STUDY OF BRIDGE REINFORCEMENT CONCRETE DESTRUCTIONTECHNIQUES USING TNT AND C4EXPLOSIVES TO OPTIMIZE THEPOWER OF EXPLOSIVES

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STUDY OF BRIDGE REINFORCEMENT CONCRETE DESTRUCTION TECHNIQUES USING TNT AND C_4 EXPLOSIVES TO OPTIMIZE THE POWER OF EXPLOSIVES

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ABSTRACT

Explosive technology is the fracturing of materials by using a number of calculations from the explosion so that the volume of breakable material can be determined. This study is to find out how the 30 cm diameter bone bridge concrete technique and how the explosive strength difference of explosive TNI and C4 at the same weight to the concrete of the bridge. The method used is literature study and field experiments. The results of this study were obtained for effective and efficient blasting of concrete and resulted in an optimum explosion with several steps: calculating concrete strength by Core Drill test, calculating the amount of current required, calculating the amount of C4 and TNT explosives required. The explosive strength difference of explosive TNI and C4 at the same weight to the concrete with the value of fc = 229.31 kg / cm2 Core Drill test. C4 explosives have more complete destructive power compared to TNT and the number of effective explosives required to destroy the concrete with the strength of fc = 229.31 kg / cm2 is 122 g.

Keywords: Concrete Power, TNT and C_4 explosive, Tamping Factor

1. INTRODUCTION

Explosive technology is the material fracturing process by using calculations from the explosion. So that the volume of breakable material can be determined. In this research, the study of reinforced concrete technique by using effective and efficient explosive of TNT and C4 to optimize the explosive power was performed. The objective of this study was to know the destruction technique of 30 cm diameter reinforced concrete. So they could be completely destroyed using TNT and C4 explosives, and to know the difference in the explosive power of TNT and C4 on the same weight of concrete bridge. As for the method used was literature study and field experiments. Explosive technology is the material fracturing process by using calculations from the explosion so that the volume of breakable material can be determined. Originally, black power was widely used to detonate materials, however there have been many developments in the use of: explosives, detonators, delay techniques and the mechanism of rock breaking with explosive (Jovisevic, et al., 2007).

Reinforced concrete is an excellent composite structure for use in building construction. There are various benefits of reinforced concrete structures resulting from the merging of two materials, namely concrete (PC + fine aggregate + rough aggregate + additive) and steel as reinforcement. We've already known that the superiority of the concrete is the high compressive strength, while the reinforcing steel is excellent for withstanding tensile and shear forces (Ilangovana, et al., 2008). The merger between concrete and reinforcing materials allows the construction agent to acquire new materials with the ability to withstand compressive, tensile, and shear forces so that the overall structure of the building becomes stronger and safer (Neville, 2011).

Therefore, the new finding in building material by adding reinforcing steel to strengthen the concrete is useful to overcome the shortcoming of concrete material. The reinforcing steel should use deformed bar steel (Shende, et al., 2012). While plain bar can only be used for spiral and tendon reinforcement, except for certain cases. However, to get the concrete strength above 35 or 40 Mpa required a very careful concrete mix design and full attention to detail such as mixing, placement, and maintenance. This requirement led to greater relative cost increases. The tensile strength of the concrete was not directly proportional to the ultimate strength of the fc '. Nevertheless, this tensile strength was estimated to be directly proportional to the square root of fc '. This tensile strength was difficult to measure with direct axial tensile loads due to the difficulty of holding test specimens to avoid stress concentrations and the difficulty of straightening the loads. As a result, two indirect tests were created to calculate the tensile strength of the concrete (Schuman & John Tucker, 1943) (Yao, et al., 2017). Both were modulus test collapse and cylindrical cleavage test.

Concrete tensile strength during flexure was important when we were reviewing cracks and deflections in beams (Khalil & R., 2013). For this purpose, we had been using the tensile strength obtained from the modulus-collapse test. The collapse modulus was usually calculated by burdening a square concrete beam (with simple support of 6m gap from asphalt) without the reinforcement and the size was 15 cm x 15 cm x 75 cm. It was performed until it collapses with a centralized load equal to 1/3 of the points on the beam corresponding to those mentioned in ASTM C-78. These loads continued to be increased until the collapse occured due to cracks in the tilted beam. The collapse modulus fr was determined later from the bending formula. The voltage determined in this way was not very accurate because we assume the concrete was in a perfectly elastic state with a voltage proportional to the distance from the neutral axis (Lee, et al., 2014).

In measuring bomb strength, there are five points to consider, the first is VOD (velocity of detonation), the second is strength, the third is sensitivity, the fourth is density, and the fifth is time saving (Bansal, et al., 2016). For military, VOD is usually large and the average is more than 4500 m/sec, has poor sensitivity, heavy beat, with higher type. The further the power, the stronger the explosive power. The TNT vapor is about 6,800 meters per minute. While the ANFO or Ammonium Nitrate has the power of 3000 meters per second and the RDX power reaches 8,000 meters per second (Al-Zuhairi & Qasim, 2016).

The benefit of this study is to know the 30 cm diameter bone bridge concrete technique and how the explosive strength difference of TNI and C4 explosive at the same weight to the concrete bridge and to know the amount of explosive C4 and TNT needed for breakable material can be determined.

In this paper, the Material and Methodology used would be described in Section 2, Research Results and Discussion in Section 3, last chapter Conclusions in Section 4.

2. MATERIAL AND METHODOLOGY

2.1. Reinforced Concrete

Concrete is a building material made of cement (Portland cement or other hydraulic cement), sand or fine aggregate, gravel or coarse agregate, water and with or without additives. The concrete compressive strength for planning is determined by the compressive strength of the concrete at 28 days. Although now we can produce concrete with a compressive strength of over 100 MPa, the compressive strength of concrete commonly used in planning ranges from 20 to 40 MPa. Concrete has a high compressive strength but has a low tensile strength, ranging from 8% to 15% of its compressive strength (Shang, et al., 2012) (Kristiawan, 2006).

Deep knowledge about reinforced concrete properties is essential before the design of reinforced concrete structures begins (Rai & Joshi, 2014). Some of the properties of reinforced concrete are:

a. Compresive Strenght

The concrete compressive strength (f'c) was performed by conducting a concrete cylinder test with a diameter of 150 mm and a height of 300 mm for 28 days with a certain loading rate. During this 28-day period, the concrete cylinder was usually placed in a room with a fixed temperature and 100% humidity. Although there was a concrete with a maximum strength of 28 days from 17 MPa to 70 -140 Mpa, most concrete had a strength in the range of 20 MPa to 48 MPa. For general applications, 20 Mpa and 25 Mpa of concrete were used, while for prestressed concrete was 35 Mpa and 40 Mpa. For certain applications, such as for columns on the lower floors of a high-rise building, concrete with strength up to 60 Mpa had been used and could be provided by ready-mix concrete manufacturers. The values of concrete compressive strength as obtained from the test results were strongly influenced by the size and shape of the test element and the manner of loading. In many countries, the test specimens used were cubes containing 200 mm. For the same concrete, the test of the cylinders with the size 150 mm x 300 mm only produced a compressive strength of 80% of the value obtained from the cubic concrete test. The concrete strength could switch from 20 MPa concrete to 35 Mpa concrete without the need to add excessive amount of labor and cement. The approximate increase of material cost to get such power increase was 15% to 20%. The stress-strain curves in the following image showed the achievement results from compression tests on a number of 28-day standard test cylinders of various strength.

1) The curve was almost straight when the load was increased from zero to approximately 1/3 - 2/3 of the concrete maximum strength
2) Above this curve, the concrete behavior was nonlinear. The nonlinearity of the concrete stress- strain curve at this higher tension led to some problems when the structural analysis of the concrete constructs was performed. It was due to the construction behavior that will also be nonlinear at higher tension.
3) One important thing to note wass the fact that no matter how large the concrete strength was, all concrete wiould reach its peak strength at a about 0.002 of strecth.
4) The concrete did not have a definite melting point, otherwise the concrete curve would remain smooth until it reached the point of rupture at about 0.003 to 0.004 of stretch.

b. Static Modulus of Elasticity

Concrete does not have a definite elastic modulus. Its value varies depending on the concrete strength, the age of concrete, the type of loading, and the characteristics and comparison of cement and aggregate. In addition, there are several definitions of the modulus of elasticity:

1) The initial modulus is the slope of the stress-strain diagram at the origin of the curve.

2) The tangent modulus is the slope of one tangent to the curve at a certain point along the curve, for example at 50% of the maximum strength of the concrete.

3) The slope of a line drawn from the point of the curve origin to a point on the curve somewhere between 25% to 50% of its maximum compressive force is called the Secant Modulus.

4) The other modulus, called apparent modulus or long-term modulus, is determined using the stresses and strain obtained after the load is given for a certain time.

5) The ACI regulation states that the formula for calculating the concrete modulus of elasticity with weight of concrete (wc) ranges from 1500-2500 kg/m^3.

6) Where: wc is weight of concrete (kg/m^3), fc' is concrete quality (Mpa), and Ec is modulus of elasticity (Mpa)

c. Dinamic Modulus of Elasticity

The dynamic modulus of elasticity, corresponding with various small instantaneous strains, is usually obtained from the sonic test. The value is usually 20% -40% greater than the static elasticity modulus value and approximately equal to the initial value of modulus. This dynamic modulus of elasticity is usually used in structural analysis with seismic or impact loads.

d. Poisson Ratio

When a concrete receives a compressive load, the cylinder is not only reduced in height but also expands in the lateral direction. The comparison of lateral expansion with this longitudinal approach is called the Poisson's ratio (Poisson's ratio). The values range from 0.11 for high quality concrete and 0.21 for low quality concrete, with an average value of 0.16. There seems to be no direct relationship between this ratio value with values of water-cement ratio, length of treatment, aggregate size, and so on. In most reinforced concrete designs, the effect of this poisson ratio is not particularly noticed. However, the ratio effect must be taken into account when we analyze and design arc dams, tunnels, and other indefinite static structures.

e. Tensile Strenght

Concrete tensile strength varies between 8% to 15% of the compressive strength. The main reason for this small tensile strength is the fact that the concrete is filled with fine cracks. These cracks have no major effect when the concrete receives the compressive load because the compressive load causes the crack closing and allows the occurrence of chanelling pressure. This obviously does not occur when the beam receives load. Although usually neglected in design calculations, tensile strength remains as an important property that affects the concrete size and how big the cracks occur. Since concrete tensile strength is not large, little effort is made to calculate the tensile elasticity modulus of the concrete. However, based on this limited information, it is estimated that the value of the tensile modulus of elasticity is equal to the modulus of elasticity of the press. The concrete is not assumed to withstand the tensile stress that occurs on a flexible bar and the steel that holds it. The reason is that the concrete will crack at such tensile strain so that the low voltages present in the steel will cause an uneconomical use of it.

f. Shear Strenght

The test to obtain a completely pure shear collapse without being affected by other stresses was very difficult. Consequently, concrete shear strength testing over the years always resulted in melting values located between 1/3 to 4/5 of its maximum compressive strength.

g. Stress-Strain Curve

The stress-strain relationship of concrete needed to be known to derive the analytical and design equations as well as the procedures on the concrete structure.

h. Column

The column definition according to SNI-T15-1991-03 is a component of a building structure whose main task is to support a vertical axial load with a high, unsupported height at least three times the smallest lateral dimension. Columns are vertical composite rods of frames structures that carry loads from both the main beam and the small beam. The column continues the load from the upper elevation to the lower elevation until it reaches the ground through the foundation.

The collapse of a column is a critical condition that can cause the collapse of the floor and the total collapse of the entire structure. The column is a structure that supports the load from the roof, the beam and its own weight is passed to the foundation. The structure of the column receives a large vertical load, in addition it must be able to withstand horizontal loads even torque due to the influence of the eccentricity of loading. Things to note are the height of the planning column, the quality of concrete, steel used and the eccentricity of loading that occurs.

i. Beam

A beam is a part of a structure that serves as a vertical and horizontal load support. The vertical loads are dead loads and live loads received by floor plates, the weight of the beams and the weight of the above insulating wall. While the horizontal wind load and earthquake load. Beams are an important part of building structures and the aim is carrying a tranversal load that can be either flexural, shear or torque loads. Therefore, the effeicient, economical and safe beam planning is essential for a building structure, especially high-rise structures or large-scale structures

2.2. C4 Explosive

Any new explosives can explode in case of collisions, friction, or elevated temperatures. In case of friction, the explosive will turn into another more stable substance followed by a high pressure that produces a violent explosion or spark. Apparently, the assembly of explosives is not too difficult, since almost all objects can produce chemical reactions that produce explosions. Moreover, currently explosives are easily found in mining or exploration industries, along with the stone miners and fishermen (Rarata & Smętek, 2016).

One of the high explosive categories is emulsion, which is a mixture of ammonium nitrate + almunium + sulfur. Ammonium nitrate is the most probable and easily formulated commercial explosive. Other materials are PETN, RDX, and Semtex (which are a mixture of RDX and PETN, originally from Czech, Eastern Europe, and usually used by terrorists) (Verkouteren, 2007). These results are subsequently coded into C, C2, C3, and C4. All of them use RDX. The difference is the presence of plasticizer and sometimes combined with TNT and PETN. C4 has the largest RDX, so it has the most damaging power. TNT, RDX, PETN, and C4 (which are a combination of RDX + PTEN + TNT) are classified as military exsplosive (Cross, 2014). C4 bombs are plastic bombs, high explosive, very sensitive, used only for military purposes (for example, for the purposes of blowing bridges). The shape is solid, can be like a small stick or square and can be detonated using a timer, remote control, key contacts, and so on, produced in America and Europe.C4 is prone to vibration, prone to light, and prone to darkness. It is often used for military duties destruction and only used by special forces.

The explosive in C4 is RDX (cyclonite or cyclotrimethylene-trinitramine), which is 91% of C4 weight like many plastic explosives and the binder is usually polyisobutylene (2.1%). The plasticizer is diethylhexyl (5.3%) sebacate or dioctyl. Other plasticizers used are dioctyl adipate (DOA). The chemical material of 2,3-dimethyl-2,3-dinitrobutane is used to help explosives detection and identify its source. A small amount of SAE 10 non-detergent motor oil (1.6%) is also added. C4 is produced by combining the recorded material with the material dissolved in the solvent (Belmas & Plotard, 1995). The solvent then evaporates and the mixture is dry and filtered. The last material is solid off-white which is similar to clay. Because the C4 bomb has several advantages, namely: This bomb can be easily formed into any desired shape, C4 is very stable and insensitive to physical shocks, thus the blasting can only occur due to a combination of extreme heat and shock waves. C4 can not be detonated by a shot or by dropping it to a hard surface. C4 also does not explode when burned or exposed to microwave radiation (Campeau, et al., 2008).

2.3. TNT Explosives

TNT as a chemical structure is actually an abbreviation of Trinitrotoluene, which is an aromatic organic chemical compound with the structure formula of C_6H_2 (NO_2) $3CH_3$ compound, commonly written under the name 2,4,6 – Trinitrotoluene (Figure 1). Where, 2,4,6 are points, where NO2 is attached with carbon in the aromatic cycle (Pitz & Westbrook, 2005) (Qasim, et al., 2007).

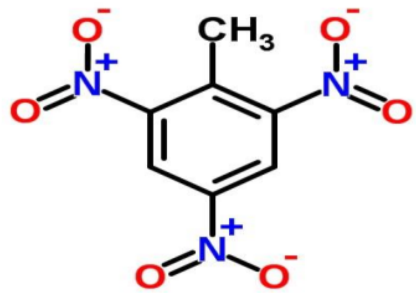

Fig. 1 Structure Formula of TNT

TNT has IUPAC (International Union of Pure and Apllied Chemical) name as 2-methyl-1,3,5 - Trinitrobenzene. This compound has a molecular weight of 227.13 grams / mol, in accordance with the total number of atomic weights that constitute it. TNT is mostly used as an explosive and in the military industry, because its use is quite easy and safe. For example, the possibility of spontaneous or accidental explosions is very small, due to high melting point and not too sensitive to shocks (Carper, et al., 1982)

Physical and Chemical Properties in physical form: TNT in normal condition is a pale yellow, crystalline. Odor: odorless. Molecular Weight: 227,13 grams/mol. Melting Point: 80 ^{0} C. Boiling Point: 240 ^{0} C. Density: 1, 6 ± 1 gram/cm_3 Water solubility: 130 mg / L at 20 ^{0} C (soluble in water). Easy soluble inside: ether, acetone, benzene, and pyridin Vapor Pressure: 0.0002 mmHg at 20 ^{0} C. Explosion Data Detonation Speed: 6900 m / s (first shock rate shortly after an explosion. Sensitivity to shock: No reaction up to shock of 15 Newton.meter Sensitivity to Friction: No reaction to frictional force 353 Newton Reaction - Synthesis.

2.4 Research Conceptual Framework

A study is a systematic process and based on the information obtained, a flow sheet it can be compiled as follows figure 2.

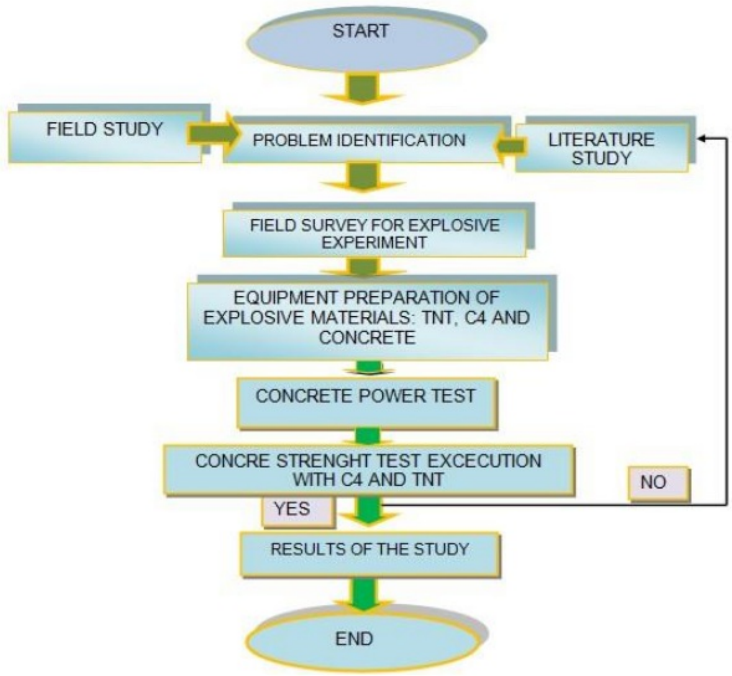

Fig. 2 Flow Chart and Stage of Research Plan

3. RESEARCH RESULTS AND DISCUSSION

3.1. Value Of Various Material

The explosive strength (K) data and Tamping value of this data affected the position where the explosive was placed on the material detenoted (Al-Homoud, 2005). The value of the explosive coefficient can be seen in the following table 1.

Table. 1 The Value Of Combustion Coefficient (C) On Various Material.

Building Thickness (m)	Hole Depth (m)	Coefficient Value (C)			
		Brick Building	Stone	Concrete	Reinforced Concrete
0,50	0,35	1,20	1,46	1,58	1,70
0,60	0,40	1,18	1,22	1,32	1,70
0,75	0,50	0,86	1	1,08	1,12
0,90	0,60	0,65	0,76	0,81	0,87
1-1,2	0,65-0,80	0,58	0,65	0,70	0,76
1,3-1,5	0,85-100	0,50	0,58	0,63	0,68
1,5-1,7	1,05-1,15	0,45	0,54	0,58	0,62
1,8-2	1.20-1,40	0,43	0,52	0,54	0,56

The tamping factor (C) is the coefficient value depending on the location of the fill and the type of tamping that is used. The value of tamping in a Demolition can be seen in the tamping image as shown below.

3.2. The Data of Concrete

Concrete data for Demolision Performance tested in ITS Core Drill Laboratory in table 2.

Table 2. Test Result of Concrete dP Core Drill Laboratory

No	Description	Unit	Core 1	Core 2
1	Press Load	kg	16550	11400
2	Cross-Sectional Area	Cm2	69,40	69,40
3	Sillinder core	Kg/cm2	238,48	164,27
4	Compresive Strength	Kg/cm2	229,31	157,95

3.3. The Measurement of TNT and C_4 Utilization

The destroying of the concrete was using the following formula: P = R3KC. That formula aimed to determine the number of C4 reuquired for the destruction of concrete bridge, with 0.50 cm thick and 0.50 cm wide, means K = 1.58, R = 0.35 C (Tamping) = 1.8

$P = R^3KC,$

$= 0{,}35^3.1{,}58.\ 1{,}8.$

$= 0{,}122$ kg

=122 gr explosives.

Based on the explosive experiments data using explosives with the amount oof 100, gr, 200 gr and 300 gr, explosion results of several explosive weight and concrete strength of fc 229.31 kg / cm3 could be obtained ands presented in the data as follows table 3-4 and figure 3.

Table. 3 Explosion Resultf of C_4 from several weight

NO	WEIGHT OF C_4 EXPLOSIVE	CONCRETE STRENGHT fc kg/cm3	EXPLOSION RESULTS
1	100 gr	229,31	Split into 15 parts
2	100 gr	229,31	Split into 16 parts
3	100 gr	229,31	Split into 16 parts
4	100 gr	229,31	Split into 17 parts
5	200 gr	229,31	Split into 100 parts
6	200 gr	229,31	Split into 120 parts
7	200 gr	229,31	Split into 125 parts
8	200 gr	229,31	Terbelah 100 bagian
9	300 gr	229,31	Destroyed with no residue = 500
10	300 gr	229,31	Destroyed with no residue = 500
11	300 gr	229,31	Destroyed with no residue = 500
12	300 gr	229,31	Destroyed with no residue = 500

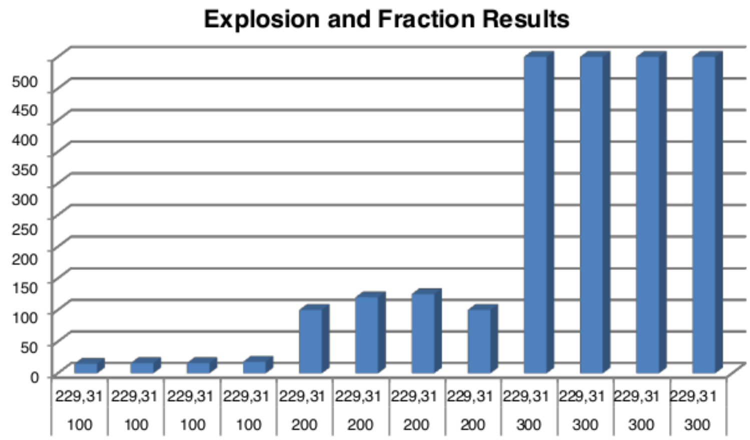

Fig. 3 Column Graph Explosive Mass And Concrete Strength With Explosion Results

Table. 4 TNT Explosion Result from several weights

NO	WEIGHT OF TNT EXPLOSIVE	CONCRETE STRENGHT fc kg/cm3	EXPLOSION RESULTS
1	100 gr	229,31	Split into 9 parts
2	100 gr	229,31	Split into 10 parts
3	100 gr	229,31	Split into 10 parts
4	100 gr	229,31	Split into 11 parts
5	200 gr	229,31	70 flakes
6	200 gr	229,31	75 flakes
7	200 gr	229,31	72 flakes
8	200 gr	229,31	71 flakes
9	300 gr	229,31	Destroyed with combustion residue
10	300 gr	229,31	Destroyed with combustion residue
11	300 gr	229,31	Destroyed with combustion residue
12	300 gr	229,31	Destroyed with combustion residue

4. CONCLUSION

a. The effective and efficient technique of concrete detonating can be done in several steps, namely:

1). The calculation of the concrete strength that will be detonated through the laboratory test is performed to find out the value of fc Core Drill test or by calculating the K strength of the concrete detonated through the correlation table of material strength along with the tamping value.

2) Calculating the amount of current required to detonate the detonator with the following formula E = IR, E = Voltage / Voltage in volt, I = Current in ampere R = Resistance in Ohm.

3). Calculating the amount of C4 and TNT explosives required by using the following formula P = R3. K.C. (P = Number of Explosive needed, R = correlation value of material thickness that is distinguished according to table 4.1, K is strength or coefficient value according to table 4.1, C = tamping factor)

b. The difference of explosive strength between TNI and C4 at the same weight to the concrete with the value of fc = 229.31 kg / cm2 Core Drill test. C4 explosives have more complete destructive power compared to TNT and the number of effective explosives required to destroy concrete with the strength of fc = 229.31 kg/cm2 is 122 g.

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