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The Experiment Research of the MoS_2 Using As the Solid Lubricant

Shi-Rong ZHANG [1,a], Jiang-Le LI [1,2,b], and She-Liang WANG [1,c]

[1]*Xi'an University of Architecture and Technology ,Xi'an 710055,China;*
[2]*Henan University of Urban Construction ,pingdingshan 467036,China*
[a]*122822169@qq.com,* [b]*35563470@qq.com,* [c]*1659128979@qq.com*

Abstract: This paper investigated the theory of the friction sliding isolation structure, The MoS_2 solid lubricant was adopted as isolation bearing friction materials, A new sliding isolation bearing was designed and made. The formula of the friction factor and the compression stress was proposed.

1 Introduction

Isolation solution is a kind of safe and economic damping technology .The friction sliding isolation system adopt a special isolation system which can separate the whole structure into three part: the upper one ,the isolation one and the lower one. It permit the upper part of the structure have a whole horizontal movement towards the foundation or the lower part. Then the transmit of the earthquake power is limited, Meanwhile it can dissipate the earthquake energy through the friction when the structure is sliding .so it can isolate the earthquake. This technology has many advantages, such as easy to carry on, low cost ,avoiding the sympathetic vibration ,extending the structure's natural vibration period and good for considering the random of the earthquake excitation. So the friction sliding system have a wonderful future as a useful isolation technology [1-6].

2 Design of Isolation Bearing and the Friction Factor Experiment

MoS2 is a solid powder with grey metallic luster, Its molecular structure is hexagonal crystal with forms of S-Mo-S connected together as show in Fig .1.S-Mo is connected with strong polar bond which is hard to break ,but S-S is connected with weak molecular link .This link is so weak that it is easy to break down and result in sliding when a small shear stress comes. This kind of sliding plane excite in every couple of sandwich layer ,So MoS2 has more lubricating properties.[7,8]

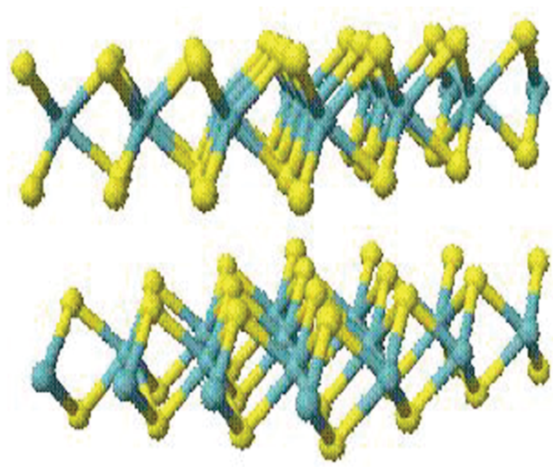
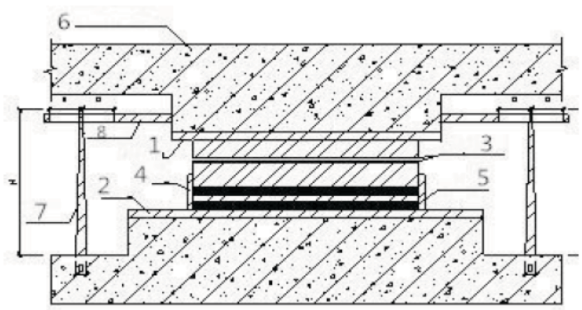


Figure 1. The molecular structure of MoS_2



(1.upper plate 2.lower plate3.MoS_2 layer4 box
5. rubber 6.the bottom foundation beam
7.displacement restrictor 8.director plate)

Figure 2. The new friction sliding isolation bearing

As a good solid lubricating powder, MoS_2 have more advantages of standing high pressure and high temperature, having low friction and wide suitability of speed. For this reason, the new friction sliding isolation bearing was invented as show in Fig .2.

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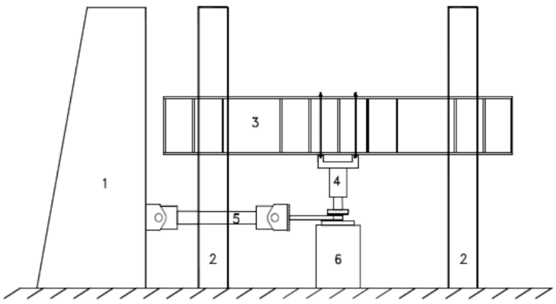
2.1 Experiment Device and Test System



(1.reaction wall 2 reaction frame 3reaction beam
4 hydraulic jack 5 servo actuator 6 pier base)

Figure 3. Experiment device system

Figure 4. Experiment load device

This experiment only test the friction efficient between the steel pate with MoS2 sprayed on for simplicity .The lower cover plate of the friction sliding isolation bearing was fixed at the pier base. The middle slider was connected with the hydraulic jack .The displacement meter were respectively fixed at the upper cover plate ,the lower cover plate and the slider . The pressure was provided by the vertical hydraulic jack. When the applied load reach to the load condition, the pressure was kept unchanged ,then the load was applied by the horizontal hydraulic jack and the value of the horizontal hydraulic jack was recorded .When the middle slider start to slide ,the slider was kept in uniform motion. Then the pressure stopped to apply when the curve of the horizontal force and the displacement occurred horizontal stable stage(the value of the displacement meter is about 6 mm).The servo actuator was unloaded . The system was reloaded and the experiment data was recorded again .The experiment device system was shown in Fig.3. The experiment device was shown in Fig.4.

2.2 Experiment Condition

To test the feasibility and the friction behavior of the designed friction sliding bearing which used MoS2 as the slip material ,The sample' upper cover plate ,lower cover plate and slider were all spayed by MoS2.The vertical pressure were 35t,45t,55t,65t,75t.Every experiment condition was loaded twice. The experiment condition was shown in table .1.

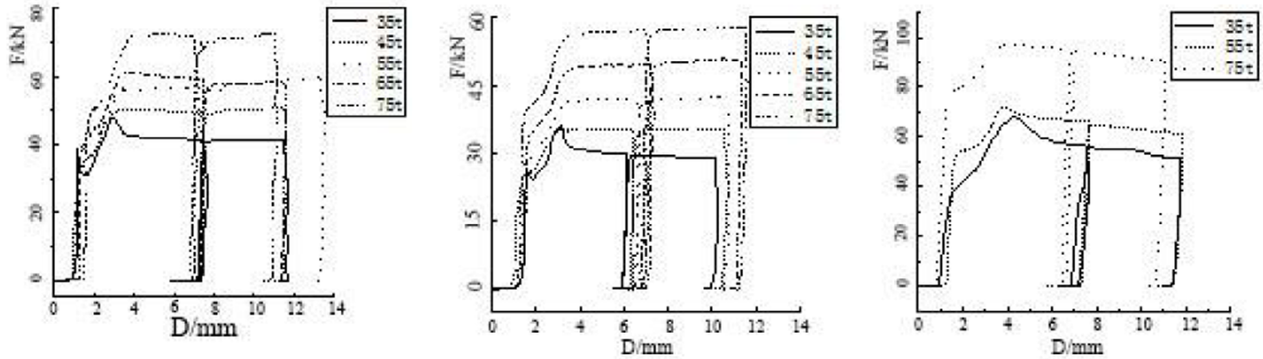
Table 1. The experiment conditions of the friction sliding bearing

Condition	sample	Material	load(t)
1	The sample slider (first, second group)	MoS_2	35
2			45
3			55
4			65
5			75
1	The sample slider (third group)	Carbon fiber cloth	35
2			/
3			55
4			/
5			75

2.3 The Results and Analysis of the Experiment

The curve of the horizontal pulling and the appropriate displacement was shown in Fig.5. The fist part of the chart is the first loading and the second part is the second loading. It shows the curve has a horizontal line at first for the space between the slider and the fixing device. As the horizontal force is increasing, the curve rise vertically. At the initial stage of the sliding ,the slider can't turn behaviors from static to motion state quickly. It is because that there is a initial touching stage at the surface of the upper cover plate ,the lower plate and the slider. At this period the horizontal force and the displacement increase at the same time ,so the curve shows an upward sloping curve. When the slider is sliding totally ,the horizontal force is unchanged but the displacement has a constant increase. The curve reach a horizontal stable stage . At the second time the curve shows more simple ,it has no touching stage just the vertical rise stage and the horizontal stable stage is there as shown.

It indicate that the friction efficient is not large with the first group and the second group. The friction curve are smooth when the bearing at the total sliding stage. The frictional behavior are stable and the material MoS_2 is a good friction material. It can be used in the isolation system. But the third group is not suitable ,The friction efficient of the third group is obviously larger .Replacing MoS_2 with the carbon fiber cloth on the bearing makes the friction efficient unstable, and the friction behavior is not as stable as the material MoS_2.So the carbon fiber cloth is not a suitable friction material.



(a) the first group (b) the second group (c)the third group

Figure 5. the horizontal force and the displacement curve

The first two group of samples had a slim abrasion on the surface of the friction plane as shown in Fig .6.The friction material and the slider were in good conditions. But the third group had a terrible tearing as shown in Fig.7.

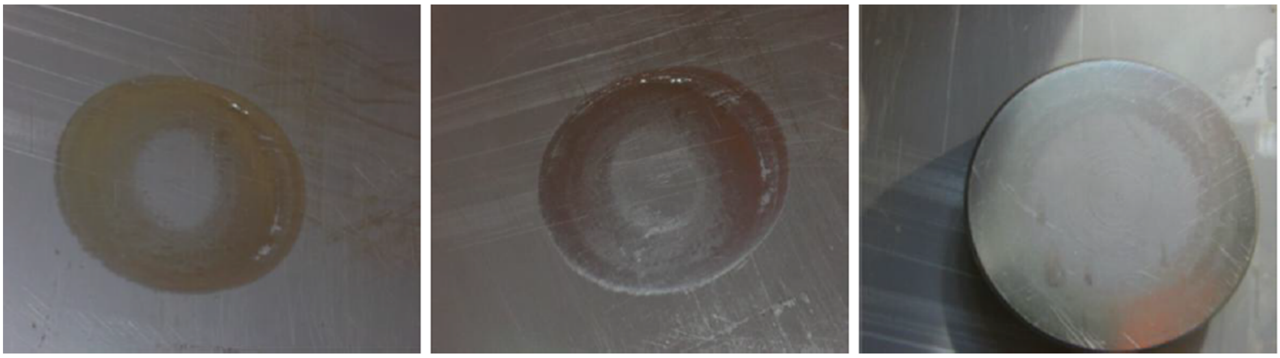


Figure 6. The upper cover plate, the lower cover plate and the slider after the experiment

Figure 7. the carbon fiber cloth before the experiment and after the experiment

The friction efficient of the MoS2 material can be tested from the respective restoring force curve as shown in Fig.8.

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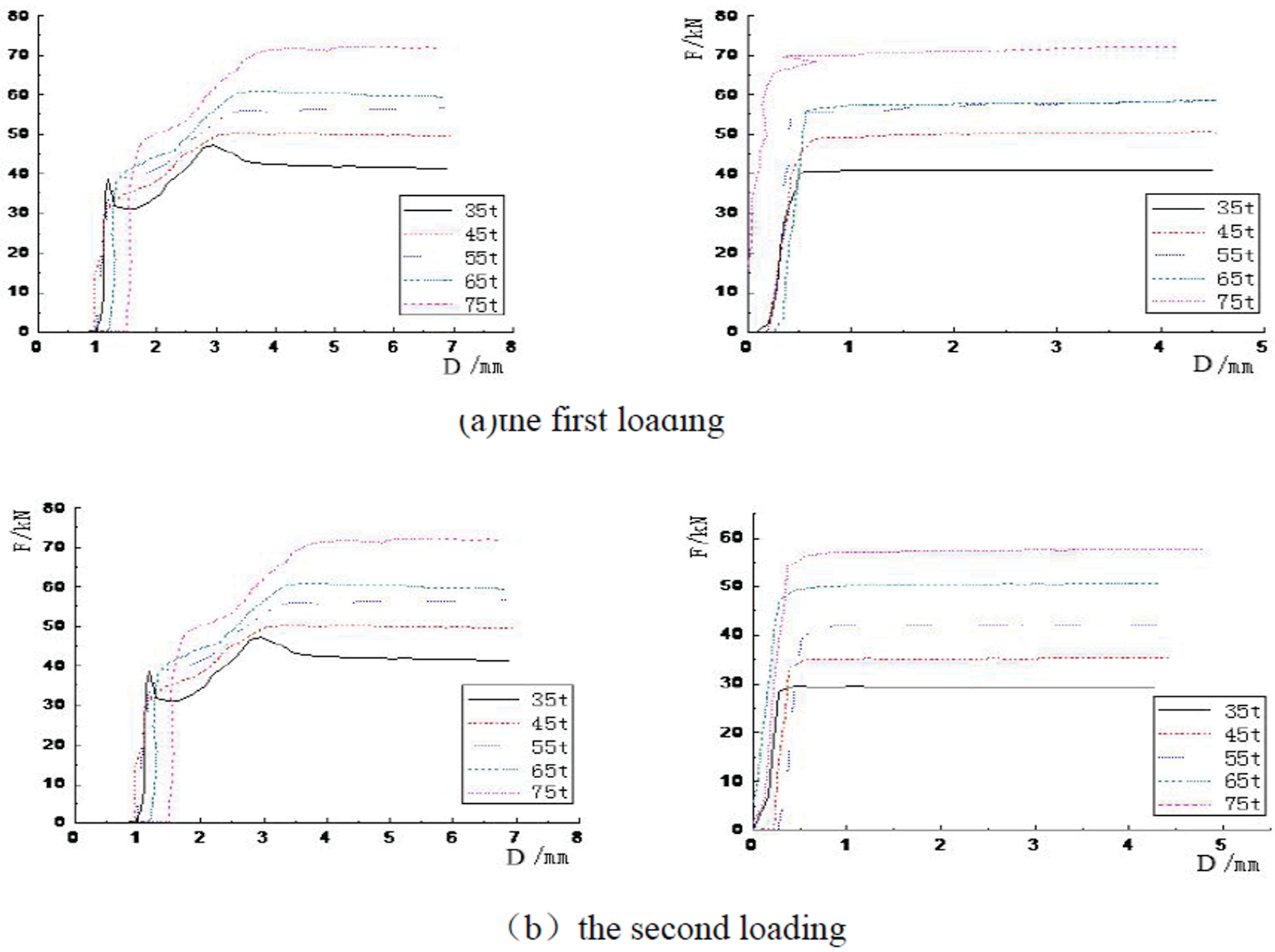

Figure 8. The restoring force model experiments

It shows that this restoring force model accords with the coulomb friction model. So it indicates that the design of the new friction sliding isolation bearing using MoS_2 as isolation bearing friction materials is reasonable .

The friction efficient can be calculated by the restoring force model. Then the curve of the vertical pressure and the friction factor is shown in Fig.9.

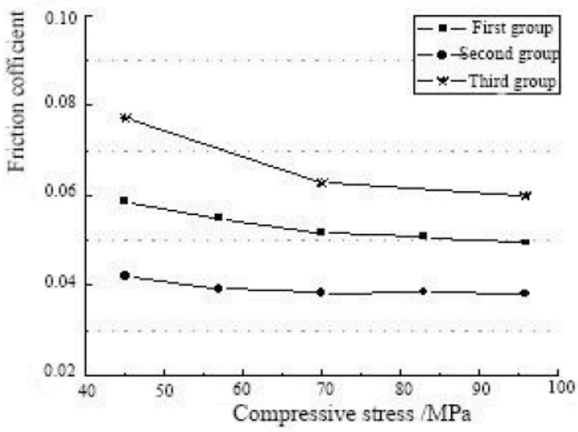

Figure 9. The friction factor under the different pressure

It shows the friction efficient is smaller and smaller as the vertical pressure is increasing. The friction efficient of the second group is smaller than the first group. It indicates that the friction factor is related to the loading times. It is changed to be smaller after many times loading .This phenomenon may be related to the rough degree of the surface, after many times loading the surface become more and more smoother than before.

Averaging the friction efficient of the two group,the curve of the friction efficient and the compress stress was shown in Fig.10.It shows the friction factor is a stable value about 0.04~0.05.As the compression stress increases from 44.58 MPa to 70.06 MPa ,the friction efficient of the isolation bearing decreases from 0.0505 to 0.0455.The decrease rate is about 10.0%.As the compression stress increase from 70.06MPa to 95.54MPa ,the friction efficient decrease from 0.0455 to 0.0438.The decrease rate is about 3.7%.The decrease bring down gradually as long as the compression stress is increasing .With the friction efficient under different compression stress be fitted with the exponential form, the formula of the friction efficient and the compression stress was shown in formula (1).

$$\mu=0.04358+0.08883e^{-\frac{\sigma}{17.44575}} \tag{1}$$

It can deduce that the friction efficient under different compression stress compared with the experiment data as the table shown in table.2,this formula is very correct .It is a good formula which can

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be used to choose the approximate friction efficient for the new friction sliding isolation bearing.

Table.2 The contrast of the friction factor's fitting value and the experiment value

Vertical force(t)	Fitting value	Experiment value	The error(%)
35	0.0505	0.0505	0
45	0.0469	0.0474	1.1
55	0.0452	0.0455	0.7
65	0.0444	0.0447	0.7
75	0.0440	0.0438	0.5

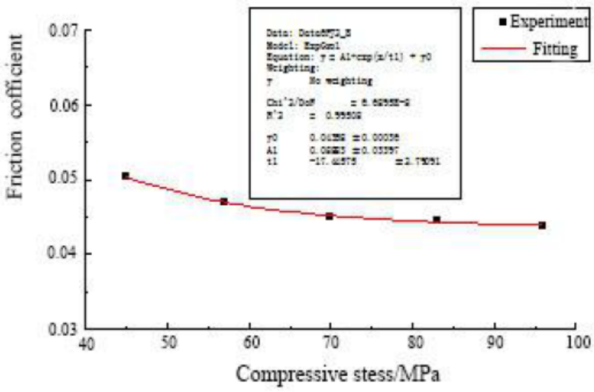

Figure 10. the curve of the friction factor and the compress stress

3 Conclusion

The MoS_2 material have a stable frictional behavior. The friction factor is about 0.04~0.05, It can be used as the friction material in the isolation system of building. The isolation layer's restoring force model accords with the coulomb friction model, it indicates that the design of the new friction sliding isolation bearing is reasonable .through the exponential fitting form, the formula of the friction factor and the compression stress is proposed. Compared with the experiment value ,the biggest error of this formula is 1.1%, so it can be used to choose the approximate friction factor of the new friction sliding isolation bearing.

References

1. Takeda junichi, JIXiaoHui.the isolation and vibration control of the structure[M].Beijing: China Architecture & Building Press, 1997.
2. Calantarients,J.A.Improvements in and connected with building and other works and appurtenances to resist the action of earthquakes and the like[R]. Paper No.325371, Engineering Library, Stanford University. Stanford, California, 1909.
3. Lee,D.M.and Medland.I.C. Base isolation ---An historical development and the influence of high mode responses[J]. Bulletin of the New Zealand national Society for Earthquake Engineering. 1978,11(4):219-233.
4. Lee,D.M.and Medland.I.C.Estimation of base isolated structure responses[J].Bulletin of the New Zealand national Society for Earthquake Engineering, 1978,11:234-244.
5. R.I.Skinner W H Robinson et al,XIELili.Introduction to engineering isolation [M].BEIJING： Seismological Press,,1996.
6. Jolivet,J and Richli,M.H. Aseimic foundation system for nuclear power stations [C]Proceedings 4th International Conference on Structural Mechanics in Reactor Technology San Francisco, California, Paper K.9/2,1977.
7. Helmut Krawinkler ,Dynamic Modeling of Concrete Structure, Harry G. Harris Editor ACI Publication,1982.
8. Dimitar Jurukovski, Experimental Testing of Materials, Elements and Components of Structures. University "Kiril and Metodij",Skopje,1982.