

A Study on Anti-Loosening Characteristics of Different 3/8 BSW Threaded Fasteners

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Abstract

A significant advantage of the threaded fastener is its capability of being dismantled using simple tools. However, threaded fasteners have an inherent and inevitable limitation that they loosen eventually under vibrating environment. The loosening of screw fasteners is caused by two factors mainly. One is the relative slip between the bolt and nut screw threads, and the other is the relative slip between the nut or bolt surface and the surface of the fastened material. In the present work, the anti-loosening ability of various 3/8 BSW locking screw fasteners with nylock nut, flat washer, nylon washer, serrated washer and spring washer are tested under accelerated vibrating conditions. The experiment has been carried out in an indigenously made testing machine. The initial clamping force given has been around 0.82 ton. Under vibrating condition, the loss of tightening force has been measured at regular intervals to adjudge the loosening of threaded fastener. From the results, it is observed that only small improvement has been obtained using flat washer over conventional nut. Outside serrated, spring and nylon washers show marginal anti-loosening ability. Nylock nut is seen to have better resistance to loosening than the other popularly known anti-loosening fastening elements tested, and hence, may be quite effective to use in vibrating conditions. However, other popularly known anti-loosening nuts or washers are found not to be that effective.

Keywords: Threaded fasteners, anti-loosening, nut and bolt, washer and vibrating condition.

1 Introduction

A significant advantage of the threaded fastener is its capability of being dismantled using simple tools. But, threaded fasteners have a limitation of loosening eventually under vibrating environment. The loosening of screw fasteners is caused by two factors mainly. One is the relative slip between the bolt and nut screw threads, the slip causing torsion of the bolt. The other is the relative slip between the nut or bolt surface and the surface of the fastened material, the slip causing slackening of the torsion.

Goodier and Sweeny [1], Hongo [2], Paland [3] and Junker [4] tested various types of threaded fasteners with

respect to its loosening tendency, and the latter described the mechanism of loosening on the basis of friction between the flank surfaces. According to Junker [4], the cause self-loosening of nut and bolt is explained by the well-known law of physics related to the effect of friction on two interacting solid bodies.

Sase and others [5-7] tested the effectiveness of different screw threads, spring washers, nylon inserted nuts, double nuts and eccentric nuts of varying sizes with regards to resistance to loosening. Test results showed that the popularly known anti-loosening fasteners do not possess much resistance to loosening. In the year of 1998, Sase and others [6] introduced Step Lock Bolt (SLB) showing its desirable anti-loosening performance using a displacement based loosening device. The displacement and turning angle of the bolts and the nuts were examined in loosening tests.

Following the experimental procedure and conclusions drawn by Sase et al. [5-7], a testing rig was designed and fabricated by a team lead by Das [8-11], where a constant vibrating force at a constant frequency and amplitude is applied perpendicular to the bolt axis. In this set-up, several tests were carried out with different screw fasteners of different materials to compare their loosening tendencies. Takemasu and Mihayara [12] and Kasai [13] have also done some experimental works on loosening of threaded fasteners and the former has proposed a rolled double threaded bolt to arrest loosening.

In the present work, the anti-loosening ability of various 3/8 BSW locking screw fasteners with nylock nut, flat washer, nylon washer, serrated washer and spring washer are tested under accelerated vibrating conditions obtained in an indigenously made testing machine.

2 Experimental Details

In the present investigation, a loosening test rig is used where vibration is created in the direction perpendicular to the longitudinal axis of the bolt for accelerated tests. Details of the test rig developed, has been discussed in [11], and a schematic diagram of the same is shown in Fig.(1).

In the testing machine developed, controlled vibration is generated, and the loss of clamping force is measured to assess the amount of loosening. With this machine, 3/8 BSW (16 TPI) high tension steel bolts with standard and anti-loosening nuts and washers are tested. The initial tightening torque given is around 0.82 ton. Actual

clamping forces given on the fastener are shown in Table 1. Up to 12,000 oscillations, the decrease in clamping force is measured. The frequency of applying repetitive forces has been maintained to be 290 strokes per minute that is made higher than that reported in [11].

Different types of nuts and washers used for the clamping of the fasteners were conventional nuts, nylock nut, flat washer, spring washer, outside serrated washers and nylon washer. All the experiments were repeated three times.

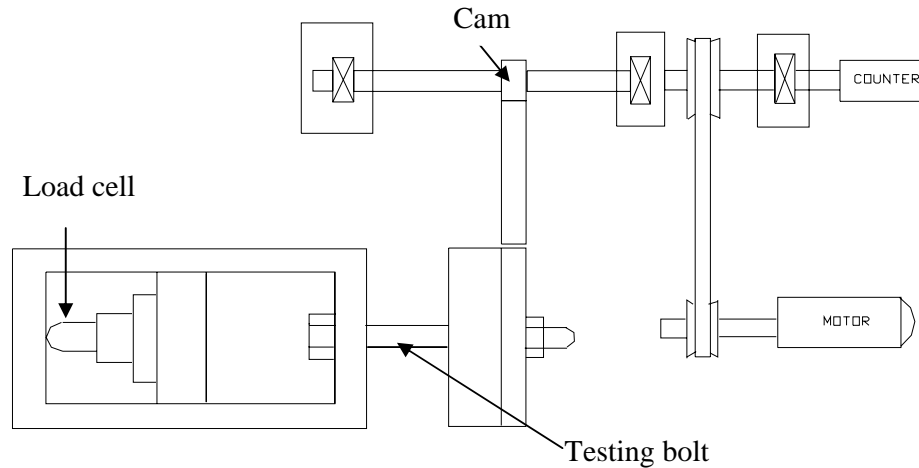


Figure 1. Schematic diagram of Test-Rig

Table-1 Details of clamping conditions for the test

Bolt	Nut and/or Washer Used	Initial Clamping Force (ton)		
		Expt-1	Expt-2	Expt-3
3/8 BSW High Tension Steel	Conventional Nut	0.822	0.822	0.828
	Flat Washer with standard nut	0.822	0.825	0.827
	Spring Washer with standard nut	0.826	0.822	0.825
	Outside Serrated Washer with standard nut	0.820	0.822	0.825
	Nylock Nut	0.823	0.821	0.828

3 Results and Discussion

Fig. (2) shows the comparison of loosening of standard 3/8 BSW threaded fasteners with high tension steel bolt corresponding to three repeat tests. From the figure, it is observed that for every experiment, initial loosening of clamping force is high. After a certain number of oscillations, the rate of loosening becomes slow. Results of repeat experiment Nos. 1 and 3 are quite similar, although initial clamping force for experiment 3 is slightly high; but results of experiment No. 2 shows substantially more loosening (to the tune of 10% after 12000 oscillations) than the other repeat tests. This kind of

variation may often occur for negligible product variability, etc.

Fig. (3) depicts loosening tendency of conventional nut with flat washer. In this case also, the initial rate of loosening is high. While repeat experiments 2 and 3 results are quite close to each other, loosening in experiment No. 1 is somewhat high compared to the other two repeat tests. Loosening of these fasteners with flat washer does not show clear benefits over conventional fasteners. In some cases, flat washer shows good retention of clamping force, while in other repeat situation, it loosens to a comparatively higher extent. Thus flat washers are not offering substantial anti-loosening effects. This observation is in line with the observations reported earlier [5-7].

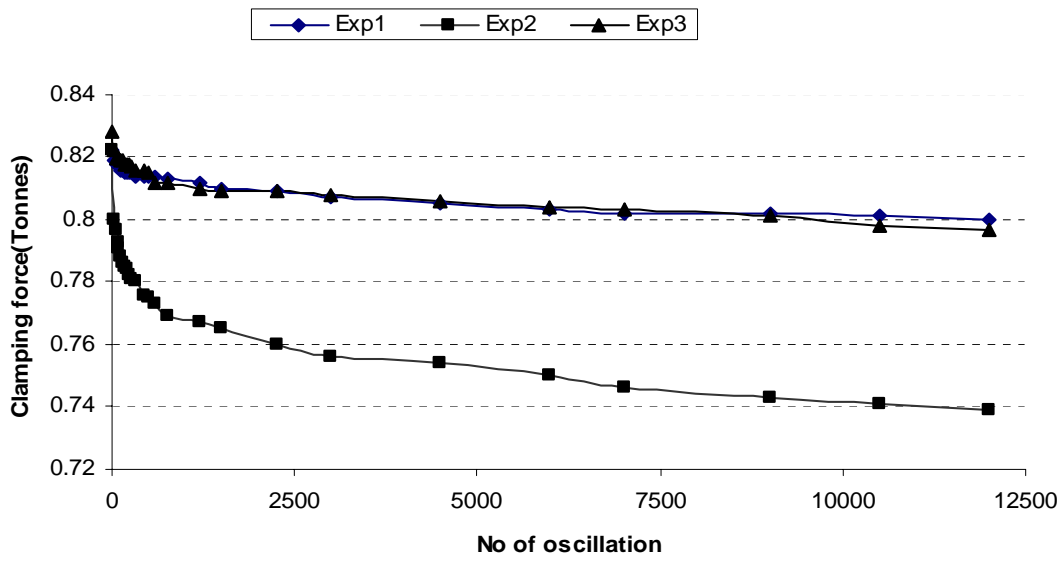


Fig. 2: Test results for 3/8 inch BSW high tension steel bolt with conventional nut

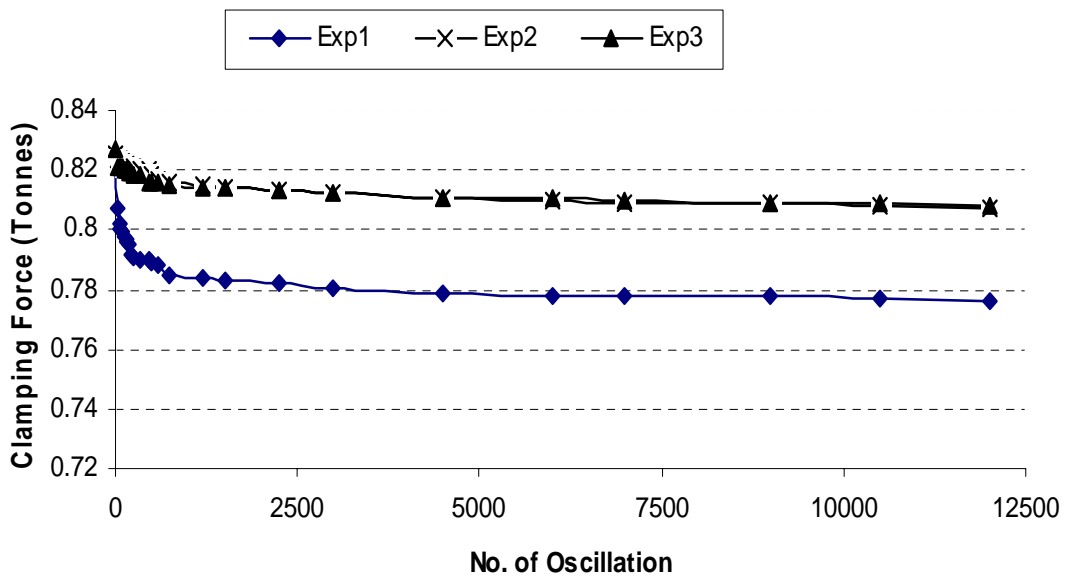


Fig. 3: Test results for 3/8 inch BSW high tension steel bolt with flat steel washer

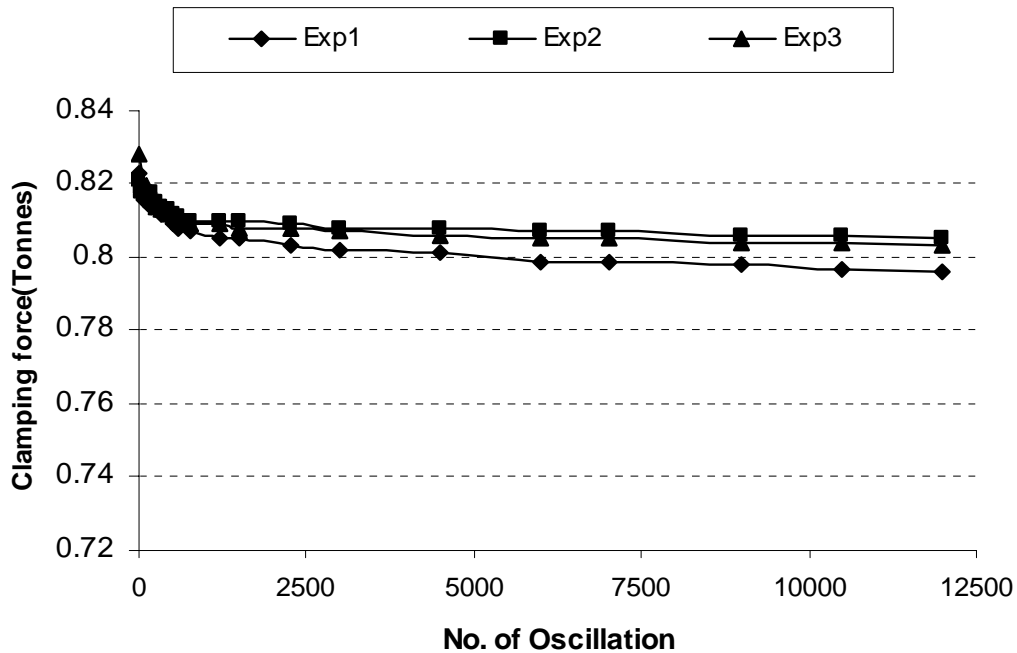


Fig. 4: Test results for 3/8 inch BSW high tension steel bolt with nylon washer

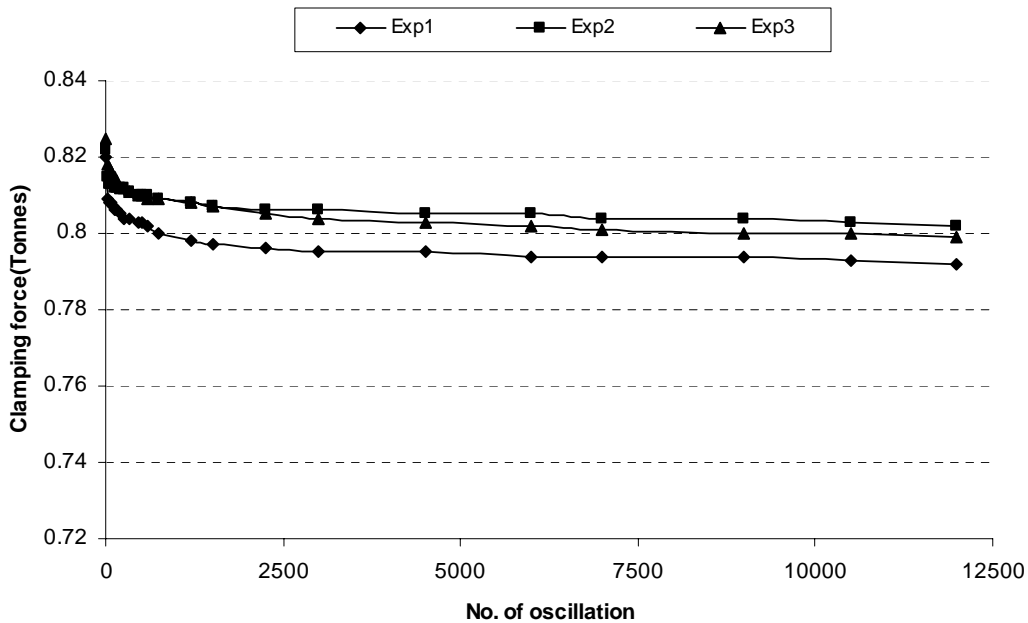


Fig. 5: Testing results for 3/8 inch BSW high tension steel bolt with outside serrated washer

Three repeat tests have also been performed with nylon washer (Fig. (4)), outside serrated washer (Fig. (5)) and spring washer (Fig. (6)). Fig. (4) is for loosening characteristics with nylon washer along with the conventional nut. After tightening, the nylon washer is deformed by the pressure of nut and shows a small

loosening. Fig. (5) shows the results for outside serrated washer, where also small loosening similar to that of nylon washer is observed. For all the three repeat experiments, it is observed that the teeth of the serrated washer get substantially deformed, and hence, an outside serrated washer cannot be used repeatedly. A spring washer is

deformed and stretched in circumferential direction, and this is often believed to result in anti-loosening effect. However, it is observed in Fig. (6) that the use of spring washer does not effectively reduce loosening tendency,

rather, it loosens at a higher rate than nylon and outside serrated washers. Similar phenomenon also happened with spring washer in the experiments done by Fuji and Sase [2] on a different fastening material.

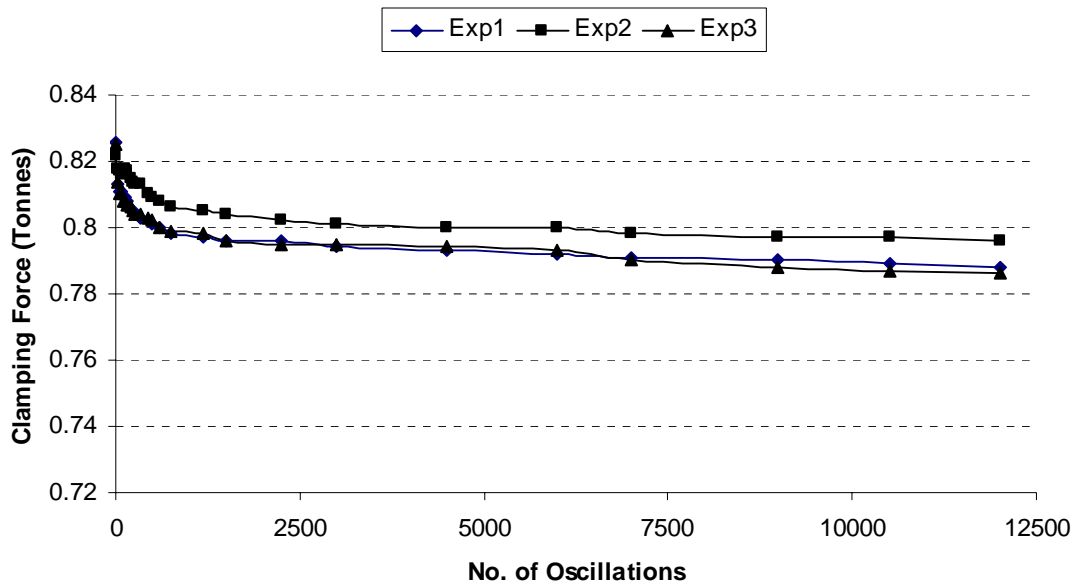


Fig. 6: Test results for 3/8 inch BSW high tension steel bolt with spring washer

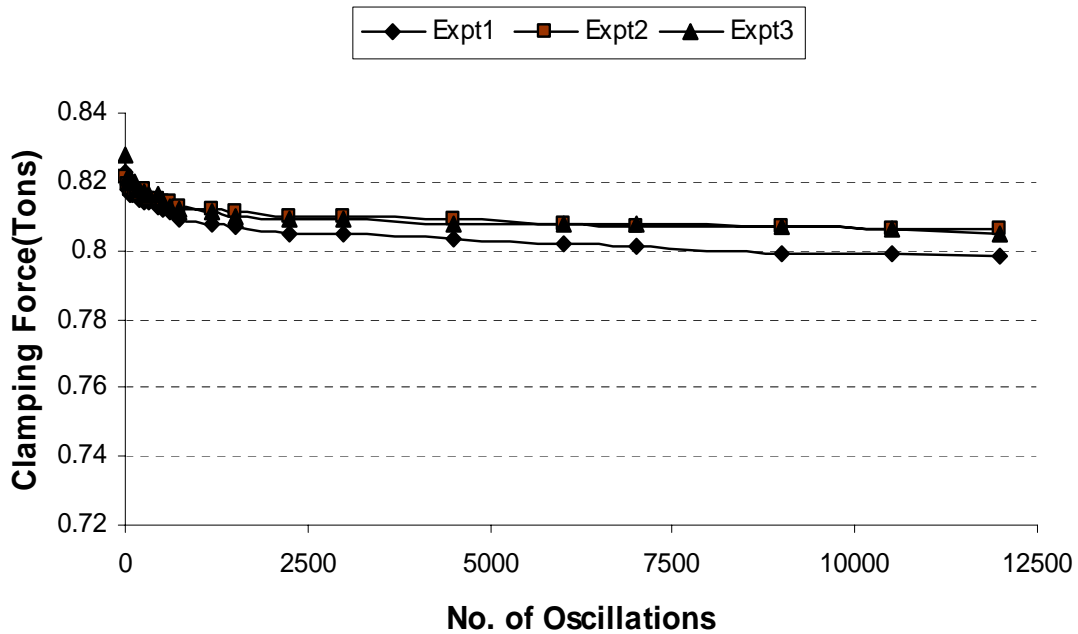


Fig. 7: Test results for 3/8 inch BSW high tension steel bolt with nylock nut

Results of nylock nut are shown in Fig. (7). It is seen that for all the three repeat experiments, nylock nut shows the least tendency to loosen up to 12,000 oscillations of all the tests made in this study, and a loosening of only 2% of clamping force is observed. All three curves are close to

each other, and the loosening effect is seen at the initial stage of the experiment as is observed in all the tests made at present. Hence, it can be stated that nylock nut has consistency in offering considerable anti-loosening property.

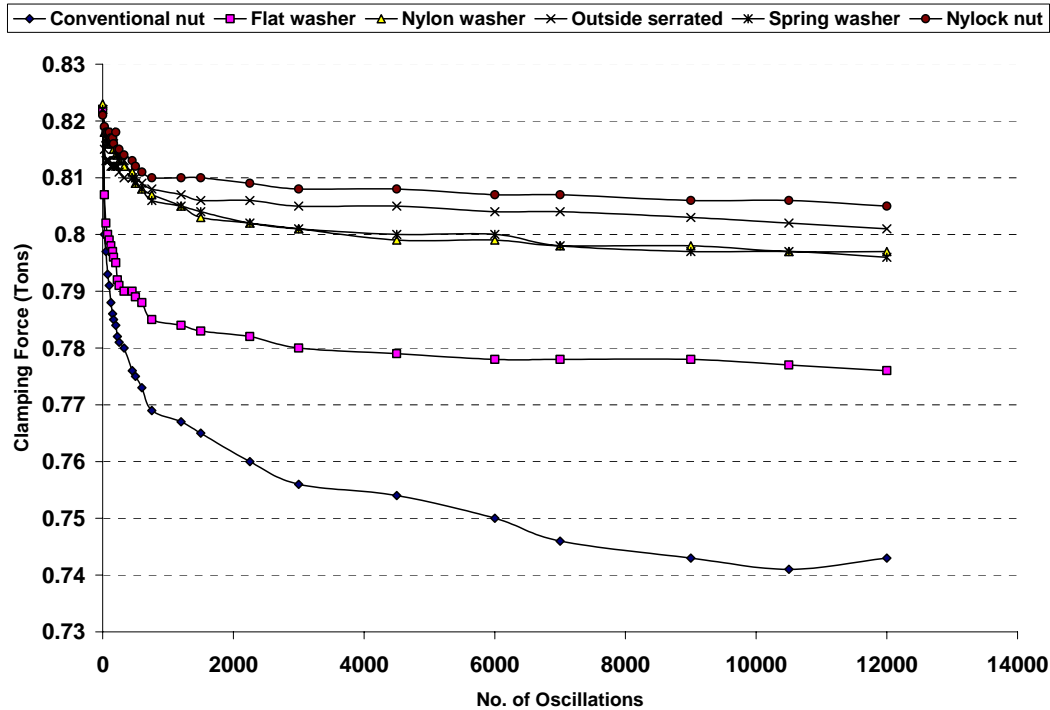


Fig. 8: Comparison of loosening for 3/8 inch BSW high tension steel bolt with different nut and washers

Fig. (8) shows the comparison of loosening for 3/8 BSW high tension steel bolt for different threaded fasteners. Data of one of the three repeat tests for each set of fastener are used to construct the plots. From the figure, following observations are made.

- Very little improvement has been found using flat washer over conventional bolt and nut.
- Nylon washer and spring washer have similar resistance to loosening that is better than flat washer.
- Antiloosening property of outside serrated washer is somewhat encouraging.
- The nylock nut is found to have the best anti-loosening characteristics of others.

- Nylock nut has better resistance to loosening than others tested
- Outside serrated, spring and nylon washers have small anti-loosening ability.

4 Conclusion

From the result obtained on the experiment observed on loosening characteristics of different combinations of fasteners with 3/8 inch BSW high tension steel bolt, it may be concluded that

- Marginal improvement has been observed using flat washer over using only conventional nut and bolt

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