JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY, WAKNAGHAT

TEST -3 EXAMINATION- 2025

Ph.D (CE)

COURSE CODE (CREDITS): 24P1WCE232 (3) MAX. MARKS: 35

COURSE NAME: CHARACTERIZATION OF MATERIALS

COURSE INSTRUCTORS: DR SAURAV MAX. TIME: 2 Hours

Note: *(a) All questions are compulsory.*

(b) The candidate is allowed to make Suitable numeric assumptions wherever required for solving problems

(c) *Use of Non Programmable Scientific Calculator is allowed*

<table>
<tr><th>Q.No</th><th>Questions</th><th>CO</th><th>Marks</th></tr>
<tr><td>Q1</td><td>i) Discuss the working principles and differences between isothermal and adiabatic calorimetry, and explain how each technique captures the heat evolution during cement hydration.
ii) Using a typical calorimetry curve, describe the major stages of cement hydration and their significance. Also analyze how the particle size distribution of cement influences the calorimetric signal, particularly the rate and magnitude of heat release.
iii) Using the data below, compute the theoretical total heat of hydration at 28 days for the cement sample.
<table>
<tr><th>Compound</th><th>% by mass</th><th>Enthalpy of hydration at 28 days (kJ/kg)</th></tr>
<tr><td>C_3S</td><td>55</td><td>490</td></tr>
<tr><td>C_2S</td><td>25</td><td>226</td></tr>
<tr><td>C_3A</td><td>10</td><td>1144</td></tr>
<tr><td>C_4AF</td><td>8</td><td>418</td></tr>
</table></td><td>2</td><td>7</td></tr>
<tr><td>Q2</td><td>i) Explain how a nickel filter is used to obtain monochromatic X-ray radiation in XRD and why this is essential for accurate diffraction measurements. Using a neat labelled sketch, illustrate the concept of Miller indices and show how they represent crystallographic planes.
ii) Evaluate the effectiveness and limitations of XRD in quantifying amorphous phases in cementitious systems.
iii) X-rays of wavelength 1.54 Å produce a first-order diffraction peak at 22°;</td><td>2</td><td>7</td></tr>
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<tr><td></td><td>using Bragg's Law, calculate the corresponding inter-planar spacing.</td><td></td><td></td></tr>
<tr><td>Q3.</td><td>i) Define specific surface area and explain why measuring surface area is important in cementitious materials by stating at least two reasons. In the context of particle size distribution, describe what D_{50} represents.
ii) Explain the working principle of the Blaine air permeability method. Why nitrogen adsorption tests are carried out at liquid-nitrogen temperature.
(iii) Cement sample has a flow time of 110 s, while the reference material with a known specific surface area of 320 m^2/kg has a flow time of 95 s. Using the Blaine relationship; calculate the surface area of the test cement.</td><td>3</td><td>7</td></tr>
<tr><td>Q4.</td><td>i) Discuss how pixelation influences the accuracy of measuring crack width in digital images, and describe the steps involved in performing binary segmentation to isolate cracks on concrete surfaces.
ii) Critically evaluate the suitability of image analysis techniques for determining the thickness of the interfacial transition zone (ITZ) in concrete, highlighting both strengths and limitations.
iii) An image of size 1024 × 1024 pixels corresponds to a physical area of 5 mm × 5 mm; if a crack in the image measures 280 pixels, calculate its actual length in millimeters.</td><td>4</td><td>7</td></tr>
<tr><td>Q5.</td><td>i) Using the Washburn equation, explain how intrusion pressure varies with pore diameter during mercury intrusion porosimetry and discuss the resulting implications for identifying fine versus coarse pores.
ii) Analyze how changes in water–binder ratio influence the pore size distribution of cement paste, and examine why pore refinement leads to an increase in the formation factor of the microstructure.
iii) A sample exhibits the following differential pore intrusion volumes
<table><tr><th>Pore diameter (µm)</th><th>dV (mm^3/g)</th></tr><tr><td>0.01</td><td>25</td></tr><tr><td>0.1</td><td>90</td></tr><tr><td>1.0</td><td>65</td></tr></table>
(a) Identify the dominant pore range.
(b) Explain what this distribution suggests about the micro structural characteristics of the material.</td><td>5</td><td>7</td></tr>
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