

Results from the Design Tool

Project name: NTNU campus development

Construction site located at: 63.4156, 10.4003

Summary of results

Total score	Score without reuse	Savings	Substitutions
9 084 kgCO ₂ eq	73 075 kgCO ₂ eq	87.57%	90.7%

The best results was obtained by the following algorithm: Greedy Algorithm Plural. This algorithm successfully substituted 907/1000 (90.7%) of the demand elements with reusable elements. Using 'GWP' as the optimization metric, a total score of 9 084 kgCO₂eq was achieved. For comparison, a score of 73 075 kgCO₂eq would have been obtained by employing exclusively new materials. This resulted in a total saving of 87.57%, which corresponds to 63 991 kgCO₂eq. The savings is equivalent to 620 flights for one person between Oslo and Trondheim. Note that impacts of transporting the materials to the construction site was accounted for and contributed to 10.45% of the total score. Open the Excel file "NTNU_campus_development_substitutions.xlsx" to examine the substitutions.

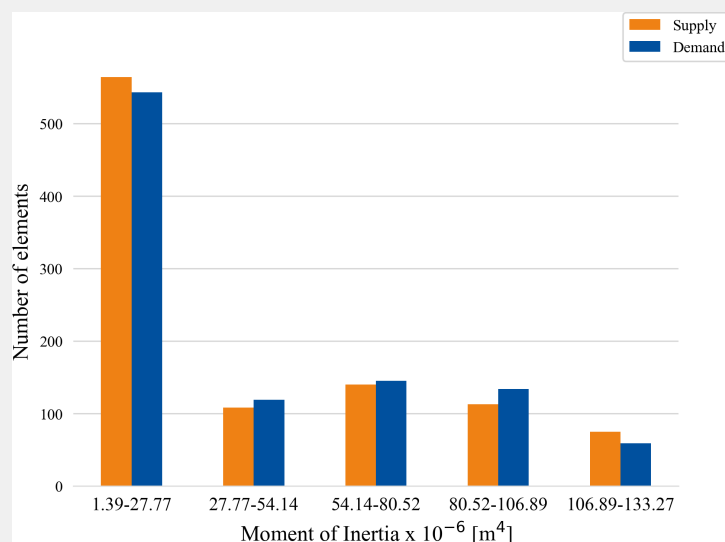
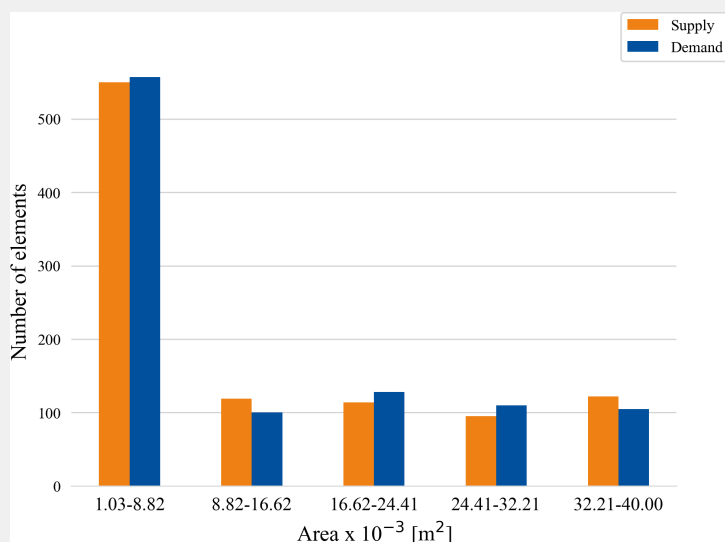
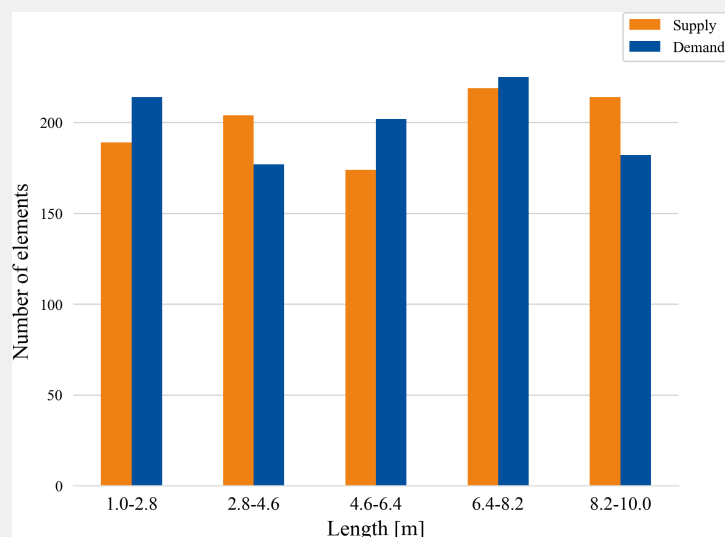
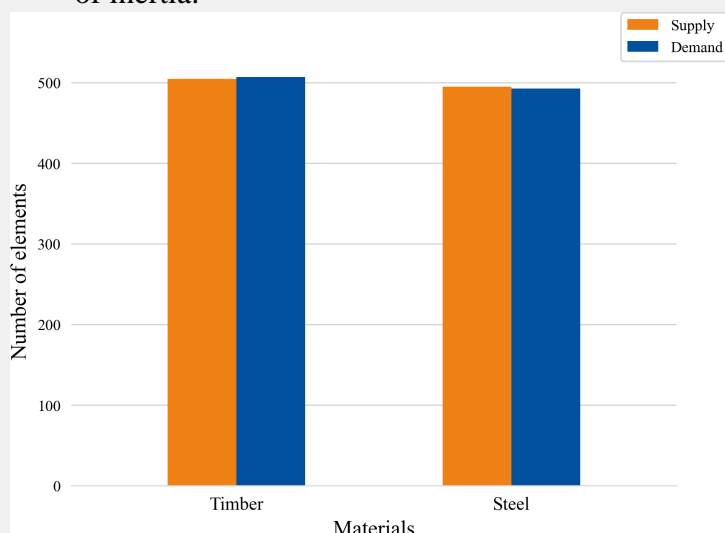
Constants used in the calculations

Constant	Value	Unit
Density timber	491.0	kg/m ³
Density steel	7850.0	kg/m ³
GWP new timber	28.9	kgCO ₂ eq
GWP reusable timber	2.25	kgCO ₂ eq
GWP new steel	9263.0	kgCO ₂ eq
GWP reusable steel	278.0	kgCO ₂ eq
GWP transportation	89.6	g/tonne/km

Information about the datasets

Elements	Filename	Number of elements
Supply	master_thesis_supply.xlsx	1000
Demand	master_thesis_demand.xlsx	1000

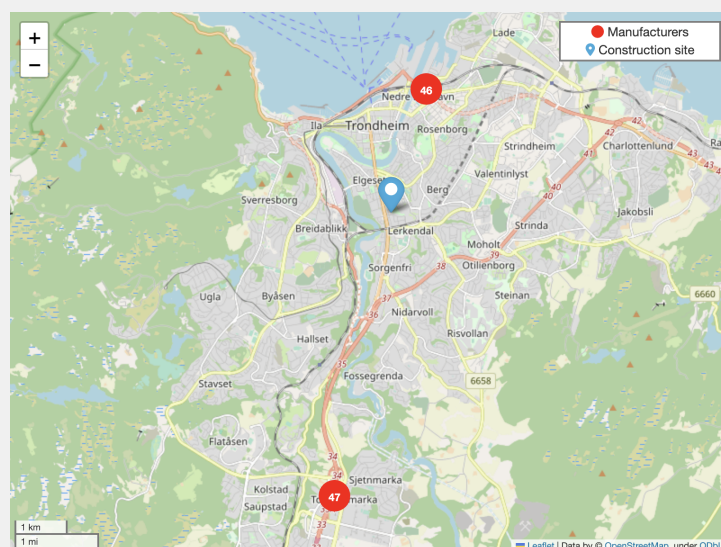
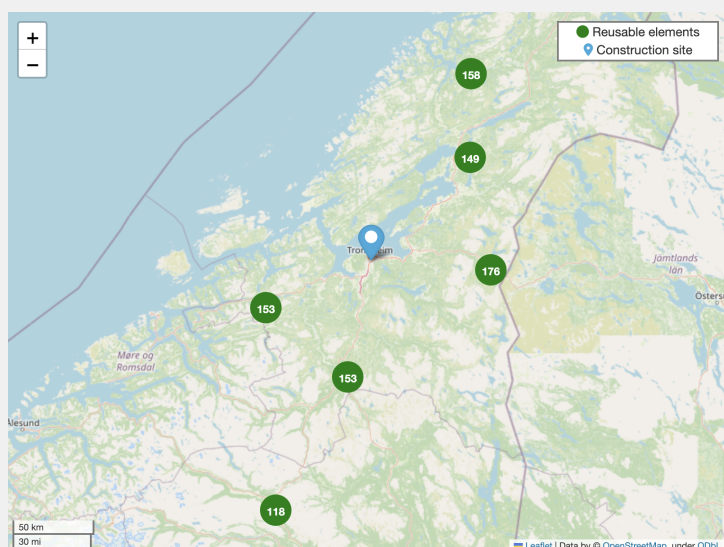
The datasets contains 1000 supply elements and 1000 demand elements. The graphs below depicts the distribution of some of the properties of the elements, including the material, length, area, and moment of inertia.



Impact of transportation

Utilizing reusable elements	Percentage of total score	Only manufactured elements
949 kgCO ₂ eq	10.45%	38 kgCO ₂ eq

All calculations in this report accounted for the effects of material transportation to the construction site. Transportation itself was responsible for 949 kgCO₂eq. This accounts for 10.45% of the total score of 9 084 kgCO₂eq. For comparison, the transportation impact for exclusively using new materials would have been 38 kgCO₂eq. Two maps are included to show the locations of the suggested element substitutions from the design tool. The numbers on the maps indicate the number of elements transported from each location.



Performance of the optimization algorithms

Algorithm name	Total score	Substitutions	Time
Greedy Algorithm Plural	9 084 kgCO ₂ eq	90.7%	11.12s
MBM Plural	9 226 kgCO ₂ eq	90.7%	20.24s
MBM	10 215 kgCO ₂ eq	89.3%	8.79s

The design tool was executed with 3 algorithms, namely: Greedy Algorithm Plural, MBM Plural, and MBM. The Greedy Algorithm Plural yielded the lowest score, as shown in the table. The substitutions by this algorithm was completed in 11.125 seconds.