Low Carbon Materials for Construction
22CVP370

Semester 2 2023 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 **not** use a calculator for this exam.

Answer **ALL** questions.

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1. Sustainable construction aims to apply the principles of Sustainable Development to the construction industry. It involves developing buildings and structures that maximise the use of sustainable resources while causing less pollution and waste.

   a) List and describe two Sustainable Development Goals (SDGs) that are relevant to the construction industry.

   [6 marks]

   b) Discuss the ‘advantages’ and ‘disadvantages’ of deconstruction.

   [7 marks]

   c) Explain construction waste origins during design; procurement; site operations and material handling.

   [7 marks]

2. You have been hired to undertake a cradle-to-grave life cycle assessment of 2 plasterboards to be used in a new building. Plasterboard A represents the “business as usual”, which includes 10% of recycled gypsum recovered from construction waste. Plasterboard B is the circular alternative, which includes 30% of gypsum recovered from demolition waste, purified using a novel chemical and washing treatment. Table 1 summarises the results of the life cycle assessment related to several impact categories named in the first column. The manufacturing process, performance and price of both plasterboards are the same. Based on this information:

   a) Compare the 2 plasterboards regarding their climate change impact, justify the results based on their composition and recommend the plasterboard that would minimise the environmental impact.

   [7 marks]

   b) Name one impact category in which plasterboard B **underperforms** plasterboard A and explain what this impact category means.

   [6 marks]

   c) Propose a possible justification for the poorer performance of plasterboard B regarding the impact category named in Q2.b, considering the information provided in Q2.

   [7 marks]

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Table 1 – Result from life cycle assessment of plasterboards A and B

Impact category	Unit	Plasterboard	
		A	B
Climate change –total	kg CO2 eq.	2.75	2.06
Climate change -fossil	kg CO2 eq.	2.52	2.04
Climate change -biogenic	kg CO2 eq.	0.042	0.032
Climate change -land use and land use change	kg CO2 eq.	0.005	0.004
Ozone depletion	kg CFC-11 eq.	1.75E-07	1.32E-07
Photochemical ozone formation	kg NMVOC eq.	0.022	0.009
Acidification	kg SO2 eq.	0.019	0.016
Eutrophication, terrestrial	mol N eq.	0.042	0.031
Eutrophication, aquatic freshwater	kg P eq.	0.0009	0.0005
Eutrophication, aquatic marine	kg N eq.	0.005	0.002
Water Use	m^3 world eq.	0.652	0.750
Resource use, minerals and metals	kg Sb eq.	5.60E-06	1.21E-05
Resource use, energy carriers	MJ	31.55	21.5
Fresh water ecotoxicity	CTUe	97.2	73.1

3. You have been hired as a consultant to recommend a new repair material applied to Victorian brickwork tunnels. You decide to use the multi-criteria decision-making methodology MIVES to compare the reference (i.e., brickwork) and 4 alternative materials (i.e., advanced cementitious, bituminous, polymer and fibre-reinforced composite). Based on this information:

   a) Propose a decision tree and the corresponding weights.

   [9 marks]

   b) Provide a brief description of 4 indicators and justify their weights.

   [8 marks]

   c) Describe a strategy to refine the decision tree and the weights.

   [7 marks]

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4. After refining the decision tree and the weights in Q3, you apply the methodology MIVES and obtain the graph in Figure 1, which shows the global sustainability index (vertical axis) for all alternatives (horizontal axis). The same figure also summarises the contribution of the economic, social, environmental and technical requirements to the global sustainability index. Based on this information:

   a) Which repair material would be the most sustainable? Justify why.

   [5 marks]

   b) Compare the repair approach recommended and the reference (i.e., brickwork) in terms of economic, social, environmental and technical requirements. Justify the differences in terms of environmental requirement.

   [6 marks]

   c) Describe a limitation of this analysis and propose a measure to mitigate it.

   [5 marks]

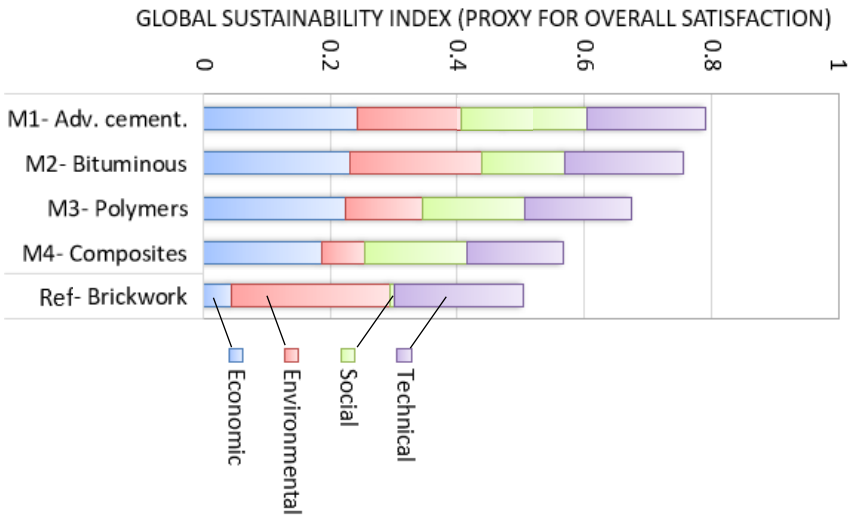

Figure 1 – Result from multi-criteria sustainability assessment

5. Concrete is one of the most prevalent artificial materials in the built environment and the primary building material applied in the construction industry.

   a) Propose and justify 2 strategies to reduce the carbon emissions associated with applications in which concrete is the primary building material.

   [7 marks]

   b) Propose and justify 2 strategies to enhance the circularity of applications in which concrete is the primary building material.

   [7 marks]

   c) Indicate 2 barriers to implementing the strategies from Q5.a or Q5.b.

   [6 marks]

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