Beautiful and Easy to Disassemble Expansion Bolt

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[*Abstract*] This paper introduces a design of expansion bolt which is beautiful and easy to disassemble. A new structure of expansion bolt is designed by using the phenomenon of inclined plane self-locking in physics. The structure converts the vertical movement of the bolt into horizontal expansion, so that the cap of the bolt can be exposed outside, which is beautiful, simple to manufacture and convenient to use, and the bolt can be installed and disassembled only by using a screwdriver, and the design is innovative. This expansion bolt design provides a more convenient and practical solution for fixing objects.

[*Introduction*] The invention of traditional expansion bolts provides great convenience for people's daily life, making it easy to fix objects on cement floors and brick walls. However, in the process of using, we also found some shortcomings. For example, when the screw is tightened, the exposed part of the outside is too long, which affects the overall beauty of the object. More importantly, when fixed objects are no longer needed, the expanding bolts are often difficult to remove, and the protruding parts left on the ground may cause the risk of tire burst to the vehicle, or trip pedestrians, which is a potential safety hazard. To solve these problems, we have designed a new type of expansion bolt with simple structure, beautiful appearance, safety and reliability, and easy installation and disassembly. This bolt consists of two metal sleeves that form a bevel. When the screw is tightened, the two sleeves squeeze against each other and become misaligned, causing the whole to expand and hold the object tightly. This design cleverly uses the phenomenon of inclined plane self-locking in physics, which not only solves the problems of appearance and disassembly of traditional expansion bolts, but also reduces the cost, simplifies the structure, and can be reused to reduce the waste of resources. Through this innovative design, we believe that the new expansion bolt will better meet people's needs, improve the quality of life, and ensure the safety of the use process.

[*Key words*] Expansion bolt inclined/self-locking/engineering design/improvement

Catelog

I. Project background

The invention of the expansion bolt brings great convenience to the life of people, and the expansion bolt can enable people to conveniently and firmly fix objects on the cement floor. But we also found problems in its use:

- As shown in Figure 1.1, when the bolt is tightened, the bolt exposed in the middle is very long, which is not beautiful.
- As shown in Figure 1.2, when the object is not used, it is difficult to remove the expansion bolt, which causes the vehicle to burst the tire and the pedestrian to trip, and there is a certain potential safety hazard.

Figure 1.1 Exposing too long part affects the appearance.

Figure 1.2 Difficult removal of expansion bolt

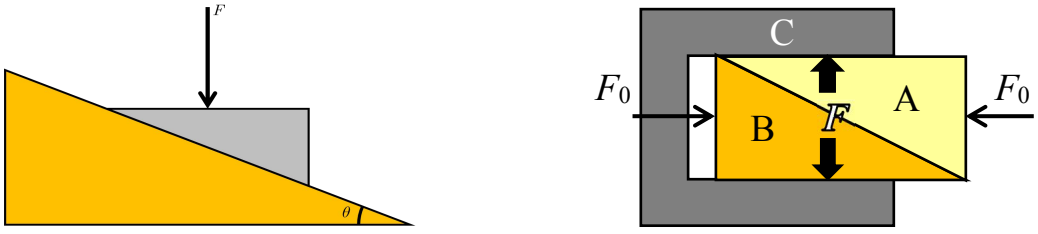
In order to solve similar problems, we hope to make an expansion bolt that can not only meet the basic functions of the current bolt, but also avoid the above two problems.

II. Design ideas

1. Principle analysis

In physics, there is a phenomenon called "inclined plane self-locking phenomenon", as shown in Fig. 2.1 (a), when $\mu>\tan\theta$, even if a large force F is pressed on the block, the object cannot move downward.

As shown in Figure 2.1(b), if a small force F_0 is applied to A and B, A and B will produce a large force F on C. On the contrary, C exerts a large force on A and B, and A and B are in a self-locking state and are not easy to loosen.



(a) (b)

Figure 2.1 Inclined self-locking phenomenon

2. Actual production

According to this principle, we use 3D software to design a sketch (Figure 2.2), so that the cap of the bolt is exposed. The vertical movement of the bolt is converted into horizontal expansion, thereby fastening the object to the wall.

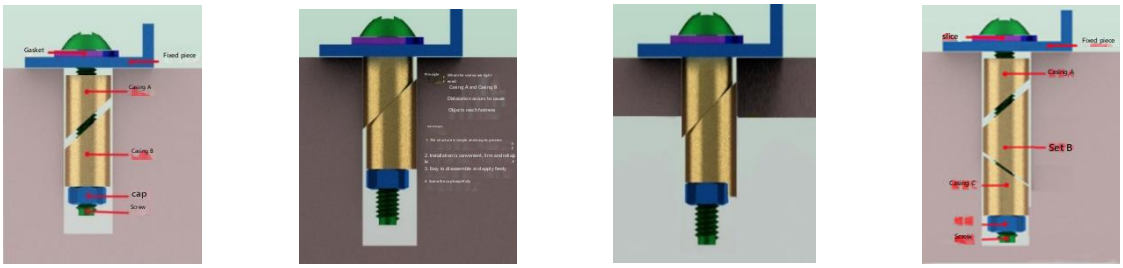


Figure 2.2 Initial sketch

As shown in Figure 2.2, the new bolt we designed is composed of sleeve A, sleeve B, sleeve C (only in deep walls), screw, nut, nut and gasket. The fastening of the object is achieved by changing the expansion of the bolt to the vertical direction to the two sides.

3. Display of finished products

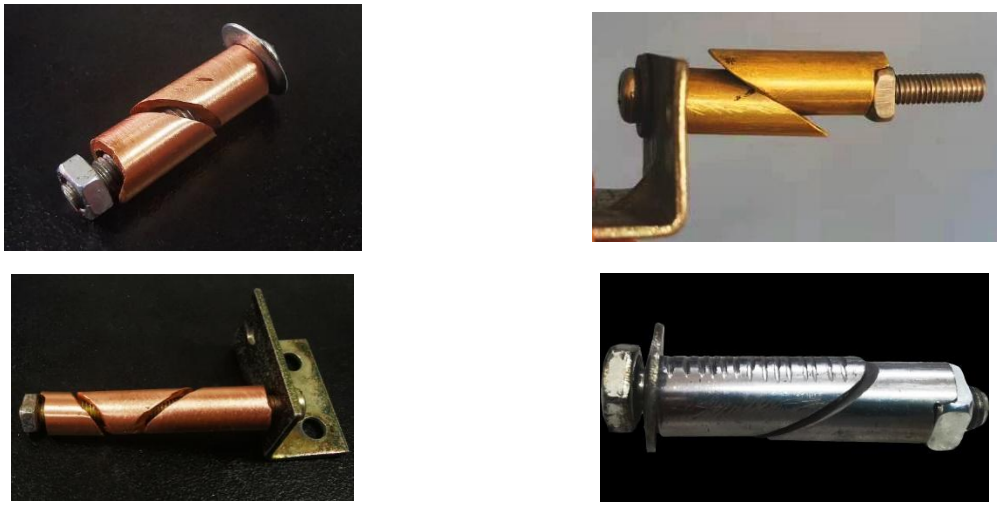


Figure 2.3 Finished product display of expansion bolt

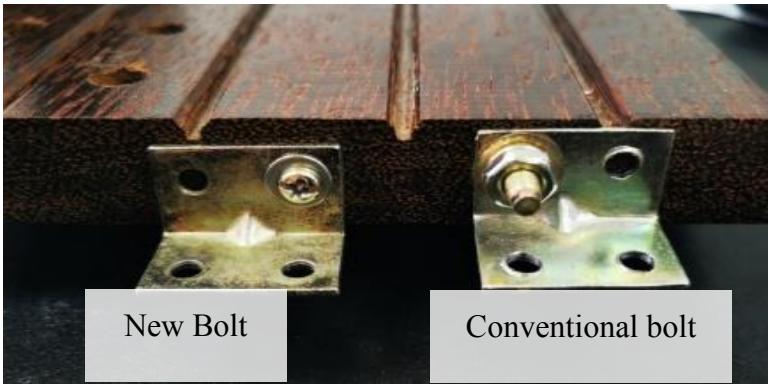
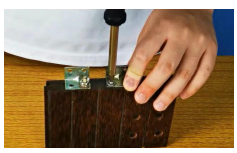


Figure 2.4 Comparison with ordinary expansion bolt

III. Product application

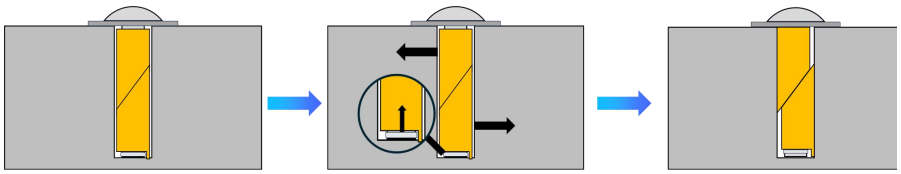
1. Usage

When we need to fix the object on the wall, as shown in Fig.3.1 (a), we only need to screw the bolt like a normal screwdriver, first make the sleeve A and B in the figure contact, and then put the bolt into the mounting hole. By continuing to turn the bolt, the nut is held against rotation by the pressure of the contact and moves upward. As shown in Fig. 3.1(b), the sleeves A and B in the figure begin to squeeze each other, resulting in dislocation and self-locking, which makes the whole expand, thus fastening the object.



Actual application process of expansion bolt

(a)



(b)

Figure 3.1 The usage process of expansion bolts

2. Application scenario

When we screw the bolt, its interior changes as shown in Figure 3.2, and the object is fastened mainly by expanding the two sleeves to the side. Therefore, the new expansion bolt is applicable to thin boards, shallow walls and deep walls.

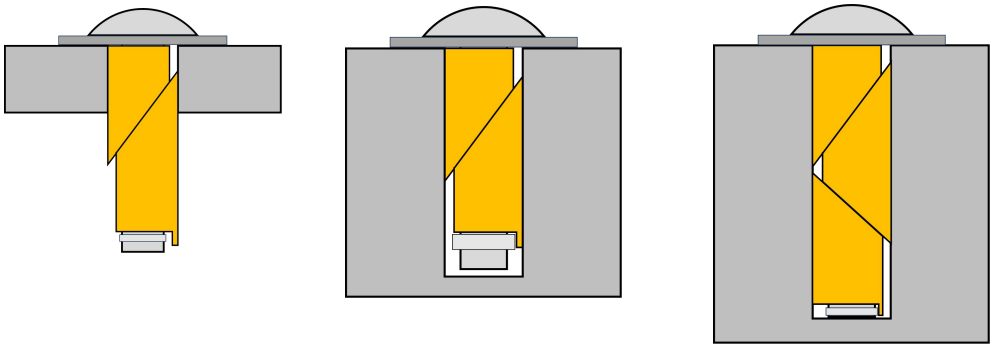


Figure 3.2 Application Scenario of New Expansion Bolt

IV. Optimization and improvement of works

1. Structural aspects

During the actual test, we found that the expansion bolt of the original design was difficult to screw. To solve this problem, we have studied the structure of the expansion bolt. As shown in Figure 4.1, when we use the hexagon nut, its fixing position is narrow, which may lead to the problem of difficult screwing. To solve this problem, we changed the hexagonal nut to a square nut for better fixation and operation.

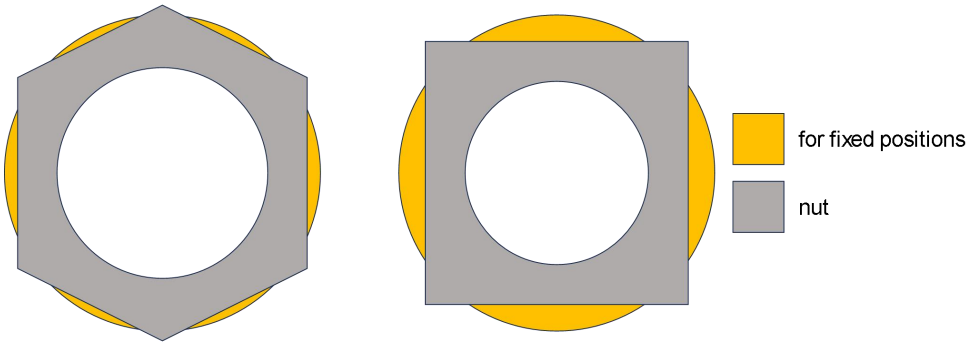


Figure 4.1 First Improvement of Expansion Bolt

2. Material aspects

In the initial stage, we used copper as the material, because of its low hardness, it is easy to deform, resulting in too small dynamic friction coefficient between the casing and between the casing and the fixed surface, which affects the reliability of the structure. So, we decided to replace it with a harder brass to improve the stability. Subsequently, to further enhance the reliability of the expansion bolt, we chose the alloy steel with greater hardness as the material to ensure better stability performance.

3. Design aspects

We have learned that increasing the coefficient of friction μ can significantly improve the fixation stability of the expansion bolt when the sleeves are in contact with each other and with the bevel. To enhance this effect, we aim to increase the coefficient of dynamic friction, thus ensuring a secure installation of the expansion bolts. To this end, we have designed a pattern on the surface of the sleeve (as shown in Figure 4.2). The purpose of this is to increase the friction when contacting with the wall, so as to achieve a more stable fixation of the object.

Figure 4.2 Adding pattern on expansion bolt

V. Load bearing test

To ensure that our expansion bolts have the necessary tensile strength, we put them through a series of weight capacity tests.

During the experiment, we prepared a counterweight weighing about 51 kg (see Figure 5.1) and mounted four different types of expansion bolts on a wooden board (see Figure5.2).

For the convenience of recording and analysis, we have numbered the four kinds of expansion bolts. Specific test data and analysis results are detailed in Table 1 below.

Figure 5.1 Weight with a mass of about 51 kg

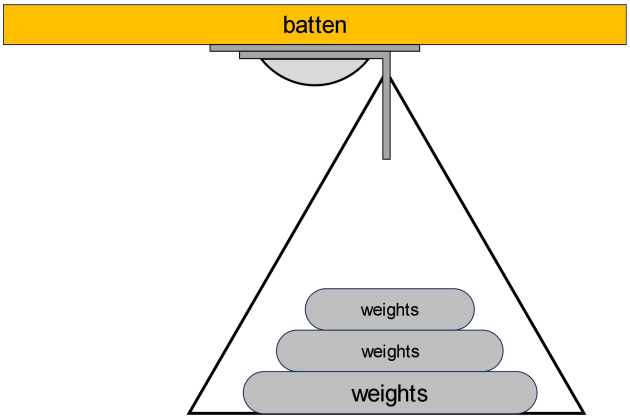


Figure 5.2 Schematic Diagram of Bearing Test of Expansion Bolt

Bolt serial number / Test quality	1.Alloy steel quadrangular nut 	2 Brass square nut 	3.Three sections of red copper casing Hexagon nut 	4 Copper hex nut 
10kg	✓	✓	✓	✓
20kg	✓	✓	✓	✓
30kg	✓	✓	✓	✓
35kg	✓	✓	✓	✓
40kg	✓	✓	✓	✓
43.5kg	✓	✓	✓	×
47kg	✓	✓	✓	-
51kg	✓	✓	×	-
Maximum bearing weight	75kg	60kg	47kg	40kg

Instructions:

1. Duration of this experiment: 24 hours. After each test is completed, if the test is successful, draw "✓" in the table. If the test is unsuccessful, draw "×" in the box and do not carry out subsequent tests.
2. The test is also related to many factors such as the material of the wall and the tightness of the screws. The test results are for reference only.

Table 1 Test results

VI. Innovation

- The outward expansion bolt of the screw cap solves the problem that the screw is not beautiful outside.
- The bolt utilizes the principle of inclined plane self-locking, is convenient to assemble and disassemble, is firm and reliable, and solves the problem that the traditional expansion bolt is difficult and easy to disassemble.
- The structure is very simple and the production is convenient. Can be used in a variety of scenarios. New structure of expansion bolt with outward nut.

VII. Summary

Problems with the use of conventional expansion bolts include unsightly bolt lengths and difficulty in disassembly. In order to solve these problems, we design a new expansion bolt structure by using the phenomenon of inclined plane self-locking in physics. This structure converts the vertical movement of the bolt into horizontal expansion, allowing the nut to be exposed. It is easy to use and can be installed and removed by using a bolt knife. This is an innovative design, which makes the bolt beautiful and safe, can be used repeatedly, and has low cost and simple structure, and can replace the traditional expansion bolt.