# Results from the Design Tool

**Project name:**    Case Study 4

**Construction site located at:**    63.4154, 10.3995

## Summary of results

| Total score | Score without reuse | Savings | Substitutions |
|:---:|:---:|:---:|:---:|
| NOK 2 442 462 | NOK 4 770 040 | 48.8% | 90.3% |

The best results was obtained by the following algorithm: MBM Plural. This algorithm sucessfully substituted 903/1000 (90.3%) of the demand elements with reusable elements. Using 'Combined' as the optimization metric, a total score of NOK 2 442 462 was achieved. For comparison, a score of NOK 4 770 040 would have been obtained by employing exclusively new materials. This resulted in a total saving of 48.8%, which corresponds to NOK 2 327 577. Note that impacts of transporting the materials to the construction site was accounted for and contributed to 1.99% of the total score. Open the Excel file "Case_Study_4_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 | kgCO2eq |
| GWP reusable timber | 2.25 | kgCO2eq |
| GWP new steel | 9263.0 | kgCO2eq |
| GWP reusable steel | 278.0 | kgCO2eq |
| Valuation of GWP | 7.0 | NOK/kgCO2eq |
| Price new timber | 3400.0 | NOK/m^3 |
| Price reusable timber | 1700.0 | NOK/m^3 |
| Price new steel | 67.0 | NOK/kg |
| Price reusable steel | 33.5 | NOK/kg |
| GWP transportation | 89.6 | g/tonne/km |
| Price of transportation | 4.0 | NOK/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.
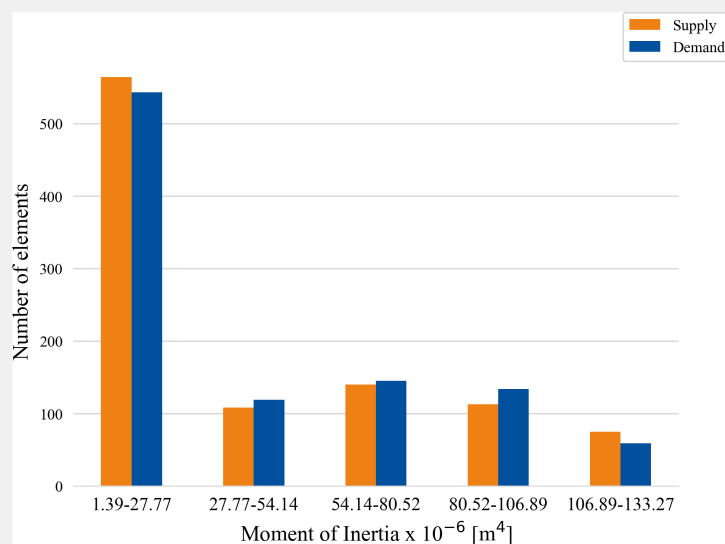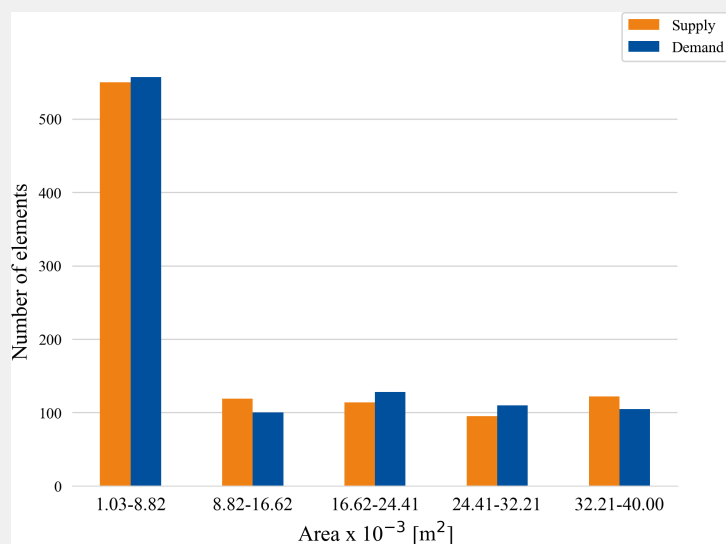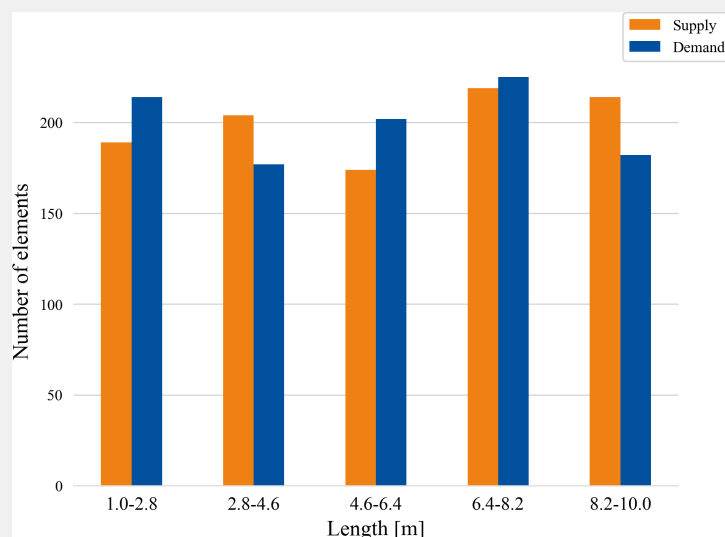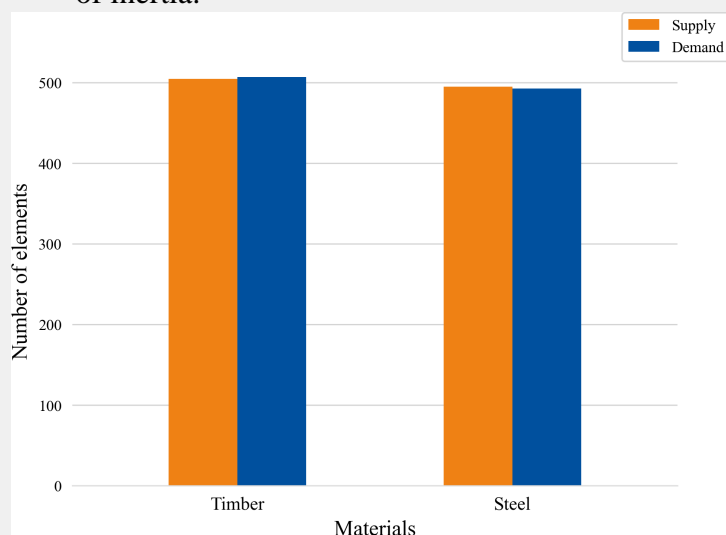
## Impact of transportation

| Utilizing reusable elements | Percentage of total score | Only manufactured elements |
|:---:|:---:|:---:|
| NOK 48 605 | 1.99% | NOK 1 928 |

All calculations in this report accouned for the effects of material transportation to the construction site. Transportation itself was responsible for NOK 48 605. This accounts for 1.99% of the total score of NOK 2 442 462. For comparison, the transportation impact for exclusively using new materials would have been NOK 1 928. 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.
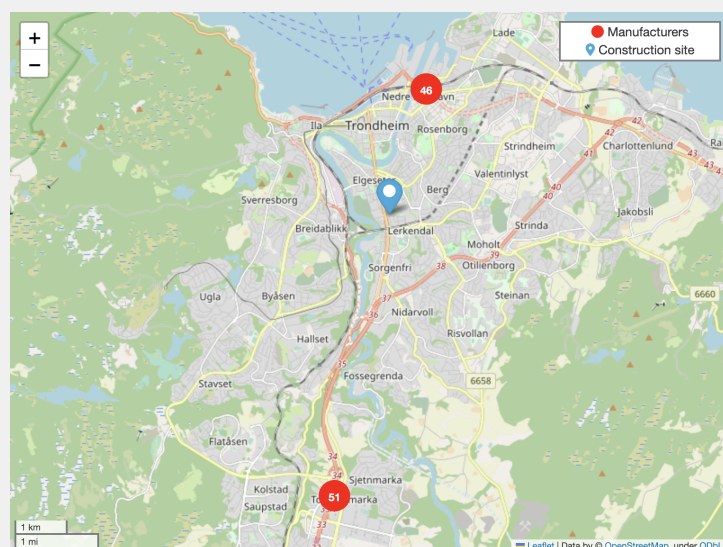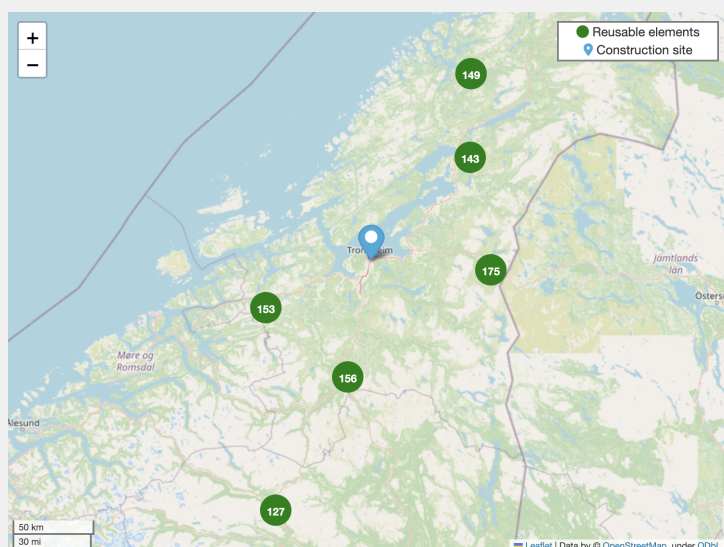
## Performance of the optimization algorithms

| Algorithm name | Total score | Substitutions | Time |
|---|---|---|---|
| MBM Plural | NOK 2 442 462 | 90.3% | 15.9s |
| Greedy Algorithm Plural | NOK 2 445 273 | 90.5% | 11.22s |
| Greedy Algorithm | NOK 2 488 956 | 88.6% | 6.68s |

The design tool was executed with 3 algorithms, namely: MBM Plural, Greedy Algorithm Plural, and Greedy Algorithm. The MBM Plural yielded the lowest score, as shown in the table. The substitutions by this algorithm was completed in 15.899 seconds.