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Parametric Design of Circular Spherical Mesh Shell

And force performance comparison analysis

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Abstract : In this paper, based on the characteristics of the single-layer spherical lattice shell with a zigzag line, a macro program for the parametric design of a zigzag-shaped single-layer spherical lattice shell was compiled using ANSYS software's APDL language. The analysis function of ANSYS finite element software was used. This structure was compared and analyzed for its stress performance.

Preface

With the development and improvement of human material civilization and spiritual civilization, people need more coverage space to meet the needs of social activities and production labor. The circular zigzag spherical lattice shell is a rectangular planar one-way polygonal linear lattice in a circle, The application of the circular building plane has good technical and economic indicators, and the structural configuration and architectural modeling can be closely matched. In order to improve the mechanical characteristics of the structure, based on the basic structural system, a number of additional ring-shaped members were added to form a reinforced structural system of a single-layered spherical reticulated shel[1].

The geometric description of loop-shaped single-layer spherical shell

The main geometrical parameters of the zigzag-shaped single-layer spherical lattice shell are: outer edge S1, inner edge S2, vector height f, number of circumferentially[2]. symmetrical regions, kn, radial node number Nx, as shown in Figure 1.1 1.2

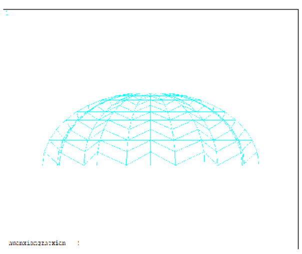

Figure 1.1

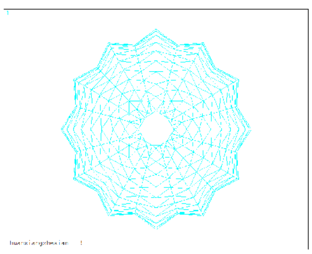

Figure 1.2

parametric design of loop-shaped single-layer spherical lattice shell

parametric polygonal single-layer spherical shell design method

(1) The basic parameter span S1, the span S2, the vector height f, the number kn of the

circumferential symmetric region, and the number of radial node turns nx in the input model[3];
(2) Determine the basic type of rod or beam element, the size of the cross-sectional area, and the nature of the material;
(3) Using APDL's statement loop to generate each node by using geometric relations and the rules of nodes;
(4) The connection of each node is based on the type of the shell, the characteristics and the law of the lattice structure of the shell structure, and each node is connected in sequence. Finally, the complete model is established [4].

parametric design of loop-shaped single-layer spherical lattice shell

(1) Calculate Node Coordinates and Define Node Numbers

First, establish a node for the reticulated shell structure, so that the vertex number is 1 and its coordinates are (0,0,f). The vector height f is first divided by the proportional coefficient t to determine the z coordinate; according to the spherical equation in the Cartesian coordinate system Determine the sphere radius R1 and R2 (R1=S1/2, R2=S2/2) and the coordinates of the ring area (x,y,z), x=R1×cos (360×() J-1)/k0) ×, y = R2 × sin (360 × (j-1)/k0) ×, z = t × f, and then node numbering is performed using the APDL loop statement.

(2)Rod connection

The ring members are connected to establish the node cycle DO,i,1,Nx, the first to the Kn-1 symmetry zone of the 1st to Nx-loop node cycles DO,j,1,Kn-1,1,the last one The symmetry zone needs to be handled separately. Connect the nodes 1+Kn×(i-1)+j and 1+Kn×(i-1)+j+1, and then make the ring rod connection DO,j,3,kn-1,2 on the first circle on the top Connect node j, j+2. The last area loop of the i-th circle is formed by connecting node 1+Kn×i and node 1+Kn×i-Kn+1.

The connection of the radial rod establishes the node of the ith (i=1,...Nx-2) loop node DO,i,1,Nx-2,j (j=1,3...Kn-1) symmetry zone The cyclic DO,j,1,Kn-1,2 connection nodes 1+Kn×(i-1)+j and node 1+Kn×i+j generate residual radial bars. The remaining radial bar connection establishes the node in the ith (i=1,...Nx-1) loop node cycle DO,i,1,Nx-1,j (j=2,4,6...Kn) symmetry zone The cyclic DO,j,2,Kn,2 connection nodes 1+Kn×(i-1)+j and node 1+Kn×i+j generate the remaining radial bars.

Connect the slanted rods to establish the cyclical DO of the i, i, ..., Nx-1 loop nodes in the DO, i, 1, Nx-1, j (j=1, 2...Kn-1) symmetry loops. ,j,1,Kn-1, connecting the left oblique node of the i-th circle and the i+1-th circle, connecting node 1+Kn*(i-1)+j and node 1+Kn*i+j+1 Unit member. Connect the i-th circle and the i+1th circle right slanting node, and connect the nodes 1+Kn*(i-1)+j and node 1+Kn*i+j-1 to generate the unit bar. The last symmetry zone node connects node 1+Kn*(i-1)+1 and node 1+Kn*(i+1)[5].

Analysis of the mechanical behavior of a single-layer spherical reticulated shell

Apply structural restraints and loads

The outer shell of the reticulated shell is restrained by a movable hinge support. Considering the weight of the structure itself and including the weights of the rod and the joint, a uniform load of 2.35 kN/m2 is applied on the surface of the structure and the weight of the structure is considered. The hinge of the structure is hinged[6]-[8].

Macro-geometrical parameters of a zigzag spherical single-layer reticulated shell

As shown in the figure below, different vector heights, displacement clouds and most unfavorable stress clouds Table 3.1

Outer edgeS1/m，	Inner edgeS2/m，	circumferential area fraction/kn	Radial area fraction/nx	height /f
80	70	32	14	20
				30
				40
				50
				60

According to the "Technical Specification for Spatial Grid Structure", the maximum deflection of a single-layer reticulated shell shall not exceed four hundredths of the short span, and the allowable stress steel strength shall be 215 mpa. The following figure shows the displacement of the reticulated shell under different vector heights. Cloud maps and most unfavorable stress clouds are shown in the figure below.[9]

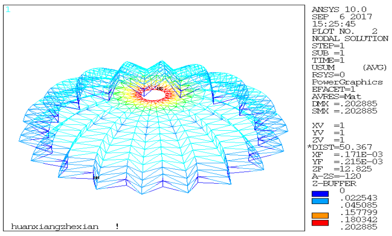

Figure 2

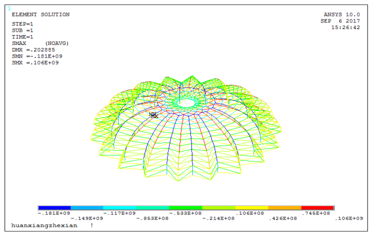

Figure 3

The table is summarized in Table 3.4

Outer edgeS 1/m，	Inner edge S2/m S2	Height/f	Span-span ratio	maximum displacement/m	structural allowable displacement/m	most unfavorable stress	structural allowable stress
80	70	20	2/7	0.301808	0.175	267	215
		30	3/7	0.203654		181	
		40	4/7	0.167523		151	
		50	5/7	0.155755		146	
		60	6/7	0.153387		145	

Comparative analysis of the mechanical properties of the same type single-layer spherical lattice shell[10]

Schwerdler single-layer spherical reticulated shell subjected to the same span

Table 3.5 Schweitzer summary

Span/S	Height/f	Span-span ratio	maximum displacement/m	structural allowable displacement/m	most unfavorable stress	structural allowable stress
80	20	2/7	0.152468	0.175	424	215
	30	3/7	0.083479		283	
	40	4/7	0.053676		214	
	50	5/7	0.042134		173	
	60	6/7	0.041172		147	

Conclusion

(1)Through the comparison of the two reticulated shells, it is found that under the same conditions, the mechanical properties of Schwigler's single-layer spherical reticulated shells are not as good as those of the hoop-folded single-layer spherical reticulated shells.
(2)The displacement of the zigzag single-layer spherical reticulated shell at the apex is the largest, and the displacement at other locations is relatively small. As the height increases, the displacement at the vertex gradually decreases.
(3)Observe the most unfavorable stress through comparison. As the height increases, the most unfavorable stress gradually decreases and meets the requirements, but when the height increases to a certain value, when the height is increased again, the upper unused space is increased, and the steel consuming beam is increased. And cost.

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