11 MONITORING AND INSTRUMENTATION

11.1 INTRODUCTION

11.1.1 General

1 The objectives of the instrumentation and monitoring of the Works are to determine:

(a) ground movements and the effects on existing structures, services and utilities in a form that will allow direct comparison with the Contractor's performance criteria and design expectations; and

(b) The movements and effects on structures comprising the Works.

2 Instrumentation and monitoring system that covers all aspects of the Works (surface, tunnel structure, bridge structure, embankment and surrounding ground) shall be designed and implemented.

3 A computer database for the integration, storage, analysis, recording and processing of all monitored data shall be established. The computer database shall be stored on a web based server

4 Real-time remote access to all monitoring data shall be provided.

5 The instrumentation and monitoring system shall include the real-time information on buildings/structures within the zone of influence of the Works.

6 An automatic data acquisition system shall be designed that captures the measured results of all suitable instruments (above and below ground), irrespective of the type of sensor and the physical measurement parameters, and can be automatically viewed in real time and transmitted to a central station outside the settlement zone.

11.1.2 Instrumentation Personnel and Resources

1 A monitoring team shall be established that is responsible for the geotechnical investigations, monitoring and to obtain the permission of third parties and/or owners for the installation of the monitoring systems for the management of hazards and level of the risk to buildings and other structures. This organization shall be staffed with experienced personnel. A representative of the Contractor's design engineer shall be part of the monitoring team and be involved actively in the analysis of data and comparison between predictions and performance.

11.1.3 Monitoring database

1 The database shall include the following but not be limited to:

(a) levelling of the surface;

(b) levelling of existing buildings and other structures;

(c) vertical and horizontal deformation of existing buildings and other structures;

(d) 3D reflectors automatic optical deformation monitoring systems;

(e) load/stress cell measurements for concrete tunnel lining;

(f) inclinometers, extensometers, and other in-ground instruments;

(g) groundwater monitoring;

(h) construction progression and data acquisition;

(i) geometrical data;

(j) vibration measurements;

(k) Geotechnics and geology support systems.

11.1.4 Zone of Influence

1 Instruments shall predominantly be placed within the influence zone of the Works. Consideration shall be given to the layout and spacing of instrumentation arrays, and shall be selected with due consideration to specific site conditions with a degree of redundancy incorporated. The minimum geometrical requirements concerning the influence zone are given in the following figures:

Figure 11.1
Influence Zone

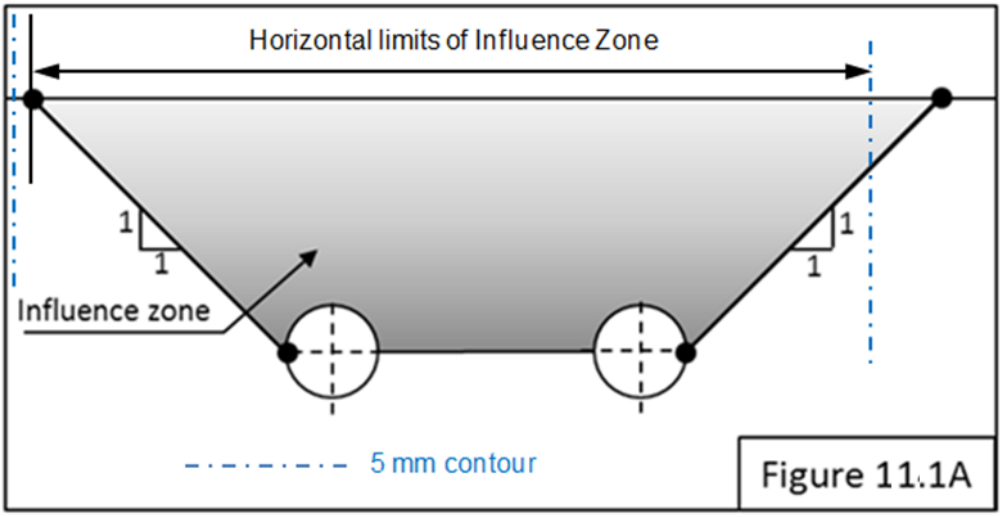

Figure 11.1A

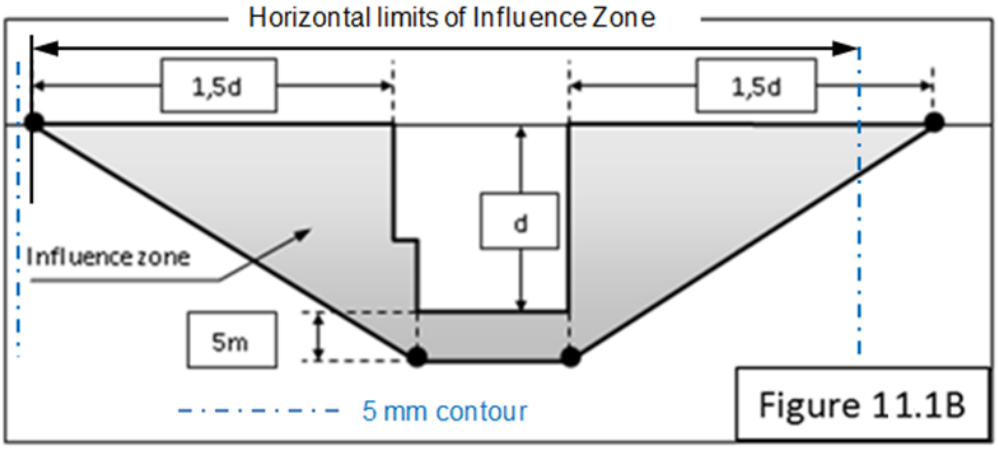

Figure 11.1B

11.1.5 Warning and Alarm levels

1 Trigger (warning and alarm) levels shall be established based on design and allowable values in accordance with the Contractor's Design Documents governing failure mechanisms assessed by the designers, enabling preventative measures to be introduced in an acceptable time.

2 When exceeding the aforesaid values the reporting chain or alarm is activated.

3 The warning and alarm levels shall account for the serviceability requirements of all monitored structures. These values shall be checked according to the observations and investigations during construction but shall not be limited to key indicator parameters of displacement, strain or pressure which determine appropriate actions in response to these values being exceeded.

11.1.6 Automated monitoring system of real time total displacements (3D)

1 An automated measuring system for the total displacements (3D) in real time shall be established, to demonstrate that the Works do not impact on sensitive buildings and other structures. Monitoring records shall be examined by the Contractors expert to detect any unexpected trends and to take necessary measures to compare predictions with observed values. All monitored observations shall be provided to the Engineer.

11.1.7 Instrument specifications

1 All instruments and measuring devices shall be manufactured by companies with proven experience in the field of construction or geotechnical instrumentation, as appropriate. The accuracy and dependability of the equipment shall not be affected by changes in temperature, humidity, stray currents or contaminants that may be encountered. Calibration certificates shall be provided by an accredited testing company. Instrumentation shall be selected to site specific conditions, but not limited to:

(a) extrusion of ground ahead of face;
(b) relative vertical movement;
(c) lateral displacement;
(d) change in inclination;
(e) change in earth pressure;
(f) change in water pressure;
(g) crack or joint movement;
(h) strain in structural member or lining;
(i) tunnel lining diametrical distortion;
(j) lining stress;
(k) lining leakage;
(l) noise and vibration.

END OF PART