THE ADJACENT BUILDINGS MONITORING REGARDING THE TUNNEL CONSTRUCTIONS IN A BIG CITY

NETCU CĂTĂLIN*, PANAITESCU VALERIU**

** Inspectoratul General pentru Situaţii de Urgenţă, Bucureşti*
*** Universitatea „Politehnica” Bucureşti,*

Abstract: This paper presents a new strategy for determining an optimum position of monitoring point and criteria with which judgment is made if the settlement values at the point are critical or not for a significant structure adjacent to tunnel construction. The position and criteria are differently given to each structure by considering its geometry and exact position. It is unlikely to the conventional monitoring scheme undertaken by a fixed criterion applied at certain monitoring points that are also intuitively placed. The strategy proposed is based on an iterative scheme by incorporating the so-called Intelligent Tunneling Information System (ITIS). Details of the iterative procedure are described with an illustrative example. In the example, the settlement criteria at three different damage levels are given at an optimum monitoring point.

Key words: *tunnel, buildings monitoring, damage, construction.*

1. INTRODUCTION

A number of urban tunnel constructions take place as the social demand for public transportation increases, in which the major concerns would be not only for safety of tunnels itself but also for safety of adjacent structures to the tunnels. The safety of the adjacent structures is subject to ground movements due to tunneling. Intensive studies have been made to date in this topic (KICT, 2000; Kim et. al., 1998; Son, 2003). In general, a prediction of ground movements and potential damages of the adjacent structures are carried out, in which a number of damage parameters such as angular distortion, deflection ratio, etc. are involved (KICT, 2000). Monitoring on the adjacent structures is also undertaken for evaluating their damages during tunnel construction. The number of monitoring points might be limited because of economical reason, etc., at which ground settlements and tilts would be monitored periodically.

In the circumstance, a new strategy is proposed for determining an optimum location of monitoring point as well as evaluation criteria at various levels for assessing the monitored values of settlements. Such information is given for individual structure independently. The strategy is based on an iterative procedure of assessing the structures with respect to the gradually increasing ground settlements in various steps, which are automatically performed considering the exact location, geometry and mechanical properties of individual adjacent structure. An illustrative example for showing how the proposed strategy works is given.

2. STRATEGIES PROPOSED

2.1 DETERMINATION OF AN OPTIMUM MONITORING POINT

With limited number of monitoring points, an attempt is made to determine an optimum monitoring point at which a maximum settlement may take place. The strategy is based on an iterative scheme. The progressive deformation of the structure can be check up by automatic calculation of 3-D settlements at the foundations of all the columns of the walls consisting of the structure. From the results, conventional damage parameters of all the walls can be calculated at every stage of tunnel progresses. The theoretical background on the 3-D settlement trough and ITIS can be found in the literature in details (Kim, 1998).

A schematic diagram for determination of an optimum monitoring point is given in Figure 1. Based on the damage parameters for the walls calculated, one of the walls, which shows the most critical values at several excavation stages, can be chosen and then a column of the wall side to tunnel would be a suggested monitoring point for the structure.

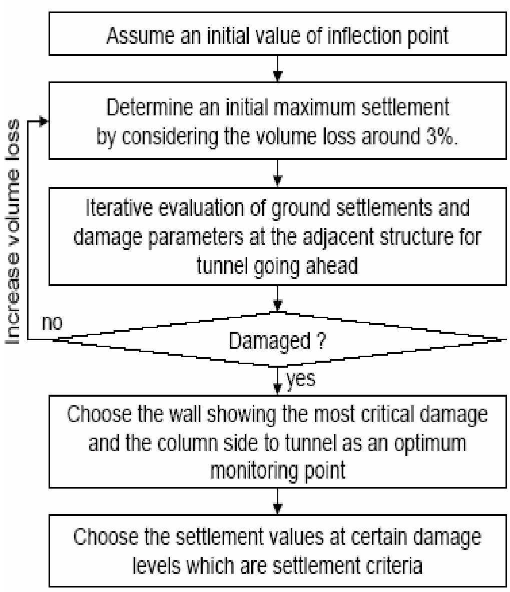

Fig 1. Plane view of the tunnel site concerned

In progressive prediction of the deformation of the structure, initial values for a maximum settlement and inflection point, which are involved in 3D equations of the ground settlement trough (Kim, 1998), should be required *a priori.* The values will be arbitrarily chosen which should be big enough to make at least one of the walls damaged on purpose. An inflection point can be determined by a ground loss which are in general 1%~3%. However, bigger values of the inflection points from assumption of about 6% ground loss, are fixed first in this study. Then a big maximum settlement of about 100~200mm is applied for the automatic progressive calculation of settlement tough. It is noted that the chosen values should be confirmed to be insensitive to determination of the monitoring point. This aspect has been confirmed by a number of verification tests that, however, is not given in this paper.

2.2. GIVING SETTLEMENT CRITERIA TO THE OPTIMUM MONITORING POINT DETERMINED

As shown in Figure 1, settlement criteria can be given to the optimum monitoring point determined by the manner addressed in previous chapter. A variety of the existing evaluation charts could be involved for the purpose (Son, 2003). In this study, the evaluation charts by lateral strain vs. angular distortion (Boscardin & Cording, 1989) is used, on which a number of line plots for all the walls under consideration can be made through all the progressive stages. One of the lines that reaches first to the boundary between the damage levels given in the Boscardin chart can be easily determined by ITIS. On the line determined, the settlement value at the calculation stage of reaching to a boundary between damage levels becomes the settlement criterion at the damage level within the boundary. Note that settlement criteria at certain monitoring point of an adjacent structure vary depending on its geometric al characteristics and lateral distance from tunnel axis.

3. ILLUSTRATIVE EXAMPLE

The strategy proposed here was applied to the design stage of the Ban-Song Subway Line. Attempts for giving an optimum monitoring points as well as evaluation criteria at different damage levels has been made for total 18 significant buildings adjacent to tunnel construction. By page limitation, only an application case is given in this paper. The plane view of the tunnel site is shown in Figure 2, in which the building concerned in this paper is located on the 11th section in Figure 2. A brief field description at location of the building is given in Table 1.

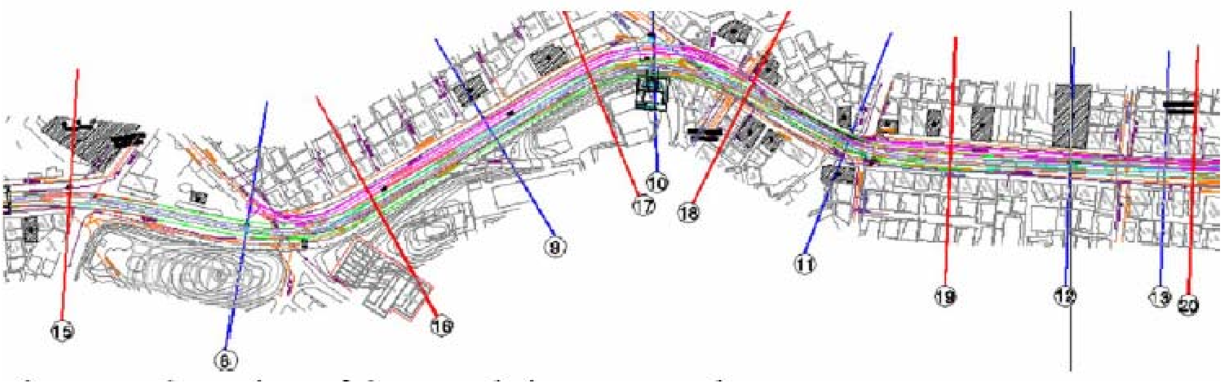

Fig 2. Plane view of the tunnel site concerned

The predicted and assumed settlement parameters with brief field description. - Table 1.

Tunnel Depth	Water Level	Pattern No.	Maximum Settlemens Predicted	Inflection Poins predicted	Ground Loss predicted	Maximum Settlemens Assumed	Inflection Poins Assumed	Ground Loss Assumed
15.71m	6.23m	PD-3A	15.1mm	14.5m	0.926%	100mm	14.5m	6.132%

First of all, the settlements parameters such as maximum settlement and inflection point and damage parameters of the building are predicted for safety evaluation by using ITIS system (KICT, 2000). The prediction is made by a neural network trained from a number of field monitoring data available in the system. The settlement parameters predicted are given in Table 1. The location of the building and variation of the damage parameters of its walls through construction stages are also shown in Figure 3.

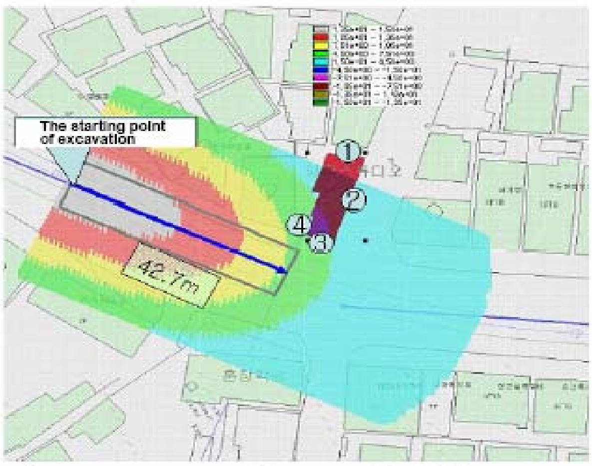

Fig. 3. An adjacent building concerned and progression of damage parameters calculated

As shown in Figure 3, all of the damage parameters predicted by the tunnel passed through seems to be within a safe domain so that no structural damage may take place. The 3D view of the damage assessment is also shown in Figure 4. Herein, the colours on the walls represent the level of damage parameters predicted for the walls, all of which are in safe range. However, the building is crucial for this site so that it is needed to place a monitoring point on the building assessments by ITIS for confirming the safety throughout tunnel construction.

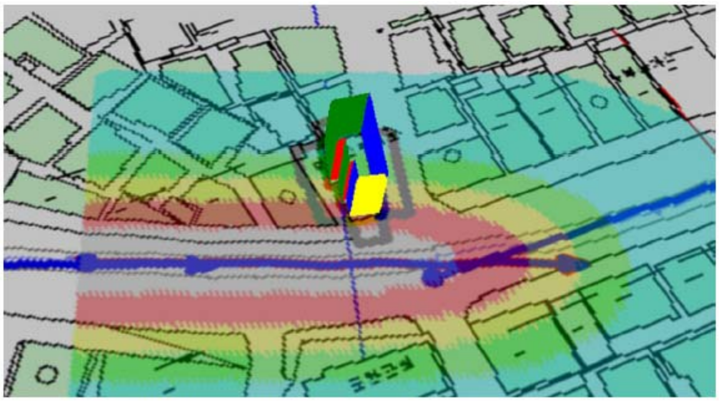

Fig. 4. 3D view of damage assessments by ITIS

By the strategy mentioned in previous chapter, another set of settlement parameters is assumed in which the settlement parameters are determined at around the ground loss of 6%. Then, the iterative calculation of ITIS is carried out again checking up the damage parameters varying on an evaluation chart. As a result, damage parameters of the 6th wall shows the most fast progress as shown in Figure 5 so that the column of the wall side to tunnel is decided as an optimum monitoring point. In addition, the ground settlements of the column are picked up at the stages circled in Figure 5. The stages are on boundaries between different damage levels. In this case, three settlement criteria have been given at three different levels of structural damages. The settlement criteria decided are 15.1mm, 23.67mm, 54.37mm at damage level I, II, III, respectively. The damage level I, II and III represent to be very slightly damage, moderate to severe damage and severe to very severe damage, respectively as shown in right hand side of Figure 5.

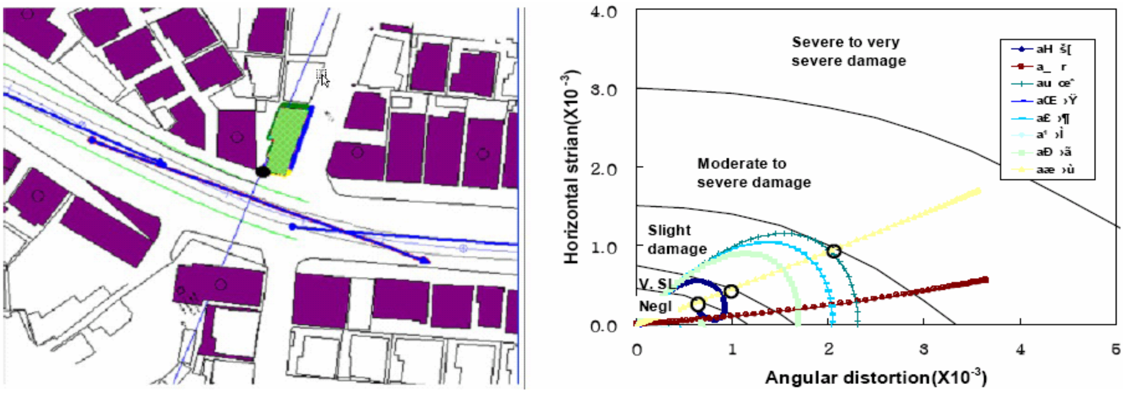

Fig. 5. An optimum monitoring point (left) and a chart used for determination of settlement criteria (right)

4. CONCLUSIONS

This paper proposed a strategy to determine an optimum monitoring point and settlement criteria at the point for significant structure adjacent to tunnel construction. The criteria will be used for making an engineering judgement on deformation of the structure monitored at several levels of damages. It can be seen in the scheme that the strategy allows us to minimize installation of monitoring points but not to miss any severe symptoms of structural damages taking place on the structure. To date, monitoring point has been installed intuitively at which the same settlement criteria have been applied, even if the same settlement at the monitoring point can lead to the different damages on the wall. Therefore, the settlement criteria should be decided based on the damage parameters expected. As the damage parameters will depend on geometry and position of the adjacent structure, it is reasonable to give settlement criteria differently for each structure by taking into account the geometry and position of the structure which are achieved by the strategy proposed in this paper. An illustrative example has been given to show how to achieve the purpose. Moreover, more verification of the strategy and field application will be made, which will be reported again in future.

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