Summary

Due to the growing computing power and increasing interest in optimization for economic as well a sustainability reasons, an algorithm was developed by students at the Delft University of Technology. This algorithm was later on streamlined and improved by ir. W. van den Bos.

The drive behind optimization is the increasing cost of resources used, using less material means a cheaper product. A usefull tool in optimization is the Finite Element Method, it allows engineer to check the stresses locally in a structure. These stresses and strains can be used to determine whether the specific element needs to be kept or can be discarded. The goal of this study is to determine how the algorithm works in oversized cranes and what may have to be altered to improve the algorithm.

To study the algorithm three crane types are used: a bulk bridge unloader, a container crane and a construction site tower crane. Each of this are size up in there range and capabilities, after sizing up the cranes they are evaluated according to NEN2018.

For all the cranes some basic parameters are used which can be found in table 1.

Parameter:	**Value/type**
Tolerance pcg solver	1e-6
Penalty	2
Type of volume reduction	0 (directly reduced with maximum volume reduction)
Perimeter constraint	0 (no penalty or bonus)
Optimization type	Compliance/Strain energy

Table 1: Parameters used.

In chapter 3 the bulk bridge crane is used for the algorithm, it is sized up to a boom length of 100 meters and a rails span of 125 meters. Further more due to an increase in outreach the lifting capacity is increased to 130 metric tons. For this crane the best optimized result is shown at 97% removal, removing less leaves unoptimized segments and removing more results in a construction that is no longer in one piece. However when 99% removal is re-optimized using a smaller element size a topology emerges which has potential.

After the bulk crane the container crane is analized, it is scaled up to an outreach of 100 meters and a lifting capacity of 154 metric tons. The results that follow are similar to the bulk crane, a clear structure emerges this time at 98% removal. However there are indications that the algorithm should be expanded with buckling analysis, part of the structure are clearly susceptible to buckling. This can also be seen in the bulk crane.

Continuing with the construction site crane, this crane is split up in a tower and a jib. This jib is sized up to 150 meters with a lifting capacity of 45 metric tons. The results here are not as clear an expected as the previous two cranes, the best result is at 90% removal and shows a unexpected type of structure. It does clearly show a structure susceptible to buckling. The result on the tower section is what is expected, except for the cross members. The cross members which prevent buckling and create rigidity in a crane are missing in the optimization results.

Therefore buckling is implemented in the algorithm, the static solving is cut up so that for each load case a buckling analysis can be made. The algorithm has been tested on a cube and the Eschenhauer

model. The new algorithm clearly shows a different structure with broader sections. This seems to indicate that the algorithm is working.

However the algorithm needs further testing on other models and with more modes.

Concluding this it shows that the algorithm is capable of optimizing large structures, it is however important to pay attention to the amount of load points and element size. Increasing the number of load cases or number of elements dramaticly increases the amount of calculation time. The buckling part of the alogorithm needs some improvement, a better understanding is necessary of how Ansys scales the stress and strain results. At this moment it is assumed the scale linearly with the load multiplier. A better understanding is needed to accurately rank the element results of all the load cases, if they are ranked to high the optimization will tend to move to a buckling optimized topology. If they are ranked to low the buckling analysis has no use.

Further more it is recommended that structures are optimized in section, this was done in this study for the construction site crane and it worked well.