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Original Article

A Feasibility Study of using Natural Rubber Latex to Increase Blast Stemming Efficiency

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Abstract *- Today's mining industry still needs mining blasting to grow and provide enough raw minerals for various industrial uses. It is essential to identify the blasting and explosion stages. Using stemming plugs in blast holes will directly influence rock fractures, ground vibration, air blast, noise, fly rock, dust, and fume. This study aimed to explore the viability of using natural rubber latex to improve blast-stemming efficiency. Testing was done at the feldspar mine in Nakhon Si Thammarat province, Thailand. The performance was evaluated using rock image software to compare the distribution of rock sizes. In conclusion, the preliminary investigation revealed that blasting latex-filled holes with conventional blasting procedures at d20, d50, and d80. The rock achieved size distribution values of d20, d50, and d80, with conventional methods at 2.31, 6.24, and 12.60 inches, respectively. While using natural rubber latex was found in d20, d50, and d80 at 2.05, 5.68, and 10.63 inches, which proportionally represented a lesser proportion of 11%, 9%, and 16% of the average size. It also found that the oversize was less than typical, with lower ground vibration and fly rock.*

Keywords *- Natural rubber latex, Size distribution, Blasting, Rock image software, Stemming.*

1. Introduction

Currently, there are many techniques of blast stemming in mining by plugging stem plugs such as plastic cones, rubber balls, rubber plugs, or cement mixed with water to mix and pour into blast holes [1]–[4]. Using ANFO primary explosives [5], [6] and together with a stem plug is becoming a popular method because, in many studies, it has been found that the use of a stem plug can increase the blasting efficiency of rock fragmentation and also reduce the problem of flying rock, repeated blasting (2nd blasting), and environmental problems. According to the economic analysis results, using stem plugs can also reduce the cost of mine blasting.

Natural rubber latex has been known as a polymer [7]. It has several remarkable qualities [8], including good mechanical characteristics, elasticity, toughness, resistance to abrasion, and the capacity to cluster into different shapes. It sticks effectively to other materials [9] and can agglomerate into the proper forms. Therefore, it is popular to apply it to various engineering applications, such as civil engineering [10]–[14], chemical engineering [15]–[19], and mining engineering [1]–[3]. In addition, most mining operations nowadays use blasting methods to break down the size of minerals and rocks to be utilised. It is necessary to use increased blast pressure to increase the efficiency of stemming the blast hole or find different methods of stemming materials. Due to the improper stemming of the blast hole, fly rock and dust were generated [20].

2. Materials and Methodology

2.1. Study Area

This research recognised the significance of researching the characteristics of natural rubber latex and blast stemming in mining activity. A feasibility study was carried out to improve the effectiveness of blast stemming using natural rubber latex preparatory. Performance is compared by measuring the distribution of rock from the blast [21] using photographic size distribution analysis with the Rock Image software; it is a fast and low-cost digital image processing method. The testing was done in the feldspar mine [28] of Sinluang Co., Ltd., located in Noppitam District. Nakhon Si Thammarat Province, Thailand. Geographic coordinates are 8° 47′ 31.995″ N latitude and 99° 43′ 47.358″ E longitude. A view of the study area is highlighted in Fig. 1.

2.2. Raw Materials

2.2.1. Natural rubber latex
2.2.2. Acetic acid
2.2.3. Plastic bottle
2.2.4. Explosive
2.2.5. Measuring tape
2.2.6. Ball

2.2.7. Camera

2.2.8. Rock image software

2.3. Research Methodology

The explosion effect was studied by using ANFO. To compare the proportion of natural rubber latex mixed with the normal blast hole stemming. The size distribution of rocks after blasting was analysed using rock image software in Fig. 2.

2.3.1. Blast holes were drilled to prepare for the experiment according to the blasting pattern [23] in Table 1 and Fig. 3.

Table 1. Experimental blasting pattern

Blasting pattern	Value
Burden (m)	1.6
Spacing (m)	2.2
Hole diameter (in)	3.0
Bench height (m)	5.0
Hole length (m)	5.5
Explosive column height (m)	3.9
Stemming height (m)	1.6
Sub-drilling (m)	0.5
Explosive factor (kg/m^3)	0.8

Fig. 1 Study area of feldspar mine

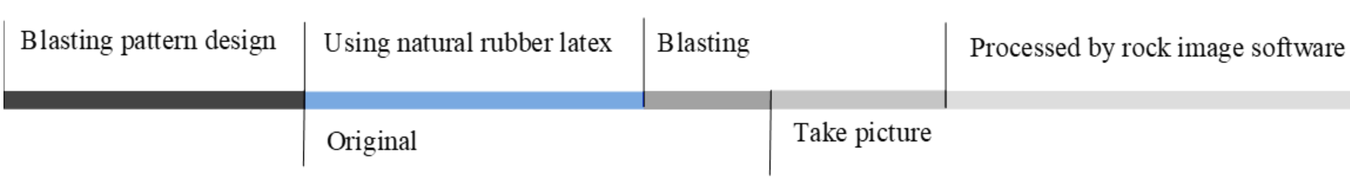
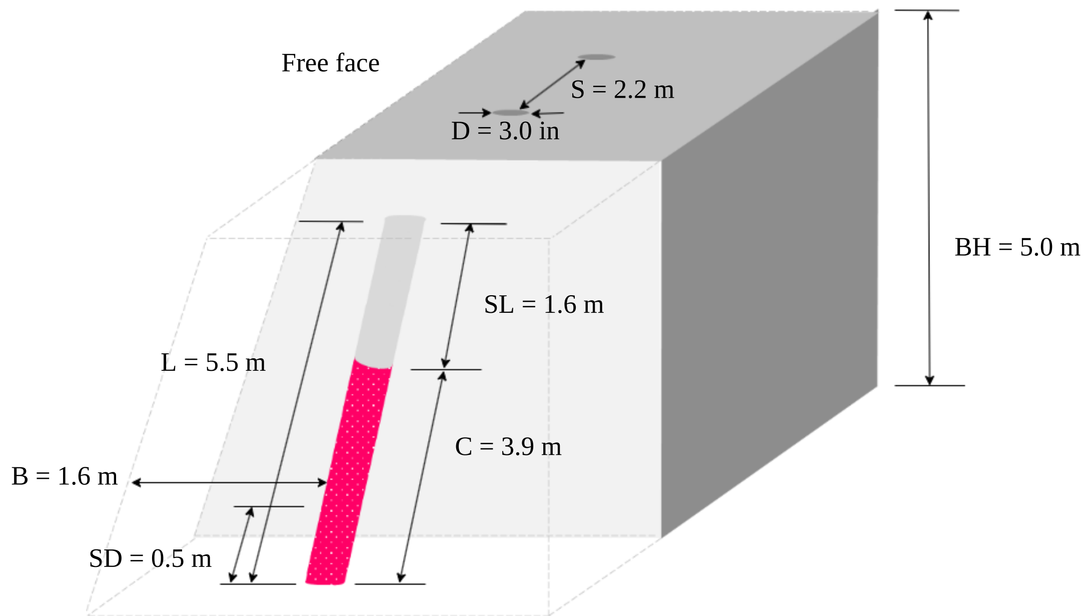


Fig. 2 Design Methodology



Burden (B), Spacing (S), Hole diameter (D), Bench height (BH),
Hole length (L), Explosive column height (C), Stemming height (SL), Sub-drilling (SD)

Fig. 3 Blast design

2.3.2. Case 1 Covers a Hole with Drill Cutting as Usual.

2.3.3. Case 2 covers a hole with drill cutting, reinforces it with natural rubber latex, covers the rest of the hole with drill cutting, and has a design instead of the actual blast hole (Fig.4).

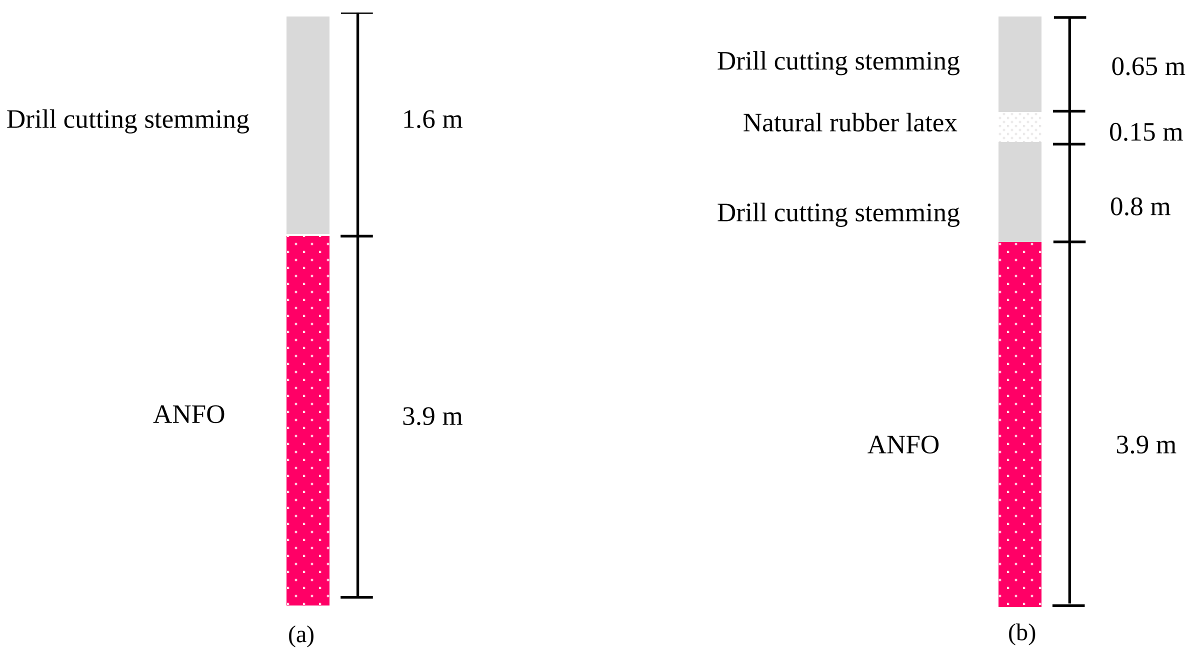


Fig. 4 (a) Pattern original and (b) Pattern using natural rubber latex.

Fig. 5 Stemming material

2.3.4. High explosives, ANFO and drill cutting are used in the original explosions to cover the blast hole (Fig 6).

(a)

(b)
Fig. 6 Original blasting process
(a) Charge high explosives and ANFO.
(b) Cover the blast hole with drill cutting

2.3.5. Using natural rubber latex for additional stemming from filling the hole. Mix 500 mL of natural rubber latex with 50 mL of 3% acetic acid to make the latex coagulates faster [24]. (Fig 7).

Load the high explosives and ANFO, then begin covering the holes with a drill cutting about half the length of the stemming. Then, mix natural rubber latex and acetic acid. Shake well before pouring into the hole. Finally, use drill cutting to cover the remainder of the hole (Fig 8).

2.3.6. Detonate using high explosives and ANFO.

2.3.7. Put two balls as reference objects on the pile of rocks [25]-[27] (Fig 9).

2.3.8. Take photos of a whole rock pile. Analyse the rock size distribution using rock image software.

Following the original blasting and natural rubber blasting, the rock image software was used to estimate the average rock size distribution using images of the pile of rocks (Fig 10).

Rock imaging software was used to photograph the rock pile after the explosion and delineate its edges for processing, and two 24-inch balls were used as the scale. (Fig 11).

The boundaries of the objects in the image are processed using rock image software. We entered by comparing the pixels from the ball scale in the figure with the pile of rocks and then with the sieve size, then converting the result to the number of pixels of each sieve size, giving an estimate of the cumulative passing rate [21], [25]-[27]. (Fig 12).

Fig. 7 Stemming plug (natural rubber latex).


(a) **(b)**

(c)

(d)

Fig. 8 Natural rubber latex blasting process
(a) Charge high explosives and ANFO,
(b) Load the drill cutting into the blast hole,
(c) Combine natural latex with acid in a bottle, and shake before pouring into the blast hole,
(d) Cover the blast hole with drill cutting.

Fig. 9 Pile of rocks after the blast.

Fig.10 An example photo with balls.

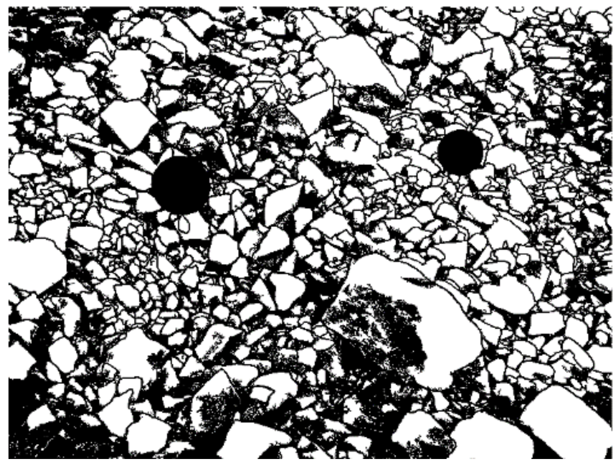


Fig.11 Rock image software analysis.

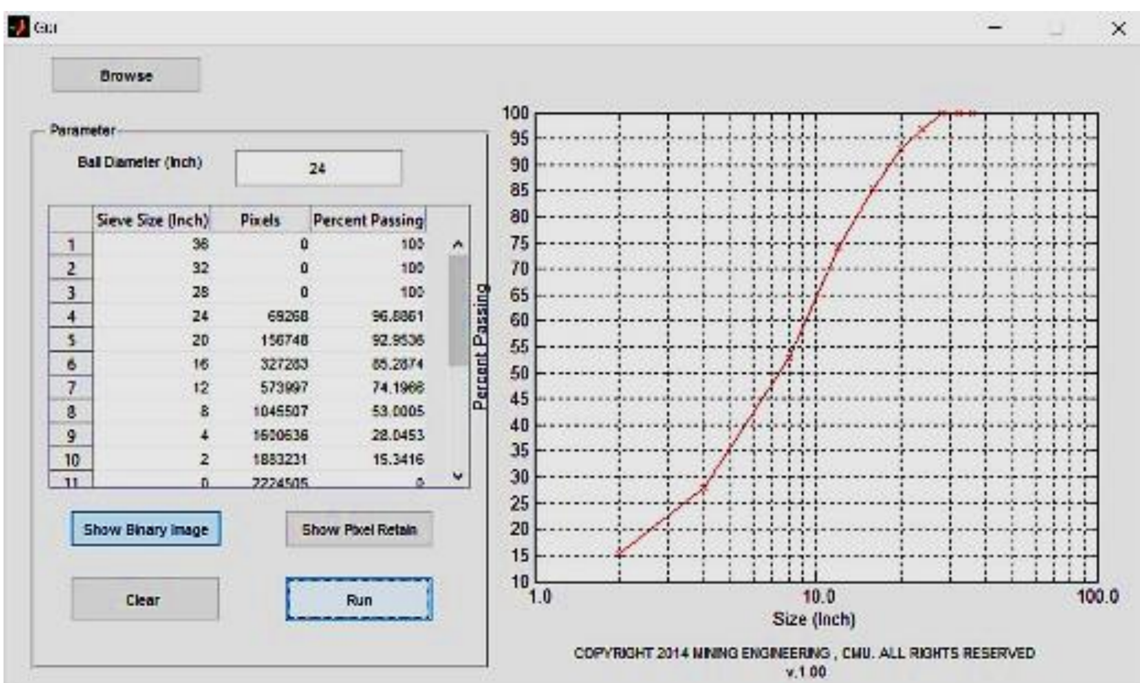


Fig. 12 Examples of size distribution analysis findings from rock image software

3. Results and Discussion

The size distribution of rock piles, the original blasting in Table 2 and Fig 13, and the use of natural rubber latex in Table 3 and Fig 14.

Table 2. Original blasting analysis results.

Size (in)	Cumulative passing percent			Average
	Test 1	Test 2	Test 3	
36	100.00	100.00	100.00	100.00
32	100.00	100.00	100.00	100.00
28	100.00	100.00	100.00	100.00
24	90.77	96.87	97.07	94.90
20	89.97	92.95	96.81	93.24
16	87.15	85.29	91.22	87.89
12	81.21	74.2	84.76	80.06
8	68.59	53.01	61.28	60.96
4	40.88	28.05	34.49	34.47
2	22.33	15.34	17.09	18.25

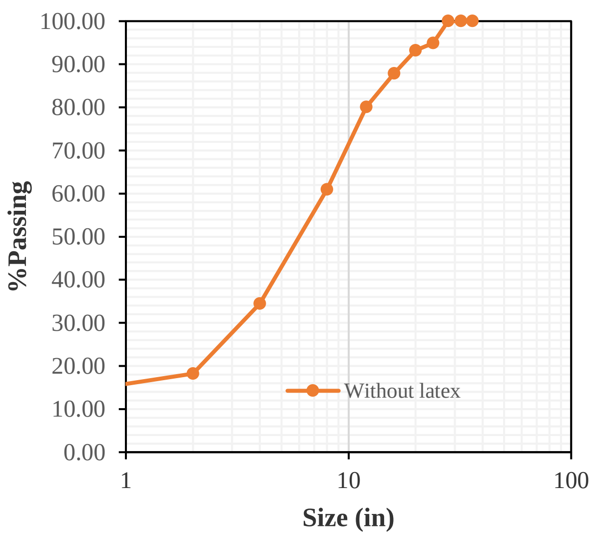


Fig. 13 Size distribution analysis using original methods.

Table 3. Natural rubber latex blasting analysis results.

Size (in)	Cumulative passing percent			Average
	Test 4	Test 5	Test 6	
36	100.00	100.00	100.00	100.00
32	100.00	100.00	100.00	100.00
28	100.00	100.00	100.00	100.00
24	100.00	95.47	94.58	96.68
20	98.06	92.3	94.75	95.04
16	95.79	87.69	87.71	90.40
12	85.07	81.46	84.68	83.74
8	71.49	69.8	59.7	67.00
4	38.69	37.93	34.52	37.05
2	21.98	15.98	19.86	19.27

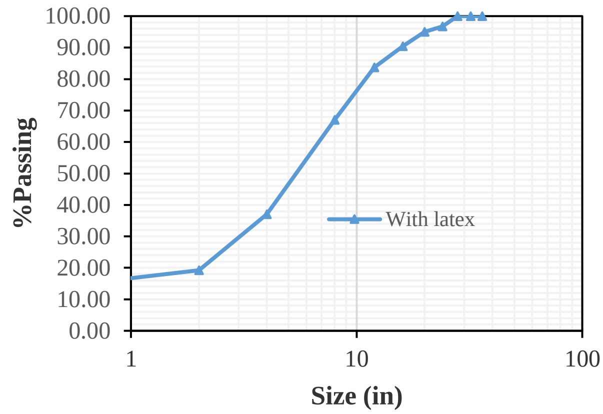


Fig. 14 Size distribution analysis using natural rubber latex methods.

Table 4. The size distribution of rock d20, d50, and d80.

Value	Original blasting (in)	Natural rubber latex blasting (in)
d20	2.31	2.05
d50	6.24	5.68
d80	12.60	10.63

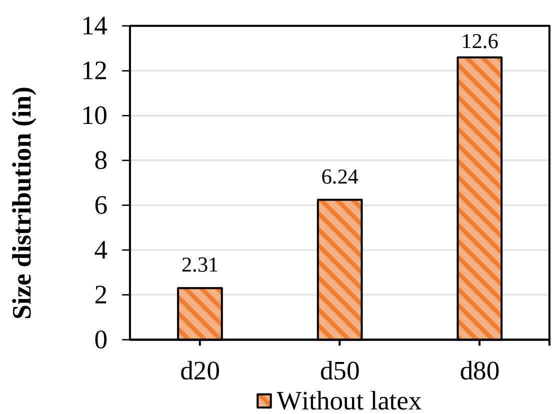


Fig. 15 Size of d20, d50, and d80 using original methods.

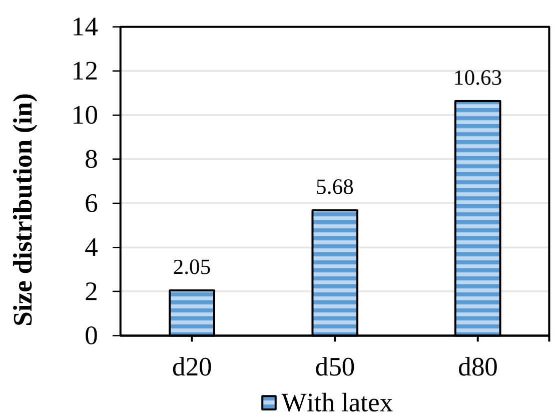


Fig. 16 Size of d20, d50, and d80 using original methods.

Comparison results of size distribution are shown in Fig17 and 18.

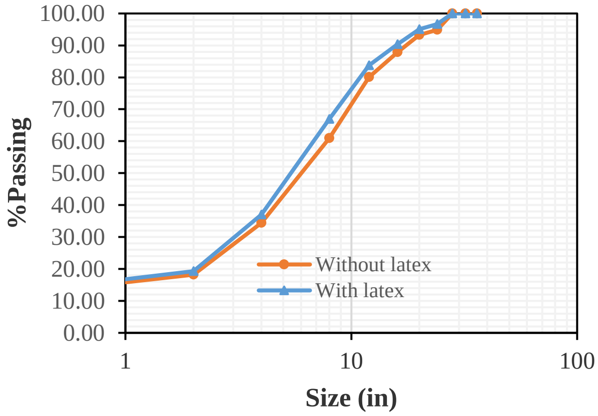


Fig. 17 Size distribution comparison result.

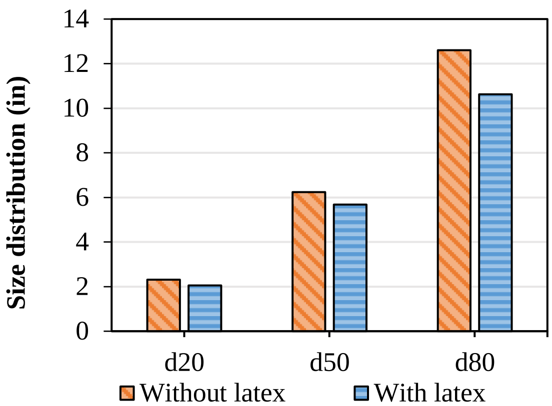


Fig. 18 Size of d20, d50, and d80 comparison result.

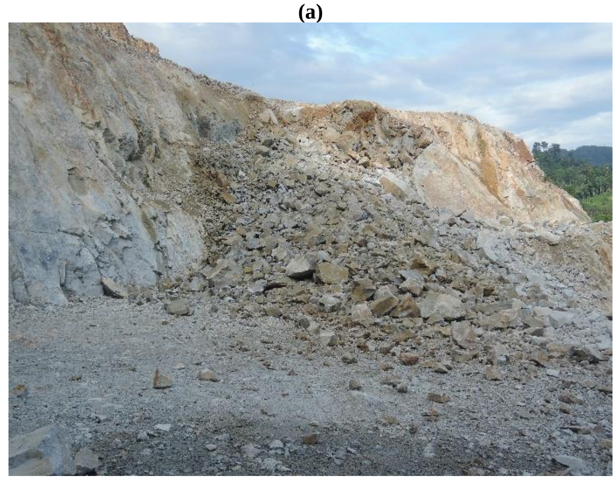
A comparison of the rock distribution during an original condition and natural rubber latex condition found that at d20, d50, and d80, the rock size was reduced by 11, 9, and 16% than the original blasting condition, respectively.

(a)

(b)

Fig. 19 (a) Original blasting, and (b) With natural rubber latex blasting.

(a)



(b)

Fig. 20 (a) Rockpile of original blasting, and (b) Rockpile using natural rubber latex blasting.

4. Conclusion

The feasibility study of natural rubber latex was compared to the original blasting results by controlling the blasting pattern. The images were captured and analysed using rock image software. Rubber latex was discovered to be potentially useful. The size distribution of rock by original blasting, d20, d50, and d80, was equal to 2.31, 6.24, and 12.60 inches, respectively, and the natural rubber latex blasting at d20, d50, and d80 was 2.05, 5.68, and 10.63 inches. When comparing results, it was found that natural rubber latex had size distribution d20, d50, and d80 reduced than original blasting at 0.26, 0.56, and 1.97 inches, representing 11%, 9%, and 16%, respectively. Furthermore, the results show that using natural rubber latex can help reduce vibration, fly rock, and the volume of oversize rock by about 35% compared to the original method. However, the problem of natural rubber latex hardening relatively quickly when exposed to air and releasing water from natural rubber latex coagulation reactions is still a challenge in progress.

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