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THE VIBRATION REDUCING PERFORMANCE OF SINGLE-LAYER OVAL LATTICE SHELL WITH BUCKLING RESTRAINED BRACES

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ABSTRACT :

This paper reports on how to reduce earthquake responses for a single layer lattice dome installed with buckling restrained braces. The software of nonlinear finite element analysis ANSYS has been used and the single-layer oval Lattice Shell is modeling and analyzed with Buckling Restrained Braces(BRBs) on vibration reducing performance. On the assumption that the material modal of steel is the perfect elastic-plastic modal, the single-layer landing oval shell works under the effect of 3-dimension El-Centro and Taft wave during the course of the analysis. The result shows that the displacement response of the key-points and the force of the structure on the shell equipped with BRBs decrease evidently. This paper compares the different position of the BRBs in the single-layer landing oval shell as well, and puts forward the arrangement principle of the BRBs.

KEYWORDS: Buckling Restrained Braces, oval Lattice shell，single-layer dome，vibration reducing performance, arrangement of BRBs.

1. BACKGROUND

Because single-layer oval lattice shell has streamline shape and good structure characteristics, there are a lot of practical engineering applications, such as the Shanghai Science and Technology Museum, National Grand Theatre and so on. The safety large public building under during strong earthquake shaking is very important. The traditional seismic design method relied on enhanced the cross sectional of components and strengthening structural rigidity. In recent years, there is emerging a new way for seismic designð vibration control techniques，namely energy dissipation and vibration reduction of structure, the essence of which is installing energy dissipation components in the structure. Buckling-Restrained Braces is a new developing energy damping devices in recent years, it has been large-scale application in Japan and Taiwan region. But ,most of them have been used in steel frame structure. In this paper, a single layer lattice dome installed with buckling restrained braces has been carried out. Figure 1 is construction of buckling-restrained braces that offers strength energy dissipation. The internal steel core encased in a steel tube filled with concreate. Buckling-restrained braceôs basic working principle is shown in Figure2.

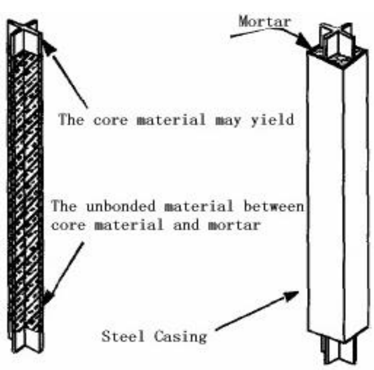


Fig.1 Construction of BRBs

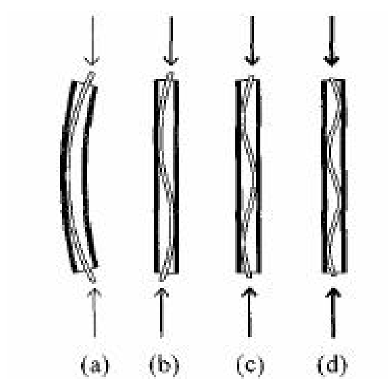


Fig.2 BRBsôworking Principle

2. FINITE ELEMENT MODEL

The finite element model has been established. The shell is K8 single-shell landed ellipsoid network(see figure 3),and the long span is 80m,short span is 50m, and high vector is 20m, vector-ratio is 0.4. Network shell landed directly, so donôt consider the lower stiffness, the bound is three ways to fixed hinge bearing, while the bottom of rib direction left about 4m high and 3m wide openings to conform to the actual situation. Ribbed by the $\phi 273 \times 10$mm circular pipe, Central rib $\phi 203 \times 8$mm, ramps at $\phi 168 \times 7$mm. Buckling Restrained Bracesô the yield strength is 100 MPa, modulus of elasticity is 210 GPa, the density is 7850 Kg/m^3, section size is about 0.8 times of the barôs. Load is 2.44 kN/m^2. Beam188(3D beam element) has been selected in ANSYS.
The structures are imposed on the three-dimensional El-Centro wave and Taft wave analysis in seismic fortification of the intensity of 8 rare earthquake, the basic acceleration of the earthquake is 0.2g in the ellipsoid shell with BRBs after the shock absorber response, the peak acceleration is 400gal. The original structure is imposed on seismic waves, the structure is found that the nodal displacements are larger universal values at the bottom, maximum nodal displacements in the structure are at the bottom. To take the six kinds of BRBs layout scheme. Layout is shown in Figure 4.

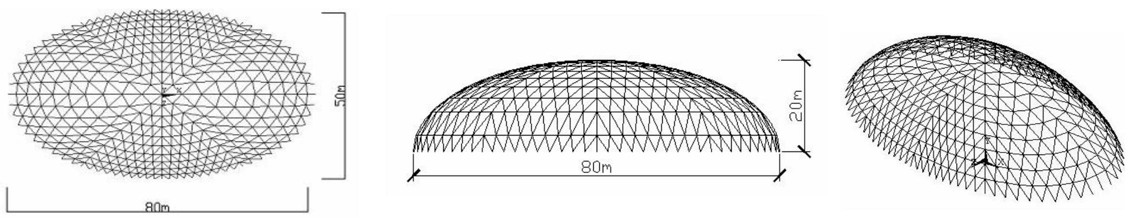


Fig.3 Finite element model diagram

3. THE RESULTS AND ANALYSIS

Generally speaking, the layout BRBs after the six kinds of programmes compared with the original structure, the nodal displacements are lower and bar axial force decreased significantly, the damping effect is obviously.

3.1 Comparison of the Nodal Displacements

In the intensity of earthquake proof 8 degrees rare earthquake, and to impose Taft wave and El-Centro wave the nodal maximum displacementôs comparison is in Table 1.

Table 1 Comparison of maximum nodal displacements under Taft, El Centro Save

Arrangement	Node maximum displacement under Taft Save		Node maximum displacement under El Centro Save	
	Node maximum displacement（cm）	Percentage of reduced nodal displacements（%）	Node maximum displacement（cm）	Percentage of reduced nodal displacements（%）
Original structure	25.6	/	27.7	/
Layout Option 1	23.9	6.64	22.0	20.58
Layout Option 2	22.9	10.55	22.9	17.33
Layout Option 3	22.0	14.06	24.7	10.83
Layout Option 4	20.9	18.36	24.2	12.64
Layout Option 5	21.6	15.63	24.3	12.27
Layout Option 6	21.5	16.02	22.8	17.69

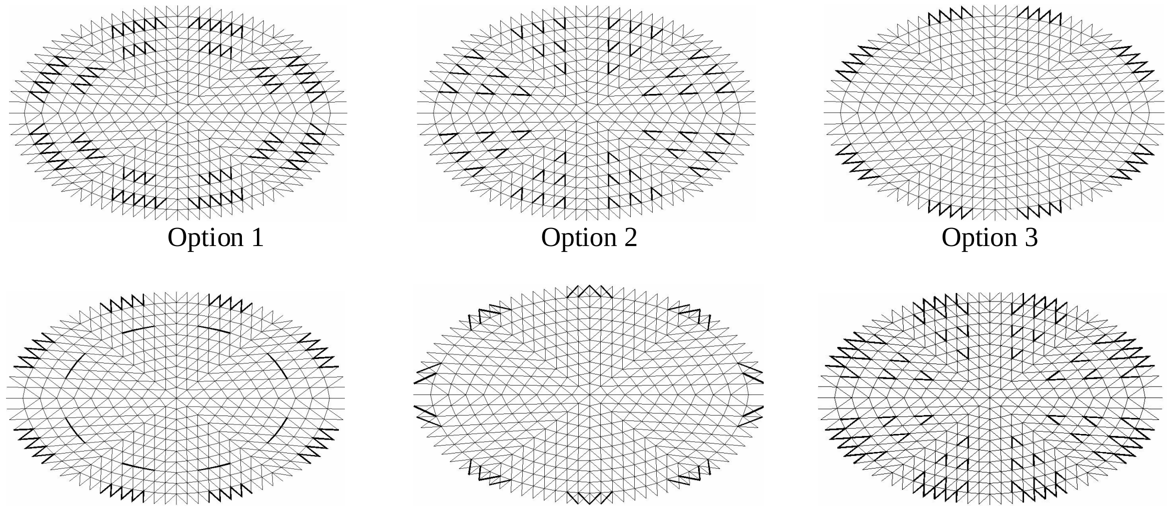
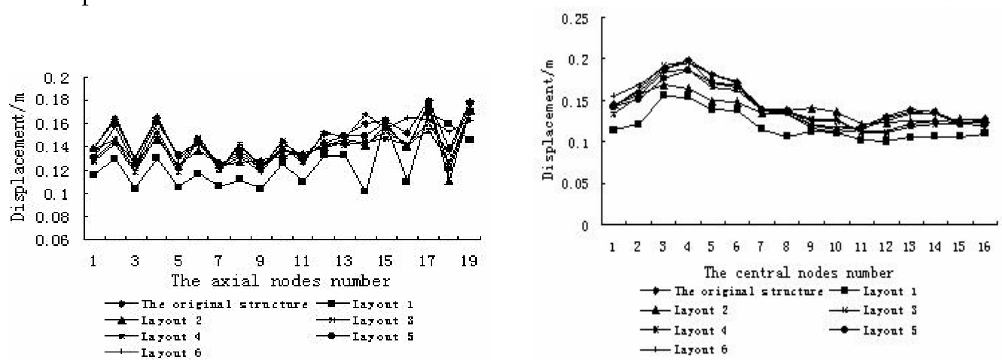


Fig.4 Layout support
Bar structure Supporting bar pieces

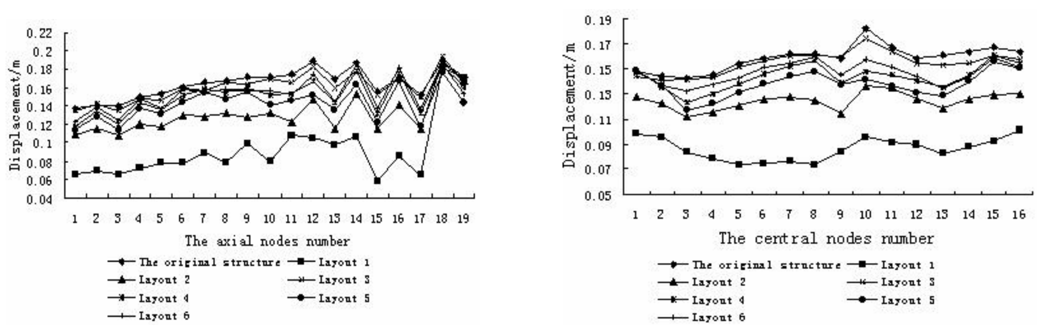
On the structure of maximum displacement, can be found from Table 1,under the Taft layout support of a programmed to reduce the maximum displacement of the smallest, and the support of other layout programmed have significantly reduced the maximum displacement. Under El-Centro wave the first programmerǿs damping effect of the displacement is the most obvious, and under Taft wave the support arrangement under Option 4 damping effect of the displacement is the most obvious. This shows that the different types of seismic waves on the same layout support for the peak displacement have different effects on the whole, however, the layout constraints buckling support structure after the peak displacement compared with the original structure is reduced. At the same time, in order to see the layout BRBs after the entire structure of the impact of displacement, and also compared the Taft wave and El-Centro wave buckling under six bound programmed support layout axial nodes, the nodes to the Central displacement of the original axial structure nodes, the nodes of the Central displacement values are shown in Figure 5 and Figure 6. From Figure 5 and 6, the displacement of structure, can be found under Taft wave action, support program 1 and 2 layout of the structure to reduce the overall value of the displacement have the most obvious effects, and other support program layout relatively are less Obviously; In El-Centro wave, the layout of various support program are more ideal, especially layout support program of Option 1 have the most obvious effects.

Under Taft wave, the structureǿs axial nodesô displacement with BRBs is less than the original axial nodesô displacement and the value of the of the largest node is 36.4% lower, and layout structure with BRBs of the Central nodal displacements has the largest decrease 28.8 percent than the original value of the ring structure of the nodal displacements. Under El-Centro wave, layout BRBsô structure the axial nodes displacement is 32.1% lower than the original value of the axial displacement of the largest node, and layout structure with BRBs of the Central nodal displacements value is 25.0% decrease largest than the central of the original structureǿs nodal displacements. Therefore, as the displacement of the structure under two seismic waves, the axial nodal displacement of structure with BRBs has better effective than ring nodes to reduce the value of the displacement. Through the above analysis can be found, support layout scheme 2 and 6 on the peak displacement of the structure have a more obvious effect of the reduction, and support layout Options 1, 2 and 6 on the entire structure of the displacement have a more obvious effect of the reduction. This shows that the support layout scheme 1,2 and 6 is relatively good for the damping effect. To analyze the reasons for the support 1,2 and 6 of the supporting bar layout uniform, and a good number of reasonable, and support layout Options 3 and 4 layout at the bottom of the structure in the main, a relatively small number, can not fully absorb seismic energy transmission, the effect of energy consumption structure is not ideal. Layout scheme 5 is additional structural support and is mainly concentrated in the bottom of the structure, number fewer but has better results than layout 3 and 4. Therefore, the arrangement should absorb the greatest degree of energy and then be good results to the displacement response of the structure, which requires not only supporting bar to the location of a suitable arrangement, the number to a reasonable layout. Through six kinds of support programmesø displacement response comparison with the displacement response of the original structure, the BRBs can be found in the layout of the structure at the bottom and the upper part should be properly layout, the number of BRBs pieces of the structure is about 10% of the number of the whole structureøs bar.



(a) The displacement of axial nodes (b) The displacement of central nodes

Fig.5 Nodal displacements of different arrangement under Taft wave

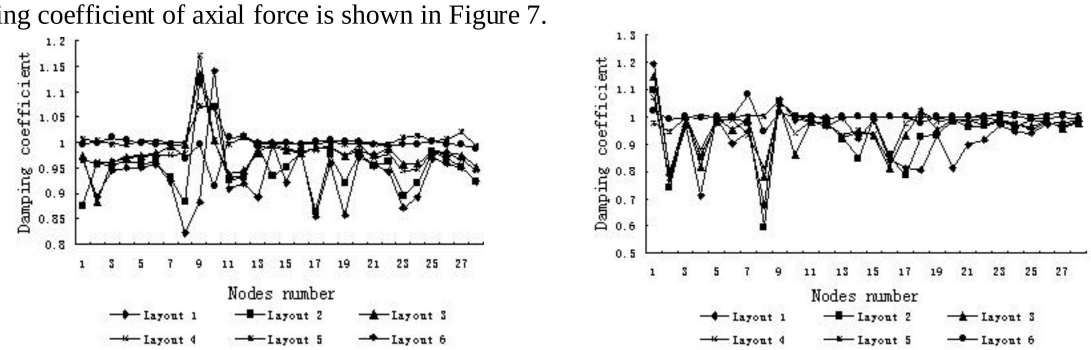


(a)Displacement of axial nodes (b)Displacement of central nodes

Fig.6 Nodal displacements of different arrangement under EI-Centro wave

3.2 Comparison Bar Axial Force

The damping coefficient has been defined K, K= N1/N2. N1 indicated the maximum axis response of structure with BRBs, N2 indicated the maximum axis response of structure without BRBs. The Two seismic waveøs damping coefficient of axial force is shown in Figure 7.



(a) Under the Taft wave damping coefficient of axial force (b) Under the El-Centro wave damping coefficient of axial force

Figure 7 Comparison of damping coefficient of axial force

Apart from the layout 5 and 6ôs damping coefficient generally close to 1, the remaining support for the majority of layout bar axial force is quite obviously lower. In addition, these layout 5 in the original structure remain unchanged, additional supporting bar pieces of the system, according to calculation can see that the additional support of structural layout of the structure under the impact of internal forces is not very obvious, but the largest displacement response can be reduced 12%, as the additional support after the overall structure of the outcome variable stiffness, the appropriate additional supporting bar of the deformation of the structure can be controlled better play the role.

4. CONCLUSIONS

This paper analyzes for single layer lattice dome installed with buckling restrained braces on the vibration reducing performance. The three-dimensional El-Centro, Taft wave was imposed on the different structure models. Structural displacement and the axis force have been carried out, the following conclusions can be obtained:

（1）Appropriate layout of the BRBs, the structure would reduce the peak displacement, and lower the overall structure of displacement.

（2）BRBs on the axial forces is a better-reduced role. However, there is the different effect under different arrangement of BRB. BRBs should be bound by buckling layout uniform and rational. At the bottom of the main structure layout, short axis direction to appropriate more, also should be in the upper appropriate layout. The total number of the BRBs should be about 10% of the structure.

（3）The displacement and internal forces response of the on the one structure is not same as under different wave. Generally, It is more sensitive under EI-Centro wave than Taft wave.

(4). BRB is a good absorber energy component. It is very effectively for large-span spatial structure to improve anti-seismic and enhance safety of large-span spatial structure.

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