Simulation and Analysis of Impacted Pipe by debris-flow

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Abstract

Based on the finite element simulation, the impacted pipe by debris-flow with ANSYS , the finite simulation element analysis software ,according to the theory and calculation method. on the basis, the pressure distribution of pipe was determined, the pressure on the exposed pipes and the buried pipes under debris-flow at different velocities and diameters of stones has calculated .

Keywords

Finite element simulation;force analysis; impact; debris-flow; pipe.

1. Introduction

Due to its motion features and characteristics of the ingredient, the performance of pipeline at different degree of the exposed pipes and the different depth of the buried pipes can't be tested easily in the practical problem of pipeline crossing during the movement process of debris-flow. The reason is that the soil around the pipe is flowed away with the debris-flow possibly which makes the exposed degree and the buried depth change . And finally big error may occur in the test data. In this paper, we can gain the numeric value of the ingredient in the debris-flow according to the simulation of pipeline crossing under the impact in which pipe reaches the limit of its stress.

In this simulation pipeline is used that its parameter is pipe diameter（508）and steel（X60）for the simulation of the pipe at the different exposed degree, the different buried depth , the different velocities and the diameters of stones. In this study it is illustrated as the example of naked pipeline and half-naked pipeline and the depth of 1m, 2m, 3m.

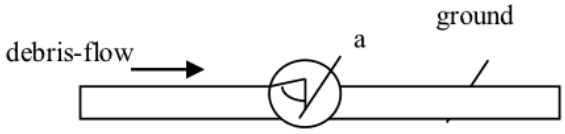

Figure 1 Exposed pipeline

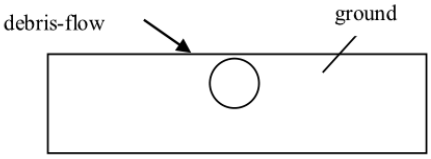

Figure 2 Buried pipeline

2. Calculating and analyzing

2.1 Establish the physical and mathematical model

In the existing research materials , impact force of debris-flow is considered to divided into two parts：one is the impact force of debris-flow slurry and the other one is the impact force of the stones

coerced within the debris-flow[1]. Also we know that the impact of debris-flow is mainly affected by the stones. When debris-flow impacts pipeline directly, the shell of pipe has the stress along with the flow direction , but don't at the axial direction； when debris-flow impacts the buried pipeline, the impact acts on the soil firstly and then acts on the pipeline through the soil[2] . The beam theory is used[3]. Debris-flow emerges the non- Newtonian rheological properties. In the process of modeling , Bingham fluid model is taken and reasonable convergence condition should be set up so that the computing speed can be improved.

2.2 Mesh

In the numerical calculation, the use of discrete grid is to replace the continuous space in which grid nodes refer to several spatial location of the solving physical quantities in the original physical problem. In the process of the mesh, any node can be named by some certain rules that is called structured grid , however, on the contrary the node is called unstructured grid . To use the structured grid makes the speed of mesh generation faster and also improve the quality. In this study , we used the method of block-structure grid to mesh the model. Grid is good or not , is directly related to the success of numerical calculation , or rather to the reliability of the calculation results. As a results, on the issue of grid, many scholars are very seriously to the good or bad of its quality. In this regard, we need to encrypt the mesh around the pipeline that is very favorable for the stress field around the pipeline and the stress calculation of the shell of the pipeline.

2.3 Solution

Debris-flow includes two parts ： the impact force of debris-flow slurry and the impact force of the stones coerced within the debris-flow. With the finite element model , the appropriate initial conditions and the boundary conditions , load should be loaded in a right way that constitutes the complete solution of the problem[4]. In the process of solution, when the stress of pipeline reaches the standard of stress limit that means the yield strength we think the pipeline is not appropriate to continue to work at this time. After the precision of pipeline model, the application of appropriate numerical calculation and the processing technology can get the numerical solution of the practical problems under different conditions.

2.4 Analysis of Result

It is an important step for numerical simulation that how we analyze the calculation gained from the study on basis of the perspective of physical process and the practical problems. In this paper, we use the large finite element software for the simulation of pipeline crossing the debris-flow to calculate the impact force in the above two conditions with the different flow velocity and different diameters of the stones under different degree of the exposed pipes and the different depth of the buried pipes so that we can gain the stress distribution and curve of the shell and the fastest flow slurry velocities and the largest sizes of the stones which can guide the engineering application in the geological disasters.

3. Numerical simulation

3.1 Grid

To modelling according to the above and mesh it. The grid as shown in figure 3. The grid around the shell of pipeline is processed that can get the accurate the impact flow field of debris-flow and the exact stress value. Due to this part far away the pipeline doesn't have obvious influence onto the stress, its grid is relatively sparse. On the basis of the magnitude of the effect on the stress of the pipeline , also considering the numerical precision and computing speed , the sparse and encryption processing is done. It is worth noting that when the bare pipes and buried pipes are in concrete grids, the different treatment about the precision processing brought by the mesh should be reflected. This is mainly because the actual situation. Models are as follow[5].

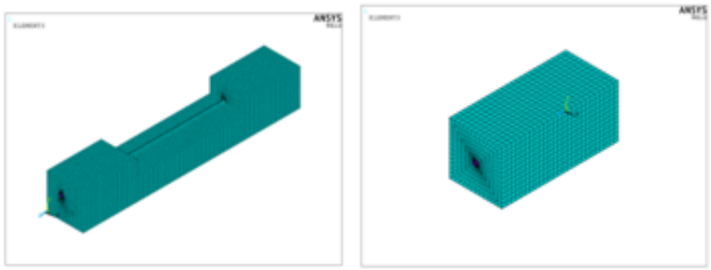

Figure 3 The grid diagram of pipe

3.2 Loading conditions

When calculating the impact of debris-flow,

it is in the velocity of 1m/s, 2m/s, 3m/s.....and the diameters of stones increase the value by 0.1m , then loading them onto the pipeline while considering the influence of gravity.

3.3 The pressure distribution

First of all, the relationship between stress and strain of the pipe is shown as follow figure 4.

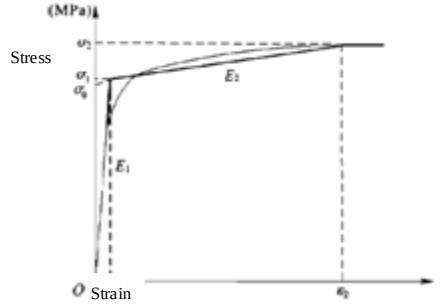

Figure 4 The stress-strain model of pipe

In the process of debris-flow impacts the pipeline, we found that when the flow direction is consistent with the outward normal direction of tube wall, the pressure is the greatest, and the migration of the direction of impact , the pressure would be decreased. This point has been verified by some documents. But according to the specific calculation results, the location of the maximum pressure is usually the location of impact by the stones. With the increase of flow velocity or the increase of the stones or the presence of a medium, this location would have some certain deviation which usually was shifted from outside surface to inner surface.

Figure5, 6 show the impact pressure curve of pipeline under the most dangerous situations.

Abscissa stands for the diameter of stone and ordinate stands for the the pressure on the tube wall.

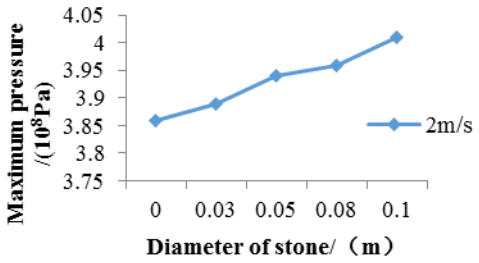

Figure 5 The pressure curve of some bare pipeline

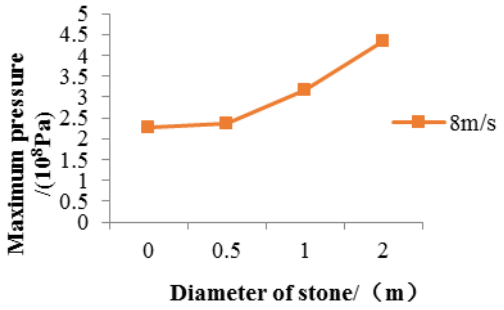

Figure 6 The pressure curve of some buried pipeline

Through the calculation, from the figure, we can found that the pressure distributions between bare pipe and buried pipe are basically identical：the pressure has the linear growth trend. The difference is that the pressure of bare pipe changes a little in the case of small diameters of stones that change little； while the pressure of buried pipe change a lot when the diameters of the stones change many.

3.4 Simulation value

When talking about that what combinations of flow velocity and particle size of the stones could make the pipeline reach its stress limit, we should pay attention to this stress is mainly the dominance of the stone. And in either flow velocity , there would be a corresponding particle size of stone. So this problem is more complex. To simplify this problem, we could get the stress value of the impact under the most dangerous situations.

The statics in table 1 show the situations at different degree of bare pipeline. L-X stands for the degree , X stands for angle parameter-a. ALL stands for the entirely exposed pipeline.

Table 1 Stress values of bare pipe under different impact by debris-flow

Bareness parameter	Combination	Stress value（MPa）
L-90	2m/s, 0.25m	414
L-80	2m/s, 0.23m	410
L-70	2m/s, 0.19m	412
L-60	2m/s, 0.18m	411
L-50	2m/s, 0.18m	410
L-40	2m/s, 0.16m	413
L-30	2m/s, 0.15m	415
L-20	2m/s, 0.14m	411
L-10	2m/s, 0.13m	412
ALL	2m/s, 0.13m	408

Note：the practical size of stones withstood by the pipe is listed under the big flow rate given priority to as shown in the table.

It can be seen from the table that the influence of the degree of bare pipe mainly depends on the impact of stones, which also proves that the impact of block stones is the dominant factor of the pressure on the pipeline.

As shown in table 2 , there lists the combinations of debris-flow impacted.

Table 2 the stress value of buried pipe under the impact

Parameter	Combination	Stress value（MPa）
1m	8m/s, 1.5m	410
2m	8m/s, 3m	414
3m	10m/s, 3.6m	416

As shown in this table, the deeper buried, the bigger the flow velocity or the particle size of stone we need. But in the practical engineering, the size more than 2m doesn't been found commonly. Even so it is significant to calculate.

3.5 Analysis of curve

The different degree of bare pipe, the different velocity and the different particle size of stones make the impact force differ from each other. to simply this question, considering the influence of the change about the particle size under the same flow rate . The results of the situation of all-naked pipe and half-naked pipe are shown in figure 7. About the buried pipe, with the same combination form of debris-flow, we investigated the influence of the depth in buried pipe that is shown in figure 8.

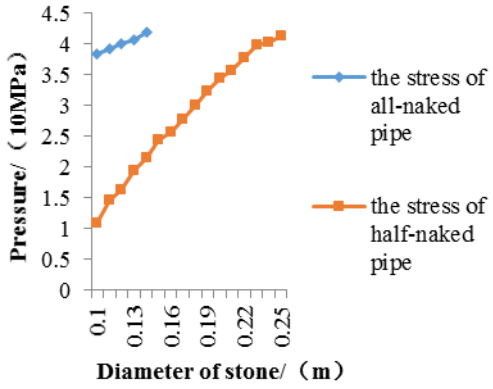

Figure 7 The pressure under the different particle size of stones

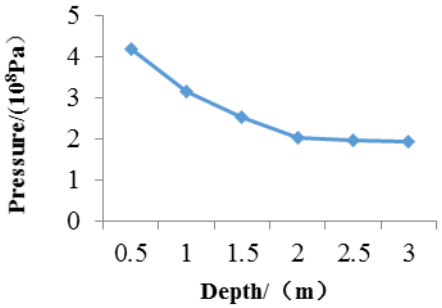

Figure 8 The pressure with the different depths

According to the figure 7 , the stress of pipe increase linearity with the increase of the size of stones. in the condition of the same flow rate, when the pipeline reaches its stress limit the size half-naked pipe needs times 1.8 the size all-naked pipe needs. figure 8 shows : the stress of buried pipe decrease under the same kind of debris-flow with the increase of depth. And in the range of 0 to 2 m, the extent of stress reduction is certain large, however, in the range of 2m to 3m, the extent notes a moderation.

4. Conclusion

(1) Through the analysis of the stress curve of pipeline, we find that with the increase of flow rate or the size of stone the stress will increase and usually the maximum stress appears in the location of the impact by the stone.

(2) We gained the stress value of pipe under different situations gave that in the most negative situations the half-naked pipe probably withstand the impact about the flow velocity of 2m/s and the size of 0.25m . the all-naked pipe could withstand the impact about the flow velocity of 2m/s and the size of 0.13m. when the depth of buried pipe was more than 3m, it was relatively safe and generally it

could resist the impact of debris-flow. we could summarize for bare pipe that 0.25m or more than this can be called the huge stone.

(3) The stress increase with the increase of the degree of bare pipe which decrease the size of stones resist and the extent increase. the stress of buried pipe decrease with the increase of the depth and the extent decrease more and more small.

(4) This study only considered the impact of debris-flow as the preliminary research. in the later research, we can add other effects of debris-flow such as scour action, erosion effect and so on.

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