Loughborough University

Engineering Materials for Construction

24CVA106

Semester 2 2025 | In-Person Exam paper

This examination is to take place in-person at a central University venue under exam conditions. The standard length of time for this paper is **2 hours**.

You will not be able to leave the exam hall for the first 30 or final 15 minutes of your exam. Your invigilator will collect your exam paper when you have finished.

Help during the exam

Invigilators are not able to answer queries about the content of your exam paper. Instead, please make a note of your query in your answer script to be considered during the marking process.

If you feel unwell, please raise your hand so that an invigilator can assist you.

You may use a calculator for this exam. It must comply with the University's Calculator Policy for In-Person exams, in particular that it must not be able to transmit or receive information (e.g. mobile devices and smart watches are **not** allowed).

Answer **FOUR** questions.

Answer **TWO** questions from **Section A** and **TWO** questions from **Section B.**

All questions carry equal marks.

Continues/…

…/continued

SECTION A

(Answer **TWO** questions from this section)

Q1. A new building is to be constructed in London. The geology locally comprises some 2 m deep of made-ground (historical building rubble, saturated weight density 18 kN/m^3) overlying more than 20 m of stiff London Clay with a saturated weight density of 20 kN/m^3. Groundwater is typically at 1 m below the ground surface (use 10 kN/m^3 for weight density of water).

The London Clay has a plasticity index (I_P) ranging between 46 and 58%, with a liquid limit ranging (LL) from 75 to 95%.

a) Sketch a cross-sectional profile of the site and briefly describe the main issues with the ground condition that are likely to affect the construction process.

[6 marks]

b) To support the new building it is considered to excavate to 3 m below ground level and then place a raft foundation exerting a foundation pressure of 200 kN/m^2.

Calculate the effective stress at the maximum excavation depth:
i) before excavation takes place,
ii) immediately after excavation has taken place,
iii) immediately when the foundation stress is applied, and
iv) a long term after the foundation stress has been applied.

[10 marks]

c) i) Plot the data for the London Clay in the Plasticity Chart of Figure Q6a.
ii) Describe the clayl in terms of its plasticity.
iii) Comment on the likely effects on the foundation if trees are planted close to the buildings.

[9 marks]

Q2. A precast concrete plant has asked you to develop a mix that will be used for precast beams. The concrete should have a characteristic compressive strength of 50 MPa at 28 days with a standard deviation of 5 MPa and 5 % defectives. The mix should include a cement class 52.5, crushed aggregate with maximum size of 20 mm, uncrushed fine aggregate (60 % passing through a 600 μm sieve) and water. The relative density of the combined aggregate is 2.6 (SSD). The slump must be between 30 mm and 60 mm. Use the tables in the Appendix.

a) *Estimate* the content (in Kg) of cement, fine aggregate, coarse aggregate, and water you will have to weigh to satisfy the project requirements and produce 1.0 m^3 of concrete using the DoE method of mix design (see Appendix). Assume that the aggregates are in SSD condition.

[18 marks]

Question 2 continues/…

…/question 2 continued

b) During the production process of the beams, you observe that the early age strength gain is not sufficient to demould the beams within the planned timeframe.

Name an appropriate supplementary cementitious material (mineral admixture) which could be added to the mix to develop higher early-age strength. *Justify* and *explain* why this modification would work (but *do not calculate a new mix*).

[7 marks]

SECTION B

(Answer **TWO** questions from this section)

Q3. a) CLT and SIPS and laminated timber ('Glulam') are three examples of structural timber systems. *Sketch* their cross sections, and *compare* the main differences between them, including how they're made, and where they may be used in a building. Present your answer in tabular form.

[12 marks]

b) Rank (by fire resistance) and c*ompare* how these three different types of timber would perform in a fire.

[7 marks]

c) *Compare and contrast* the strength and durability of the two main *classification types of timber*, with an example (tree) of each. Where might each be used in a building and why?

[6 marks]

Q4. a) What are the five main constituents of a paint?

Compare two different examples of *special paints*, *what* they are used for and *where* they might be used in a building or structure.

[9 marks]

b) What is *cullet*, and why is it used in the manufacturing process for glass?

What are the advantages and disadvantages of adding *lead* or *borax* to the manufacture of glass. Which do you think is the most sustainable and why?

[8 marks]

c) *Compare and contrast* the difference between the *linear* use of materials in a construction project and the *circular* use of materials. Use aggregate and structural steel as examples for each.

Describe why a diesel car has a different *carbon footprint* to an electric car.

[8 marks]

Continues/…

…/continued

Q5. a) *Explain*, with the aid of *sketches*, how a standard 300 x 150mm diameter concrete cylinder specimen can be subjected to compressive loads to produce either a *compressive strength* value or a *tensile strength* value. Show the forces applied and generated within the specimen.

[6 marks]

b) *Compare*, with the aid of *sketches*, the cube and the cylinder as compressive strength test specimens for concrete. Which of these will give a better indication of the *true uniaxial compressive strength*, and *why*?

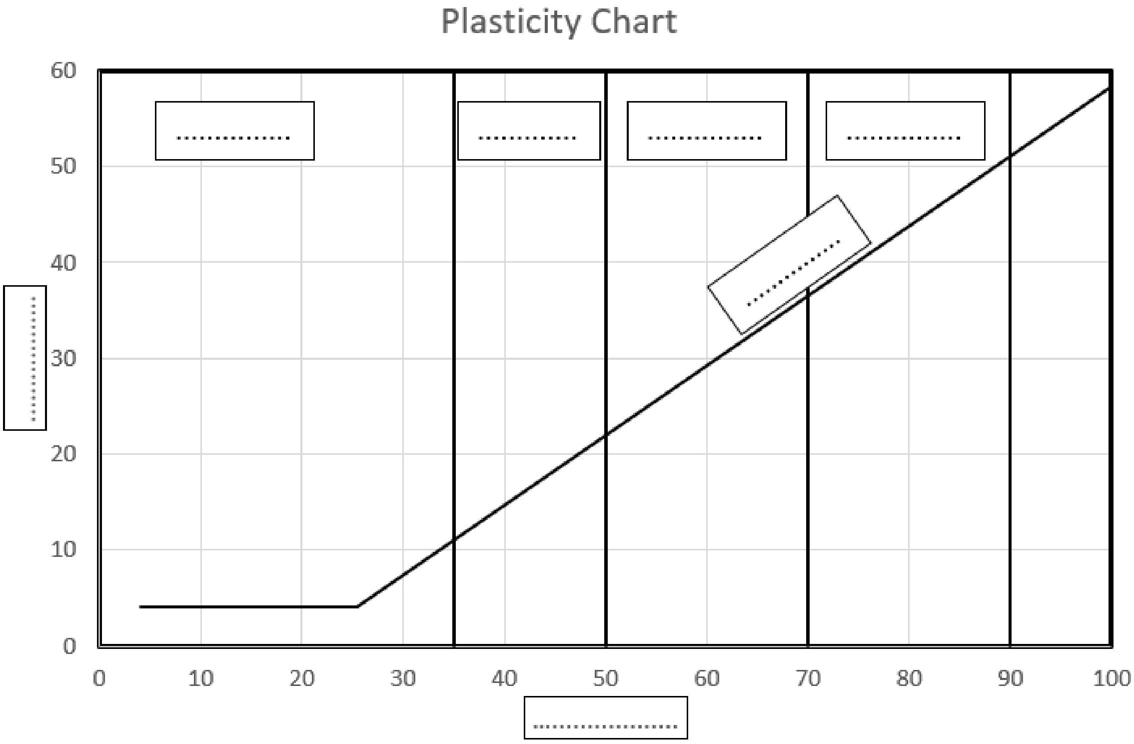
[7 marks]

c) *Compare and contrast in tabular form these test methods and equipment for the non-destructive testing (*NDT) of reinforced concrete: Cover meter, Rebound hammer, and UPV. State what property(s) they measure, and comment on their accuracy, speed, and cost effectiveness.

[12 marks]

C I Goodier
A Blanco
T Dijkstra

APPENDIX A (for use with Q1)



APPENDIX A (for use with Q2)

Table 2 Approximate compressive strengths (N/mm²) of concrete mixes made with a free-water/cement ratio of 0.5					
Cement strength class	Type of coarse aggregate	Compressive strengths (N/mm²) Age (days)			
		3	7	28	91
42.5	Uncrushed	22	30	42	49
	Crushed	27	36	49	56
52.5	Uncrushed	29	37	48	54
	Crushed	34	43	55	61

Throughout this publication concrete strength is expressed in the units N/mm².
1 N/mm² = 1 MN/m² = 1 MPa. (N = newton; Pa = pascal.)

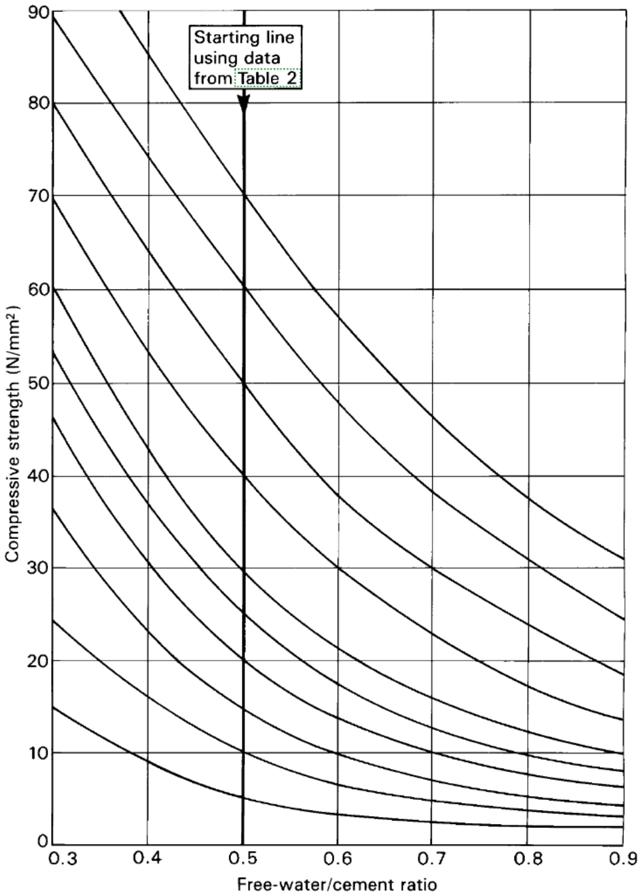


Figure 4
Relationship between compressive strength and free-water/cement ratio

Table 3 Approximate free-water contents (kg/m³) required to give various levels of workability					
Slump (mm)		0–10	10–30	30–60	60–180
Vebe time (s)		>12	6–12	3–6	0–3
Maximum size of aggregate (mm)	Type of aggregate				
10	Uncrushed	150	180	205	225
	Crushed	180	205	230	250
20	Uncrushed	135	160	180	195
	Crushed	170	190	210	225
40	Uncrushed	115	140	160	175
	Crushed	155	175	190	205

Note: When coarse and fine aggregates of different types are used, the free-water content is estimated by the expression:

$\frac{2}{3} W_f + \frac{1}{3} W_c$

where W_f = free-water content appropriate to type of fine aggregate
and W_c = free-water content approporiate to type of coarse aggregate.

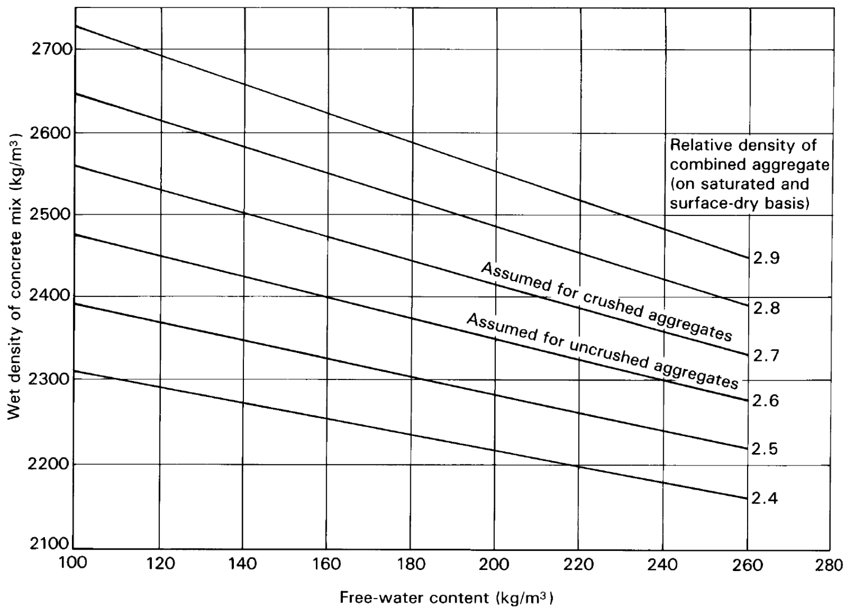


Figure 5 Estimated wet density of fully compacted concrete

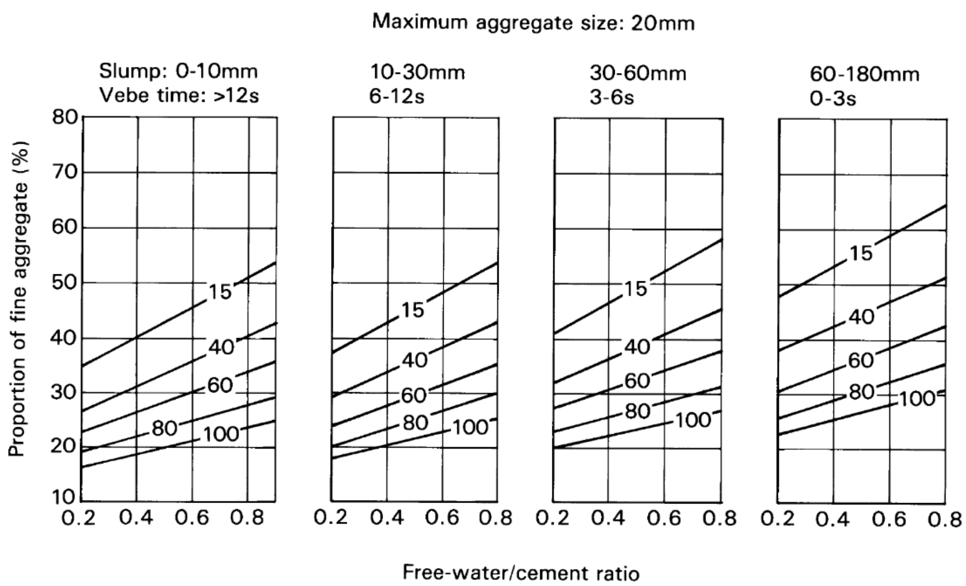


Figure 6 (continued)