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Research Article

Study on Stress Distribution of Casing under Different Elliptical Combinations

Zhang Bengbeng, Cu Yanghua
College of Civil Engineering and Architecture, Northeast Petroleum University, Daqing 163318, China

***Corresponding author**
Zhang Bengbeng
Email: 963270758@qq.com

Abstract: The study is based on the mechanical model of soil-cement ring-casing and uses the finite element software ANSYS. We select a certain combination of loads, study the situation of ideal round casing and ideal round cement ring combination, the situation of Ideal round casing and oval cement ring combination, and the situation of initial elliptical bushing and elliptical cement ring combination. In addition, we obtained the stress distribution of each part in different cases .It is concluded that the existence of casing ellipticity and the presence of cement ring will greatly affect the distribution of stress values of casing, cement ring and formation, and will affect the maximum size and appearance of each part s position.
Keywords: casing; cement ring; soil layer; ellipticity; stress distribution.

INTRODUCTION

Based on the research results of domestic and foreign scholars on casing damage, a lot of useful conclusions have been made in the case of casing with initial ellipticity. Xu Lixiong [1] According to the principle of rock mechanics, under the condition of non-uniform stress, the borehole is regarded as oval. Cai Zhengmin *et al* [2] and Chen Yong *et al* [3] studied the change of anti-crushing strength with a certain initial elliptical casing under non-uniform stress. And Wang Jianjun *et al* [4] and Lou Qi *et al* [5] through experiments to verify the existence of casing ellipticity will significantly affect the casing anti-crushing strength worth the size. Li Zengliang *et al.* [6] elaborated on the effect of non-uniform stress on the anti-crushing strength of elliptical sleeves. The size of the wellbore is irregular and circular, and it is useful and necessary to study the borehole shape as an oval shape. And the casing in the actual production, transportation, use the process will inevitably occur elliptical deformation. Therefore, whether alone consider the initial oval with the oil field casing or oval cement ring, or at the same time taking into account the joint action of the casing under the stress situation, for the casing damage research and protection are very helpful .

DEFINITION OF ELLIPTICITY

The ellipticity of the casing refers to the inner and outer diameters of the casing concentric to form the same ellipse with the same wall thickness. If the maximum dimension of the outer diameter of the ellipse is D_{max}, the minimum size is D_{min}, the ellipticity can be defined as [7]

$$\varepsilon = \frac{2(D_{max} - D_{min})}{(D_{max} + D_{min})} \times 100\%$$

In the formula, the maximum outside diameter is D_{max}, the minimum outside diameter is D_{min}. The ellipticity of the cement ring [1] reflects the degree of ellipse of its outer diameter, expressed by the ratio of the length to the length of the ellipse, that is, the ellipse: r = a/b, usually r in the range of 1-1.5, the belly is even higher.

FINITE ELEMENT MODEL AND RELATED MECHANICAL PARAMETERS

When the cementing quality is good, considering the size of the casing is much smaller than its axial size, according to the theory of elasto-plastic mechanics [8], the problem can be simplified as a plane mechanics model. In order to simplify the study of the problem and refer to the previous related research [9], we make the following basic assumptions:
①casing, cement ring wall thickness uniformity;
②the casing is not affected by the residual stress and is isotropic material;

③does not consider the impact of casing eccentricity, and after deformation relative to the center of the casing is symmetrical.

We selected the depth of a casing to study the cross section. According to the relevant knowledge of rock mechanics, when the boundary of the strata is larger than 5-6 times of the radius of the borehole, the influence on the stress of the well is very small. In this paper, the boundary of the formation is 6 times of the radius of the wellbore. Considering the symmetry of the problem and the purpose of simplifying the calculation, the 1/4 mechanical model is used to study the boundary. Mechanical model shown in Figure 1, with elliptical cement ring as an example:

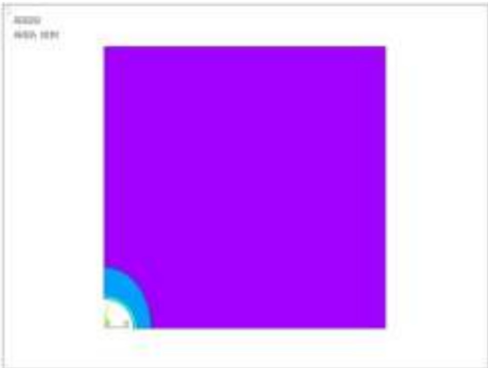

Fig-1: soil - cement ring - casing mechanical model

The stress values used in this study are measured at depths of 1900 m in an oil field, and the horizontal ground stress values are expressed by P_1, the vertical stress values are expressed by P_2, and the pressure in the casing is indicated by P_0 .we also apply a symmetric constraint to the symmetrical edges of the model. Select a load combination, the stress distribution of the casing and the circular cement ring, the ideal circular casing and the elliptical cement ring and the elliptical ring and the elliptical cement ring are studied respectively.

The casing model is N80, cement ring and soil related mechanical parameters for a field technical staff to provide. See Table 1:

Table 1: The physical and mechanical parameters of soil, casing and cement ring

	Outer diameter	thickness	Elastic Modulus /G Pa	Poisson's ratio	Cohesion	Internal friction angle /(°)	Yield Strength /M Pa
casing	139.7	7.72	2.10	0.3			551
cement ring	199.7	30	0.1	0.21	6.3	18	
formation			0.04	0.20	9.7	25	

FINITE ELEMENT CALCULATION RESULTS

Finite element calculation results for circular cement rings and circular bushings

When the finite element model is established by the finite element software ANSYS, the 8-node Plane183 solid element is selected. The casing pressure value is 11.46MPa, the horizontal ground stress value is 30MPa, and the vertical direction stress value is 50MPa.

First of all, we do not consider the casing and cement ring oval, both of them are regarded as ideal round. The finite element model is shown in Figure 2.Under the action of the external load, the finite element calculation results are shown in Fig 3 to Fig 5:

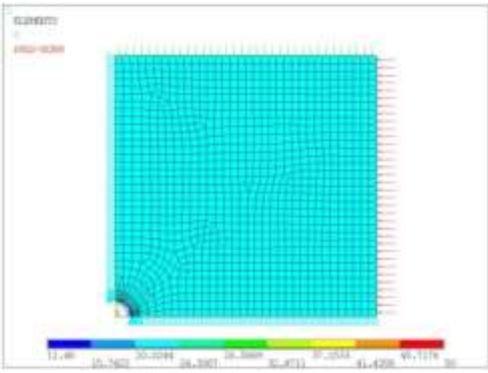

Fig-2: Finite element model

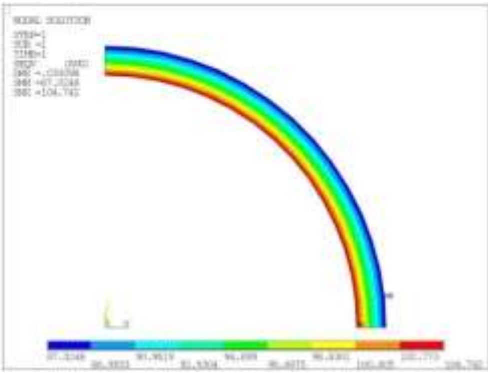

Fig-3: Equivalent stress distribution of casing

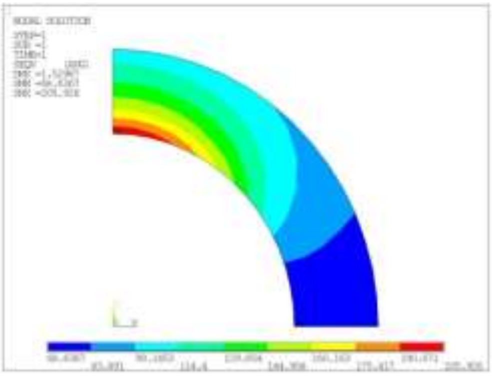

Fig-4: Equivalent stress distribution of cement rings

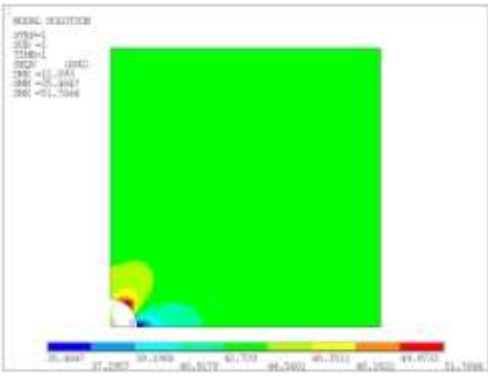

Fig-5: Soil equivalent stress distribution

Finite element calculation results for elliptical cement rings and circular bushings

Only consider the elliptical cement ring, casing selection ideal circle to establish the finite element model. The elliptical value of the cement ring r = 1.3. The selected unit and the pressure value of each direction are the same as 3.1. Finite element model shown in Figure 6, the finite element of each part of the calculation results shown in Figure 7 to Figure 9:

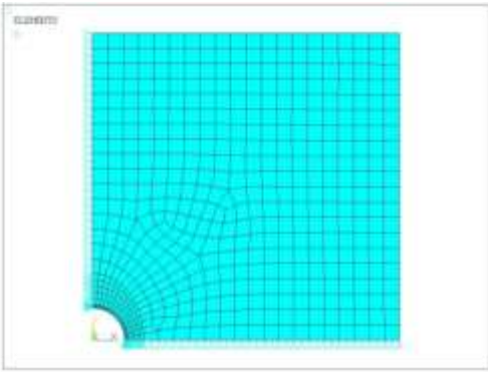

Fig-6: Finite element model

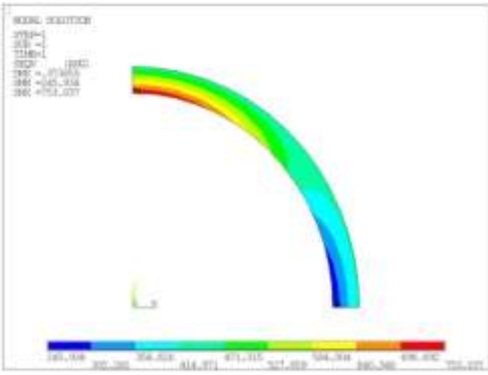

Fig-7: Equivalent stress distribution of casing

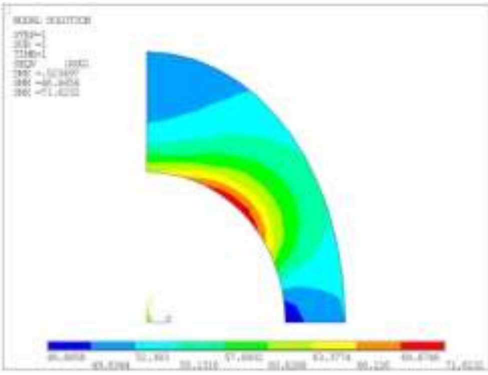

Fig-8: Equivalent stress distribution of cement rings

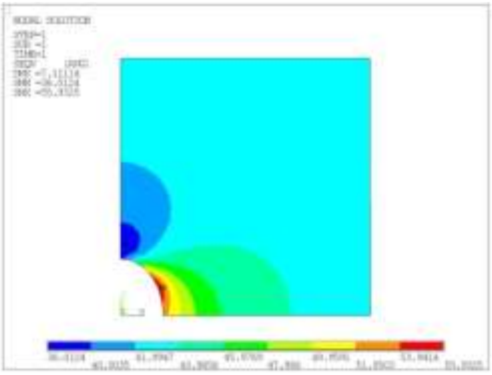

Fig-9: Soil equivalent stress distribution

Finite Element Calculation Results for Elliptical Cement Ring and Oval Casing

At the same time, considering the irregular shape of cement ring and casing, the elliptic cement ring and elliptical casing are used to establish the finite element model. The ellipticity of the casing is 1.5% and the ellipticity of the cement ring is r= 1.3. When selecting a finite element model, the selected units and the pressure values used are the same as 2.1. The finite element model is no longer given here, and the finite element analysis results are shown in Fig. 10 to Fig 12.

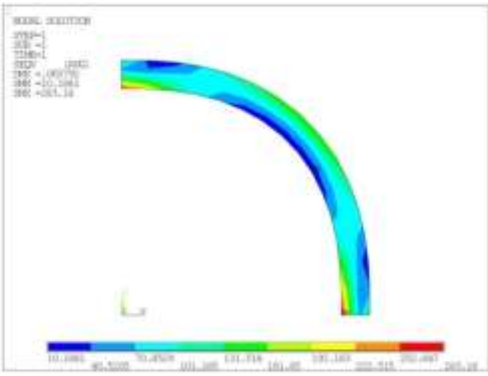

Fig-10: Equivalent stress distribution of casing

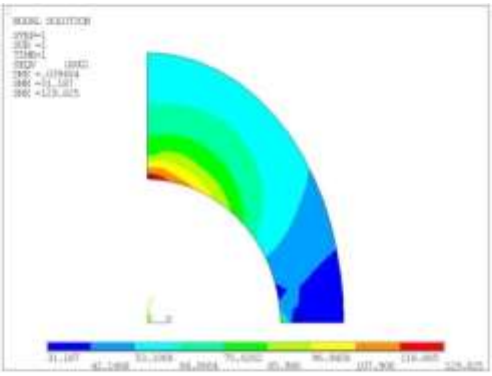

Fig-11: Equivalent stress distribution of cement rings

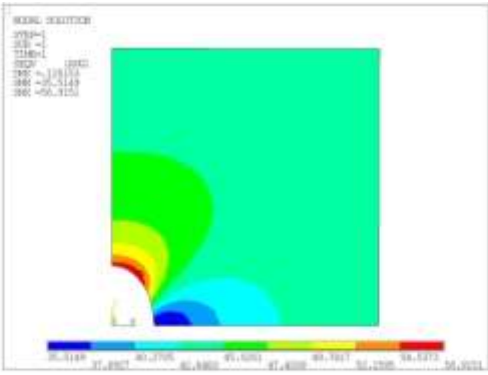

Fig-12: Soil equivalent stress distribution

RESULTS AND DISCUSSION

Here we think 0 ° for the X axis positive direction, 90 ° direction for the Y axis positive direction. When the casing pressure value is 11.46MPa, the horizontal stress value is 30MPa, the vertical direction stress value is 50MPa, first, the casing and the cement ring do not consider the ellipticity, the casing stress is evenly distributed along the radial direction, the maximum stress Appears in the casing wall, the minimum stress appears in the casing wall. The stress of the cement ring near 0°-25° is equal and minimum in the radial direction. The maximum stress appears in the 90° direction of the cement ring, where the stress decreases gradually in the radial direction. The minimum stress in the soil is near 0°-15° and the maximum stress appears near 45°-60°. When the ellipticity of the cement ring is 1.3, the casing is regarded as the ideal circle, the casing stress distribution is not uniform, the minimum stress appears in the casing 0° direction near the casing wall, the maximum stress appears in the 90° direction of the casing wall, The maximum stress of the cement ring appears in the inner wall of the casing 0° direction, the maximum stress appears in the inner wall of the casing in the direction of 50°, and the stress of the cement ring is smaller than that of the circular cement ring The minimum stress value appears in the 90° direction, the maximum stress value appears in the 30° direction inside. Elliptical cement ring and elliptical casing, the maximum stress value of the casing appears in the inner wall of the casing at 0° and 90°, the minimum stress value appears in the direction of the casing near the 45° direction; the maximum stress of the cement ring appears in the 90° direction, The minimum stress appears in the direction of 20°; the maximum stress value of the soil appears in the 45°-90° direction, the minimum stress value appears in the 0 ° direction inside.

CONCLUSION

Studies have shown that both the ellipticity of the casing and the ellipticity of the cement ring affect the stress distribution of the casing, the cement ring and the soil, and at the same time affect the maximum value of the stress in each part. Therefore, in the actual study of casing damage process, we must take into account the ellipticity. In this study, we only choose a non-uniform stress load combination. The stress distribution of each part of the system may be related to the combination of external loads. In addition, in order to ensure the accuracy of the research, we should select different ellipticity

REFERENCES

1. Lixiong X. Finite element analysis of casing damage mechanism in mudstone section . Southwest Petroleum Institute, 2005.
2. Zhengmin C, Jun Z, Zhaoting S, Meicheng J, Shujia Z. Effect of Elasticity of Casing on Anti-squeezing Strength under Nonuniform Load . Petroleum Geology and Mineral Machinery. 2010; 05: 20-22 + 74.
3. Yong C, Zhanghua L, Haiqing Z, Yanmin W, Xiaojun L. Analysis of casing anti-load capacity considering initial ellipticity. Petroleum Mine Machinery. 2007; 07: 35-38.
4. Jianjun W, Xiangzhen Y, Kai L, Yaorong F, Shengyin S. Effects of Inner Wall Ellipticity on Crushing Deformation of High-grade Casing. Journal of China University of Petroleum (Natural Science Edition). 2011; 02: 123-126.
5. Qi L, Guanglu Z, Dan Z, Xinli H, Peng Y, Yu Y. Study on the main influencing factors of casing anti-crushing strength . Petroleum Mine Machinery. 2012; 06: 38-42.
6. Zengliang Y, Lina C, Mule W, Xinxue Z, Chuanwei Z. The influence of geostress on the strength of elliptical casing . Petroleum Machinery. 2013;11: 14-16 + 20.
7. Ruodong Z. Effect of ellipticity on casing crushing strength . Xi'an University of Petroleum, 2015.
8. Guitong Y. Elasto-plastic mechanics . Beijing: People's Education Press. 1981; 60-85.
9. Du Q, Yishan L, Xiaopeng Z, Yunhe L, Can C. Finite element analysis of casing deformation under non-uniform stress. Petroleum Geology and Engineering. 2011; 05: 109-111 + 2.