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Selection of the Length of the Additional Rubber Fabric Shock Absorber of the Developed Insurance Belt

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ABSTRACT: The article provides a constructive diagram of a belay belt. The method for determining the length of the lengthening of the additional shock absorber of the belay device is given. Taking into account the stiffness coefficients of the shock absorber of the sling and the additional shock absorber?As well as the weight of the worker, a formula was obtained to calculate the length of the additional rubber-fabric shock absorber of the safety belt. Based on the analysis of the constructed graphical dependencies of the safety belt parameters, their best values are recommended.

KEYWORDS. Belay device, vest, shoulder pad, load foot, buckle, gas cartridge, back, carabiner, shock absorber, rubber-fabric, vibration, stiffness, amplitude, tension.

I. INTRODUCTION

Personal protective equipment, including safety belts, are widely used in construction, during construction and installation, repair and restoration, maintenance or other types of work at height, to fix (hold) a working posture and protect a worker in case of a fall from a height. Known safety belt containing a belt with a buckle, a sash, a sling with a carabiner and a stitched shock absorber [1]. The disadvantage of the belt is the cumbersomeness of the shock absorber (a large length of the belt is required to ensure complete safety, which increases the consumption of material and labor intensity of manufacture).

In the work of V.A. Oguretsky [2], the safety belt is made with a shock absorber in the form of a sewing tape in a certain part of the belt. At the same time, it was revealed that the breaking force of the belt reaches 7890 H. The disadvantage of this design is the limited deformation of the sewing tape, which does not allow the necessary depreciation and insurance when falling from a height.

The belay device includes shoulder, chest and hip straps and corresponding buckles for them sash, distribution ring, sling and carabiner [3]. The disadvantage of this design is the impossibility of ensuring sufficient reliability during operation and has a narrow range of applications. The existing structure has been improved to provide maximum insurance for the worker.

II.RECOMMENDED HARNESS DESIGN.

The essence of the design lies in the fact that the belay device consists of a safety harness, including a shoulder strap, a chest strap, a hip strap and a belt leash, a belt buckle, a sash, a distribution ring, a carabiner sling, a textile (spring) shock absorber, a chest strap, lining, fasteners (zipper tape), side parts, halyard with carabiner and shock absorber. The harness is shown in Fig. 1.

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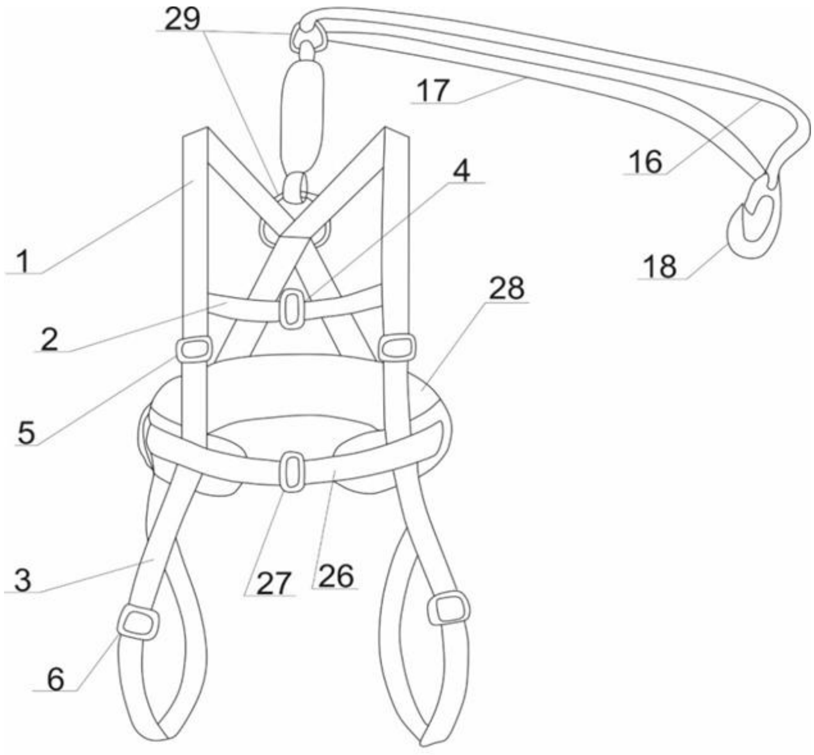

Figure 1: View of the belts of the belay device

The design includes a shoulder strap 1, a chest strap 2, a hip strap 3, a buckle 4 of a chest strap 2, a buckle 5 of a shoulder strap 1, a buckle 6 of a hip strap 3, an adjusting strap 7, a distribution ring 14, a halyard 16 (sling) with a snap hook 18 and a shock absorber 15 and in parallel with it a separately installed textile (or spring) shock absorber 17, a collar 19, a belt 26, a belt buckle 27, a sash 28, a distribution ring 29. In this case, the length of the shock absorber 17 is made (15 ÷ 20)% less than the length of the sling 16 with shock absorber 15.

The safety device works as following. When a person working on a sling 16 breaks off and hangs, the shock absorber 15 is deformed, and in parallel with the sling 16, the installed textile (spring) shock absorber 17 is deformed more than the shock absorber 15 due to the shorter length by (15 ÷ 20)%, while energy is significantly absorbed. At the same time, thanks to the installed shock absorber 17, abrupt changes in dynamic loads are eliminated (due to greater deformation and dissipation).It also eliminates the rupture of the line 16 by reducing the sharp dynamic loads by the shock absorber 17.

III. CALCULATION OF THE LENGTH OF THE ADDITIONAL SHOCK ABSORBER OF THE SAFETY BELT.

In the recommended device for reliable personal protection of a worker in construction, during assembly, repair and restoration work at a height, a rubber-fabric shock absorber is used in parallel with the sling to fix the working posture and protect the worker in case of a fall. In the existing device, as noted above, there is a shock absorber with a limited deformation characteristic in the lower end part. The recommended additional shock absorber allows a significant reduction in the tension of the main line. The additional shock absorber has a (15 ÷ 20)% shorter length relative to the line length. In this case, it is important to justify the length of the additional shock absorber. Figure 2. the layout of the main sling and an additional rubber-fabric [4,5] shock absorber is presented.

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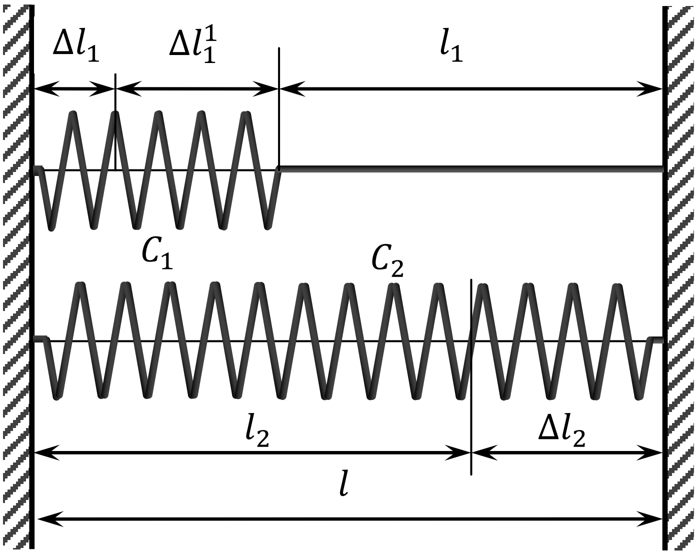

Figure 2: Design diagram of the installation of the main sling and additional shock absorber of the belay device

According to the design scheme, the total length of the sling with a shock absorber [7,8,9] will be

$$l=l_1+l_1'+\Delta l_1 \quad (1)$$

where, l_1 is the length of the rigid part of the sling; l_1'- the length of the shock absorber in the initial part; Δl_1 - maximum deformation of the line shock absorber.

Accordingly, the length of the additional shock absorber:

$$l=l_2+\Delta l_2 \quad (2)$$

where l_2 is the length of the additional shock absorber in the initial zone; Δl_2 is the maximum deformation of the additional shock absorber.

Considering that the load from the worker's weight is evenly applied to the sling and the additional shock absorber, as well as the length of the sling by (15 ÷ 20)% more than the length of the additional shock absorber, we get:

$$l_2=(5{,}0\div 6{,}8)\left[\frac{G}{2}\left(\frac{1}{C1}-\frac{1}{C2}\right)-l_1'\right] \quad (3)$$

where G is the weight force of the worker c_1, c_2 are the stiffness coefficients of the line shock absorbers and the additional shock absorber. Based on the solution of the problem (3), graphical dependencies of the parameters of the safety device were built. Figure 3 shows the plotted graphical dependencies of changes in the relative length of additional shock absorbers. The analysis of the graphs shows that with an increase in the weight of the worker working in the safety device, it leads to an increase in the length of the additional shock absorber, since with an increase in G from $0{,}25\cdot 10^2$kg to $0{,}75\cdot 10^2$kg l_2/l_2^p increases from 0.23 to 0.74 at $c_1/c_1^p=1{,}5$; $c_2/c_2^p=1{,}5$. With an increase in the stiffness coefficients of shock absorbers up to c/c^p to 1.5, the value of l_2/l_2^p decreases (Fig. 3, graph 3).

With the value of the relative stiffness coefficient $c/c_p=0{,}65$, the relative length of the additional shock absorber increases from 0.38 to 1.52. This means that with a large worker weight, the stiffness characteristics of the shock absorbers should be increased. Therefore, when $G\geq 70$kg, it is recommended to choose: $c/c_p=(1{,}1\div 1{,}2)$ и $l_2/l_2^p=(0{,}9\div 1{,}2)$

Figure 4 shows the plotted graphical dependences of the change in the relative length of the additional shock absorber on changes in the stiffness coefficients of the shock absorbers. Analysis of the graphs shows that an increase in c/c_p to 1.5, the value of l_2/l_2^p decreases according to a nonlinear pattern from 1.12 to 0.36 with the length of the shock-absorbing part of the line $l_1'/l_1=0{,}06$. An increase in this part of the line leads to an increase in deformation and, accordingly, to an increase in the length of the additional shock absorber. So, at $l_1'/l_1=0{,}12$, the value of l_2/l_2^p decreases from 1.47 to 1.05. Therefore, the recommended parameter values are $c/c_p=(0{,}8\div 1{,}0)$; $l_1'/l_1=(0{,}1\div 0{,}12)$, at which $l_2/l_2^p=(0{,}9\div 1{,}1)$ is provided.

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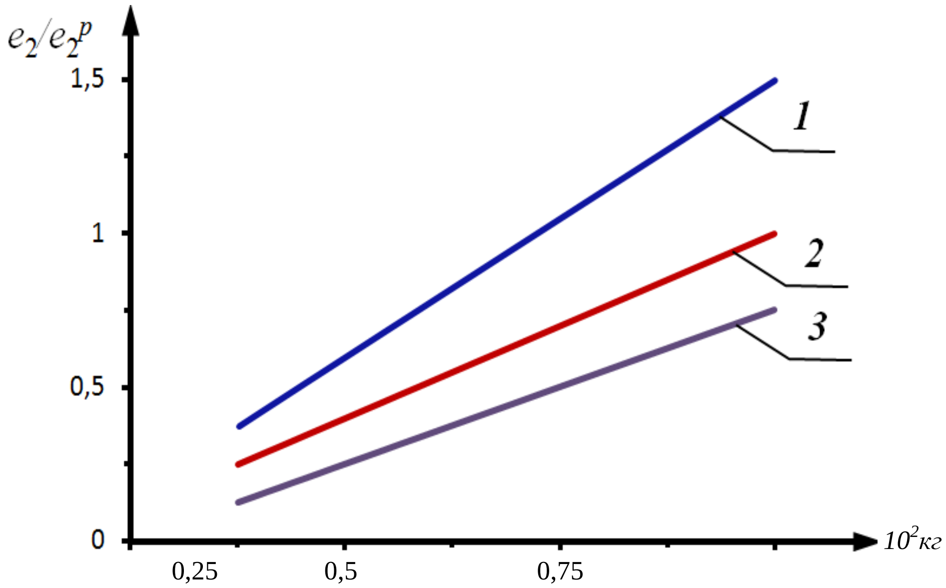
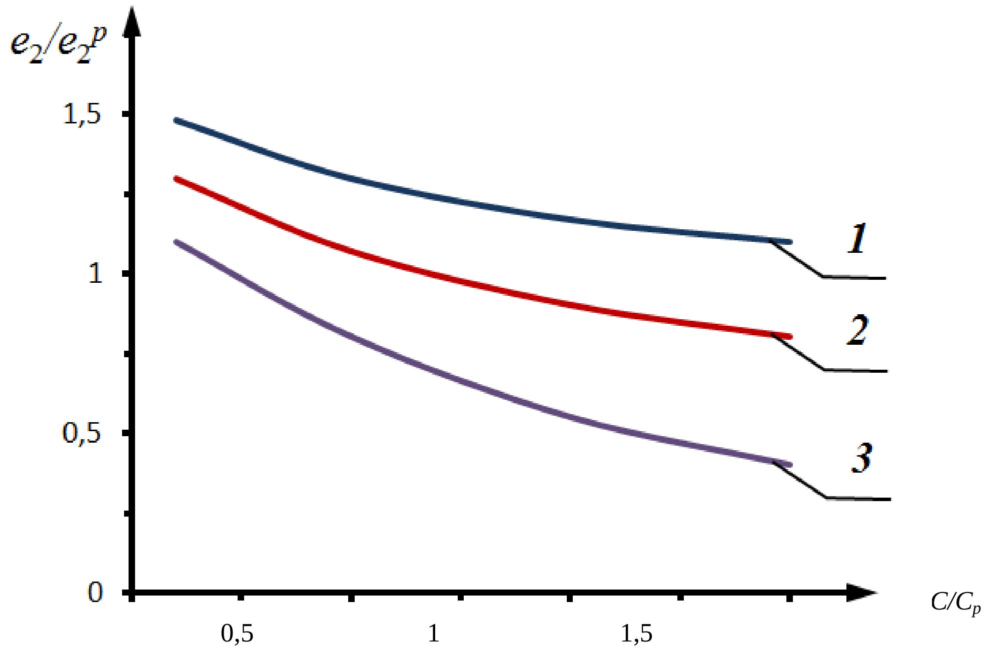


1– at $\frac{c}{c^p} = 0.65$; 2 – at $\frac{c}{c^p} = 1.1$; 3 – at $\frac{c}{c^p} = 1.5$

Figure 3: Graphical dependences of the change in the relative length of the additional shock absorber on the force of the weight of the working and the stiffness of the shock absorbers.



1 - at $\frac{l'}{l_1} = 0.12$; 2 –at $\frac{l'}{l_1} = 0.09$; 3 – at $\frac{l'}{l_1} = 0.06$

Figure 4: Graphical dependences of the change in the relative length of the additional shock absorber on the change in the stiffness coefficients of the shock absorbers

CONCLUSIONS.

Improved safety harness design recommended. A formula for calculating the length of the additional shock absorber of the belay device is derived, taking into account the weight of the worker, the length of the sling and its

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shock absorber, as well as the stiffness coefficients of the shock absorber of the line and the additional shock absorber. Graphical dependences of the change in the relative length of additional shock absorbers on the change, on the weight force of the worker and the stiffness coefficients of the shock absorbers at $G \geq 70$kg are plotted. Recommended parameter values are $c/c_p=(0,8 \div 1,0)$; $l_1'/ l_1= (0,1 \div 0,12)$, at which $l_2/ l_2^p=(0,9 \div 1,1)$ is provided.

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