The Influence of Tunnel Cavity on Seismic Advanced Prospecting

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Abstract

The seismic data of tunnel on-site acquisition in addition to effective reflection signals, also there is various jamming signal. Among that, the tunnel cavity is important reasons for tunnel seismic prospecting advanced detection interference. Through 3D numerical modeling to study the effect of tunnel cavity detection to the earthquake. Calculation results showed that because of the influence of the tunnel cavity, receives the seismic record contains waves, tunnel cavity reflection and sides scattering wave, etc. Its corresponding interference can be suppressed or filtered by using F-K filter.

Keywords

Advanced detection, tunnel cavity, seismic prospecting.

1. Introduction

In essence, the inner tunnel seismic prospecting and seismic wave have no difference in general, they all meet the various theorem of seismic prospecting theory (huygens-fresnel theorem, Neil, format's last theorem, etc), also can be divided into longitudinal wave, shear wave and surface wave. However, due to its present unique tunnel environment, causes the wave field characteristics and ground seismic exploration exist obviously different. Seismic data of tunnel on-site acquisition in addition to effective reflection signals, also there is various jamming signal. Therefore, collected seismic record is the valid wave and all kinds of interference wave added record. Typical tunnel seismic prospecting field records include reflection wave, direct wave, refraction wave, surface wave and sound wave, industrial noise, etc. But in our tunnel advanced forecast, only need reflection wave information, therefore it is necessary to suppress various kinds of interference wave, improve signal-to-noise ratio of seismic record. Leading to an important reason of the inner tunnel wave field is more complex than the ground: there exists influence of tunnel cavity in tunnel advanced detection. Therefore, research on tunnel cavity has the influence of seismic prospecting advanced detection is profitable to suppress, improve signal-to-noise ratio seismic record, reduce the exceptional interference of detection results.[1-3]

2. Forward modeling in tunnel

In order to research the tunnel cavity effect on seismic wave advanced detection, we adopt the means of forwarding imitation. Forward imitation adopts staggered grid-ding finite difference method for three dimensional heterogeneous medium first-order rate-stress full wave equations (two-way wave equation) fast, high precision numerical simulation. [4-5]

We establish three dimensional model as follow: model size is 200m×200m×400m, model background parameters of wall rock is compression wave velocity is V_p=4000m/s, shear wave velocity is V_s=2388m/s. The model only exist tunnel cavity, does not contain other geologic abnormal body. In order to simulate a real tunnel detection environment at the same time, the tunnel

cavity and boundary of tunnel export adopt free boundary conditions. Other boundary absorption absorb boundary condition.

Seismic model observation system adopt linear observation system of negative apparent velocity, the exact layout of the observation system as Figure 1 showed below. The hypocenter and detector layout on the same line. Detector is three-component geophone, spacing of 2m, total of 10, the first detector distance constrains 5m. Hypocenter distance the final detector 10m.

The whole model and observation system of 2D schematic diagram as shown in figure 1.

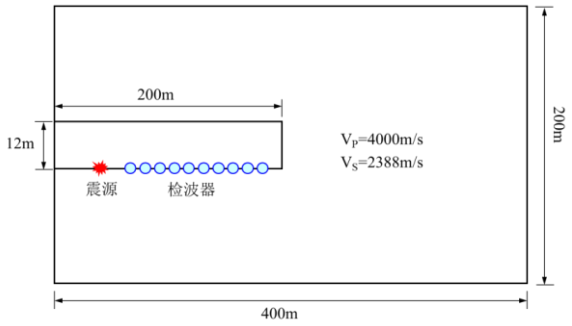

Fig. 1 Model 2D diagram

3. The result and analysis

Figure 2 is the wave field snapshot when 20ms, figure 3 is seismic detector trace set records.

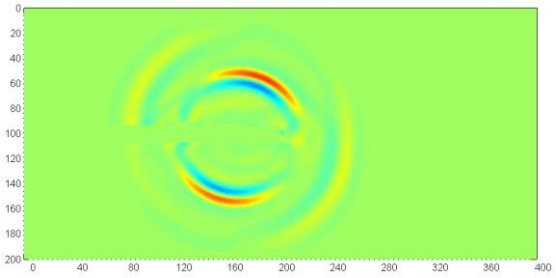

Fig. 2 Wave Field snapshot.

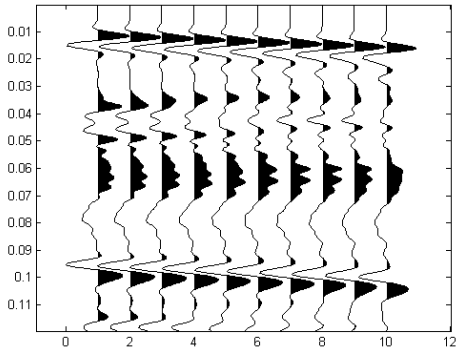

Fig. 3 Seismic trace set records.

Combined with the wave field snapshot and the analysis of seismic record as follow:

(1) Due to the existence of tunnel space, there will produce various interference after the seismic wave in the tunnel cavity. After arouse hypocenter, first length and width wave are generated, as well as surface wave between the cavity and free boundary at the same time. The speed of surface wave and a transverse wave are basically consistent. Both sides cannot separate in the wave field. Because of the existence of the tunnel cavity, length and width wave can produce reflection at the interface of a tunnel cavity. When length and width wave spread to tunnel constraints, it will produce scattering. (or reflection)

(2) On seismic records in addition to receiving direct length and width wave, also receives the above-mentioned interface wave: surface wave, tunnel cavity constraints reflection an scattering wave. Because of tunnel cavity length is longer, so its lineups width is bigger on seismic records.

Above interference is due to the occurrence of the tunnel cavity. In data processing, need to filter and move it, due to we adopt the observation method of negative apparent velocity, under this observation method, the direction of effective wave velocity and tunnel cavity produced interference is different. The effective wave velocity came from constraints scattering and in front of the constraints is negative. But the direct surface waves of tunnel cavity and cavity reflect apparent velocity is positive. Thus, through filtering waves, we remove partial interference wave produced by the tunnel cavity.

Removing the tunnel cavity interference wave by using F-K filtering. The principle of F-K filtering is built on two-dimensional Fourier transform. For 2D seismic section $g(t,x)$, you can use a two-dimensional Fourier transforms, and determine its corresponding frequency wave number spectrum of $G(\omega,k_x)$, namely.

$$G(\omega,k_x)=\frac{1}{2\pi}\int_{-\infty}^{\infty}g(t,x)e^{-j(\omega t-k_x x)}dtdx \quad (1)$$

$$g(t,x)=\frac{1}{2\pi}\int_{-\infty}^{\infty}G(\omega,k_x)e^{j(\omega t-k_x x)}d\omega dk_x \quad (2)$$

When space sampling is suitable, different signals in the t-x plane tilted phase axis signal in F-K plane can be separated automatically due to the different inclination. Different types of wave in F-K plane, the apparent velocity, frequency distribution are also different.

For seismic data of negative apparent velocity method, we will remove quadrant of positive velocity in F-K plane, then can remove surface wave and tunnel cavity reflection. We have two kinds of processing methods for constrains scattering, one is to keep it, when dealing with constraints on position will be a reflection interface, another way is that we can through the τ-p filter to remove from its corresponding time position.

4. Conclusions

Adopting model simulation obtained wave field snapshots and seismic records of no abnormal body at the front of constrains in a tunnel environment.

Through the analysis of forward modeling results found that due to the existence of the tunnel cavity will produce surface wave , tunnel cavity reflection a constrains scattering wave interference, etc.

Under the linear class observation method of negative apparent velocity, to submit method of using F-K filtering to reject tunnel cavity part interference.

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