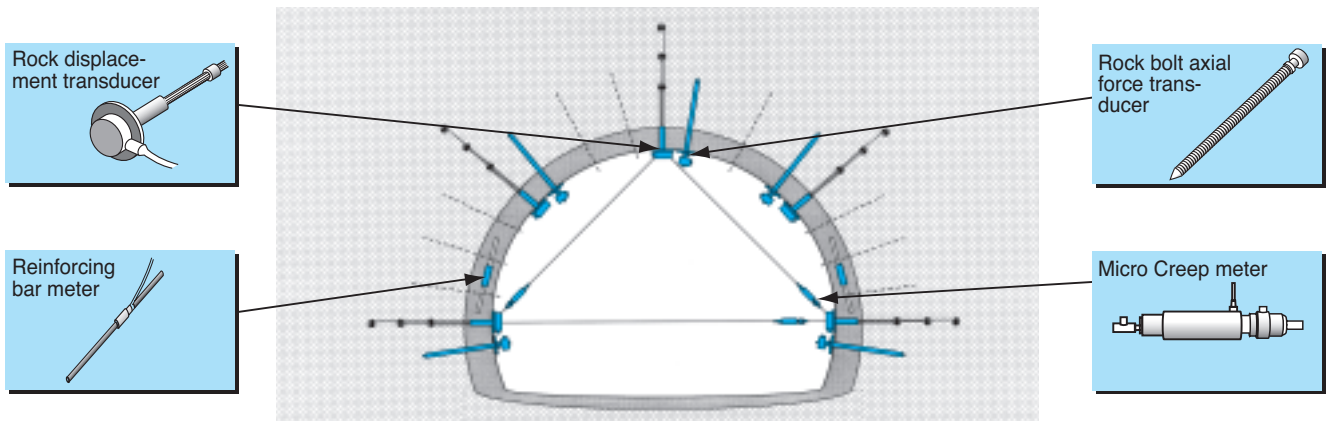


# 8 Tunnel Measurement

## NATM Measurement

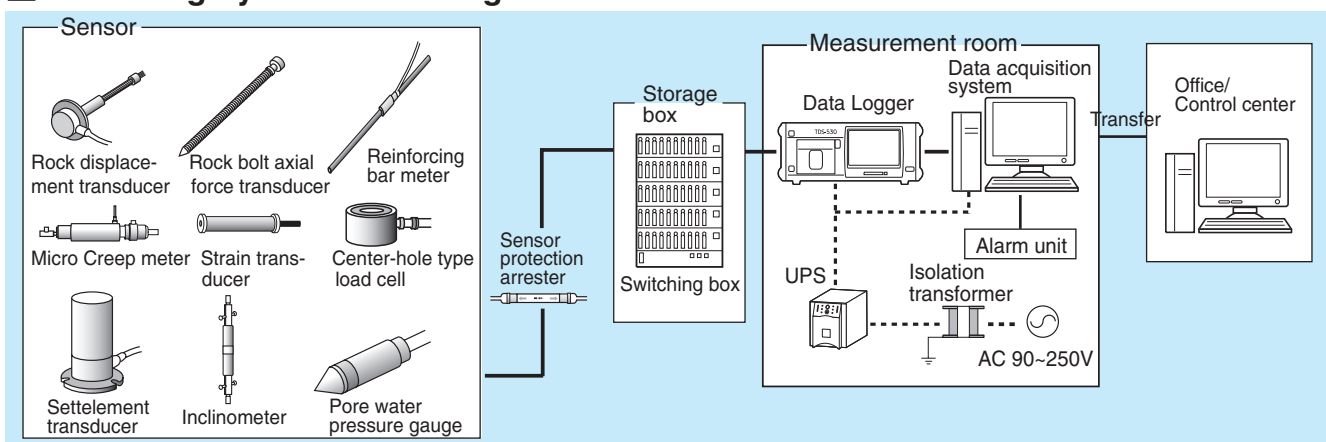
The displacement of surrounding ground and tunnel support structures along with stress conditions are measured during tunnel excavation to ensure work safety and economic efficiency.



### A list of Measuring Instruments

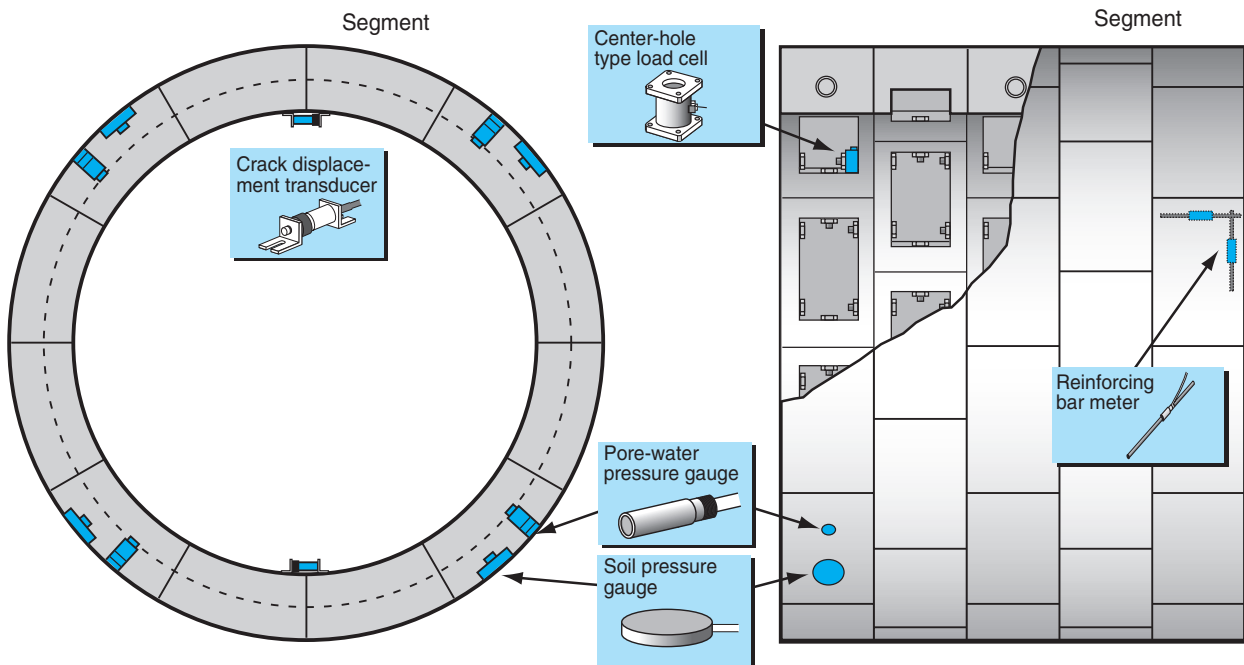
Measurement items		Instruments	Type	
Convergence		Micro Creep meter	KH-A	
Displacement of ground		Settlement transducer	KLA-A, NKLA-A, KLC-A	
		Inclinometer	KB-GC, KB-HC	
Relative displacement in tunnel		In-place inclinometer	KB-JE, KB-KE, NKB-LD, NKB-MD	
Change of ground stress		Rock displacement transducer	KLB-A	
Ground stress	Change of ground stress	Soil Pressure Gauge	KDB-PA, KDD-PA, KDF-PA	
	Pore water pressure	Pore Water Pressure Gauge	KPA-PA, KPC-PA	
Force and stress on support members	Axial force of rock bolt	Force distribution of rock bolt	Rock Bolt Axial Transducer	KRA-A
		Axial force of washer	Center-hole type load cell	CLC-NA, KCM-NA
	Concrete stress	Spraying concrete stress	Strain transducer	KM-A, KM-AT, KM-B, KM-BT
		Stresses of lining concrete	Reinforcing bar meter	KSA-A, KSAT-A
	Stress of steel arch	Stresses of support and members	Strain transducer	KM-A, KM-AT, KM-B, KM-BT
		Strain Gauge	FLA	
	Ground load	Ground load on lining	Soil Pressure Gauge	KDB-PA, KDD-PA, KDF-PA
Back water pressure		Pore Water Pressure Gauge	KPB-PA, KPD-PA	
Effects on surroundings	Behavior of ground surface and structures	Settlement and heave of ground surface	Water-tube Displacement Transducer	KWL-E
		Settlement transducer	KLA-A, NKLA-A	
	Settlement, heave and inclination of structures	Water-tube Displacement Transducer	KWL-E	
		Inclinometer	KB-AB, KB-AC, KB-DB, KB-EB	
Movement of ground surface	Extensometer	KLG-A, KLG-B, NKLG-A, NKLG-B		

### Measuring System Block Diagram



## Shield Measurement

Deformation of segment ring and effects on urban structures are observed.



### A list of Measuring Instruments

	Measurement items	Instruments	Type
Behavior of segment	Soil pressure acting on the ring	Soil pressure gauge	KDB-PA, KDD-PA, KDF-PA
	Water pressure acting on the ring	Pore-water pressure gauge	KPA-PA, KPC-PA
	Stresses and strains in the ring's rebars	Reinforcing bar meter	KSA-A, KSAT-A
	Deformation of segment joint	Crack Displacement transducer	KG-A
Behavior of ground surface and adjacent structures	Settlement and heave of ground surface	Water-tube Displacement transducer	KWL-E
	Settlement, heave and inclination of structures	Multi-layer Settlement transducer	KLA-A, NKLA-A
		Water-tube Displacement transducer	KWL-E
	Surface Inclinator	KB-AB, KB-AC, KB-DB, KB-EB	
	Movement of ground surface	Extensometer	KLG-A, KLG-B, NKLG-A, NKLG-B
	Horizontal and vertical movement of underground	In-place inclinometer	KB-JE, KB-KE, KB-DB, KB-EB, NKB-LD, NKB-MD
Change in ground water	Water level meter	KW-C	
	Pore-water pressure gauge	KPA-PA, KPC-PA	

### Measuring System Block Diagram

