

## Summary (English)

Window cleaning activities at skyscrapers are done with large telescoping devices. These devices are located at the roof of buildings and can slide out to provide a reach to make sure the cradle can reach the whole window surface area of the building. Using composite materials for these devices leads to a decrease in own weight. The saving of weight by using composite materials is not only profitable for the construction of the buildings roof but also for the device itself.

The main aims of this design exercise are to investigate if it is possible to fabricate such a telescoping arm out of a composite material. Not only technically but also when looking to the aspects of costs and use. A suited composite and fabrication method are chosen and the basic calculations are given. The final design is modeled in the simulation program Ansys to check if the construction is reliable and safe. The complete design of such a telescoping arm is very complex and extensive. In this report the focus is on the three tubular parts sliding in each other and to investigate if these parts can made of a composite. Other design parts of the device are not treated in this report or are treated very superficially!

For the composite material, carbon fibre is the most suitable option. Beside carbon fibre the material glass fibre is considered. The lower stiffness of glass fibre is a decisive factor to choose carbon fibre. HM Carbon (High Modulus) has the best properties for this design. To ensure that all forces are absorbed in the telescoping arm a two layer shell is needed. The first layer has fibres in longitudinal direction to absorb tensile forces in the length of the arm (bending). The second layer has fibres with an orientation of  $-45^\circ$  and  $45^\circ$  to the longitudinal axis to absorb the forces perpendicular to the longitudinal axis and in other directions. Both layers have a thickness of 5 mm. The total thickness of the shell is 10 mm. For the fabrication of long and large tubular parts pultrusion and filament winding are very suited.

The total length of the arm is 23 meter. The length of part 1, 2 and 3 is 9000 mm. The overlap between two parts is 2000 mm. The width of the outer part is 200 mm and height is 310 mm.

For the simulation in Ansys the failure criteria are defined. Some unwanted effects are shear slip and buckling. The critical parts are the contact area's of the inner part at the outer part of the arm. The first contact area is located at the bottom of the end of the part, the second contact area is located at the top of the part at  $L = 3000$  mm. The largest tension and compression forces are acting at the top and bottom area's. The side walls are loaded on shear. An element solution is made to see if the stresses, shear and strains in the elements do not exceed the allowable values. The failure criteria are defined and checked. Finally the results from Ansys are given and no allowable values are exceeded.

Technically, the three parts of the telescoping arm can be made of carbon fibre. Although the costs of the material, production process and design are higher, the benefits of using carbon fibre are profitable. The construction of the buildings roof and the construction of the device itself have to deal with lower forces and loads (up to 50 % less). Composites are more expensive than steels, but their mechanical properties are much better. The saving in weight is almost 85 %. Aspects of chemical resistance and lower maintenance costs are additional advantages.

Finally, the author recommends a further investigation for the optimalization of dimensions of the construction.