3D-OPTICAL DEFORMATION MEASUREMENT AND ITS AUTOMATION APPLICATIONS IN TUNNELING

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Abstract: The New Austrian Tunneling Method (NATM) is spreading out fast over Taiwan to tunneling, the measurements of deformations are an integral part of NATM. The paper will discuss the 3-Dimensional optical measuring system developing by Europe used in Chung-Liao Tunnel, the first soft rock tunnel of Taiwan Second Southern Freeway in southern Taiwan, to assist automatic data logging, to make proper judgement by rapidly safety evaluation from monitoring raw data, and should be used wherever possible.

Keywords: 3D-optical deformation measurement, NATM, tunneling, convergence, monitoring

1. INTRODUCTION

Due to the mountainous and hilly region occupied the more than 60% area of Taiwan, the total tunnel length in past ten years has been planed and built in major rail transit and freeway projects was over three hundred kilometers, the amount and magnitude of tunneling must be increasing in the future. The distinctive features of tunneling are danger, dirty, difficult to make deficiencies of manpower. The automation in tunneling can help to improve the shortcoming.

The New Austrian Tunneling Method (NATM) is spreading out fast over Taiwan to tunneling, the measurements of deformations are an integral part of NATM. The accuracy and reliability of the measurement results are affected on bad working conditions such as ventilation and dust often, and to happen accident making the addition of cost and the drop of construction advance rates. The 3D-optical measuring system developing by Europe used in Chung-Liao Tunnel, the first soft rock tunnel of Taiwan Second Southern Freeway in southern Taiwan, it has produced some fantastic results, and should be used wherever possible.

2. DESCRIPTION OF THE 3D-OPTICAL MEASURING SYSTEM

Successful tunneling must be able to react to the varied rock conditions with the accurate, reliable monitoring results, and are necessary not only is assuring the safety of the tunnel and verifying design assumptions, but often used to finalize the design of support elements and to enhance construction procedures. The essential requirements of any instrument are reliability, simplicity, easy and fast installation, operation and calibration without any effect on construction work; the instrument must be durable in the long term and not prone to damage during and after installation. The instrumentation commonly used includes: convergence pins to determine deformations in the tunnel lining, extensiometers to evaluate the behavior of ground around the excavation, and often pressure cells for observation of stress in the lining. Convergences

measured (Figure 1.) by tape enable an overall impression about the deformation of the tunnel, but they are not suitable for evaluation of the actual movement of a point.

Figure 1. The conventional displacement monitoring methods (Convergence)

The 3D-optical measuring system consisted of the following major components: Electronic theodolite with an integrated coaxial electro-optical distance-measuring system (Total Station); special bireflex targets (Figure 2.); hardware requirements including: PC or notebook, interface for data-transfer theodolite to PC, output devices and comprehensive software system including: data base management, geodetic calculations, graphical evaluation, utilites and drivers (Figure 3.). The 3D-optical measuring system instead of conventional displacement monitoring methods can assist automatic data logging, to make proper judgement by rapidly safety evaluation from monitoring raw data.

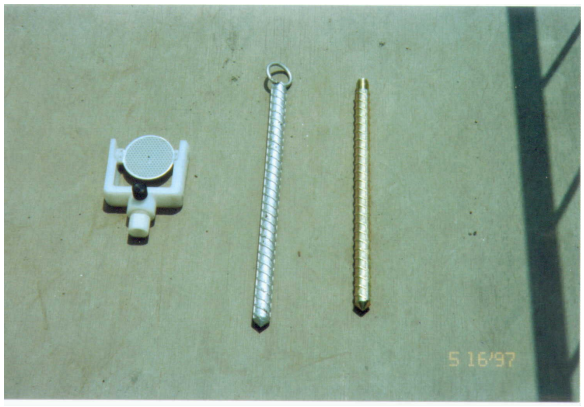

Figure 2. Bireflex targets, convergence and settlement pins

Figure 3. Minimum hardware configuration

3. COMPARISONS

The important differences to conventional displacement monitoring methods may be drawn:

All readings are carried out from the most convenient place depending on activities and geodetic requirements (Free Station), distances from 10 to 140 meters (Figure 4., 5., 6.).

Figure 4. 3D coordinates of selected points represented by adequate stabilisation

Figure 5. The conventional displacement monitoring methods (Roof-leveling)

Figure 6. The 3D-optical monitoring

Readings are normally carried out by one surveyor (and one rod-man) without any effect on construction work (Figure 7.) and spend 3 to 5 minutes per cross-section.

Figure 7. The 3D-optical monitoring (Shotcrete)

Necessity to get up to targets only for installation and cleaning.

Readings to desired cross-sections to get actual 3D coordinates of these points, maximun data security due to automatic data logging and complete data flow, some typical diagrams are shown in Figure 8. ~ Figure 11..

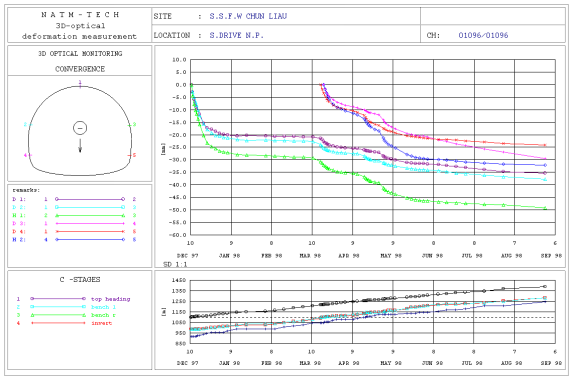

Figure 8. Graphical evaluation (Convergence-time related diagram)

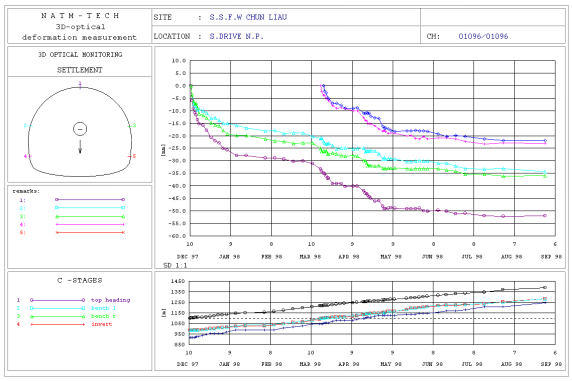

Figure 9. Graphical evaluation (Settlement-time related diagram)

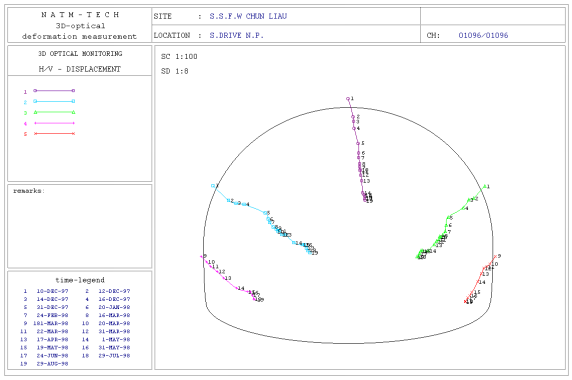

Figure 10. Graphical evaluation (Lateral displacement-time related diagram)

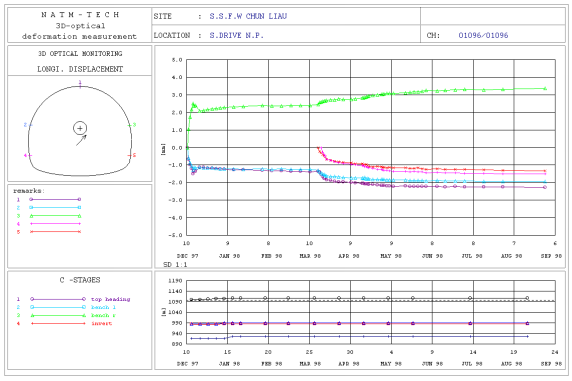

Figure 11. Graphical evaluation (Longitudinal displacement-time related diagram)

The deviation to conventional displacement monitoring method are –1.5 to +0.29 mm for settlements and –0.3 to +0.14 mm for Convergences〔1〕.

4. CONCLUSIONS

The New Austrian Tunneling Method (NATM) is spreading out fast over Taiwan to tunneling. The measurements of deformations are an integral part of

NATM, and are necessary not only is assuring the safety of the tunnel and verifying design assumptions, but often used to finalize the design of support elements and to improve construction efficiency and to drop risk and cost.

The essential requirements of any instrument are reliability, simplicity, easy and fast installation, operation and calibration without any effect on construction work. Convergences measured by tape enable an overall impression about the deformation of the tunnel, but they are not suitable for evaluation of the actual movement of a point.

The 3D-optical measuring system developing by Europe used in Chung-Liao Tunnel, to assist automatic data logging, to make proper judgement by rapidly safety evaluation from monitoring raw data, it has produced some fantastic results, and should be used wherever possible.

ACKNOWLEDGEMENTS

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REFERENCES

〔1〕China Engineering Consultants, Inc., *The Report of Monitoring in Chung-Liao Tunnel*, 1998.