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Excel Programming and Application for Concrete Filled Steel Tubular Structures

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Abstract. We used to use the method from <Specification for design and construction of concrete-filled steel tubular structures> for the calculation on bearing capacity of steel pipe columns for a review. This paper improves this method, and uses excel in formula programming to calculate the internal forces from SAP2000. It effectively improves the efficiency of the structure designing.

Introduction

At present, the super high-rise buildings are widely constructed. In domestic structural designing, in addition to common software PKPM, foreign software like SAP2000 and ETABS are also getting more and more widely used. However, the foreign software generally only has the analytical skills, and doesn`t support the check function for domestic specification. So we have to do the hand-checking based on the domestic specification after structure analysis.

This article provides an Excel programming method, intended to provide an idea on the bearing capacity examination for the colleagues.

Project Description

In this paper, the example draws from a super high-rise building. As shown in the Fig1~2. This structure altogether 55 layers above ground, each layer has 12 columns. The height is about 238.8 meter and the construction plane area is 43.2×43.2 square meters like a square. The main structure is a hybrid structure which includes a concrete core tube and a mega-frame with arm strengthening layers. In this structure, elevators and equipment levels are arranged in the reinforced concrete core-tube and the mega-frame includes 12 concrete filled steel tubular columns, steel frame beams and three loop truss components.

This structure uses SAP2000 to carry on the internal force analysis and uses the excel table to calculate all columns` bearing capacity under the seismic action. Take the condition 1.2DL+0.5LL±1.3×2.8EX as example, consider the positive and negative effects of the earthquake, it will has to check 55×12×2=1320 columns` data. Therefore, it`s very necessary to use the appropriate excel tables for calculation to improve work efficiency. The following author will take condition 1.2DL+0.5LL-1.3×2.8EX as example to introduce how effectively use SAP2000 and excel tables to do the calculation.

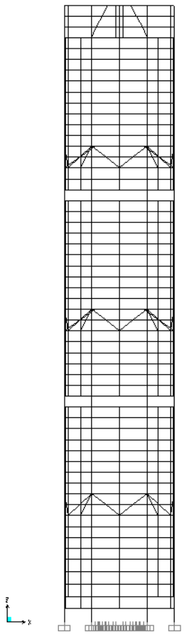

Fig1: Façade of super high-rise building

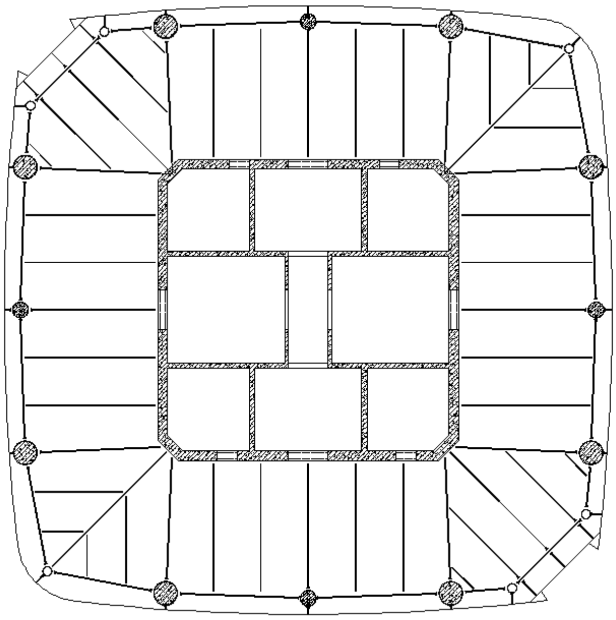

Fig2: Plane of super high-rise building

Excel Programming and Application Description

Data preparation

The structure uses SAP2000 to carry on the internal force analysis, the modeling and parsing process slightly. After structure analysis, output the data we needed. In SAP2000, select all columns, open Display, show Tables, mark the needed load patterns and cases(this paper taking the load cases 1.2D+0.5L and EX as examples), Click OK, then output the table of element forces to excel, thus completed the Excel data preparation.

Introduction to excel table programming ideas

Excel programming mainly has two methods: the formula programming and VBA programming. The formula programming is easy to learn, and the programmed tables are easy to use and direct-viewing. So the followed of this paper will introduce this method. In this paper the working thought mainly based on <Specification for design and construction of concrete-filled steel tubular structures>. Considering the engineering calculation habits and convenience of programming, this paper improves the calculation method for effective length and programs it in the table.

Fig3 shows the idea of excel programming.

Introduction to Excel table interface

As shown in table1~10, for the convenience of expansion and application, put all cross items in one table. Attention please: the first line of these tables is only used to show the location of excel-cells, actually it isn`t existed. Obviously you can find these letters on the interface of excel itself. Data in the table1~10 comes from a concrete filled steel tube column located in first layer, numbered C18.

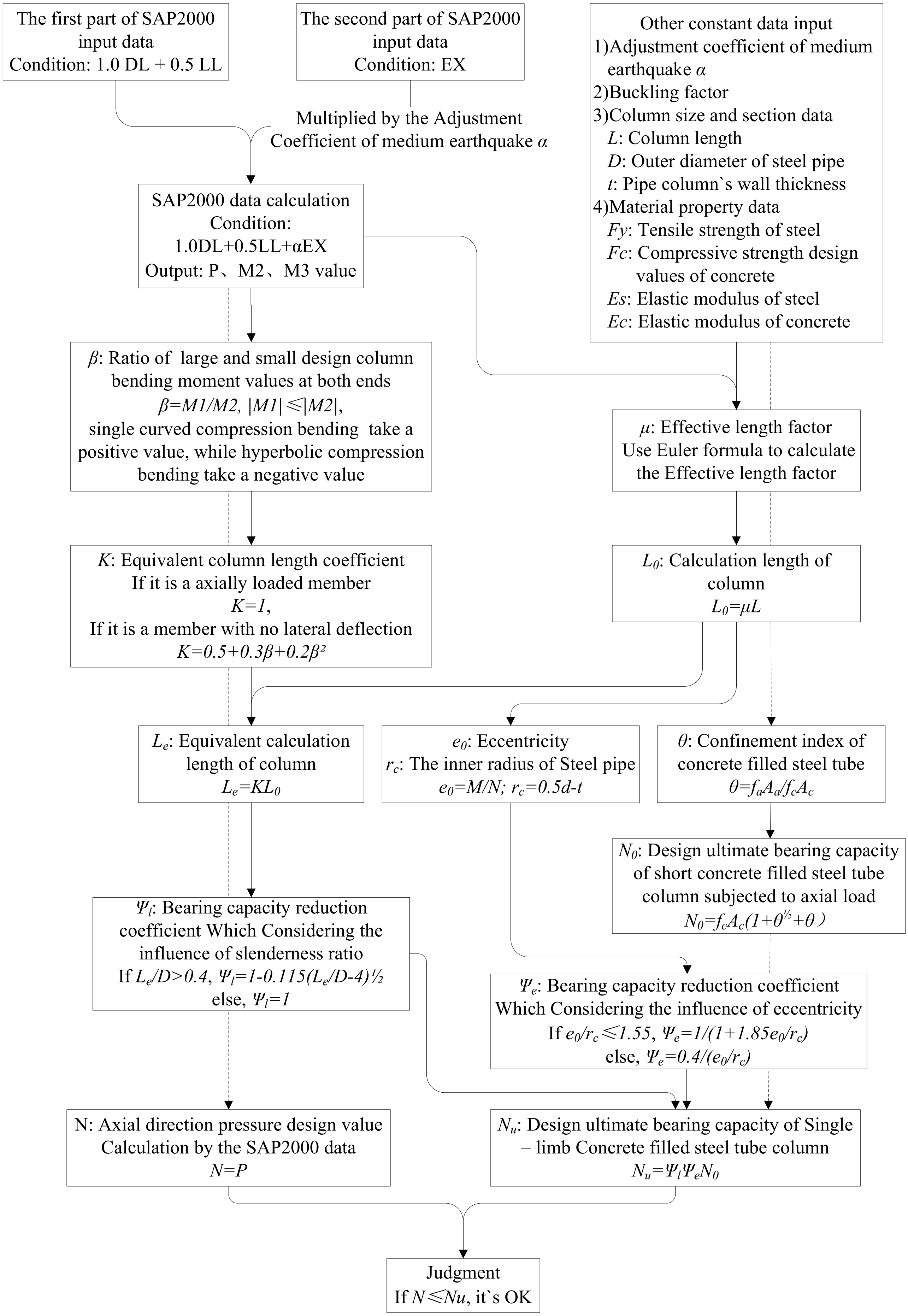

Fig3: The idea of excel programming

Table 1:

A	B	C	D	E	F	G	H	I	J
The first part of SAP2000 input data (unit: kN m C)									
Storey	Member number	Cases combination	Measuring Point	P	V2	V3	T	M2	M3
				kN	kN	kN	kN·m	kN·m	kN·m
STORY1	C18	1.0DL+0.5LL	4.4	-58151	36.84	120.8	0.35	-370.12	-83.80
STORY1	C18	1.0DL+0.5LL	0	-58568	36.84	120.8	0.35	161.22	78.31

Table 2:

K	L	M	N	O	P	Q	R	S
The second part of SAP2000 input data (unit: kN m C)								
Member number	Cases combination	Measuring Point	P	V2	V3	T	M2	M3
			kN	kN	kN	kN•m	kN•m	kN•m
C18	EX	4.4	10263.40	28.00	344.15	6.34	2544.16	155.10
C18	EX	0	10263.40	28.00	344.15	6.34	3945.96	249.94

Table 3:

T	U	V	W	X	Y	Z	AA	AB	AC
SAP2000 data calculation (unit: kN m C)									
adjustment coefficient	Member number	Measuring Point	Cases combination	P	V2	V3	T	M2	M3
				kN	kN	kN	kN·m	kN·m	kN·m
1.3	C18	4.4	1.0DL+0.5LL -1.3×2.8EX	-95509	-65	-1132	-22.72	-9631	-648.4
1.3	C18	0	1.0DL+0.5LL -1.3×2.8EX	-95926	-65	-1132	-22.72	-14202	-831.5

Table 4:

AD	AE	AF	AG	AH	AI	AJ
column size and section data			material property data			
L	D	t	fy	fc	Es	Ec
m	mm	mm	N/mm^2	N/mm^2	N/mm^2	N/mm^2
5.4	2000	50	295	27.5	206000	36000
5.4	2000	50	295	27.5	206000	36000

Table 5:

AK	AL	AM	AN
design ultimate bearing capacity of short concrete filled steel tube column subjected to axial load			
As	Ac	theta(θ)	N_0
mm^2	mm^2		kN
306150.00	2833850.00	1.16	252139.51
306150.00	2833850.00	1.16	252139.51

Table 6:

AO	AP	AQ	AR	AS	AT	AU
Effective length factor calculation (Euler formula)						
Is	Ic	EI	Buckling factor	Buckling internal force (P)	μ	l_0
mm^4	mm^4	$N \cdot mm^2$		N		
1.46E+11	6.40E+11	5.30E+16	19.07	1821360940	3.14	16.95
1.46E+11	6.40E+11	5.30E+16	19.07	1829313321	3.13	16.92

Table 7:

AV	AW
ψ_0 calculation (take k=1)	
le/D	ψ_0
8.48	0.76
8.46	0.76

Table 8:

AX	AY	AZ	BA	BB	BC	BD	BE	BF
Ψ_1 calculation at M2 direction (k calculation)				ψ_e calculation at M2 direction				
β	k	le/D	ψ_1	M_{max}	e_0	r_c	e_0/r_c	ψ_e
						mm		
0.68	0.80	6.74	0.81	14202.07	148.70	950	0.16	0.78
0.68	0.80	6.73	0.81	14202.07	148.05	950	0.16	0.78

Table 9:

BG	BH	BI	BJ	BK	BL	BM	BN	BO
Ψ_1 calculation at M3 direction (k calculation)				ψ_e calculation at M3 direction				
β	k	le/D	ψ_1	M_{max}	e_0	r_c	e_0/r_c	ψ_e
						mm		
0.78	0.86	7.25	0.79	831.47	8.71	950	0.01	0.98
0.78	0.86	7.24	0.79	831.47	8.67	950	0.01	0.98

Table 10:

BP	BQ	BR	BS	BT	BU	BV	BW	BX
Pressure test			Tension test			Results judgment		
Nu	Nu/RE	DCR	Nu	Nu/RE	DCR	Pressure	Tension	judgment
kN	kN		kN	kN				
158285.9	186218.72	0.51	90314.25	120419.00	0.00	0.51	0.00	OK!
158540.4	186518.12	0.51	90314.25	120419.00	0.00	0.51	0.00	OK!

Excel cell`s formula Description:
Cell A ~ W are all input items from the first and second part of SAP2000 output data mentioned at Part “Data preparation”.

Cell X~BX are formulas which programmed according to Fig3.

Table 11 shows the formulas programmed in the cells.

Table 11 Description of Formulas in Excel cells

Cell A~W	Input data
Cell X	=E4-$T4*2.8*N4
Cell Y	=F4-$T4*2.8*O4
Cell Z	=G4-$T4*2.8*P4
Cell AA	=H4-$T4*2.8*Q4
Cell AB	=I4-$T4*2.8*R4
Cell AC	=J4-$T4*2.8*S4
Cell AD~AJ	Input data
Cell AK	=0.25*3.14*(AE4^2-(AE4-2*AF4)^2)
Cell AL	=0.25*3.14*(AE4-2*AF4)^2
Cell AM	=AG4*AK4/(AH4*AL4)
Cell AN	=AH4*AL4*(1+AM4^0.5+AM4)/10^3
Cell AO	=1/64*PI()*(AE4^4-(AE4-2*AF4)^4)
Cell AP	=1/64*PI()*(AE4-2*AF4)^4
Cell AQ	=AI4*AO4+AJ4*AP4
Cell AR	Input data
Cell AS	=AR4*ABS(X4)*1000
Cell AT	=SQRT(PI()^2*AQ4/(AS4*(AD4*1000)^2))
Cell AU	=AT4*AD4
Cell AV	=AU4*1/AE4*1000
Cell AW	=IF(AV4>4,1-0.115*(AV4-4)^0.5,1)
Cell AX	=IF(MOD(ROW()-3,2)=1,IF(AB4*AB5<0,MAX(AB4/AB5,AB5/AB4), MIN(AB4/AB5,AB5/AB4)),AX3)
Cell AY	=0.5+0.3*AX4+0.2*AX4^2
Cell AZ	=AY4*AU4/AE4*1000
Cell BA	=IF(AZ4>4,1-0.115*(AZ4-4)^0.5,1)
Cell BB	=IF(MOD(ROW()-3,2)=1,MAX(ABS(AB4),ABS(AB5)),BB3)
Cell BC	=BB4/ABS(X4)*1000
Cell BD	=0.5*AE4-AF4
Cell BE	=BC4/BD4
Cell BF	=IF(BE4>1.55,0.4/BE4,1/(1+1.85*BE4))
Cell BG	=IF(MOD(ROW()-3,2)=1,IF(AC4*AC5<0,MAX(AC4/AC5,AC5/AC4), MIN(AC4/AC5,AC5/AC4)),BG3)
Cell BH	=0.5+0.3*BG4+0.2*BG4^2
Cell BI	=BH4*AU4/AE4*1000
Cell BJ	=IF(BI4>4,1-0.115*(BI4-4)^0.5,1)
Cell BK	=IF(MOD(ROW()-3,2)=1,MAX(ABS(AC4),ABS(AC5)),BK3)
Cell BL	=BK4/ABS(X4)*1000
Cell BM	=0.5*AE4-AF4
Cell BN	=BL4/BM4
Cell BO	=IF(BN4>1.55,0.4/BN4,1/(1+1.85*BN4))
Cell BP	=AN4*MIN(BA4*BF4,BJ4*BO4,AW4)
Cell BQ	=BP4/0.85
Cell BR	=ABS(X4)/BQ4
Cell BS	=AG4*AK4/1000
Cell BT	=BS4/0.75
Cell BU	=IF(X4>0,X4,0)/BT4
Cell BV	=BR4
Cell BW	=BU4
Cell BX	=IF(AND(BR4<1,BW4<1),"OK!","NOT OK!")

Handling skills description:

1): After structure analysis, SAP2000 will output the internal force data at both upper and lower ends of columns in different load conditions. Such as the example shown in Table 1, the axial force in the load case 1.0DL+0.5LL at the top end of the C18 column is -58150.45kN, and the bottom is -58567.46kN. The negative sign means pressure.

2): According to<Specification for design and construction of concrete-filled steel tubular structures>, calculation is taken at both strong and weak axis.

3): In an actual project, there is always thousands of data to be calculated, so how to program all the formulas in a cross line is the main difficulty. In this paper, there are 660 columns in a table, which means 1320 lines of data waited to be calculated. So how to program a formula to calculate every two rows of data is a difficulty. The following will introduce how to program such formulas.

Take the formula in cell AX as an example:

The formula is:

=IF(MOD(ROW()-3,2)=1,IF(AB4*AB5<0,MAX(AB4/AB5,AB5/AB4),MIN(AB4/AB5,AB5/AB4)), AX3)

a) Function Description:

If(): Syntax: *IF(logical_test, value_if_true, value_if_false)*, Description: The IF function returns one value if a condition you specify evaluates to TRUE, and another value if that condition evaluates to FALSE.

Mod(): Syntax: *MOD(number,divisor)*,Description: Returns the remainder after number is divided by divisor. In this example *Mod()* worked with *row()*, to carry on checking every two rows of data.

Row(): Syntax: *ROW(reference)*, Description: Returns the row number of a reference. In this example *row()* worded with *mod()*, to carry on checking every two rows of data.

MAX(): Syntax: *MAX(number1,number2,...)*, Description: Return the maximum of a set of values contained in a specified field on a query.

Min(): Syntax: *MIN(number1,number2,...)* Description: Return the minimum of a set of values contained in a specified field on a query.

b) The function of Cell AX:

Based on the statutes 4th, section 1.4 in the Specification, to get the value β at the weak axis (2 axis direction). β: ratio of large and small design column bending moment values at both ends. $\beta=M1/M2, |M1| \leq |M2|$. Single curved compression bending takes a positive value, while hyperbolic compression bending take a negative value.

c) Formula programming Description

This formula consists of two "if statements", the first "if statement", used to make the loop judgment. The second "if statement", used to achieve the value β at 2 axis direction.

if(MOD(ROW()-3,2)=1,"achieve the value β", AX3):this loop statement is used to do a judgment every two lines, which means select the data on the both top and bottom of a column to do a calculation. Attention: *row()-3* means there are three lines of useless data at the front of the table.

If(AB4*AB5<0,MAX(AB4/AB5,AB5/AB4),MIN(AB4/AB5,AB5/AB4)):this statement is used to achieve the value β

In addition, the formulas in this paper are programmed for application of SAP2000. But by making some little changes, this table also can be used for ETABS. Pay attention to the default ETABS output data: it will output three data of the same column in the upper, middle and lower endpoint. So during the calculation it has to select the data every three lines. The formula in the same cell AX can be rewrite as below:

=IF(MOD(ROW()-3,3)=1,IF(AB4*AB6<0,MAX(AB4/AB6,AB6/AB4),MIN(AB4/AB6,AB6/AB4)), AX3)

4) Effective length calculation introduction

In this paper, the main structure is a hybrid structures which includes a concrete core tube and a mega-frame with arm strengthening layers. The behavior of giant concrete filled steel tube column is different from the conventional frame column under the seismic action. When under the vertical and horizontal loads, the giant column usually bears a greater pressure. Its stability is not only related to its own section size, pressure and constraints, but also adjacent to other components` s stress condition and floor stiffness. So it`s necessary to do the stability analysis, and determine the column`s effective length under kinds of different loads.

In the calculation, first get the buckling smallest eigenvalue λ through the linear buckling analysis. Then calculate the critical load in this particular load mode.

$$P_{cr} = P\lambda \tag{1}$$

Use Euler formula to calculate The Effective length.

$$P_{cr} = \frac{\pi^2 EI}{(\mu L)^2} \tag{2}$$

Then:

$$L_e = \mu L = \sqrt{\frac{\pi^2 EI}{P_{cr}}} \tag{3}$$

P: column pressure
P_{cr}: column critical pressure
EI: column bending stiffness
L: column length
μ: column effective length factor
L_e: column effective length

Conclusions

In this paper, the concept of concrete-filled steel tubular structure calculation was reviewed. The method based on the code was developed and the excel programmed tables were presented. Also, the main formulas in cells were listed in order to help readers do a further application. Through practice, the method provided in this paper can effectively improve the efficiency of structural design.

References

[1] CECS 28-1990 Specification for design and construction of concrete-filled steel tubular structures [S].(in Chinese)

[2] Zhigang Zhang. *Research on Design Methods of Stability of Single-layer Spherical Latticed Shell Structure* [D]. Guangzhou: South China University of Technology. Structural engineering, 2011 (in Chinese)

[3] Information on http://office.microsoft.com/en-us/excel-help/.

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