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Vibration Analysis of I Section Cantilever Beam

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Abstract- **This paper discusses the effect of vibration on I section cantilever beam using computer aided software ANSYS. The vibration induces damage/cracks in the structure which can alters the various properties of structure like frequency, mode shape, stiffness etc. to avoid this and to increase the life of structure vibration analysis is very necessary. In this study vibration analysis is carried on steel cantilever beam. The results obtained from ANSYS are validated with experimental results.**

Keyword:- ANSYS, Cracks, Frequency, **Steel Beam, Vibration analysis.**

I. INTRODUCTION

The structure must be safe during its service life. But most of the structural members like beams can operate under loading conditions, which may leads to damages or cracks in overstressed zones. The presence of crack is common structural defect [6]. Cracks are present in structures due to various reasons. Cracks may be caused due to fatigue failure under operating conditions because of the limited value fatigue strength [11]. They may be caused due to mechanical defects. Some of cracks are generated during the manufacturing processes. They also developed due to mechanical vibrations. The presence of cracks in a structural member, such as a beam, causes local variations in stiffness, the magnitude of which mainly depends on the location and depth of the cracks [13]. Cracks in vibrating structure can lead to a sudden and total failure from which recovery is impossible. The presence of cracks causes changes in the physical properties of a structure which in turn alter its dynamic response characteristics [13].Scientific study on the changes in these characteristics can be widely utilized for the identification of crack in structures. Generally cracks are small in sizes and shapes. Such small cracks are later on propagates due to fluctuating stresses acting on components. If these propagating cracks remain as it is and reach their critical size, then a sudden structural failure may occur. Hence Therefore there is need to know dynamics of cracked structure. Every material in the nature having different natural frequencies i.e. it vibrates on its own at highest frequencies When these natural frequencies match with external excitation force body will vibrate at its maximum amplitude and Resonance will occur which leads to catastrophic failure of body [12]. This can be avoided if natural frequencies of materials are known. Modal analysis is a process to determine the vibration characteristics such as natural frequencies and mode shapes of a structure while it is being designed. It has become a major alternative to provide a helpful contribution in understanding control of many vibration phenomena which encountered in practice. That's why our project is to calculate natural frequencies of beam having different cross-sections. For this we are using different methods like Software and Actual Experimentation [12]. After getting frequencies from all methods we are able to compare results from all methods and find out variations in them. Vibration analysis is very important for constructions as well as designing of structural and mechanical system. This information helps us to predict the behaviour of structure under different load distribution and helps to design system to control the excessive amplitude of vibration.

Following are objectives of this study:

[1] To carry out vibration analysis on beam without crack by using computer aided software ANSYS.

[2] To carry out vibration analysis on beam with crack by using computer aided software ANSYS.

[3] Comparison of Results.

Two types of Methods are used for finding the natural Frequency of Different Modes . Here for aluminium and mild steel test results are carried out analytically and experimentally. It is found that, Result found by analytically and experimentally is approximately same.[1]

The theoretical analysis of transverse vibration of fixed free beam is carried out and the mode shape frequency are investigated. All the theoretical values are analysed with the numerical approach method by using ANSYS program package and co relate the theoretical values with the numerical values to find out percentage error between them [2].

The free vibration analysis of the cantilevered beams of different materials and lengths is carried out using the EMA technique. EMA is implemented using OROS FFT analyser and NV Gate software to acquire the vibration data of the specimens. The results obtained by experimentation are cross checked using the ANSYS simulation package [3].

The natural frequency for different material having same I and T cross- sectional beam is investigated. The cantilever beam is designed and analysed in ANSYS. The cantilever beam which is fixed at one end is vibrated to obtain the natural frequency, mode shapes and deflection with different loads[4]

The modal analysis of cantilever beam with T section is carried out using ANSYS. The beam is modeled, designed and analysed in in finite element analysis software ANSYS. Modes and the natural frequencies pertaining to it are computed in finite element analysis software.[5]

The vibration analysis of beams is carried out both experimentally and using FEM software ANSYS. vibration analysis is carried out on different cantilever beams with transverse cracks and with different boundary conditions[6].

The natural frequency of aluminum, brass and steel is investigated by free vibration analysis experimentally & verify theoretically. The natural frequency of the beams obtained from experimental & theoretical methods will be compared with harmonic analysis using ANSYS software [7].

The vibration response of a cantilever beam to harmonic forcing using different types of finite elements has been performed using a finite element model of the beam. While modeling the beam, different types of elements are used. Results are compared with the result obtained analytically[8].

The Effect of cracks presence and crack propagation on one end fixed beam`s vibration is considered. A finite element model will be developed for the blade in which the modal response of the structure with and without crack will be studied [9]

The dynamic behaviour study of reinforced concrete propped cantilever beam under various damaged conditions is carried out. mode shape curvature method is used for locating cracks in beam[10].

II. METHODOLOGY

Modal analysis of cantilever beam is used to determine the natural frequencies and mode shapes, which are important parameters in the design of a structure for dynamic loading conditions. They also required for spectrum analysis or for a mode superposition harmonic transient analysis.

4.1 Beam Model

In the present case cantilever beam of length 425mm is considered. One end of the beam is fixed and the system is subjected to vibration. The material which is used is structural steel.

Beam Specifications:

Table I

Dimensions and Properties of a Cantilever Beam

Dimensions/ Properties	Structural Steel
Length (mm)	425
Width (mm)	46
Flange Thickness (mm)	3
Web Thickness (mm)	3
Height (mm)	92
Young Modulus (MPa)	$2x10^5$
Density(Kg/m3)	7850

4.2 Modal Analysis with ANSYS WORKBENCH R14.5

The modal analysis for the cantilever beam. is executed by ANSYS Workbench Fig. 1.

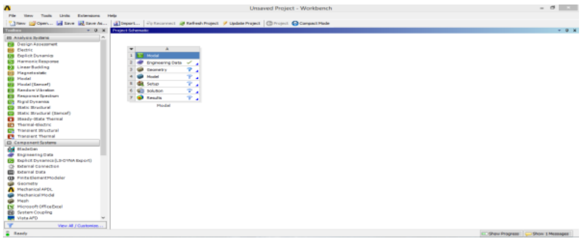


Fig.1. Graphical environment of ANSYS Workbench

4.3 Geometry

First geometry of beam is created using Design Modeler.

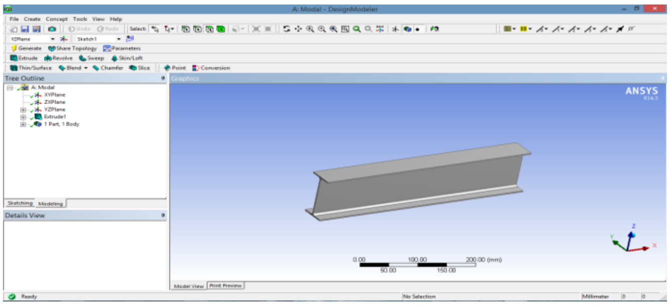


Fig.2. Geometry Of Beam

4.4 Generate Mesh

Mesh on the beam is generated automatically by ANSYS. SOLID186 element is used . The element is defined by 20 nodes while each node has three degrees of freedom. The SOLID186 has a quadratic displacement behaviour. The size of the element is 2mm.

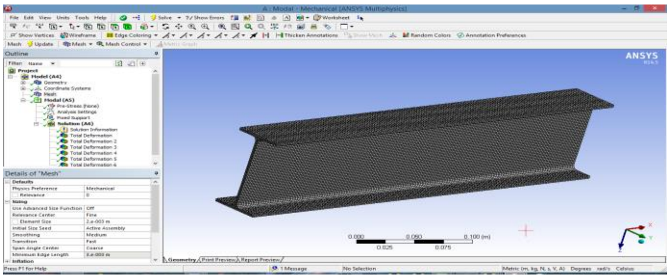
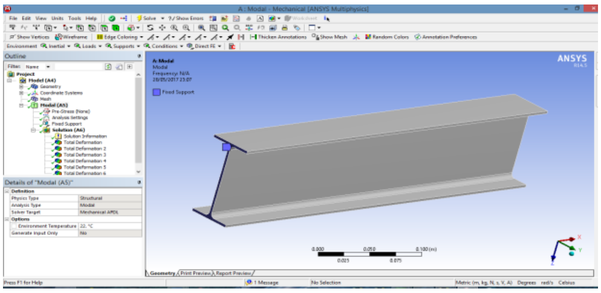


Fig. 3. Meshing of Beam

4.5 Apply Boundary Conditions

The material properties are assigned to the beam and boundary conditions are defined. The beam's all degrees of freedom on surface are taken. They are denoted with the blue flag Figure 4. This condition prevents the movement of the surface in a space.

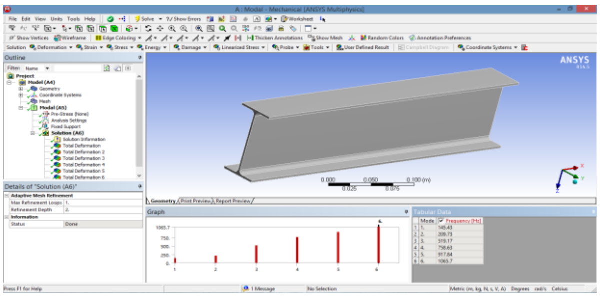


Definition
Physics Type: Structural
Analysis Type: Modal
Solver Target: Mechanical APDL
Options
Environment Temperature: 22. °C
Generate Input Only: No

Fig. 4. Boundary Conditions

4.6 Solution

The type of solver and the solution method in program ANSYS is selected automatically. For this modal analysis the direct solver including the block Lanczos method is used.



Adaptive Mesh Refinement
Max Refinement Loops: 1.
Refinement Depth: 2.
Information
Status: Done

	Mode	☑ Frequency [Hz]
1	1.	145.43
2	2.	209.73
3	3.	519.17
4	4.	758.63
5	5.	917.84
6	6.	1065.7

Fig. 5. Solution

4.7 Modal Analysis of Cracked Cantilever Beam

The modelling of cracked beam done using CATIA V5 then analysis is carried out using ANSYS WORKBENCH R14.5 as per above procedure. 2mm transverse crack is used for analysis.

III. RESULTS

[1] Un-cracked Beam

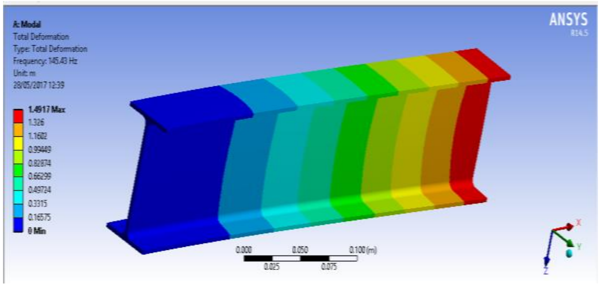


Fig. 6.First Frequency And Mode Shape

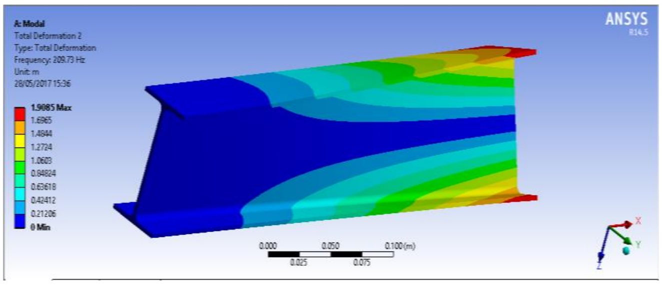


Fig. 7. Second Frequency And Mode Shape

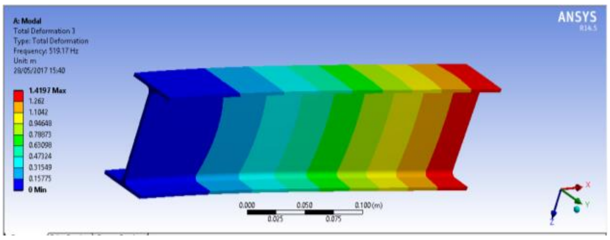


Fig. 8. Third Frequency And Mode Shape

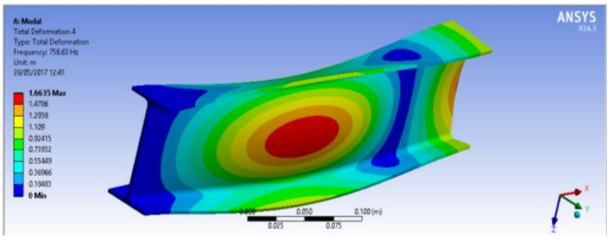


Fig. 9. Fourth Frequency And Mode Shape

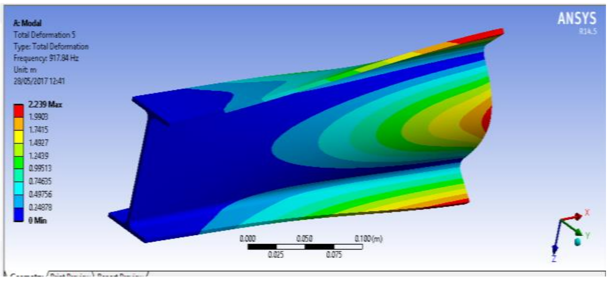


Fig. 10. Fifth Frequency And Mode Shape

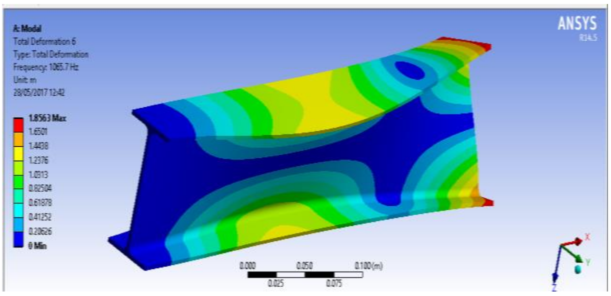


Fig. 11. Sixth frequency And Mode Shape

[2] Support Crack

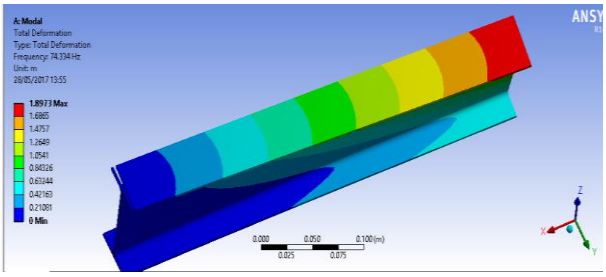


Fig. 12. First Frequency And Mode Shape

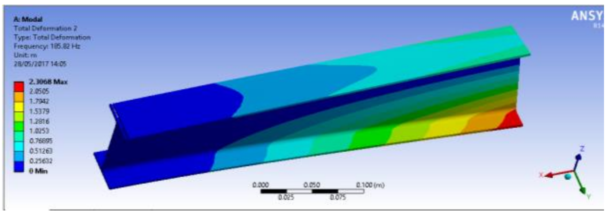


Fig.13. Second Frequency And Mode Shape

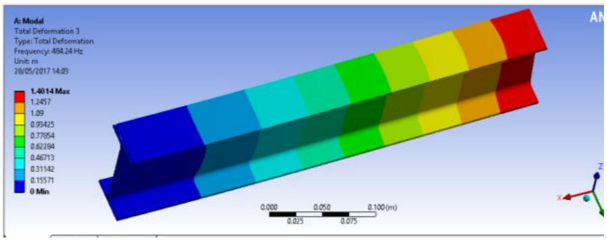


Fig. 14. Third Frequency And Mode Shape

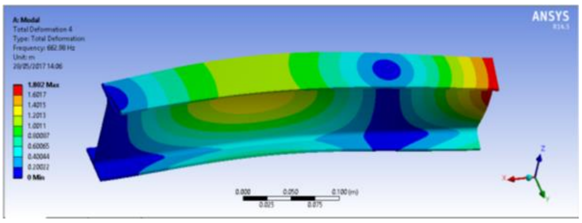


Fig. 15. Fourth Frequency And Mode Shape

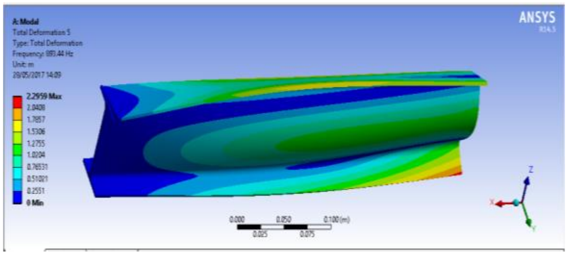


Fig. 16. Fifth Frequency And Mode Shape

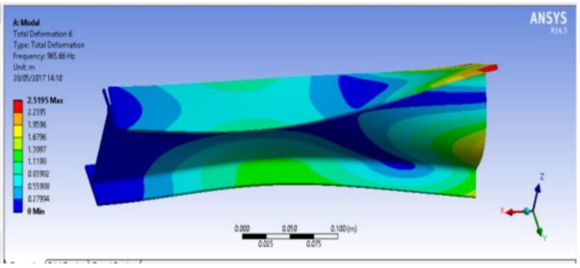


Fig. 17. Sixth frequency And Mode Shape

[3] Centre Crack

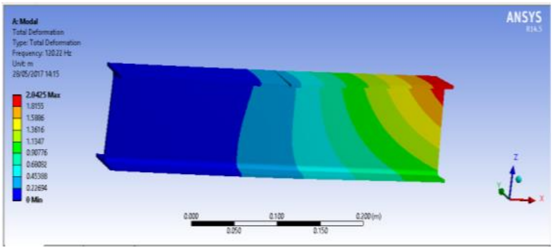


Fig. 18. First Frequency And Mode Shape

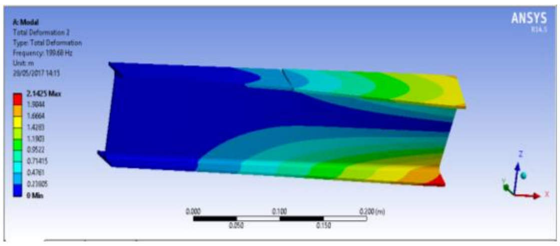


Fig. 19. Second Frequency And Mode Shape

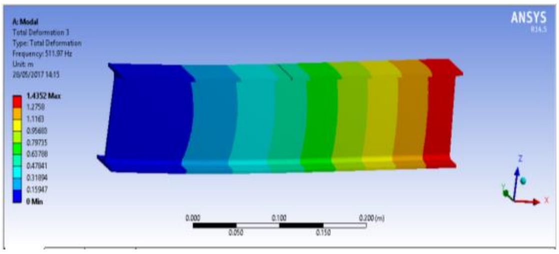


Fig. 20. Third Frequency And Mode Shape

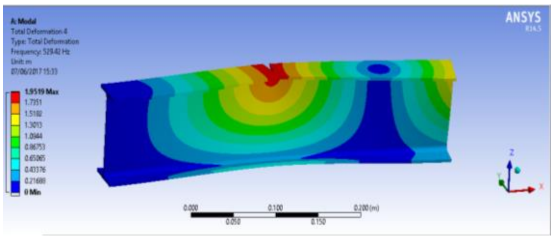


Fig. 21.Fourth Frequency And Mode Shape

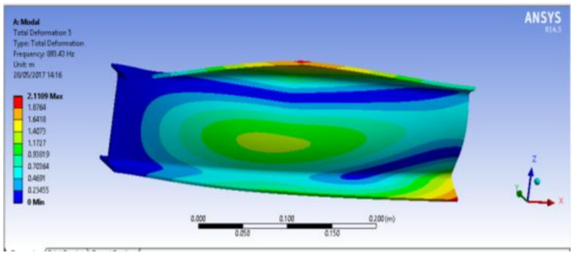


Fig. 22. Fifth Frequency And Mode Shape

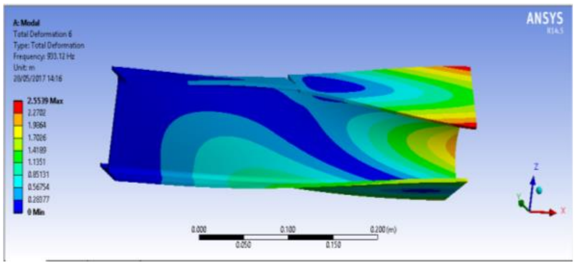


Fig.23. Sixth frequency And Mode Shape

Table II

I Section Un-cracked Beam Frequency

NO	ANSYS	EXPERIMENTAL	%ERROR
1	145.43	148.92	2.34
2	209.73	213.62	1.82
3	519.17	518.79	0.07
4	758.63	756.84	0.23
5	917.84	960.69	4.46
6	1065.7	1085.2	1.79

Table III

I Section Support Cracked Beam Frequency

NO	ANSYS	EXPERIMENTAL	%ERROR
1	74.334	70.8	4.7
2	185.82	183.1	1.46
3	484.24	485.84	0.32
4	662.98	671.38	1.25
5	893.44	906.98	1.49
6	965.66	970.45	0.49

Table IV

I Section Centre Cracked Beam Frequency

NO	ANSYS	EXPERIMENTAL	%ERROR
1	120.22	108.64	9.6
2	199.68	203.85	2.04
3	511.97	482.17	5.82
4	529.42	540.77	2.09
5	893.43	833.74	6.6
6	933.12	939.94	0.72

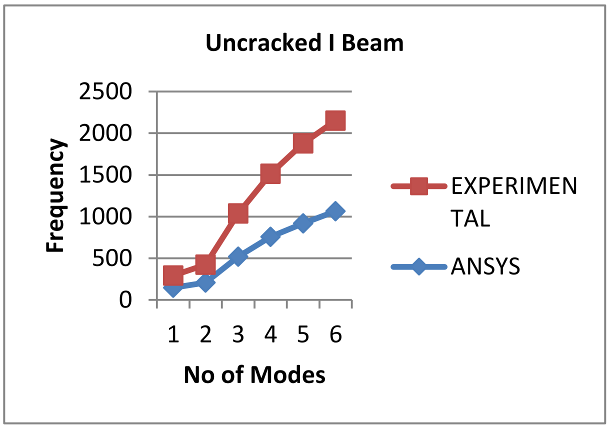


Fig. 24. I Section Un-cracked Beam Frequency

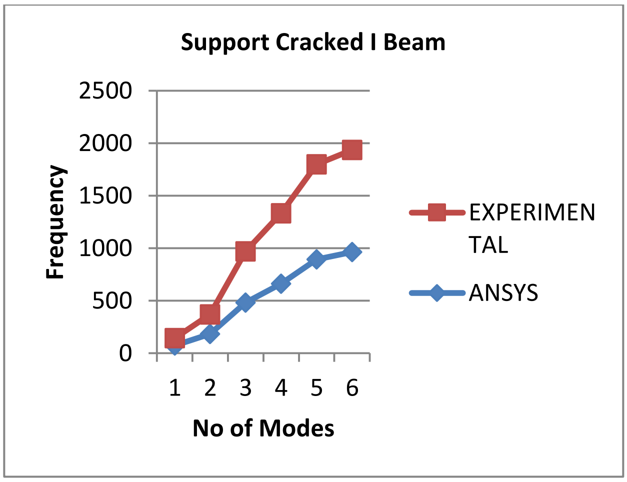


Fig.25. I Section Support Cracked Beam Frequency

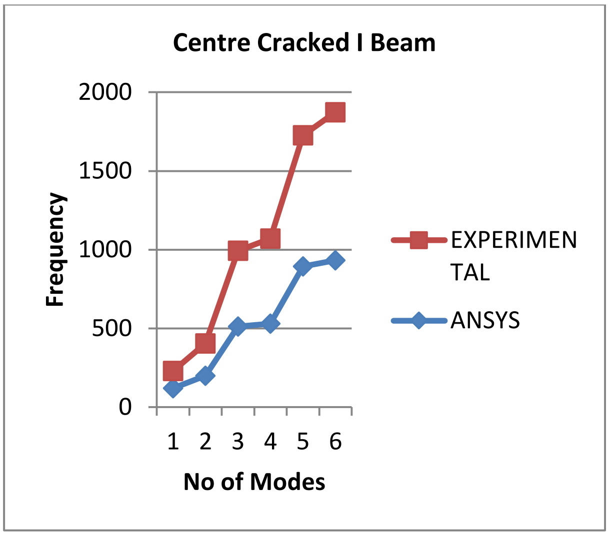


Fig. 26. I Section Centre Cracked Beam Frequency

IV. CONCLUSIONS

[1]The natural frequency of beam increases with no. of mode shapes.

[2]The frequency of beam decreases due to presence of crack.

[3]Support crack is more dangerous than centre crack.

[4]The results obtained from ANSYS are in agreement with the results obtained from experimental analysis.

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