# The earthquake to one folding plate space truss structure roof lower chord nodal displacement influence

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**Abstract.** In the ANSYS environment, when the connection between the steel roof and bearing are rigid and hinged, do the modal analysis for this gird roof by using the subspace iteration method, get the former 50 order natural frequencies and mode shapes of this structure, and do time-procedure analysis to understand the seismic performance of the gird roof structure. By doing contrastive analysis of the former 50 order mode shapes, we find that the frequency distribution of the structure is relatively dense, so we not only need to consider the low order modes, and also should consider the impact of the higher modes of the structure during seismic analysis; under eight degree rare earthquake, we use revised EI-Centro earthquake wave to do time-procedure analysis for this structure, the result shows that: in high seismic intensity area, the influence of Vertical seismic to the large span structure is relatively obvious, so we can't neglect the influence of Vertical seismic during the seismic analysis; the kinds of the bearing type has little effect on overall structural dynamic performance of this structure.

## Introduction

As a new form of the spatial structure, the folded plate grid structure is the combination of plat-panel. With good mechanical properties, sleek figure, easy to construct features, the folded plate grid structure has been wildly applied to varieties of public buildings. This paper takes a newly built railway station as research object due to its folded plate truss roof structure and focus on the analysis of mechanical characteristic hoping to provide a reference for later design and construction .Finite element model of a roof. This paper analyze the grid structure between two expansion joints of a folded plate type latticed roof of a train station with the ANSYS finite element and simulates the structural Members in the grid structure with space beam element. Regarding to this station, the roof is supported on steel columns. This paper simulates the folded plate type grid structure with hinge support and fixed support and investigates the influence that different types of support to stress performance of grid structure. The roof bottom chord nodes as shown in Figure1:

Under the influence of structure weight, all the materials which the model was built with are linear elasticity. And the steel structure's elastic modulus E is 206-109, Poisson's ratio of 0.3, a density of 7850kg/m3 [23-24].Top view of finite element model of a roof showed in Figure 2.

## Analysis Model

An 8-degree seismic fortification intensity and a 0.2g earthquake acceleration are applied in the construction. According to the Current China Seismic Design Code of building GB50011-2010, it is better to do Elasto-plastic time-history analysis of reinforced concrete structure and steel structure when soil type Ⅲ and Ⅳ with 7-degree seismic fortification intensity or RC Category II Framework with 8-degree seismic fortification[12]. Meanwhile Seismic Design Code of building GB50011-2010 set up specific provisions that different intensity should take certain peak of earthquake acceleration time histories: peaks of earthquake acceleration in rare 6, 8, 9 degree of seismic intensity are 18cm/s2, 70cm/s2, 140cm/s2 separately; as for peak of frequent 6, 8, 9 degree

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of seismic intensity are 125cm/s2, 400cm/s2, 620cm/s2 separate The paper is focus on time-history analysis in rare earthquake response. And the peak ground acceleration of 8 degree earthquake is 400cm/s2. The Imperial Valley earthquake happened in 1940 is the EI Centro waive with 0.02s time steps.

## Results and Analysis

Tab.1 Node displacement of A axis of the roof lower boom

| Node | UX(mm) | | UY(mm) | | UZ(mm) | |
|---|---|---|---|---|---|---|
| | hinge | fixed | hinge | fixed | hinge | fixed |
| 67 | -32.591 | -32.842 | 12.134 | 12.037 | 31.911 | 32.893 |
| 68 | -33.595 | -33.873 | 11.551 | 11.541 | 16.378 | 16.899 |
| 69 | -33.16 | -33.422 | 10.888 | 10.887 | 25.328 | 25.34 |
| 70 | 20.494 | 19.994 | 7.9823 | 8.1968 | 23.357 | 23.634 |
| 71 | 16.61 | 15.973 | 6.7802 | 6.9707 | 26.268 | 26.021 |
| 72 | 14.827 | 14.164 | 5.4253 | 5.5575 | 23.789 | 23.116 |
| 73 | 13.429 | 12.755 | 4.3344 | 4.4297 | 15.025 | 14.772 |
| 74 | 12.616 | 11.773 | 3.1394 | 3.1851 | 4.6823 | 4.6937 |
| 75 | 13.435 | 12.374 | 2.1607 | 2.1641 | -10.012 | -9.5462 |
| 76 | 15.57 | 14.296 | 1.8798 | 1.8461 | -17.795 | -16.859 |
| 77 | 18.23 | 16.715 | 2.3216 | 2.5705 | -16.249 | -14.906 |
| 78 | 19.48 | 17.848 | 2.5075 | 2.7754 | 7.2994 | 7.2962 |

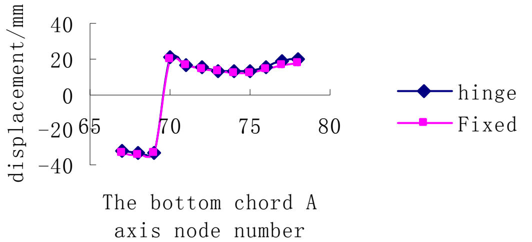


Fig.3Node displacement UX of A axis of the roof lower boom

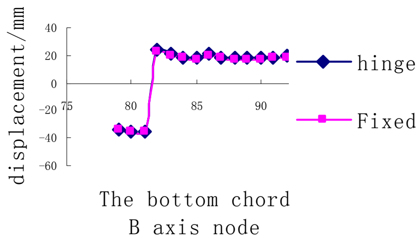


Fig.6Node displacement UX of B axis of the roof lower boom

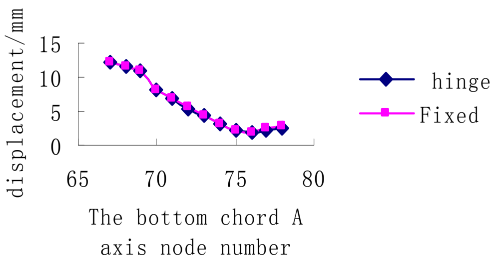


Fig.4Node displacement UY of A axis of the roof lower boom

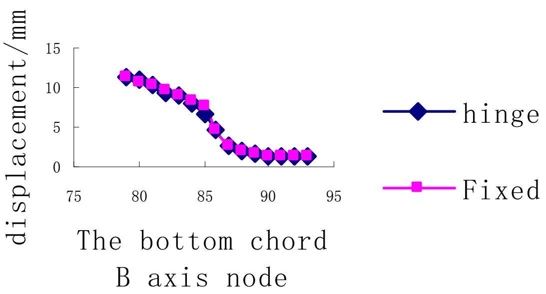


Fig.7Node displacement UY of B axis of the roof lower boom

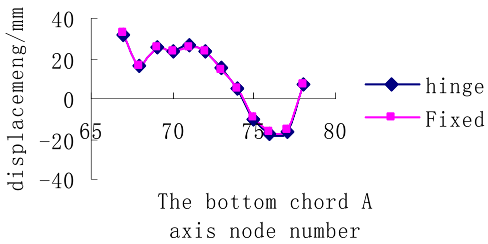


Fig.5 Node displacement UZ of A axis of the roof lower boom

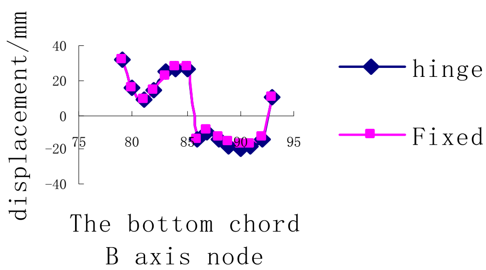


Fig.8Node displacement UZ of B axis of the roof lower boom

From Table 1 and Figure 3 to 5, we know that when we take hinge support, the horizontal displacement UX of node 67 to node 69 in A axis of the bottom chord of roof is less than that of fixed support. The maximum gap showed when the node is 69, that is, the horizontal displacement of hinge support is 99.216% of that of fixed support. When it comes to the remaining nodes, the horizontal displacement of hinge support is more than that of fixed support. And maximum gap occurred when the node is 78, that is horizontal displacement of hinge support is 109.244% of that of fixed support.

Other than node 76, the hinge support's horizontal displacement UY of node 70 to node 78 is less than that of fixed support. And maximum gap happened when the node is 71, that is, hinge support's horizontal displacement is 97.267% of that of fixed support; when it comes to the remaining nodes, the horizontal displacement UY of hinge support is more than that of fixed support. And maximum gap occurred when the node is 76, that is horizontal displacement of hinge support is 101.825% of that of fixed support.

Node 67 to 70 and the node 74 in the hinged support's vertical displacement UZ are less than that of fixed support. And maximum gap happened when the node is 68, that is, the vertical displacement of hinge support is 96.917% of that of fixed support. When it comes to the remaining nodes, the vertical displacement UZ of hinge support is more than that of fixed support. And maximum gap occurred when the node is 77, that is vertical displacement of hinge support is 109.009% of that of fixed support.

Tab2 Node displacement of B axis of the roof lower boom

| Node | UX(mm) | | UY(mm) | | UZ(mm) | |
|---|---|---|---|---|---|---|
| | hinge | fixed | hinge | fixed | hinge | fixed |
| 79 | -33.343 | -33.603 | 11.318 | 11.217 | 31.342 | 32.183 |
| 80 | -35.046 | -35.357 | 10.841 | 10.815 | 15.491 | 15.918 |
| 81 | -34.982 | -35.294 | 10.331 | 10.389 | 9.1474 | 9.1461 |
| 82 | 24.376 | 23.262 | 9.4065 | 9.5516 | 14.317 | 14.306 |
| 83 | 20.989 | 20.153 | 8.9653 | 9.0349 | 24.86 | 22.593 |
| 84 | 18.828 | 18.076 | 7.9656 | 8.2476 | 26.691 | 27.161 |
| 85 | 18.256 | 17.453 | 6.7802 | 7.6408 | 26.981 | 27.348 |
| 86 | 20.833 | 19.985 | 4.6118 | 4.6616 | -14.559 | -14.812 |
| 87 | 18.623 | 17.727 | 2.5431 | 2.5778 | -9.6508 | -8.2727 |
| 88 | 18.136 | 17.212 | 1.8976 | 1.8831 | -14.311 | -12.508 |
| 89 | 18.006 | 17.053 | 1.6845 | 1.6408 | -17.734 | -16.078 |
| 90 | 18.206 | 17.213 | 1.3975 | 1.3604 | -19.349 | -17.613 |
| 91 | 18.751 | 17.711 | 1.3484 | 1.4074 | -17.937 | -16.331 |
| 92 | 19.922 | 18.808 | 1.2089 | 1.4062 | -14.767 | -13.464 |
| 93 | 20.732 | 19.574 | 1.2348 | 1.4218 | 10.6448 | 10.616 |

From Table 2 and Figure 6 to 8, the hinged horizontal displacement UX of node 79 to 81 in B-axis of lower chord of a roof is slightly smaller than when the horizontal displacement UX fixedly connected, in which node 81 the difference between the maximum horizontal displacement when the hinge is 99.216% of the solid bonding;

when it comes to the remaining nodes, the horizontal displacement UY of hinge support is more than that of fixed support. And maximum gap occurred when the node is 78, that is horizontal displacement of hinge is 101.825% of that of fixed.

Node 81 to 87, and node 91 to 93, the hinge horizontal displacement UY is less than that of fixed support. And maximum gap happened when the node is 92, that is, hinge horizontal displacement is 85,695% of that of fixed connection; when it comes to the remaining nodes, the horizontal displacement UY of hinge is more than that of fixed connection. And maximum gap occurred when the node is 96, that is horizontal displacement of hinge is 101.825% of that of fixed.

Node 79 to 80 and the node 84 to 86 in the hinged vertical displacement UZ are less than that of fixed. And maximum gap happened when the node is 80, that is, the vertical displacement of hinge is 96.318% of that of fixed. When it comes to the remaining nodes, the vertical displacement UZ of hinge is more than that of fixed. And maximum gap occurred when the node is 89 that is vertical displacement of hinge is 110.348% of that of fixed.

## Summary

Under the same form of support, although the maximum displacement of the roof node in the vertical seismic action is less than in the horizontal direction under earthquake displacement, the displacement of the structure in the vertical seismic action is non-negligible, indicating that it is necessary to take into account the impact of the horizontal seismic action on structures, but also consider the impact of vertical seismic effects on the structure when do the rare earthquake time history analysis of he folded plate latticed frame structure.Above comparative analysis shows that support types have little effect on the overall structural dynamic performance of this structure.

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