RESEARCH OF GPS TECHNOLOGY IN SEISMIC MONITORING SYSTEM

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ABSTRACT :

Effective earthquake monitoring and forecasting speeds up restoration of sites and reduces earthquake losses. In the 1970s, with the rapid development of the GPS technology, a new era of Geodesy that overcomes conventional means's limitations has come. During the 1990s, GPS accuracy has reached to 10-8. China has basically established a GPS seismic monitoring network，with this network the dynamic crust changes can be monitored and the Earth's interior and crust movement trends can also be analyzed. In this paper, based on the data of GPS seismic monitoring network a new model that can improve earthquake monitoring and forecasting is presented.

KEYWORDS: GPS，Seismic monitoring，The earth deformation monitoring

1. INTRODUCTION

1.1. The Ruinous Earthquakes

As one of the major natural disasters, earthquake disaster has been a constant threat to human survival and development since ancient times. Strong earthquakes cause the collapse of building facilities, and will also induce landslides, and cracks, sandblasting, and other phenomenon, leading to casualties and economic losses. And the devastating earthquake also can trigger fires, floods, tsunamis, landslides and bust up the lifeline of human race, such as urban pipelines and transportation projects, which cause secondary disasters. The earthquake disaster monitoring and forecasting has been an important subject of scientist. In 1975, due to the success of earthquake prediction, the number of casualties in the earthquake with magnate of 7.3 was the total number of 0.32 percent in densely populated areas of the Haicheng, the success of the prediction shocked the entire world. Accreditation by the UNESCO, China as the sole right to make earthquake forecasting short-term success of the country, was recorded in history. Haicheng earthquake successful prediction mainly rooted in the importance of observation. This shows that earthquake monitoring and forecasting to reduce the losses caused by earthquake disaster was great practical significance.

1.2. *The Reasons of Earthquakes Bringing out*

According to theory of global tectonic plates, plate movement was one of the main reasons of the earthquake. The crust was divided with some tectonic activity for the relative motion between the plates, some big plates, and some small plates. The global total has six plates: the Pacific plate, the Asia and Europe plate, the African plate, the Inter-American plate, the Indian Ocean plate and the Antarctic plate. Most of earthquakes occur in the border of the big crustall plate, part of earthquakes in the riftzones of the internal activities plate. China was between the two major seismic zone - the Pacific seismic belt and the Europe and Asia seismic zone, so it was extruded by the Pacific plate, the Indian plate and the Philippine Sea plate. Since the 20th century, the earthquakes above magnate of 6 have happened in China more than 800 times, around our country except Guizhou, Zhejiang and Hong Kong. Therefore, it was an important research direction in earthquake studies that making use of crustal deformation information studies the gestation process and laws about earthquake, then for earthquake monitoring and forecasting.

2. THE SPATIAL TECHNOLOGY- GPS

Spatial geodetic technology opened up a brand new way for the current monitoring crustal movement, especially the GPS technology, with its observation of high precision, small size equipment, operating efficiency fast, not-as between stations, all-weather advantages etc., has brought revolutionary change for monitoring the global and regional crustal movement. Using GPS to study crustal movement and explore geodynamic phenomenon in the world were developing rapidly, the application of GPS in geodesy, geophysics, geology, and other field, was more extensive, and the application of GPS observing technology were increasingly learning of the broad masses of workers to the attention.

GPS (Global Positioning System) was an artificial satellite system being composed of 24 artificial satellites covering entire earth. The system can guarantee that at any moment, any point on earth, and at least four satellites can be observed contemporaneously, to ensure that the satellites can be collected to the latitude, longitude and height of the observation points, in order to achieve navigation, positioning and timing capabilities. GPS global positioning system was consisted of three parts: the space part - GPS constellation; ground control part - the ground monitoring system; users of the equipment - GPS signal receivers. GPS positioning technology with the advantages of all-weather, high coverage, high precision, high efficiency and low cost, has been more wide range of application in all types of geodetic control network to strengthen reform and establishment, and in highway engineering survey and large-scale structures of measuring deformation measurement.

GPS positioning including absolute positioning and relative positioning:
Absolute positioning methods: absolute positioning also called single-point position, it refers to directly determine the coordinates of observation stations with the coordinate system whose center was the Earth's center as coordinate origin. The principle was to take distance between consumer receiver air wire and GPS artificial satellite observation amounts as basis, and according to the known instantaneous satellite coordinates, to determine the user receiver antenna at the corresponding point coordinates. The microtime satellite bell and the receiver bell were difficult to keep strict synchronism, so the distance between the actual observation points and the satellite contains the distance affected by bell difference; this distance was called "pseudo-range ". The satellite bell error can be corrected by bell difference parameters of navigation message, but the receiver clock error can not know in advance, so it ought to go to find the solution together as a unknown with the three-dimensional coordinates of observation points in the data processing, so a Real-time observation point to solving four unknowns using at least four satellites which were observed at the same time.
The relative positioning was used two GPS receivers placed in the two ends of the baseline, in parallel, the same GPS satellite observations, to determine the relative position of a baseline in the coordinate system or baseline vector. Because in two or more simultaneous observation points observing the same satellite can effectively eliminate or weaken the satellite orbit errors, satellite clock error, the impact of poor receiver bell. At present, China's crustal movement monitoring was static relative positioning using this method, the accuracy of10-8～10-9.

3. CRUSTAL MOVEMENT OBSERVATION NETWORK OF CHINA

Crustal Movement Observation Network of China (acronym for CMONOC) was based on the global positioning system (GPS) observations technology, associated with spatial technologies of the radio Very Long Baseline Interferometry (VLBI) and human-ranging (SLR), precision gravity and the precision leveling in a large-scale, high precision and high temporal and spatial resolution of the crustal movement. CMONOC was a comprehensive, multi-purpose, open, data sharing resources, nationwide observation network, with continuous dynamic monitoring function. Networks essentially improved the dynamic monitoring matters in the Earth's surface solid, liquid, gas.
The network was composed of datum network, basis network, regional network and analysis system. Datum network includes 25 GPS observation stations, with many observation means, such as absolute gravity, relative gravity and level. Some stations can observe objects using VLBI and SLR, and every station was equipped with satellite communications and cable communications equipment. 56 regular re-testing GPS stations consist of the basis network. The frequency in west was two one year, and four times in east. Regional Network owns 1000 regular re-testing GPS stations, of which about 300 distribute equably, and about 700 laid intensively in the fault zone and earthquakes surveillance zone.
Accuracy of the baseline length changed rate per-year between two datum networks was better than 2 mm. GPS satellite precise orbit accuracy and the IGS network were better than 0.5 meters, and independent orbit accuracy was better than two meters. Measure accuracy of datum change rate of VLBI between adjacent stations was 2-3 mm. Absolute coordinates accuracy of fixed SLR was better 3 cm, mobile SLR better than 5 cm. Absolute gravity accuracy was better than 5-Gaya.The GPS baseline between basis stations and regional stations was also required, the horizontal component 3-5 mm, vertical component 10-15 mm, and the relative gravity accuracy 15 to 20-Gaya.
The observation crustal movement data was basis of quantitative study of earth science. These data with large-scale and time continuity were very valuable data resources about quantitative research in China region even the global plate movement.

4. FORECASTING EARTHQUAKES USING GPS MONITORING NETWORK

Monitoring and forecasting earthquakes via GPS mainly reflected in the following aspects:

1) Firstly, the opposite movement among plates was researched using GPS monitoring network. With several decades of efforts, both the value and direction of relative movement had been measured, and the results were coincident with the results inferred by geological method, to confirm the plate movement. For example, in China in the early 1990s, "modern crustal movement and Geodynamics Research" planning topics were implemented, laid the 22 non-retesting of GPS stations throughout the country. 22 nonscheduled measure GPS stations were established. After re-testing seven edge, the result indicated that the main energy of striking the movement of Chinese land plate was derived from the Indian plate pushing the Eurasia in northern direction, with pushing volume to 3.4 × 10 -8 / A. At the same time, a series of north-south rhombus blocks between southwestern region of Jinsha River and the North-South Red River fault zone did have a very significant sliding in the south and a little west, where southward slide was 1.8 cm /a, and westward slide was about 1.0 cm /a. The establishment and improvement of GPS monitoring network would no doubt provide new knowledge and understanding for the plate structure and division. GPS research on non-rigid internal characteristics of plates and plate boundaries types were under way, and they would provide new evidence for monitoring and forecasting earthquakes.
2) Secondly, Using GPS monitoring network, tectonic activity area in particular the crustal deformation cumulative in earthquakes, volcanic activity areas was monitored. According to location and the structural characteristics of Southern California, in the region scientists processed a large number of works to monitor crustal deformation, and made a lot of important reference value in forecasting earthquakes; in the Soviet Union, the use of geodetic monitoring accumulation of elastic deformation and vertical stem fault laid GPS stations was stressed to detect bending characteristics of the rock displacement; in Japan's earthquake prediction program, crustal deformation observation was a very important project, and a variety of means was participated in geodesy. But in recent years GPS had been used to do this work, crustal deformation information was also acquired in earthquake preparation process; using GPS monitoring data in western Yunnan, our country monitored the apparent activities in the Jianchuan - Lijiang fault and the Red River fault zone. According to active faults and deformation of the inversion, in the 1993 a magnitude of 6.8~7.0 earthquake was forecasted to happen in the fault zone, but in 1996 in Lijiang, a magnitude of 7.0 earthquake occurred. The distance between the practical epicenter and the forecast epicenter was only 30 km, and the validity of GPS was confirmed.
3) Thirdly, Using GPS had characteristics of real-time and continuity, the position displacement curve in earthquake monitoring process, with seismic released energy data, and the study of crustal stress provided monitoring and forecasting for aftershocks.

5. CONCLUSIONS

With the accelerating pace of globalization, earthquake monitoring and forecasting earthquakes should be facing a broader scope and committed to the establishment of trans-regional or even global seismic monitoring network, to solve the world's problems in monitoring and forecasting earthquake. Using GPS to monitor crustal movement in the mid-term, some short-term precursor might arise before earthquakes, the instantaneous changes in the post-earthquake, as well as the characteristics of crustal movement after earthquakes might be discovered, and there was still great potential to utilize. Active faults in the displacement and changes, the earth's rotation parameters of change, the earth's interior structure of the inversion, and so on, were being researched in foreign, and there were a lot of application prospects.

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