Tunnel Soundness Diagnostic System

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At railway tunnels, general inspections, which include a judgment on tunnel soundness, are carried out periodically. Since there are many railway tunnels, general inspections take much time and labor. Besides, since the judgment on the soundness of railway tunnels depends much on the manual work of inspectors, it may differ from one inspector to another. We studied a diagnostic system that permits judging tunnel soundness automatically and developed a prototype of the system, with the aim of making it possible to judge the soundness of railway tunnels efficiently and objectively.

The general flow of the diagnostic system is shown in Fig. 1. The main characteristic of this system is that it allows for automatic judgment on both the soundness of the tunnel against concrete spalling and the soundness of the tunnel against anomalies caused by external force and the like by inputting the positions and shapes (length and width) of cracks detected by general inspection to the anomaly development diagram on the system CAD, and selecting the appropriate hammering test results and basic tunnel information by pushing the buttons associated with them.

In terms of tunnel soundness against concrete spalling, the closure, crossing and parallel run of cracks are automatically extracted from the anomaly development diagram on the CAD as shown in Fig. 2 and the tunnel soundness (α, β, γ) judged, with consideration given to the presence or absence of water leakage and the results of hammering tests. This judgment is done for each 1 m × 1 m mesh.

With respect to tunnel soundness against anomalies caused by external force and the like, the system employs an algorithm that judges the soundness from the results of collation with the appropriate pattern of cracks and from the causes of anomalies that are automatically determined from the possibility of occurrence of anomalies. The patterns of cracks show combinations of possible cracks and compressive failure based on three divisions (uneven earth pressure, plastic earth pressure, vertical earth pressure) of anomalies caused by external force and the like and indicate the positions of cracks and compressive failure which belong to each of the divisions. For the diagnostic system, 50 different crack patterns have been prepared based on the results of load tests with small-scale lining models and various field tests. Cracks in the lining inner surface are sequentially collated with the crack patterns as shown in Fig. 3, and when a corresponding crack pattern is found, the cracks are rated and weighted based on the crack length, width, angle and the like. Anomalies caused by external force and the like have strong connections with the topography, geography and so forth of the site of the tunnel, as well as the tunnel structure. Therefore, a flowchart for judging the probability of anomalies due to uneven pressure, plastic pressure or vertical pressure has been prepared from the basic tunnel information for soundness judgment.

For diagnostic results, the system outputs rough soundness and presence or absence of anomalies for each span so that the points of important anomalies can be seen at a glance (Fig. 4). When any of the DETAIL buttons at the extreme right are pushed, the system outputs detailed judgment results and comments on the point of anomaly.

As described above, we have developed a system for automatic judgment on the soundness of railway tunnels that is carried out as part of the general inspection. It has been confirmed that the prototype system is capable of automatically judging tunnel soundness with a fair degree of accuracy using inspection data obtained from actual railway tunnels (100 spans of 30 tunnels).

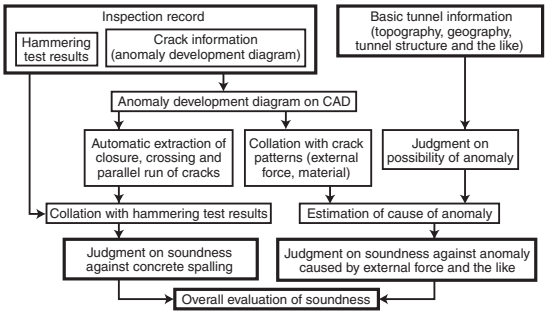

Figure 1. General flow of soundness diagnostic system

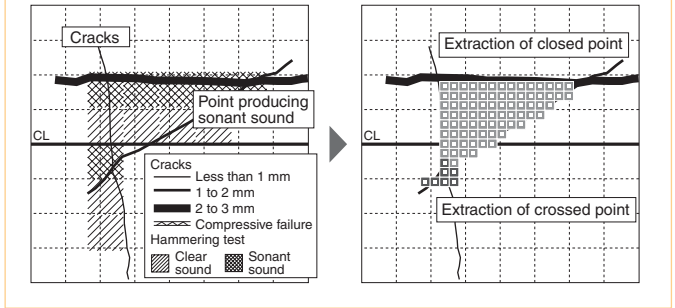

Figure 2. Example of anomaly development diagram on CAD and automatic extraction

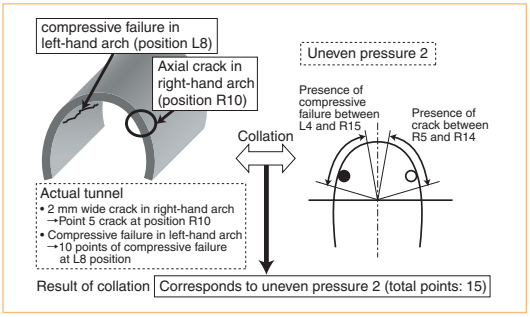

Figure 3. Example of collation with crack pattern

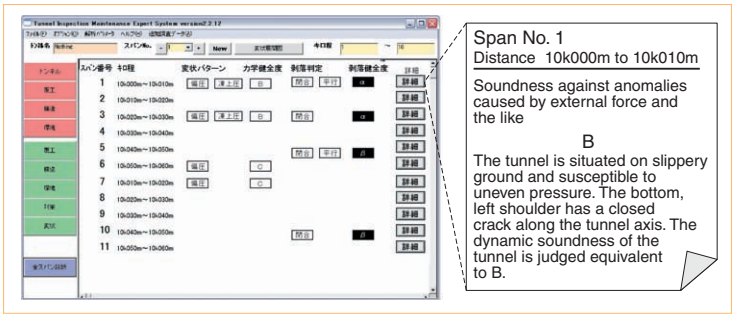

Figure 4. Example of diagnostic result output screen