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# The Influence of Low Temperature on Isolation Bearing is Briefly Discussed

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## Abstract

**With the continuous development of the isolation system, the use of the isolation bearing environment is more and more complex, and there will be a large temperature difference in the actual project. In China, the mechanical property parameters of the isolation bearing under different temperature conditions are generally fixed values and the isolation bearing will produce errors when working at low temperature. The low temperature will have a great impact on the mechanical properties of the isolation bearing. How to give full play to the performance of the isolation bearing in a low temperature environment has become an inevitable problem.**

## Keywords

**Low Temperature; Isolation Bearing; Working Performance.**

## 1. Introduction

China is located in the middle of the Pacific Seismic Belt and the Eurasian seismic belt, with complex geological structures and frequent earthquakes. To reduce the loss caused by earthquakes, many researchers continue to explore,and great progress has been made in isolation technology [1][2][3].Base isolation technology is widely used because of its low cost and good performance [4]. The isolation bearing weakens the damage to the structure and effectively improves the stability of the superstructure. Many engineering structures have adopted isolation technology to successfully withstand the damage of earthquakes [5].In winter, the temperature in the northern part of China isotherm is basically below zero [6], especially in northeast China. It is necessary to study the influence of low temperature on the working performance of isolation bearing in these places. In this paper, the influence of low temperature on stiffness, deformation and hysteresis curve of isolation bearing is summarized briefly.

## 2. Research Status of Influence of Low Temperature on Isolation Bearing

### 2.1 The Influence of Low Temperature on the Working Performance of Isolation Bearing

#### 2.1.1 Effect of Low Temperature on Laminated Rubber Bearing

You Shiqi et al [7].conducted vertical deformation test, horizontal deformation test, horizontal reciprocating loading test and different compressive stress tests to study the influence of low temperature on laminated rubber bearings. The isolation bearing includes two laminated rubber bearings, which are provided by Shantou Isolation Equipment Industrial Company and Huazhong University of Science and Technology respectively. The first kind of vibration isolation bearing rubber pad material is hard, using a integral vulcanization process, bonding type; The second kind of isolation bearing is the use of soft rubber pad, the production of laminated, non-bonding type, its external diameter, height, effective pressure diameter, effective pressure area, the total thickness of the rubber layer is less than the first kind of isolation bearing.

In the vertical deformation test, the vertical compressive stress is 1MPa, 5MPa, 10MPa and 15MPa successively. The vertical deformation value is measured at -13℃ and 3℃, and the vertical compression stiffness of laminated rubber bearing is observed at low temperature. With the increase of vertical compressive stress, low temperature has a great influence on vertical compression. The deformation of the second kind of isolation bearing is larger at the same temperature, and the deformation increases with the increase of the force. At different temperatures, the lower the temperature, the smaller the deformation. In the horizontal deformation test, the fixed value of vertical compressive stress is 5MPa, the temperature is different, and the displacement value of horizontal dislocation is 0.25 times the thickness of the rubber layer. The horizontal force is tested, and the horizontal stiffness of the laminated rubber bearing is observed at low temperature. The experiment shows that low temperature has a certain influence on the horizontal stiffness of the isolation bearing. The horizontal stiffness of the second kind of isolation bearing with soft material is greatly affected by low temperature. At -14℃, the horizontal stiffness increases by 2.81 times.For laminated rubber bearing,see Figure 1.

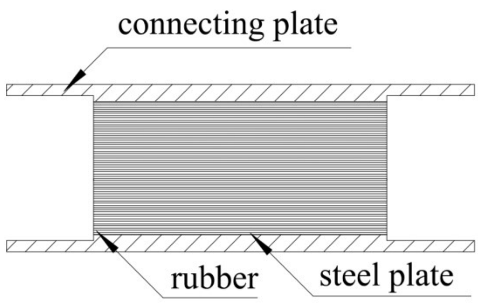


**Figure 1.** laminated rubber bearing

### 2.1.2 Influence of Low and High Temperature on Lead Rubber Bearing

Cheng Zhiyuan et al [8].studied the influence of low and high temperature on lead rubber bearing and conducted pseudo-static tests. Two kinds of experimental devices are used, pressure and shear testing machine, temperature control box and GZY400 type isolation bearing. Data sources are mainly for controlling vertical loading and horizontal loading, collecting displacement data and force data, and drawing hysteresis curves. The isolation bearing into the temperature change control box, adjust the temperature of the device, reach the set temperature, 24h after the placement of rapid handling of the isolation bearing to the compression shear testing machine, this process requires the use of an insulation cotton pad to maintain the isolation bearing temperature, the use of compression shear testing machine for the isolation bearing pressure of 12MPa vertical loading, horizontal displacement γ=100% hysteresis test, After the completion of the first experiment, the next experiment was carried out after 24h cooling. The hysteresis curve of isolation bearing is affected by low temperature and its mechanical properties change gradually. At high temperature, the hysteresis performance of isolation bearing is not different from that at room temperature. At low temperature, the hysteresis curve is significantly different from that at normal temperature. The hysteresis curve has an upward trend. With the decrease in temperature, the hysteresis area gradually increases and the energy consumption increases.

In this study, a five-story reinforced concrete frame building with LRB isolation supports is taken as an example.To simplify the calculation, eccentricity is not considered and the mass distribution and stiffness distribution are assumed to be uniform. The input seismic waves are the Kobe wave, El-Centro wave and Duzce wave. In the case of earthquakes, the peak acceleration is 70 cm/s2, and in the case of rare earthquakes, the peak acceleration is 400cm/s2. In the case of frequent earthquakes, the maximum restoring force of isolation bearing decreases with the increase of temperature, which is contrary to the changing trend under the action of rare earthquakes. Under the comparison of different temperatures, the error of restoring force of isolation bearing is greater in frequent

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earthquakes than in rare earthquakes. When the temperature is lower than 0℃, the calculation error of the restoring force of isolation bearing is greater than 5% in the case of an earthquake. When the temperature is lower than -30℃, the calculation error of the restoring force of isolation bearing is more than 5% in the rare earthquakes. Therefore, it is important to consider the influence of temperature. The restoring force of LRB isolation bearing varies between the calculation results of low temperature and normal temperature. The lower the temperature is, the greater the error will be.

Yang Jiayu et al [9].conducted pseudo static tests to study the influence of extremely low temperature on the mechanical properties of lead-core rubber bearings. The experimental equipment includes a temperature control box, load-shear test machine and GZY500-type isolation bearing. The comparison between low temperature -40℃, -30℃, -20℃, -10℃ and normal temperature 23℃ was studied. The horizontal performance test and vertical compression test were carried out on the lead rubber bearing.

Check whether the temperature control box is working normally. If it is normal, put the isolation support into the device and reduce its temperature by 2 to 3℃ basis on the set temperature. After cooling and insulation for 24h, wrap the isolation bearing support with an insulating cotton pad to the load-shear test machine and install it quickly. Firstly, the vertical compression of the GZY500 isolation bearing is carried out, and then the horizontal performance test is carried out. The first, second and third times of the test are carried out, and then the hysteresis loop is drawn using the data of the third experiment. After the end of the first test, the isolation bearing was left standing at room temperature for 24 h. After the isolation bearing returned to the performance at room temperature, the mechanical property test at other temperatures were repeated. This scheme is different from the above two experiments in this paper. This paper considers the heat transfer problem during transport.

The vertical stiffness measured at low temperature and obtained at 23℃ increased with the decrease in temperature. The vertical stiffness at -40 ℃ increased by 93% compared with that at 23℃. The ratio of vertical stiffness measured at low temperature to that obtained at 23℃ increases with decreasing temperature. It can be seen that the isolation bearing will harden and its performance will be reduced at low temperature. By analyzing the hysteresis loop, it is found that the hysteresis curve area increases with the decrease in temperature.Low temperature has a great impact on the energy dissipation capacity of the bearing, and there is a trend of upward warping. Cheng Zhiyuan et al reached the same conclusion.For lead rubber bearing,see Figure 2.

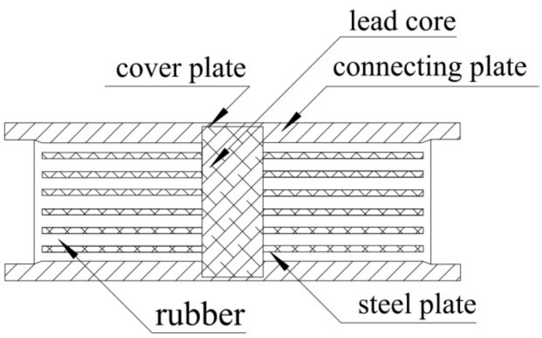


**Figure 2.** lead rubber bearing

### 2.1.3 Effect of Low Temperature on Natural Rubber Bearing

Du Jiewei et al [10].studied the influence of low temperature on natural rubber bearings and conducted a pseudo-static test. Two experimental devices were used, the electro-hydraulic servo loading system and the high and low temperature test chamber. The natural rubber bearing with a shear modulus of 0.392MPa was used as the isolation support, with diameters of 500mm and 600mm respectively. Three different temperatures of -20℃, -30℃ and -40℃ were set to compare with the normal temperature of 23℃.

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The isolation bearing support is placed in the high and low temperature test box, after reaching the set temperature, it is placed for 24h and sent to the pressure testing machine with thermal insulation material. After the completion of the first experiment, the next experiment is carried out after cooling for 24h. In the vertical compression test,a sinusoidal loading wave is applied to the isolation bearing support; in the horizontal shear test, the cyclic three-circle method is used. When the isolation support is pressed 12MPa, the horizontal shear test is carried out on the isolation support, and the horizontal strain is 100%. The experiment shows that LNR500 and LNR600 have roughly the same overall change trend under the influence of low temperature. The influence coefficient of vertical compression stiffness and low temperature on isolation bearing increases with the decrease of temperature. When LNR500 is at the lowest temperature of -40℃, the vertical compression stiffness increases compared with the initial temperature. The vertical compression stiffness of LNR600 also increases compared with that of LNR500. At -30℃ and -40℃, the vertical compression stiffness of LNR500 did not change significantly. The horizontal equivalent stiffness increases with the decrease in temperature, while LNR600 has no obvious change.For natural rubber bearing,see Figure 3.

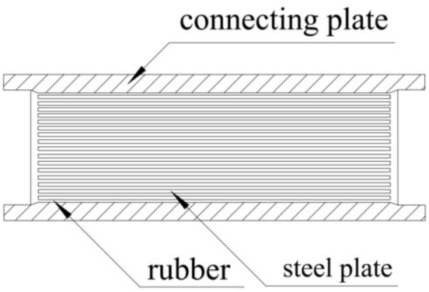


**Figure 3.** natural rubber bearing

### 2.2 Rubber Isolation Bearings with Internal Coils for Cold and Hot Medium

The new isolation bearing studied by Wang Changsheng et al [11].can be used normally under harsh environment. At low temperature, the isolation bearing becomes hard and brittle, and the mechanical properties of the isolation bearing will deteriorate. Through the resistance wire heating change the temperature of the isolation bearing, so that it can keep at the right temperature,to play its best performance. The new isolation bearing is composed of the upper and lower connecting plates and rubber isolation components, the interior is a layer of rubber and steel plate superimposed vulcanization, the internal arrangement of resistance wire and temperature sensor device, when the temperature is lower than the set temperature, resistance wire start, after reaching the set temperature stop. To prevent the resistance wire from having adverse effects on the rubber layer, the resistance wire sleeve is set to prevent adverse factors.

Subsequently, a rubber isolation bearing which can control the temperature was proposed. The isolation support is composed of a cold and hot media coil, temperature sensor and temperature control system and internal vulcanized rubber layer and steel plate layer and other components. When the environment is affected by temperature, the isolation support can be automatically switched on and off, so that the isolation support will work at the appropriate temperature. This new isolation bearing is very similar to the construction principle of the isolation bearing with internal resistance wire, only the resistance wire is changed into cold and hot media coil. When multiple isolation supports work together, the temperature a control system of all isolation supports can be connected in series to realize temperature control jointly for convenience of use. Thus solving the problem that the isolation bearing works normally under low and high temperature conditions.For Rubber isolation bearings with internal coils for cold and hot medium,see Figure 4.

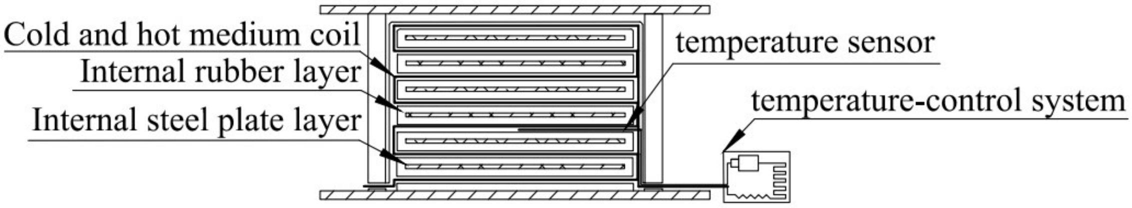


**Figure 4.** Rubber isolation bearings with internal coils for cold and hot medium[11]

## 3. Conclusion

In summary, the influence of low temperature on the isolation bearing cannot be underestimated. low temperature will greatly affect the ground performance of the isolation bearing, so that the protection ability of the isolation bearing on the superstructure is reduced. The lower the temperature, the smaller the deformation of the isolation bearing, and the horizontal stiffness is greatly affected by low temperature. Compared with normal temperature, the hysteresis curve has a great difference, and has an upward trend. The lower the temperature, the larger the hysteresis area increases. The influence coefficients of vertical compression stiffness and low temperature on isolation bearing increase with decreasing temperature. The ratio of vertical stiffness of the isolation bearing increases with the decrease of temperature. The isolation bearing will harden at low temperature, and its performance will be reduced.

The root cause of preventing the influence of low temperature on the isolation bearing is insulation and isolation of cold air. The isolation support is located at the bottom of the structure, and the insulation material is used to wrap the isolation support. Especially in the north of our country, we must consider the local geological condition. If there is a frozen layer, we need to strengthen protection. New temperature control rubber bearing has opened up a new research direction, but it can not be ignored that the problem of how to work normally under bad temperature needs to be solved as soon as possible. Hopefully, more novel controllable temperature bearing will come out, so that the influence of temperature on isolation bearing will be well solved.

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