Question Set 6: Concrete and Timber Questions with Comments and Answers

Question 1

Find values for the coefficient of thermal expansion of concrete, steel reinforcing bars and epoxy.

Comment on the values you find and their consequences for the thermal behaviour of reinforced concrete.

Fibre-reinforced polymers with an epoxy matrix are used in rehabilitation of reinforced concrete structures by bonding them to the face of the concrete. Based on the values you found, what should designers consider when designing this form of rehabilitation?

Question 2

What does “embodied” carbon mean for a material, and what are its units?

What are the main sources of embodied carbon in concrete?

It has been proposed that crushed concrete from buildings after demolition is spread over fields and left there to reduce its net carbon emissions. How would this reduce the net carbon emissions? Do you think it is a good idea?

Question 3

A concrete mix uses aggregate with Young’s modulus 140GPa and a cement matrix with Young’s modulus 22GPa. The concrete comprises $0.3m^3$ of aggregate (including course and fine), and $0.2m^3$ of hardened cement matrix. Using the rule of mixtures, estimate the Young’s modulus of the concrete.

Using sketches at appropriate scales, indicate the effect of plasticizers on the microstructure of concrete.

Question 5

Because timber grows rather than being manufactured, we need to have ways of estimating its mechanical properties before it is used. This process is called “grading” and requires us to use observations and measurements we can make from the timber without damaging it to estimate properties that we can only really know by breaking it (such as strength).

Based on what you’ve heard and seen in the timber videos, what observations and measurements do you think could be used for grading?

Question 6

Table 1 shows the embodied carbon and the global production rate of three major construction materials. If the total global anthropogenic carbon emissions are 14.1GT per year, estimate the percentage of those emissions due to each material.

You plan to use both concrete and timber in a construction project. Suggest two methods to reduce the embodied carbon of the material you use.

Table 1: Embodied carbon and production rate of construction materials

Material	Embodied Carbon (kgC/kg)	Annual Global Production (Tonnes)
Concrete (as generally used in low-rise buildings)	0.035	1.9×10^{10}
Steel (including 42.3% recycled content)	0.482	9.8×10^{8}
Timber (wood, pulp and paper)	0.125	2.1×10^{9}

Question 7

Sketch the cellular structure of wood.

If the solid cell wall material in wood has a Young's modulus of 40GPa, and makes up 30% of the volume of the wood, use the rule of mixtures to estimate the Young's modulus of the wood parallel to the grain and perpendicular to the grain.