thammasat School of Engineering, Thammasat University, Pathumthani, Thailand*
[b] *Innovative Construction Materials Research Unit, Department of Civil Engineering, Faculty of Engineering, Chulalongkorn University, Bangkok, Thailand*
[c] *Faculty of Civil and Surveying Engineering, Graduate University of Advanced Technology, Kerman, Iran*

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Strengthening of the existing reinforced concrete (RC) column is nessesary to enhance their axial load-carrying capacity or ductility. This paper presents the results of an experimental study relating to the performance of reinforced concrete columns strengthened with different techniques such as the steel angle, steel straps, and ferro-cement under pure axial load. A total of six square short reinforced concrete columns were constructed. The cross-section and height of tested columns are 150×150 mm and 1.2 m, respectively. Two specimens were set as the control columns (without strengthening). The other four reinforced concrete columns were strengthened with different techniques. Two columns are strengthened with four steel angles at each corner of the column confined with prestressed steel straps. Another two columns are also strengthened with four steel angles confined with prestressed steel straps and ferro-cement. The experimental results are reported in terms of the load-deformation curves as well as the failure modes. A significant enhancement of the maximum axial load-carrying capacity and the ductility is observed for the strengthened reinforced concrete columns. Finally, the discussion of the use of different strengthening techniques is also carried out in this paper.

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1. INTRODUCTION

There are several effective approaches that can be used to enhance the axial load-carrying capacity and the ductility of RC structures. For instance, many researchers in the past have employed ferro-cement [1-5], fiber-reinforced materials [6-12], or steel angle/strips [13-15], to strengthen the reinforced concrete structures. Previous works by Mourad and Shannag [1], Kaish et al. [2], and Sirimontree et al. [3] employed the ferro-cement jacketing to strengthen RC column. The ferro-cement jacketing was utilized to repair concrete beams by Jongvivatsakul et al. [4-5]. In addition to ferro-cement jacketing, the fiber-reinforced materials is one of the strengthening composites widely used to increase the capacity of several RC structures (e.g., Kianoush and Esfahani [7], Maghsoudi et al. [8], Nateghi and Khazaei-Poul [9], Rahmanzadeh and Tariverdilo [10], Al-Akhras [11], Shadmand et al. [12]). The use of steel jackets is also a simple procedure to strengthen various types of RC structures, where its good performance was demonstrated by Abdel-Hay and Fawzy [13], Ma et al. [14], and Tarabia and Albakry [15].

The main elements supporting a building structure are the columns. The failure in columns can lead to the progressive collapse of the whole building. Thus, column strengthening is an essential issue in the seismic retrofitting of a building structure. To enhance the axial load-carrying capacity, the stiffness, or the ductility of the reinforced concrete columns, several researchers have used steel angles, steel jackets, or ferro-cement jackets to experimentally investigate the strengthening of

*Corresponding Author Institutional Email: noroozinejad@kgut.ac.ir (E. Noroozinejad Farsangi)

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