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Innovative Tower Construction for Wind Power Generation

First-time implementation of a semi-precast construction method with double-wall elements for the quick and cost-efficient erection of high towers for wind turbines

The call for an energy transition requires the development of renewable energies such as wind power. As the availability of windy locations is declining, wind power plant constructors increasingly switch to low-wind regions. For wind power plants to deliver acceptable energy generation rates even in low-wind areas, they must be erected as tower constructions with increasing hub heights.

For towers with great hub heights, hybrid construction methods have become state of the art: The lower section consists of pre-stressed, solid reinforced concrete precast elements; a steel section is placed on top. This construction method established itself on the market due to its quick erection process and the resulting cost effectiveness. However, it shows lower fatigue resistance compared to an cast-in-place concrete construction with the same material consumption, which has a limiting effect on the tower height from an economical point of view.

Two double-wall construction segments

Objective

The research group headed by Prof. Kollegger at the TU Wien Institute of Structural Engineering had the aim to harness the advantages of modern concrete construction methods for towers of wind turbines. The technique was to combine the advantages of the cast-in-place concrete construction method characterised by its high fatigue resistance with the economic advantages of the precast element construction methods to enable the efficient erection of towers with great hub heights. The aim was to use standard double wall concrete elements to produce a tapered tower construction while avoiding the use of special pre-stress techniques altogether or at least to a large extent.

Approach

The tower construction developed by the TU Wien researchers consists of ring segments positioned on top of each other to form a tower. At the construction site, the segments are assembled from semi-precast reinforced concrete parts (double walls) at a pre-assembly site. The double walls' geometry may be selected in such manner as to allow for cost-efficient transport. After positioning each individual ring, the lower segment is filled with concrete above the horizontal joint, thus, firmly connecting the two rings. The lifting and filling of the segments is carried out at such speed as to form a continuous process. This results in a reinforced filling concrete without joints.

Results

Proof of the new construction method's potential was first established by calculation: For a given construction height, a lower concrete quality is sufficient – and therefore the costs are lower – to achieve the same fatigue resistance in the tower as with conventional precast construction methods. A prototype demonstrated that the semi-precast construction method is feasible in practice and that it nearly reaches the structural and mechanical quality of an cast-in-place concrete construction method. The prototype consists of six segments that together form a tower of approximately 16.0 m in height. The top segment measures 6.0 m in height. The tower has a nine-angled cross section and an outside diameter of approximately 4.1 m at the base. The walls are inclined at 1 degree and therefore taper toward the top. This geometry corresponds to the upper part of the concrete section of a hybrid tower for a wind turbines with a hub height of 140 m. The prototype delivered a positive evaluation of this construction method with large segment heights (up to 13 m) and filling these through continuously injecting self-compacting concrete.

Prototype erected using the new construction method

By erecting the prototype, proof could be given that the semi-precast construction method enables the erection of tower constructions from standard and inexpensive double walls. Therefore, no special production plants involving long transports of precast parts to the construction site are required. Moreover, higher segments can be assembled using the light weight double-walls resulting in a low number of horizontal joints and an accelerated tower erection.

Rendering of a polygonal model tower

Benefits

- The new tower construction method is a holistically economic method for wind power plants with a hub height of more than 100 m
- Efficient construction method even for low-wind regions and sites that are difficult to access (e.g. in the mountains)
- The precast parts are easy to adapt to possible transport restrictions such as low bridge clearances
- The use of semi-precast parts (double walls) enables fast construction progress, a short construction time and leads to a high bearing capacity
- The light-weight double walls reduce transport as well as erection costs
- Filling the segments with concrete and reinforcing them on site results in a material-efficient construction method
- Flexible geometries through customisable polygonal cross section and variable tower wall inclination
- High resistance to cyclic loading and aggressive environmental conditions

Contact

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