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Experimental study on the construction shape-forming process and static behaviour of a double strut cable dome

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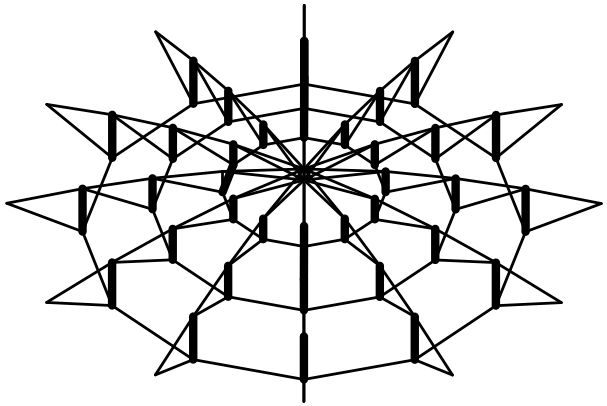
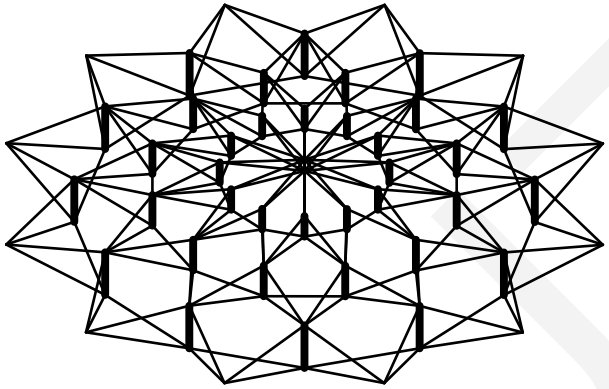
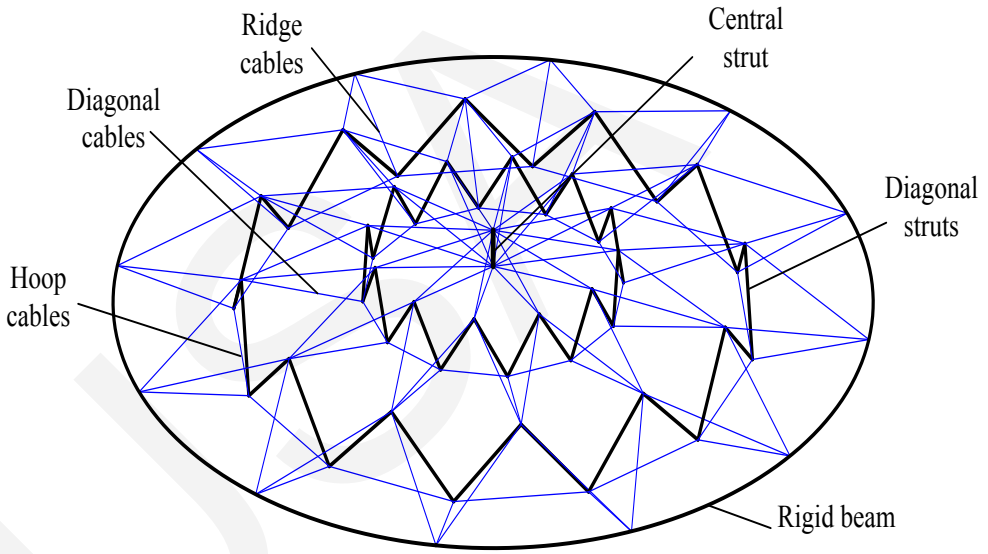
Characteristics of the double strut cable dome



(a) Geiger type



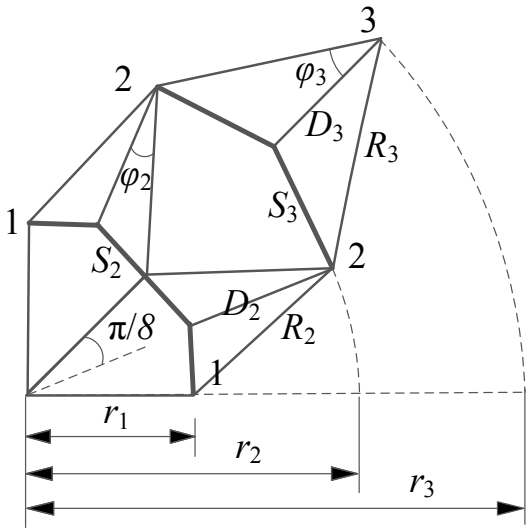
(b) Levy type



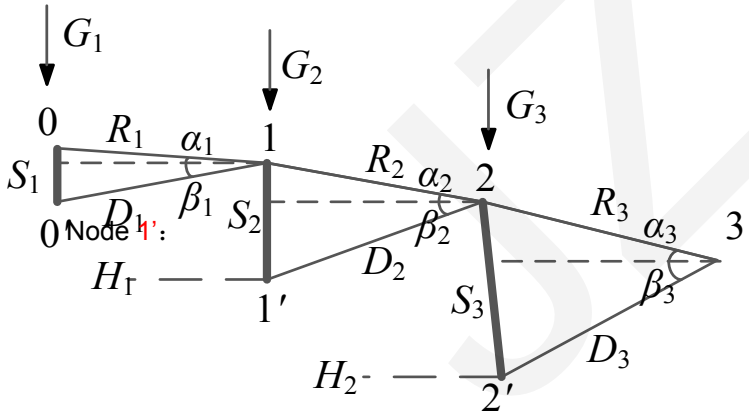
(c) Double strut cable dome

- All joints are connected to two diagonal struts
- Better structural stiffness than Geiger type because of triangular nets of ridge cables.
- Less diagonal cables comparing to Levy type, requiring less jack equipment to apply prestress.

Simplified equations for calculating initial prestress



(a) Plan graph



(b) Profile graph

Node 0:

$$D_1 = \frac{-S_1 + G_1'}{8\sin\beta_1}, \quad R_1 = \frac{-S_1 - G_1}{8\sin\alpha_1},$$

Node 1:

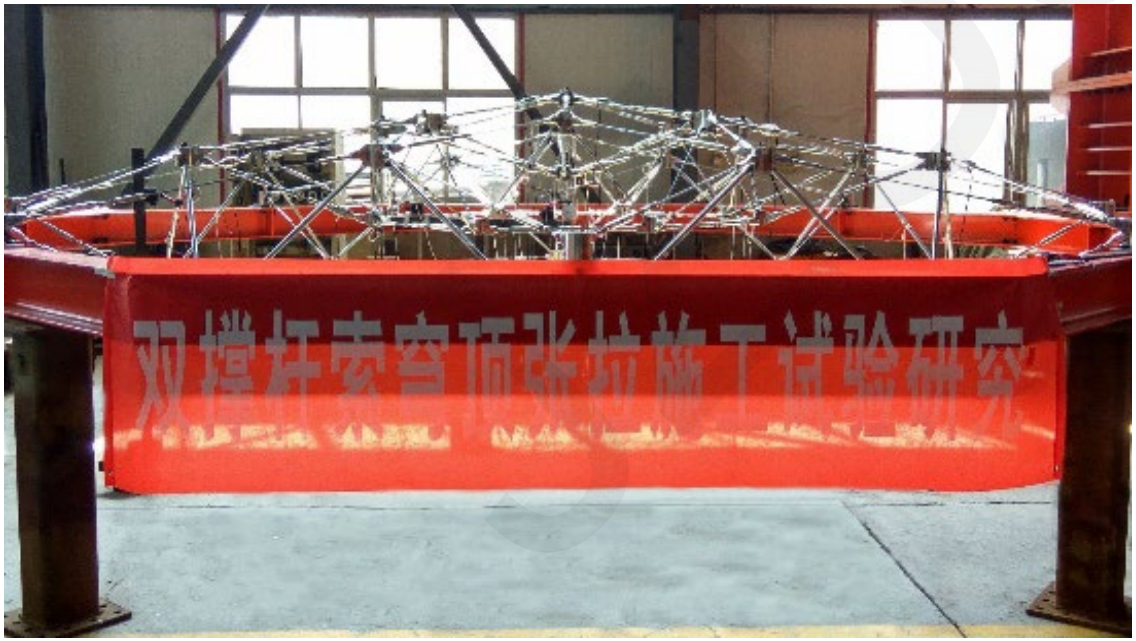
$$\begin{cases} R_2 = \dfrac{1}{2\cos\alpha_2\cos(\varphi_2 + \pi/8)}\left(R_1\cos\alpha_1 + D_1\cos\beta_1\right) \\ S_2 = \dfrac{1}{2\sin\theta_2}\left(R_1\sin\alpha_1 - 2R_2\sin\alpha_2 - D_1\sin\beta_1 - G_2\right) \end{cases},$$

$$\begin{cases} D_2 = \dfrac{-2S_2\sin\theta_2 + G_2'}{\sin\beta_2} \\ H_1 = \dfrac{D_2\cos\beta_2}{2\sin\pi/8} - S_2\cos\theta_2 \end{cases},$$

Design of test model

Cables with and without a tension sensor

Lower joint of ST3

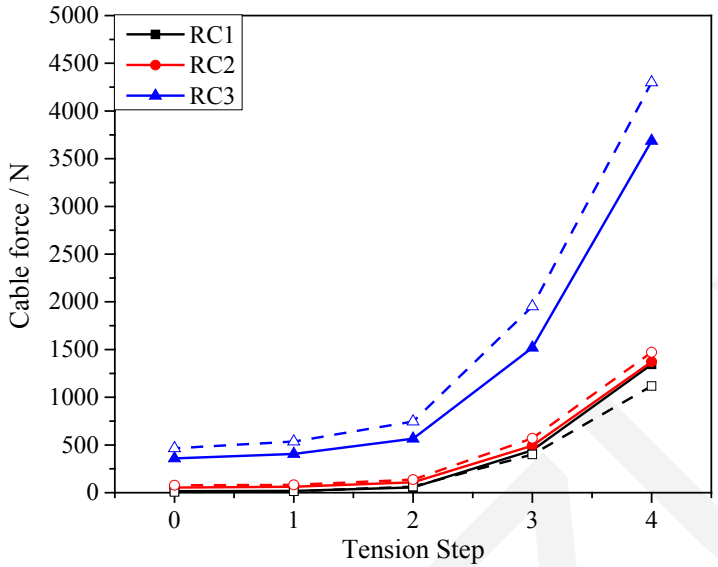


Model photograph

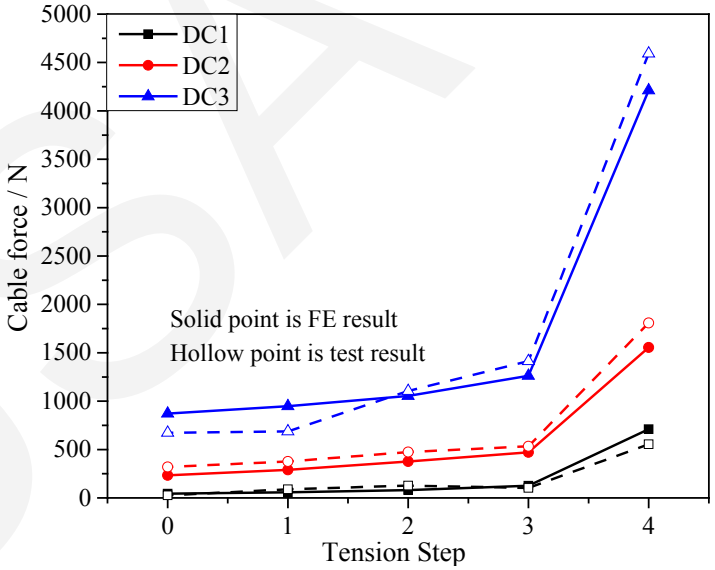
Upper joint of ST2

Test of the construction process

Internal force of the diagonal cables



(a) Tensioning DC3

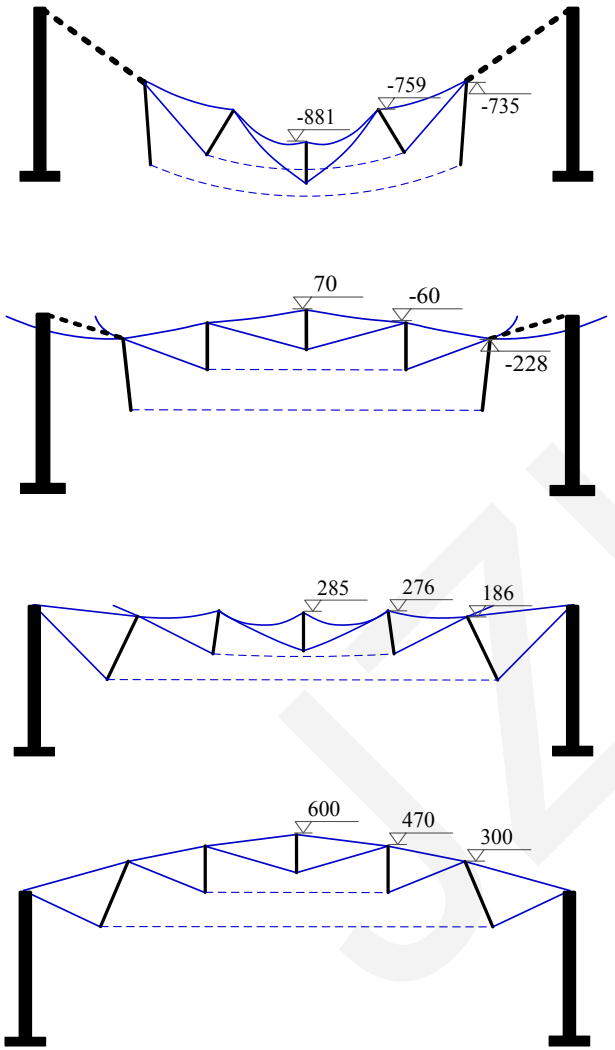


(b) Tensioning RC3

The two tensioning methods are both feasible, the structure can be formed by only tensioning the cables in the outer ring.

However, number of DC3s is half of RC3s, for practical engineering construction, tensioning DC3 can significantly reduce the tension equipment and workload.

The construction method for integral lifting



First assemble all the components except for the RC3 and DC3 on the ground.

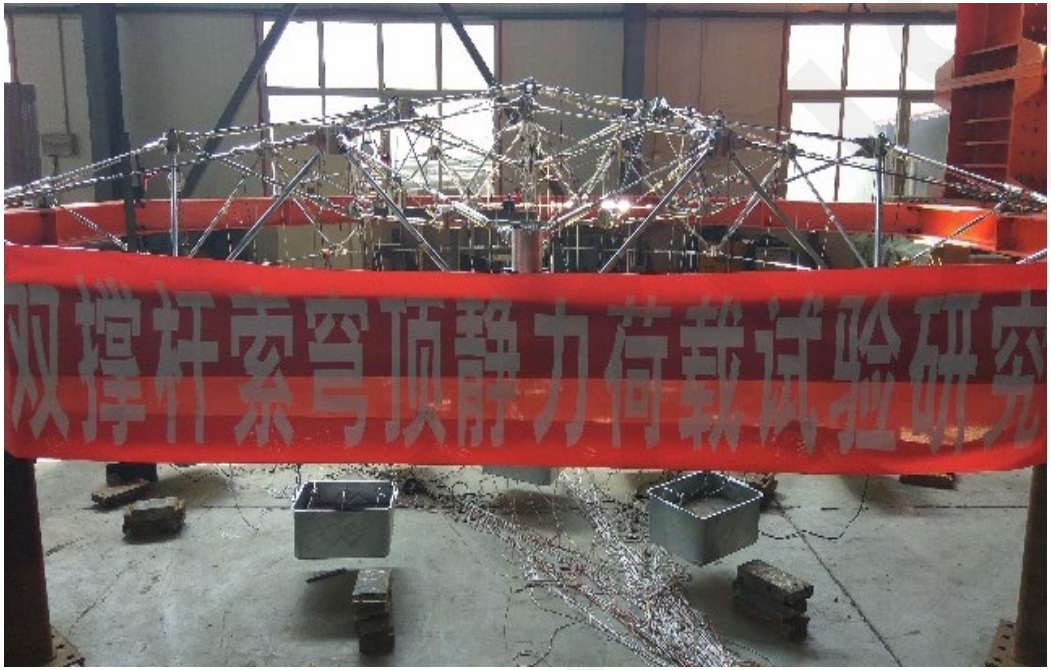
Then use tool cables to lift the partially assembled structure to the appropriate height.

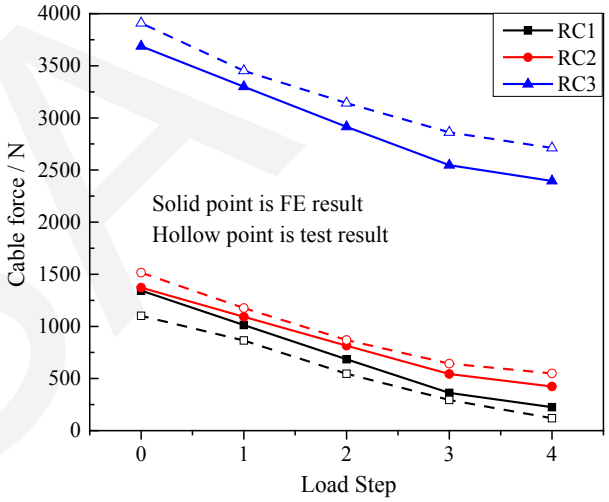
Connect the remaining components in the outer ring (RC3 and DC3.

Finally tension DC3 to complete the forming process.

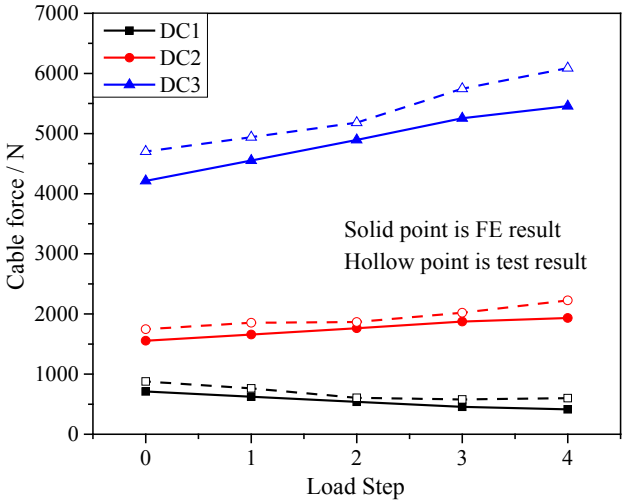
Static loading test

Lateral view of the model under a full span load





Internal force of the ridge cables



Internal force of the diagonal cables

Conclusions

- The formula proposed in this paper can obtain the actual initial prestress of a double strut cable dome considering the structural weight in a simple and accurate way.
- Tensioning the outer diagonal cables to apply prestress to this cable dome can significantly reduce the tension equipment and workload required.
- The construction method through integral lifting can avoid complex operation at a high altitude and greatly reduce the construction difficulty, making the double strut cable dome more suitable for practical engineering.