

Case Study of Seismic Exploration in Complex Urban Areas

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Abstract: Seismic projects in complex surface areas, especially in urban areas with dense buildings, the layout uniformity of shot points and operation efficiency will be seriously affected. In this paper we take the efficient 3D acquisition project in the Middle East with a super-large spread and omnidirectional geometry as an example. The work area includes an urban area of over 300 square kilometers. This paper proposes a series of technical measures. The first is to design low-drive level shot points based on PPV safety distance calibration. Second is the application of vibrator pseudo-random signal for building protection. The third is the hybrid application of WTU nodes and 508XT wired instruments. Fourth is the receiver points interleaving and thinning method based on data uniformity in the urban area. Finally, we propose the automated matching technology of point codes based on the multi-process type of instruments. We obtained good data quality and high production efficiency by applying the measures. In conclusion, the proposed measures significantly improve the uniformity of acquired data and stabilize production efficiency. It has potential applications in complex seismic projects.

Introduction

Since 2018, we have been using a crew equipped with 100,000 channels of 508XT instruments and nearly 30 INOVA-380 vibroseis with omnidirectional geometry of 62-line 496-channel operation in continuous multi-block for a dynamic slide sweep. In order to be able to complete all the blocks on time and reach the requirements of the Client as scheduled, a project including an urban area of over 300 square kilometers was implemented at the end. At the end of March 2022, we had completed the field acquisition of this block safely and efficiently, and the data quality has been Highly recognized by the client; There was no resident complaint in the urban operation, which was highly praised by the government; The production efficiency of the urban area is stable, and the acquisition task was completed ahead of plan, achieving a win-win situation for all parties.

Solutions

1) PPV safety distance calibration

Based on the principle of seismic exploration, the near offset pair describes the shallow layer information, and the far offset pair describes the deep layer reflection information. When the shot point is offset or skipped, it has a great influence on the shallow target. When the diameter of the empty area is large enough, there will be a gap in the shallowness of the stack.

In addition to being directly affected by obstacles, we also need to set a safe distance between the shot points and the obstacles to reducing the damage to the facility caused by vibration. Before PPV (Peak Particle Velocity) safety distance calibration was introduced into the seismic, in order to reduce the compensation and disputes after the operation, we could only set a larger safety distance based on the previous experience, which leads to a larger area that cannot set shot points and worse data uniformity.

Based on using PPV, provides a quantitative reference index for safety distance calibration. Before the start of the operation, through PPV test on the different surfaces in the urban, the relationship curve between distance and vibration velocity, displacement and acceleration with different drive levels were established. Determine the safe distance for different drive levels to different facilities through the upper limit of their requirements for velocity and acceleration of vibration. And we can reduce the drive level of the vibrator to reduce the safety distance, so the area cannot layout shot points was minify and improve the uniformity of shot points.

When analyzing the shot records to determine the drive level, we pay more attention to the reflection information and signal-to-noise ratio of the medium and deep target layer. However, when encountering a single restricted obstacle with a large area, by reducing the drive level to minimize the restricted area and can layout more shot points closer to the facility, the focus is on recovering the blank of the shallow target. so as long as the data acquired with a low drive level has good continuity reflected information in the shallow layer, the shot points are contributing to the shallowness of the stack.

2) Pseudo random sweep

The autocorrelation wavelet of the pseudo-random sweep signal has higher resolution, prominent main lobe, and smaller side lobes, and it is an ideal wavelet. This sweep method is an effective way to improve the resolution of the correlation wavelet. However, it has not been industrially applied in seismic projects because the output energy is reduced while improving the wavelet resolution. However, when operating in urban areas, the characteristics of low output energy and random frequency are used to reduce the damage caused by resonance to obstacles, reduce the safety distance, and improve the uniformity of shot point layout.

Before operation in the urban area, in the startup system test the PPV vibration velocity and shot records are compared and analyzed between pseudo-random sweep, linear sweep, and customer sweep signals of different drive levels, and got the conclusion, in areas with dense buildings, the shot points with pseudo-random sweep method can be used to increase the uniformity of shot point layout.

3) Hybrid use of WTU and 508XT

508XT instrument uses cable for data transmission, which is affected by the activities of vehicles and other residents in the city. Cable broken frequently or the cable stability in data transmission is often affected. Spread recovery takes production acquisition time and affects production efficiency seriously.

To reduce the HSE risk of cables crossing highway and improve the stability of the spread, 12,000 WTU nodes are hybrid used together with 100,000 channels 508XT. The application of WTU also improve the percentage of the receiver points match with the design location and also improves uniformity of data in urban area.

4) Receiver points staggered thinning

The equipped WTU cannot meet the requirement of receiver points in the urban area, though scouting and analysis, after the number of receiver points reduce to a half, the WTU can meet the requirement of the production. There are three options to thin the density of receiver points: receiver lines thinning, receiver points thinning regularly (thinning the 25m channel distance to 50m), receiver points staggered thinning (alternating the odd and even line extraction channels). By comparing the attributes of these three geometries and the thinning imaging effect of three schemes in the completed area, the receiver point staggered thinning scheme is adopted because of its better imaging effect and better splicing with the data panel grid of adjacent areas.

To some extent, the suggestion of receiver points thinning can be chosen because the ADNOC's great attention to safety and harmonious local relations. I would like to thank them.

5) Automatic matching of different sweeps

Different sweeps with different drive levels are designed for different urban area. The parameters are frequently modified manually by the recorder observer and vibrator operators during operating, which is very easy to make mistakes, it has high risk in data quality and operation safety.

The different customer sweeps signal with different modes and drive levels and are stored in the specified positions of the instrument and match to different sweep signals by different process types. When the geophysicists set the SPS indoors for the Recorder, uses different Point Code for different sweep parameters. When the observer loads SPS files, they select the process type as "From SPS" and associates the point code with the preset different process types to realize the purpose of automatically selecting corresponding sweep signals according to the process type.

Conclusions

- 1) The PPV calibration provides scientific data support for reasonable setting of different safety distances, it is an effective measure to improve uniformity of source points in restricted area.
- 2) The pseudo random sweep improves the resolution of wavelet and reduces the output energy at the same time. Its disadvantage of reducing the output energy becomes the advantage of application in sensitive building areas. It can be combined with conventional sweep to improve the uniformity of source points.
- 3) Node instruments have obvious operation advantages in restricted areas such as urban areas, it can reduce the operation risk of HSE, improve the punctuality and spread stability of receiver points, and then improve the data quality and operating efficiency.
- 4) Reasonable receiver points thinning scheme can reduce the impact on data quality, and will get better data Imaging effect if combined with the data reconstruction of indoor data processing, which has the same concept with the compressive sensing of high concern.
- 5) Based on the point code automatic matching technology of process type, the manual intervention parameter adjustment is turned into machine automatic matching, which can reduce the error rate, eliminate the hidden danger of quality and improve the operation efficiency.
- 6) Through the application of a series of measures, it has achieved good effort in improving uniformity of the shot points and stabilizing production efficiency.

The specific application effects will be shown in the presentation.

Thanks ADNOC for agreeing to publish the paper.

Reference:

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