Replacing a tower at Cape Verdes – Challenges from hard environmental conditions and a modular concept

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Summary

The hitherto existing accessible tower used for atmospheric measurements in Sao Vicente / Cape Verdes consisted of a galvanized steel structure heavily deteriorated by corrosion already in a very short time. The high level of corrosion was caused by the fairly hard environmental conditions prevailing at the coast of the island due to the unprotected exposure to strong winds in combination with the spray of seawater. Consequently, the design of the needed replacement structure was reconsidered resulting in a structure built from hardwood connected with stainless steel components. The paper presents the major challenges of designing a sustainable structure in order to resist extremely hard exposition to seawater, high temperatures and heavy wind loading. Additionally, the structure has to be designed for a modular assembling scheme in order to meet the requirements arising from the shipment in containers.

Keywords: replacing, tower, mast, modular system, timber, hard environmental conditions, corrosion, stay cables.

1. Environmental conditions

The roughness of the sea in combination with strong winds lead to spray of seawater covering all buildings near the coast nearly all year long. In addition with heavy sunshine and high temperatures these are extremely hard expositions to humans and structures as well. Therefore sustainable structures with high resistance to environmental conditions are needed.

2. Deterioration of existing tower

Due to the described environmental conditions the steel structure heavily deteriorated by corrosion already in a very short time. The deterioration shown exemplarily in figure 1 already appeared after 27 months of use. The picture is taken in late 2008. Especially the pipes and the connectors of the pipe rack had been affected by extensive and widespread corrosion.

Fig. 1: Deterioration of existing structure with corroded pipes and connectors (detail)

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3. Replacement structure - Engineering design and detailing

The aim was to be as simple and easy as possible to set up the structure, which did the same time made be fragmented enough to remain shippable in regular 20 foot maritime containers. Therefore, minimizing the number of bolts for connecting the components was essential. This was achieved by molding stainless steel components that were also used for centralizing.

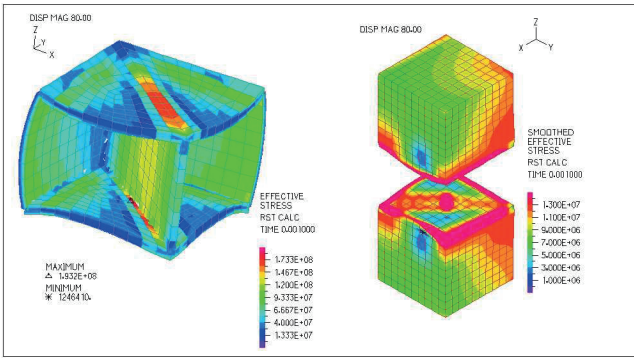

Fig. 2: Detailed nonlinear FE-model for steel connector (left) and hardwood columns (right)

The design of the connection steel to timber was planned single-shear only to avoid imperfect fit and difficulties in building. This was also the reason for not to make the columns continuous at the height of the crossbars, but to interpose the steel connector. For detailing and optimization of the steel connectors between two columns and two crossbars a nonlinear finite element analysis using ADINA-Software has been carried out. The steel connectors have been simulated by shell elements, the wooden parts by using solid elements and the interaction of the two components are contained therein using contact elements with a realistic friction coefficient of 0,4. This model allowed in addition to the dimensioning of the mean stiffeners against stability failure and the wall thickness determination of the horizontally arranged plates, especially the detection of sufficient compressive strength of wooden columns. As shown in figure 2 the unequal pressure distribution in the hardwood columns due to low stiffness of steel plates and high stiffness around the stiffeners. Moreover, this effect can hardly be reduced by creep since the full weight of the columns to normal force only occurs from time to time under full wind load, and also does not occur in the same direction each time as well.

4. Conclusions

The paper showed the major challenges consisting of designing a sustainable structure in order to resist extremely hard exposition to seawater, high temperatures and heavy wind loading as well. Additionally, the structure had to be designed for a modular assembling scheme in order to meet the requirements arising from the shipment in regular 20 foot maritime containers.

To conclude, a sustainable structure could be achieved by using suitable materials, highly sophisticated engineering and experienced und well-skilled manpower for work preparation in Germany and on site at Cape Verdes. According to the authors' opinion the tower also fulfils architectural requirements of a well designed and created piece of building (see figure 3).

Fig. 3: Replacement structure at final position