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2023/2024 SEMESTER 1

(University of Choice)

MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY (MMUST)

MAIN CAMPUS

UNIVERSITY EXAMINATIONS 2023/2024 ACADEMIC YEAR

FIRST YEAR FIRST SEMESTER EXAMINATIONS

FOR THE DEGREE OF MASTER OF SCIENCE IN STRUCTURAL ENGINEERING

COURSE CODE: CSE 814

COURSE TITLE: ADVANCED STRUCTURAL MATERIALS

DATE: 20TH DECEMBER 2023 **TIME:** 3 HOURS

INSTRUCTIONS:

1. This paper contains FOUR questions.
2. **Question ONE (1) is Compulsory**
3. **Attempt a total of THREE questions in this booklet.**
4. Marks for each question are indicated in the parenthesis.

Examination duration is **2 Hours.**

MMUST observes ZERO tolerance to examination cheating.

This Paper Consists of 4 Printed Pages. Please Turn Over.

Question 1 COMPULSORY (30 marks)

(a) Based on the information provided in **case study Q1A,** you are required to:

i. Discuss the effect of MWCNT concentration on the mechanical properties of cement mortar. **(6 mks)**

ii. Discuss how the MWCNT concentration influences the strength development process of the cementitious composites. **(6 mks)**

iii. Provide a conclusion for the study. **(3 mks)**

(b) Discuss the significant contribution of each component used to manufacture ferrocements? **(4mks)**

(c) Describe the Extrusion-Based 3D Concrete Printing technology. What are the striking materials characteristics requirement for 3D concrete printing? **(7 mks)**

(d) The Fiber reinforced Polymers FRPs are increasingly being considered as an enhancement to and/or substitute for infrastructure components or systems that are constructed of traditional civil engineering materials. Discuss FOUR concerns that need to be addressed to further accelerate the application of these materials in the construction industry **(4mks)**

Question 2 (20 marks)

(a) With an aid of a sketch describe the structure of an Expanded Polystyrene (EPS) Wall panels. Discuss the engineering properties of EPS panels produced in Kenya. (8 mks)

(b) Describe the design, mix proportioning and the mechanism involved in the production of geopolymer concrete? what are the draw back in the application of geopolymer concrete. (8 mks)

(c) Describe the difference between Single-wall Nanotubes (SWNT) and Multi-wall Nanotubes (MWNT). (4 mks)

Question 3 (20 marks)

(a) "Nanotechnology is an enabling technology that allows us to develop materials with improved or totally new properties". What do you understand by the term nano technology? Discuss comprehensively, how nanotechnology has impacted on the properties of cement and its composites. (8 mks)

(b) Fiber reinforced cementitious composites (FRCC) are of a few superior material properties which make them attractive for use in structural application. Outline the advantages and disadvantages of FRCC and Discuss the factors that affects the properties of carbon fiber reinforced cementitious composites. (8 mks)

(c) Describe how metakaolin (MK) and slag (GBS) can be used to improve the properties of ferrocement. (4 mks)

Question 4 (20 marks)

(a) What is Pultrusion? By the aid of a neat sketch, Discuss how **Pultrusion** process is used in the manufacturing process of Polymer Matrix Composites (10 mks)

(b) Explain how the constituent materials and their properties affects the engineering characteristic of geopolymer concrete. (6 mks)

(c) Explain the advantages of self-healing concrete (4 mks)

Case study Q1A

In a study aimed to investigate the potential use of carbon nanotubes (CNTs), the mechanical properties such as the compressive strength and flexural strength were tested with respect to the proportion of multi-walled CNTs (MWCNTs) in cement composites. **Table Q1A** shows mix proportions of the samples.

Proportion of binder to aggregate was 0.5 for the mortar mixtures. The aggregate used in this study, ISO standard sand, were natural and fine, and consisted of round particles with more than 98% silica contents. As shown in Table Q1A, the paste mixtures were named as "PC-" with various amounts of MWCNT contents, ranging from 0 to 0.5% to binder mass. "PC00" is the paste label of OPC and FA without MWCNT, and "PC05" indicates 0.5 mass% of MWCNT were added in binders to cast paste specimens for the experiments. The "MC-" mixtures were identical with the "PC-" mixtures, except for the additions of ISO sand. The results for the compressive and flexural test are as highlighted in **Table Q1B** and **Table Q1C**.

Table 2: Mix proportions of paste and mortar samples containing multi-walled carbon nanotubes.

Specimens	OPC (g)	FA (g)	Water (g)	MWCNT Solution (g)	ISO Standard Sand (g)
PC00	80	20	28.0	-	-
PC01			23.1	5	
PC02			18.2	10	
PC03			13.3	15	
PC04			8.4	20	
PC05			3.5	25	
MC00	80	20	28.0	-	200
MC01			23.1	5	
MC02			18.2	10	
MC03			13.3	15	
MC04			8.4	20	
MC05			3.5	25	

Table 3. Compressive strengths of mortar mixtures.

Curing Time	Compressive Strength (MPa)					
	MC00	MC01	MC02	MC03	MC04	MC05
3 d	40.0	37.7	37.1	32.1	36.3	33.4
7 d	49.6	50.4	46.7	44.2	43.0	42.5
28 d	61.9	58.1	58.6	56.2	56.0	55.9
56 d	63.9	63.9	61.0	58.2	59.4	58.0
91 d	66.1	65.9	64.7	63.1	62.1	62.6

Table 4. Flexural strengths of mortar mixtures

Curing Time	Flexural Strength (MPa)					
	MC00	MC01	MC02	MC03	MC04	MC05
3 d	9.7	9.0	8.8	8.5	9.3	9.3
7 d	9.4	9.1	9.1	8.9	9.5	9.2
28 d	9.4	9.5	9.2	9.2	9.4	9.5
56 d	11.3	10.9	10.9	10.5	10.7	10.4
91 d	11.4	11.4	11.0	10.6	11.2	11.1