Real Time Instrumentation and the Application in MRT Circle Line Projects In Singapore

实时监测系统在新加坡地铁环线工程中的应用

深圳， **2010**

张庆华 博士 （GeoApplication Engineers Pte Ltd）

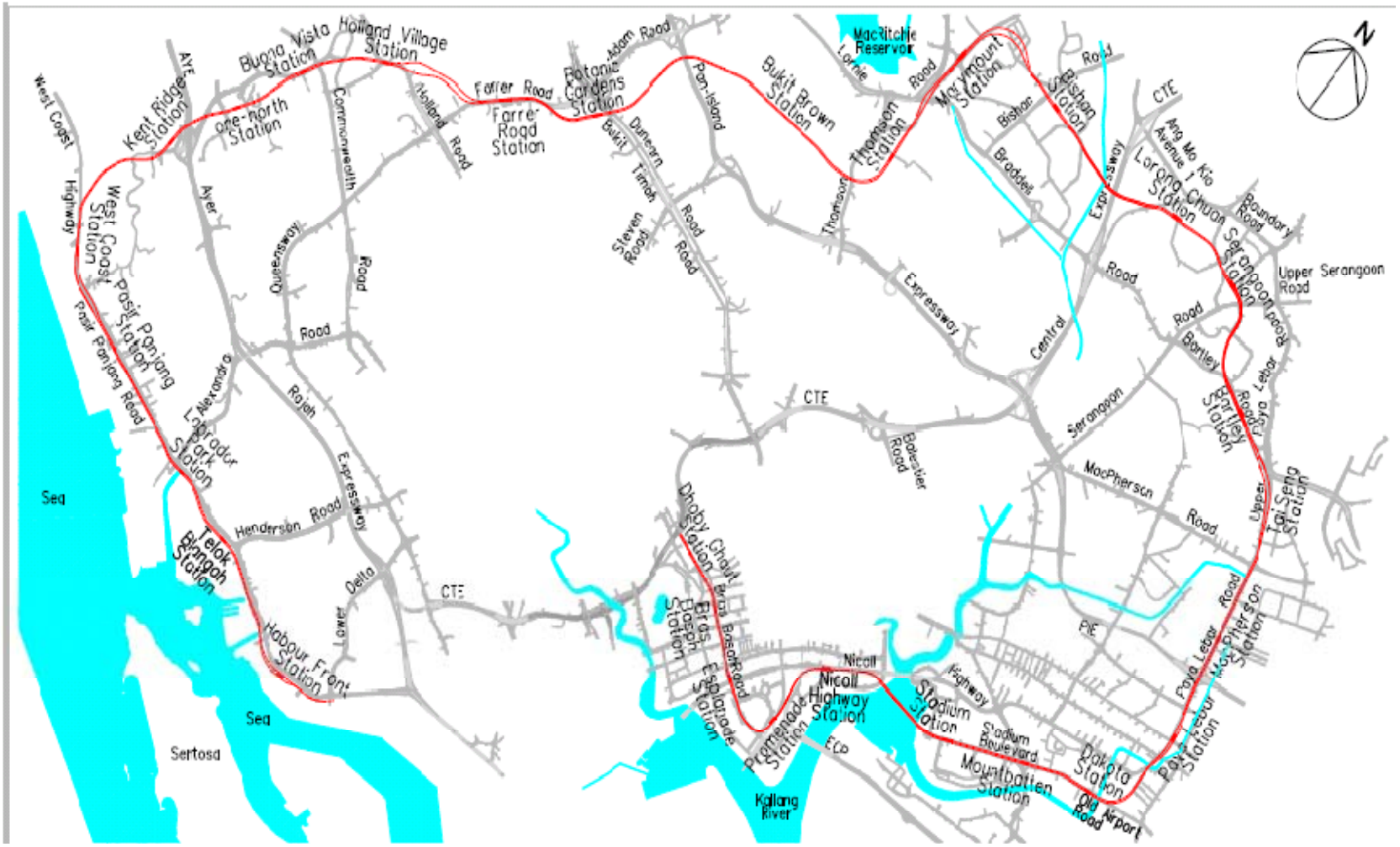
Possible Topics for Today
汇报提要

1. General Overview of MRT CCL projects in Singapore
   新加坡地铁环线概览
2. Engineering Challenges and Main Construction Method
   工程技术上挑战和主要的施工方法
3. Design Code and Software used for MRT projects
   应用在地铁项目中的软件以及设计规范
4. SGP MRT Protection Code and Instrumentation Work.
   新加坡地铁保护规范，实时监测与短信告警系统
5. Project Picture
   工程图集

MRT Circle Line in Singapore
新加坡地铁环线

The CCL (Circle line) will be 33.3 km long with 29 stations.
新加坡地铁环线全程**33.3**公里，途经**29**个站点
Costing $6.7 billion.
工程预算**67**亿新元（约**335**亿人民币）
A fully underground orbital line will interchange with North-South Line, East-West Line and North East Line.
全程地下运行，与南北线，东西线以及东北线相连接
The project will be in five stages and to complete in 2010.
工程分五个阶段，预计**2010**年完工

Circle Line 1 to 5 map
环线一到五期全貌



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Benefits 好处

Using the CCL, will be able to bypass the busy major interchanges.

通过地铁环线，可以缓解几个拥挤的换乘站压力

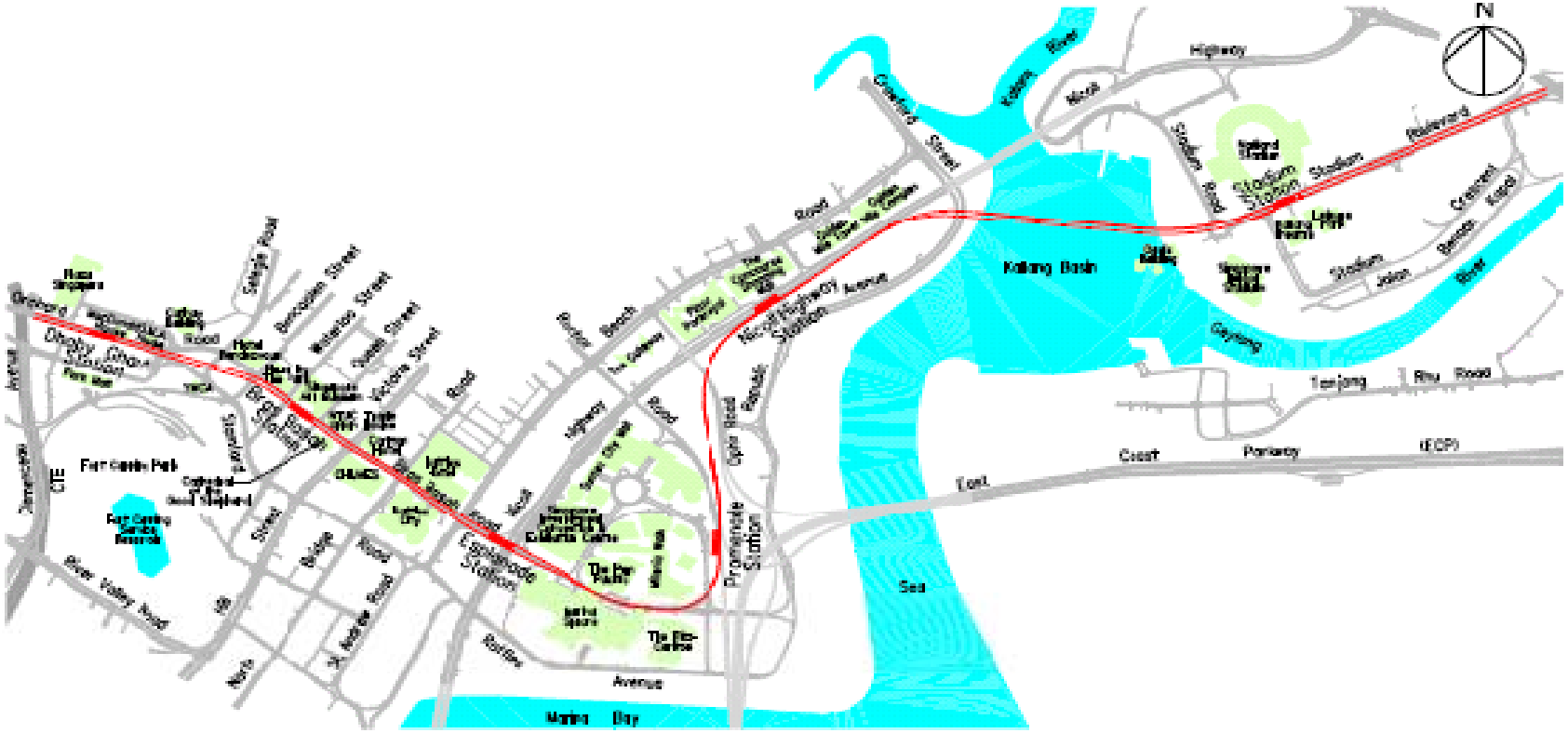
Challenges 挑战

- Traffic diversions. 施工期间的交通改道
- Soft soil at the Millenia & Nicoll Highway stations.
  Millenia and Nicoll Highway站点的软土地质条件
- Boring tunnels under the Kallang Basin.
  隧道施工穿过 Kallang 河
- Interface of tunnels with proposed KPE, DTSS tunnels @ Upper Paya Lebar/ Airport Road.
  与 KPE, DTSS 隧道在 Upper Paya Lebar/ Airport Road 的交汇连接

Circle Line 1环线 1 期–

$1.39b; 5.4km; 6 Stations; Starting @ March 2002

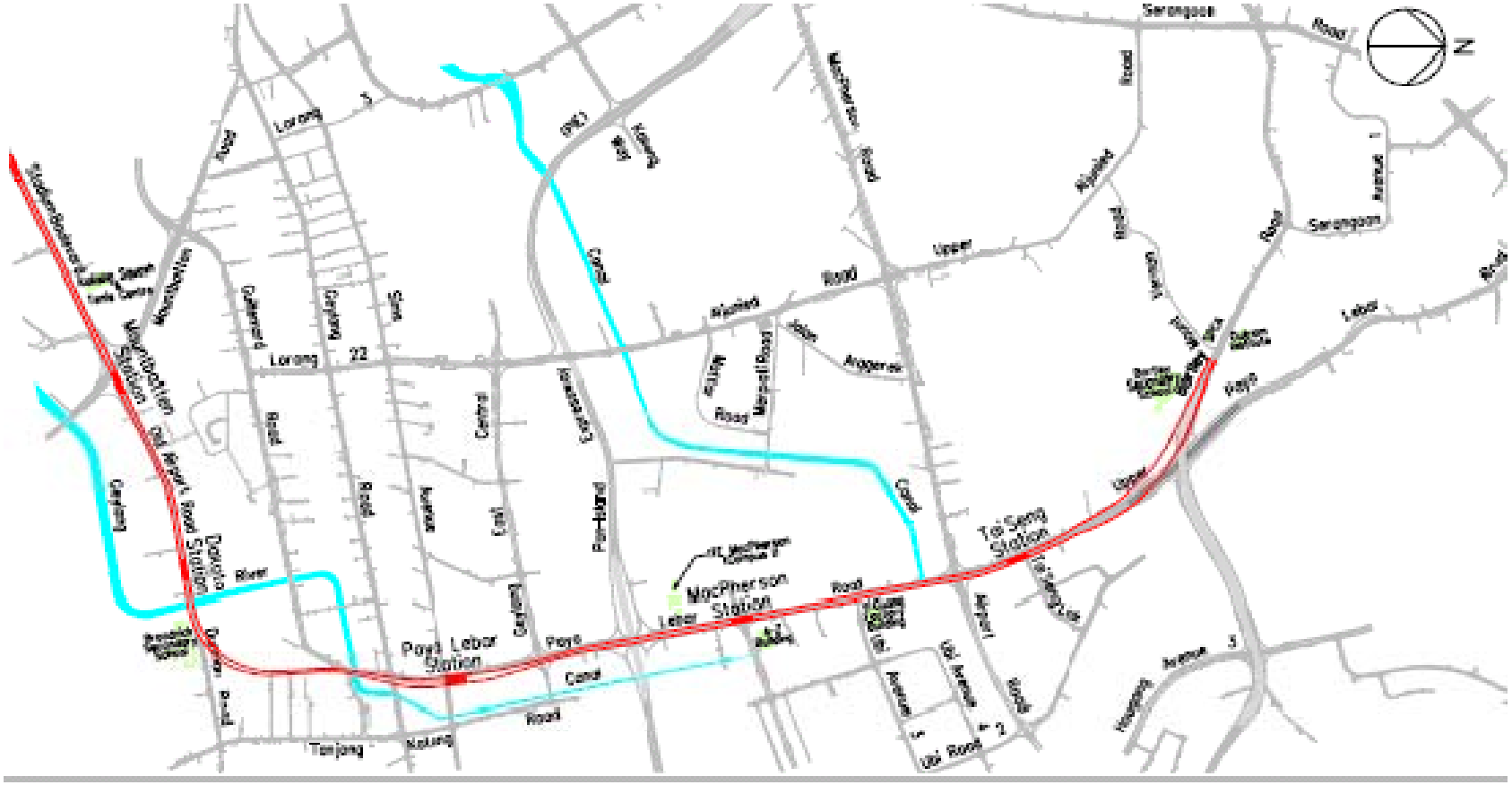
耗资**13.9**亿新币；全长**5.4**公里，途经**6**个地铁站；**2002**年**3**月开工



Circle Line 2 环线 2期–

$1.55b; 5.6km; 5 Stations; Starting @ August 2002

耗资**15.5**亿新币；全长**5.6**公里，途经**5**个地铁站；**2002**年**8**月开工



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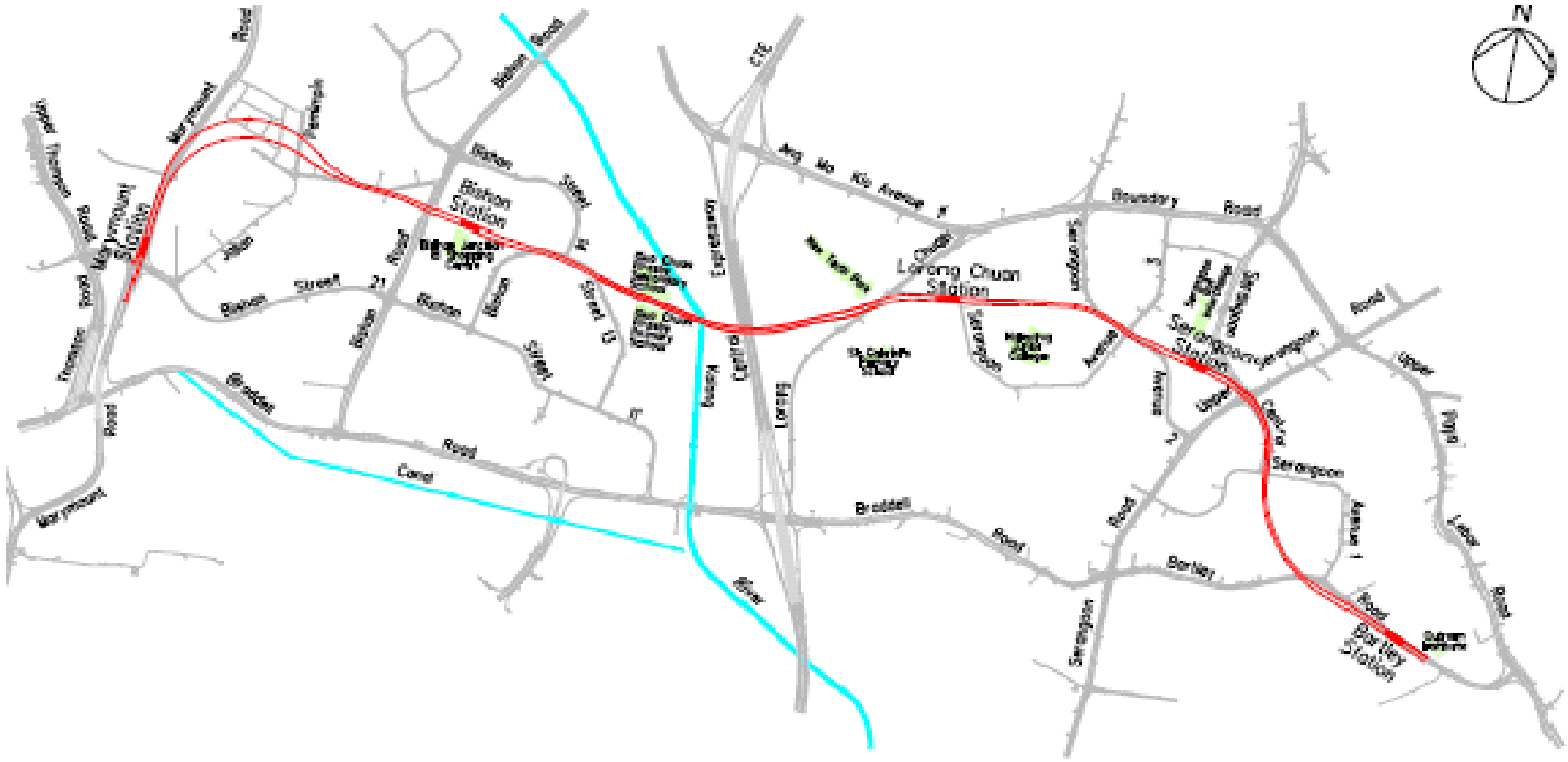
Circle Line 3 环线 3期–

$1.2b; 5.7km; 5 Stations; Starting @ Oct. 2003

耗资12亿新币；全长5.7公里，途经5个地铁站；2003年10月开工



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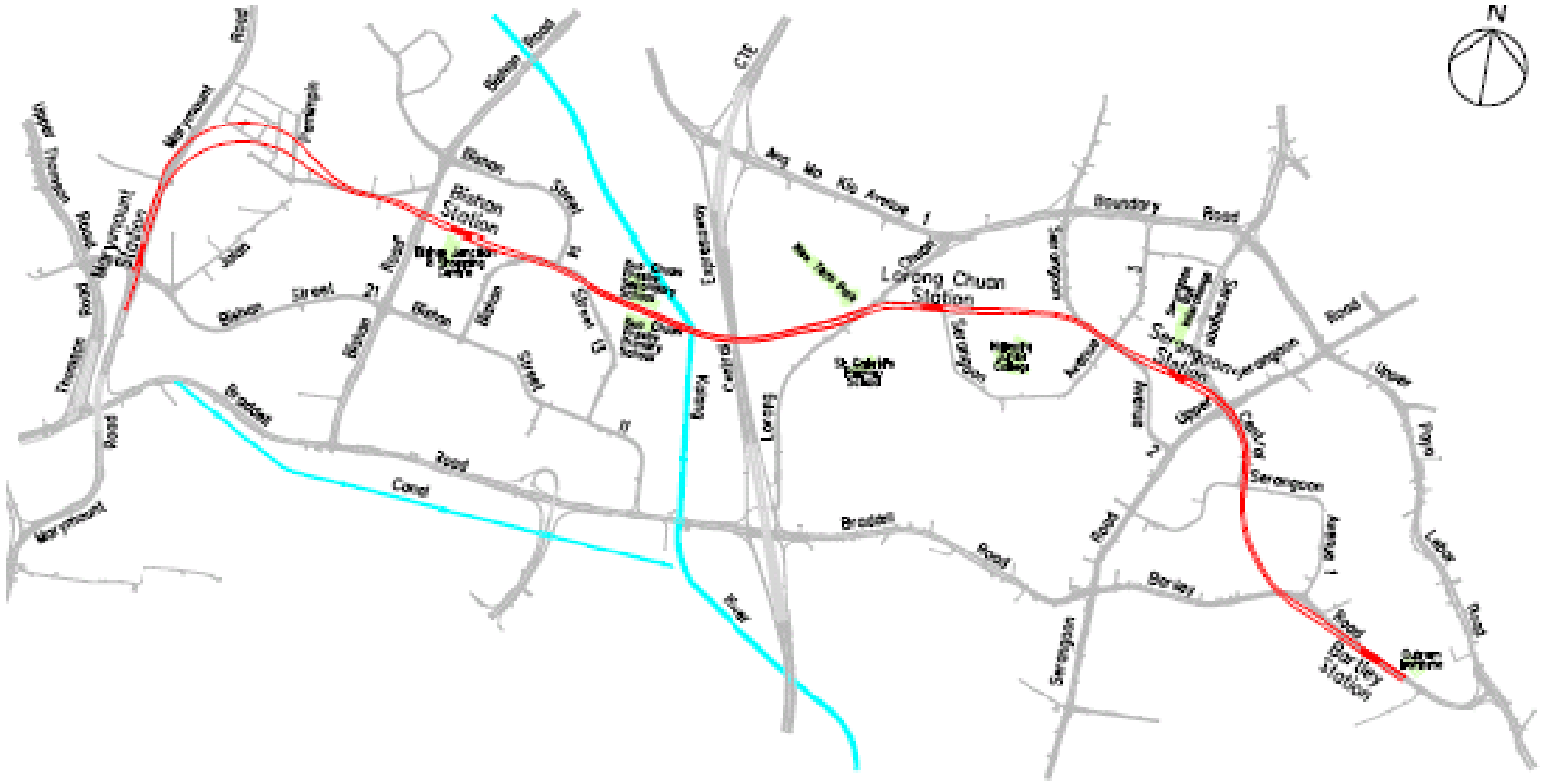
Circle Line 4 &5 – 1 环线4 &5 期– 1

$2.5b; 17km; 13 Stations; Starting @ Oct. 2004

耗资25亿新币；全长17公里，途经13个地铁站；2004年10月开工



Circle Line 4 &5 – 2 环线4 &5 期– 2

$2.5b; 17km; 13 Stations; Starting @ Oct. 2004

耗资25亿新币；全长17公里，途经13个地铁站；2004年10月开工

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Construction Method
施工方法

- Top-down Construction - Dhoby Ghaut, Museum, Convention Centre, Millenia, Nicoll Highway, Lorong Chuan and Holland stations.

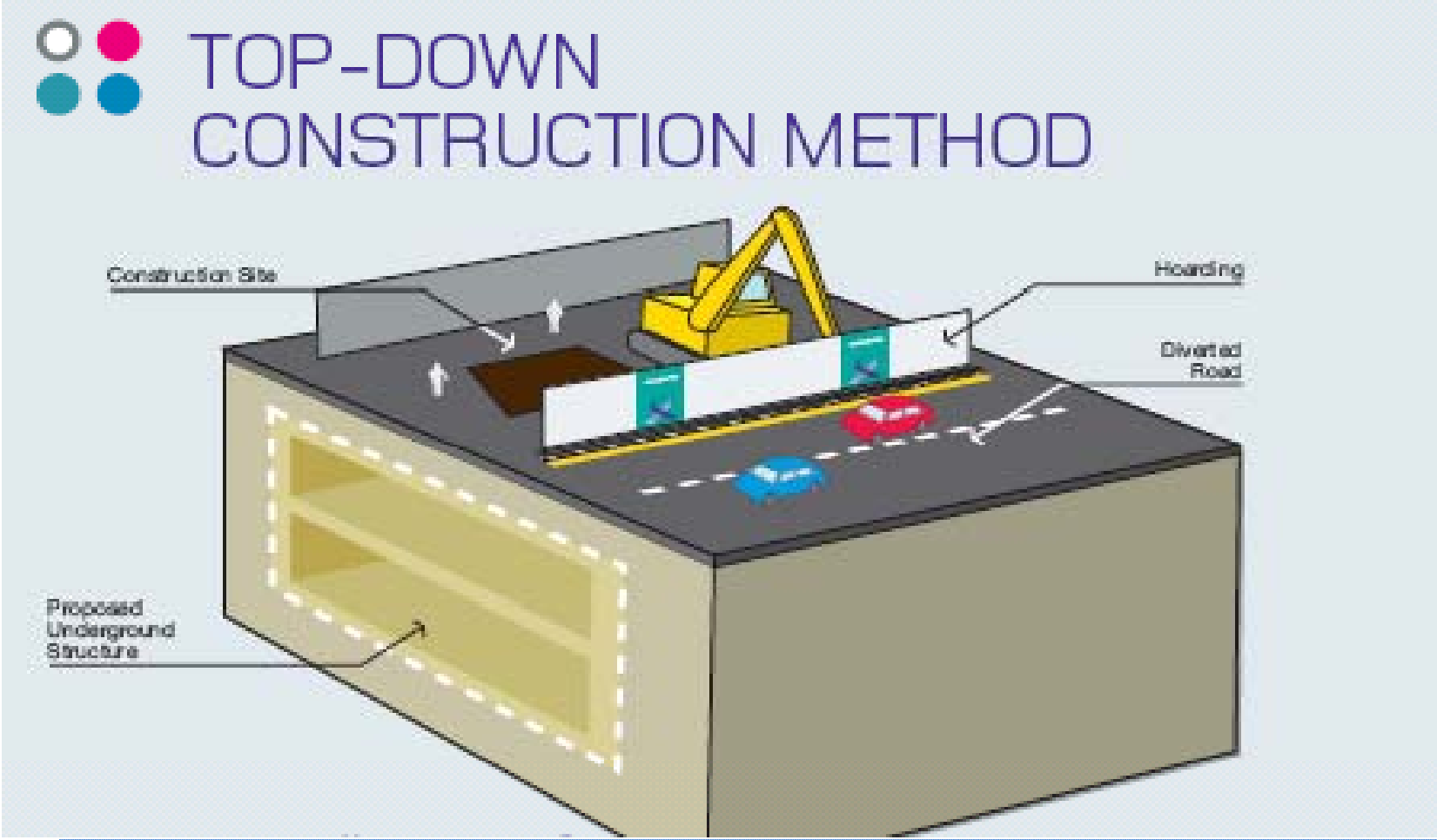
  逆作工法 - **Dhoby Ghaut, Museum, Convention Centre, Millenia, Nicoll Highway, Lorong Chuan 和 Holland 地铁站**

- Construction of Secant Pile Wall. **Secant Pile墙工法**
- Construction of Contiguous Bored Pile Wall.

  钻孔灌注桩连续墙工法

- Construction of Diaphram Wall 地下连续墙工法
- Construction of Sheet Pile Wall 钢板桩工法

Top –Down Construction
逆作工法



Top – Down & Diaphram Wall
逆作工法与地下连续墙工法

Decking路面

Opening

空间

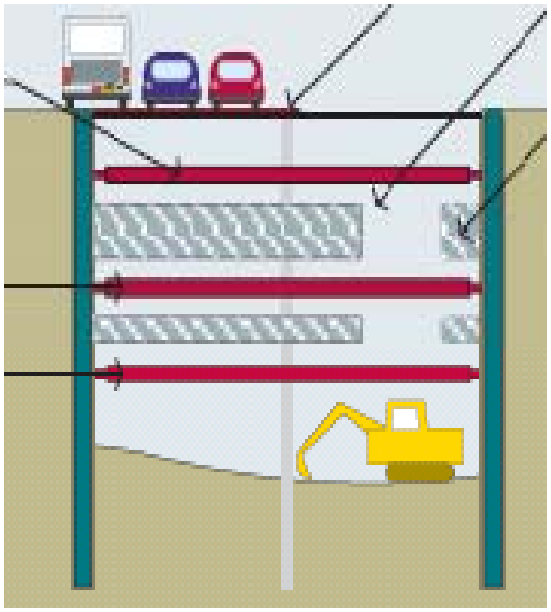
Slab

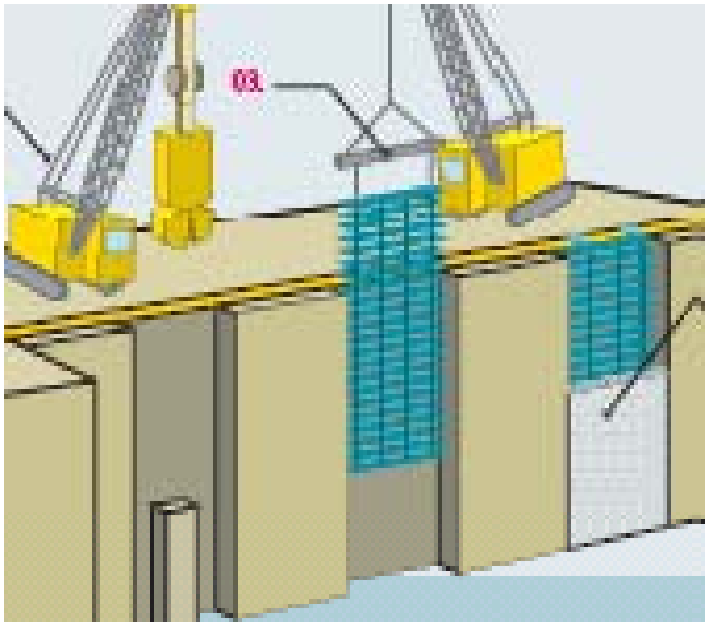
楼板

Strutting支撑

Strutting支撑

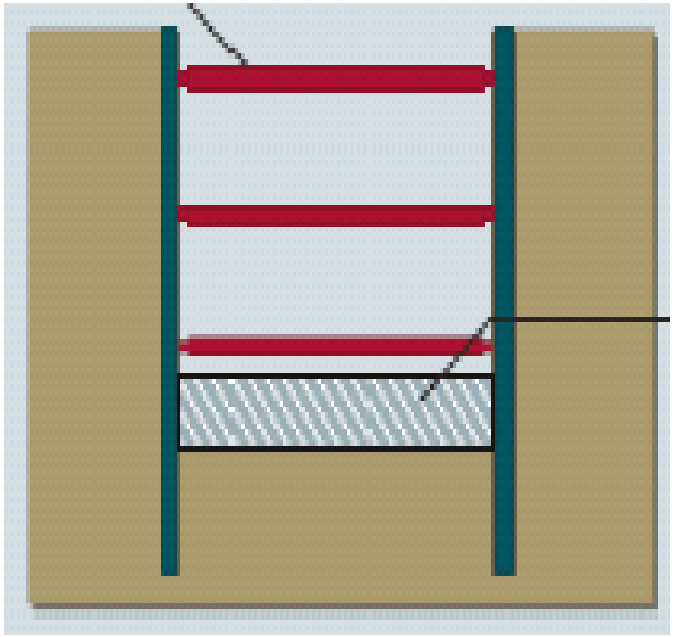
Strutting支撑





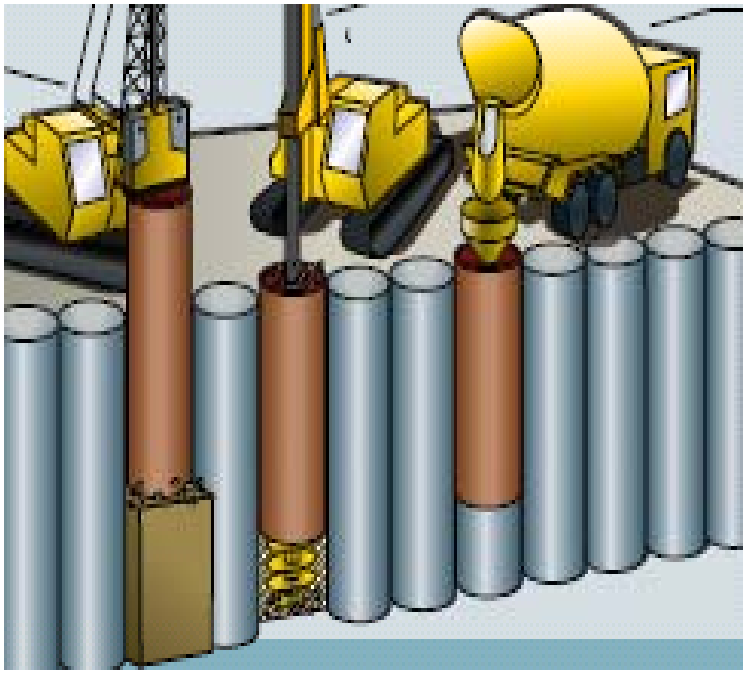
Contiguous Bored Pile Wall
钻孔灌注桩连续墙工法

Strutting支撑



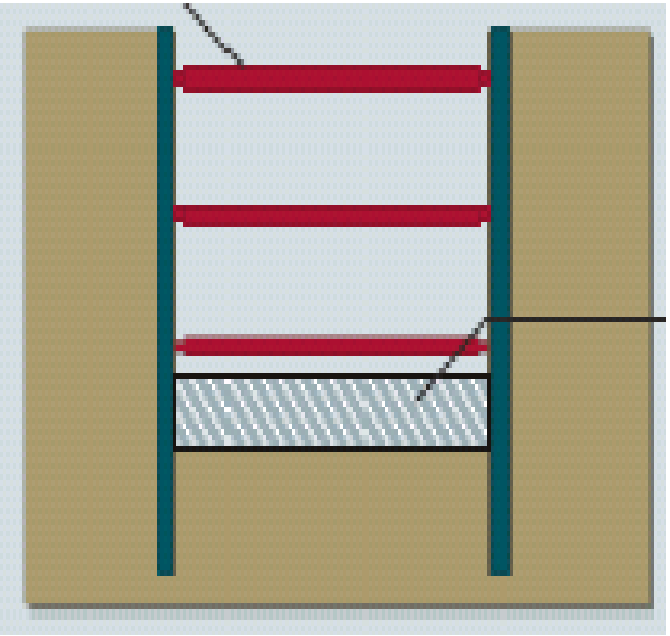
Slab

底板



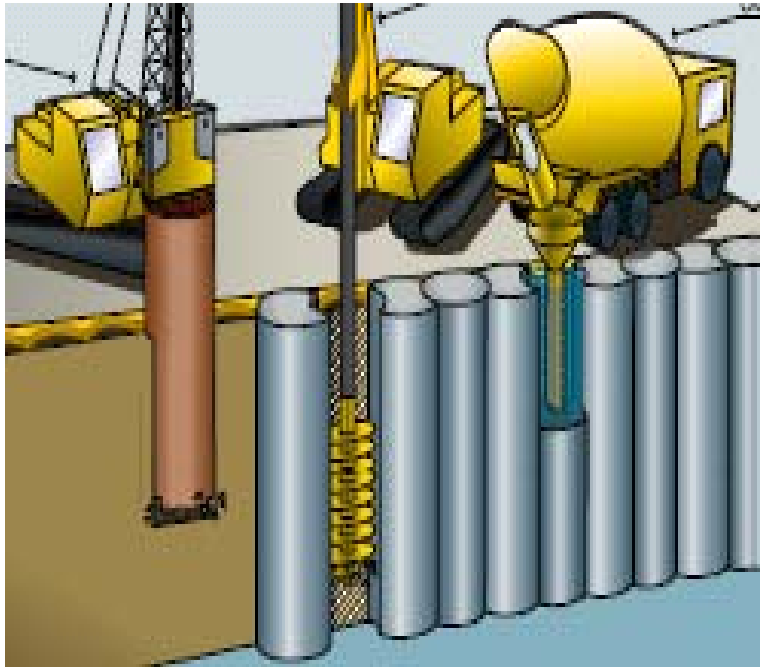
Secant Pile Wall
Secant Pile 墙工法

Strutting支撑



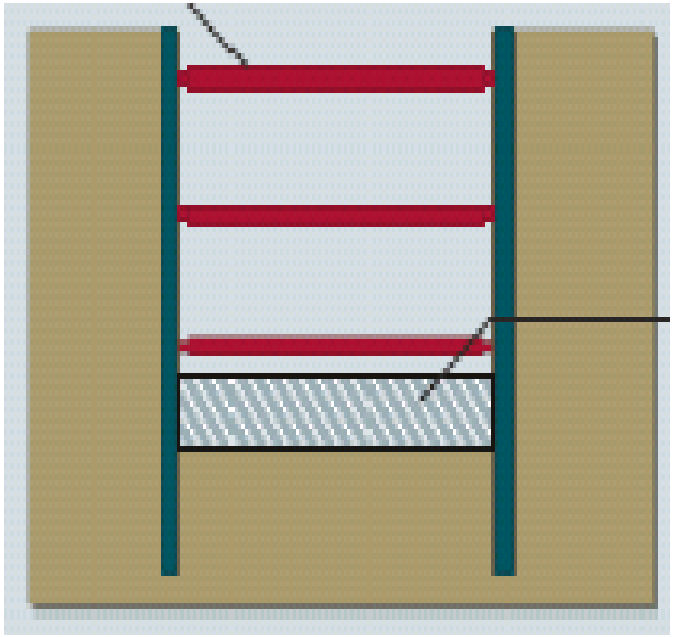
Slab

底板



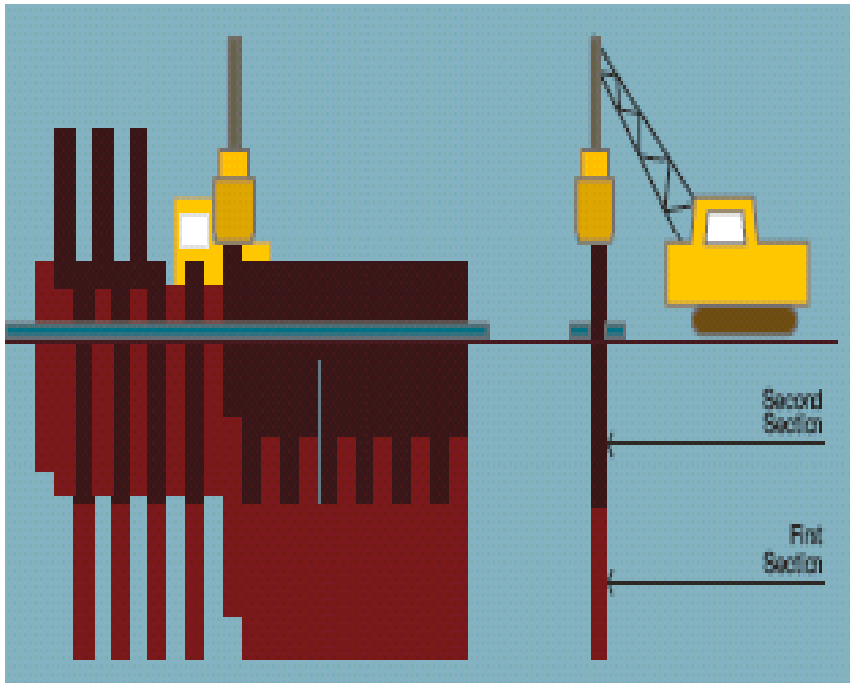
Sheet Pile Wall
钢板桩工法

Strutting支撑



Slab

底板



Design Code & Software
软件与设计规范

Based on British Code.

基于英式规范

- BS5950 &CP65 – Structural Use of Steelwork in Building
  钢结构规范
- BS8004 – Foundation 地基规范
- BS 8002 – Earth Retaining Structure 挡土墙规范
- BS 8110 PT – The Structure Use of Concrete 混凝土规范
- BS6399 PT – Design Loading for Building
  建筑设计荷载规范

Common Used Geotechnical Software
普遍应用的地质软件

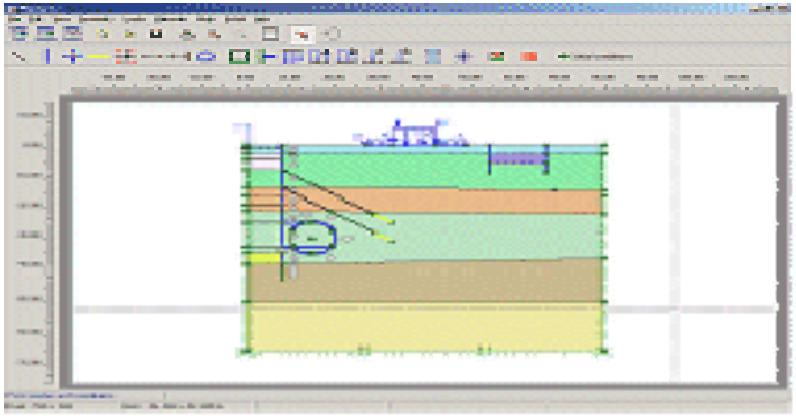
- Plaxis, Excave97, Wallap, RIDO and Slope/W

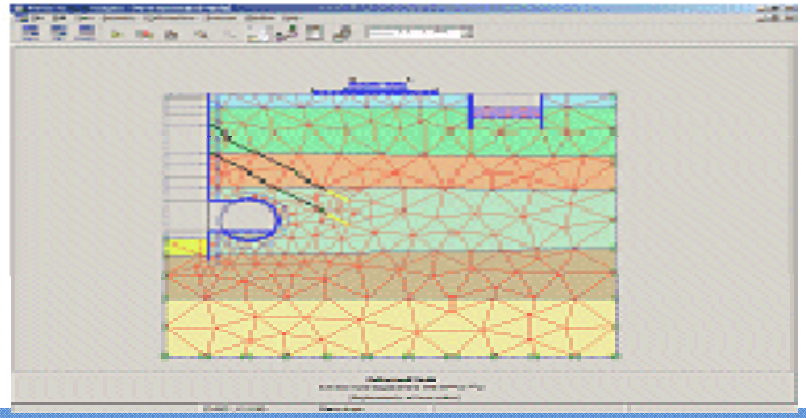
Geotechnical Software - Plaxis
岩土工程分析设计软件 - **Plaxis**

- 2D &3D FEM software for Soil and Rock.

  2D &3D FEM 岩土工程软件
- Developed in 1987 by Technical University of Delft.

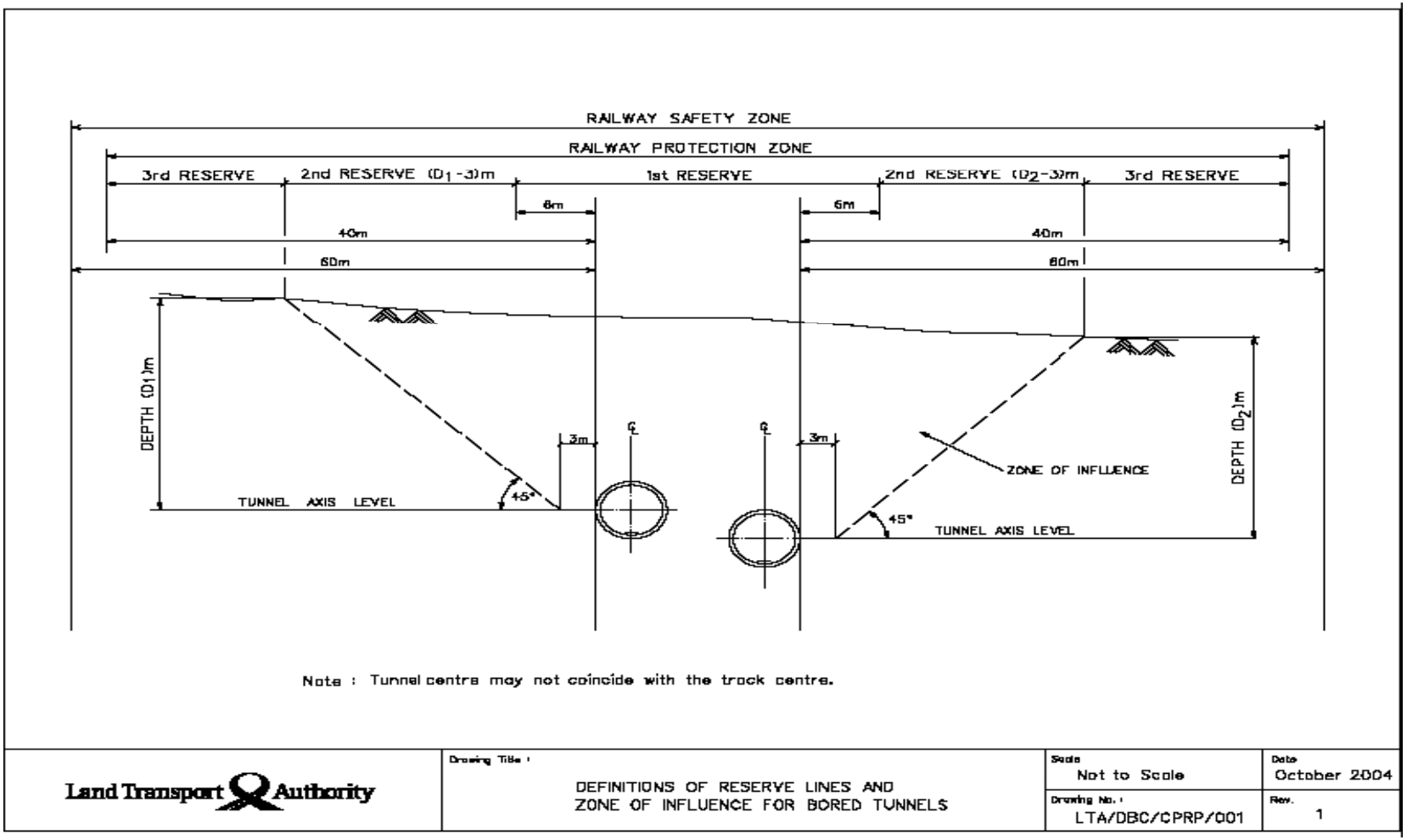
  Delft科技大学1987年开发
- Used by 30 over European Country for more than 20 years.
- **30多个欧洲国家使用超过20年**





MRT Protection Code – 1of 3

地铁保护规范



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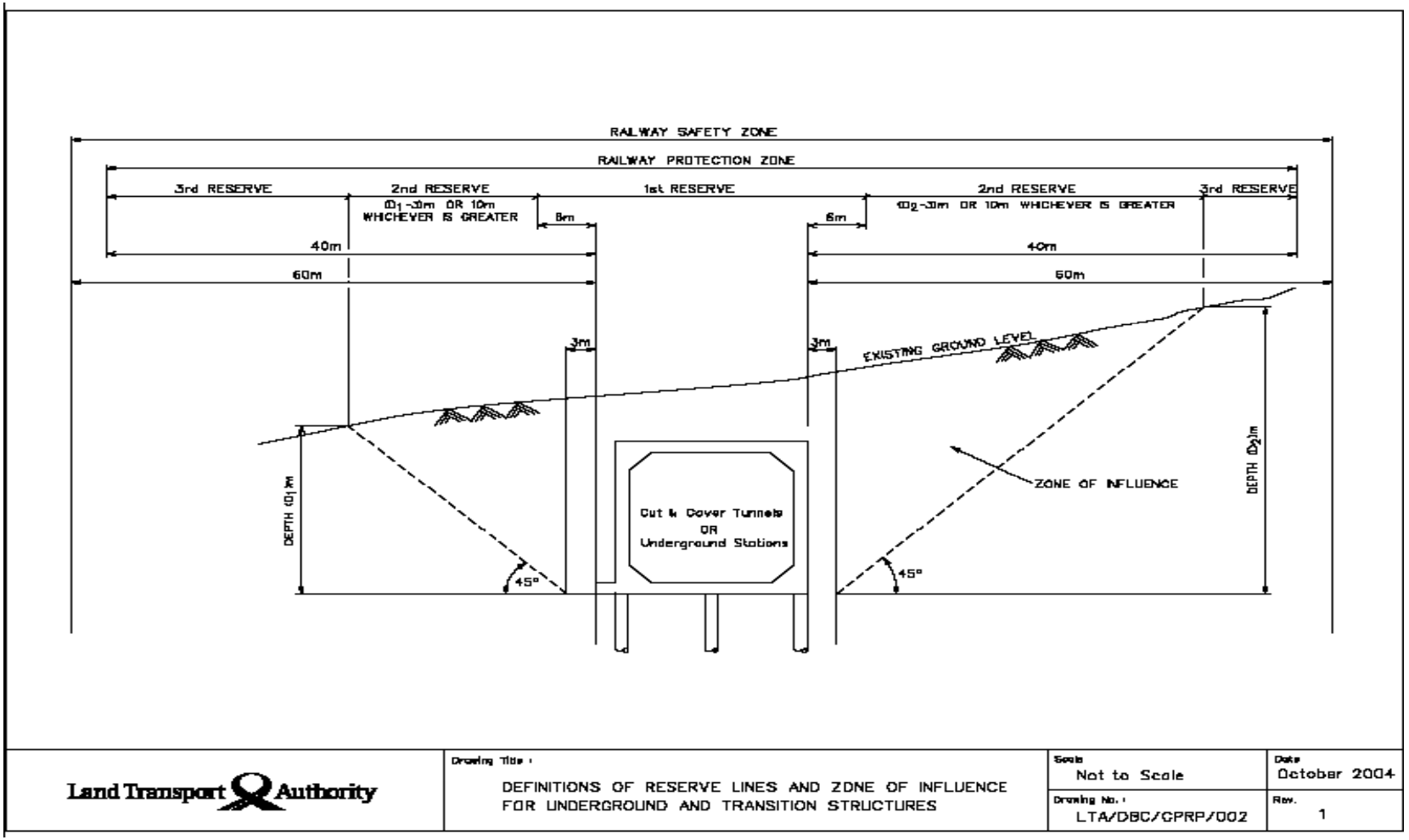
MRT Protection Code – 2of 3

地铁保护规范



MRT Protection Code – 3 of 3
地铁保护规范

Allowable Engineering Parameter:
工程参数

- Structure/track Movement in any Plane -15mm
  任意平面上结构和轨道位移 **-15mm**
- Differential movement /Twist – 3mm in 6m (1:2000)
  差异位移 / 扭曲 **– 3mm in 6m (1:2000)**
- Peak Particle Velocities (Vibration) – 15mm/sec
  振动 **– 15mm/sec**
- Change in Pore Water Pressure – 10KN/m2
  孔隙水压力变化 **– 10KN/m2**

Real Time Instrumentation @ CCL MRT Project
地铁环线工程的实时监测

- Environmental Monitoring – Corrosion & VWSG
  环境监测 – 腐蚀计、弦式应变计
- Strutting Monitoring System– VWSG and Load Cell
  支撑监测系统– 弦式应变计、压力盒
- Structure Monitoring – EL Sensor, VW Cracking, Vibration
  结构监测 – 电子水平尺, 弦式测缝仪, 振动传感器
- Ground Monitoring – In Place Inclinometer, Piezometer Rod Extensometer
  地下土层位移监测 –**IPI,** 孔隙水压力计， 多点深层位移计
- MRT Structure Monitoring – ATM Survey, Vibration, EL track Monitoring
  地铁结构监测 – 自动全站仪测量系统, 地铁轨道扭曲电子水平尺监测系统

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Monitoring Results 监测结果

The monitoring results consist of ground, structural and environmental monitoring results. All results presented in the real time display and report includes:

监测结果包括地下，结构和环境监测数据。
实时显示以及报告中记载的数据包括：

1. Horizontal, vertical and lateral deformations
   水平，垂直和横向的变形
2. Pore pressure changes / Water level change
   孔隙水压力变化 / 水位变化
3. Rotational tilting of structures
   结构物的倾斜扭曲
4. Vibration and Noise level
   振动和噪音

实时监测系统

自动岩土数据采集器

Acquisition Logging System

自动环境监测数据采集器

Acquisition Logging System

全站仪测量系统

Acquisition Data System

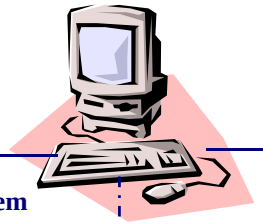
自动结构监测数据采集器

Acquisition Logging System

网络服务器管理系统

网络打印机

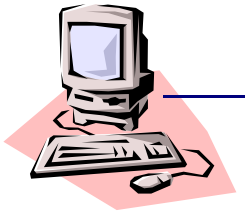
GSM / GPRS Modem



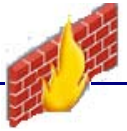
实时数据可见

GSM/ GPRS Modem

监测数据服务器



网络服务器



防火墙

邮件发送告警信息

手机或书面发送告警

邮件发送告警

手机或书面发送告警

GW Web 顾客

允许顾客随时在线浏览、下载数据、报告和施工方案

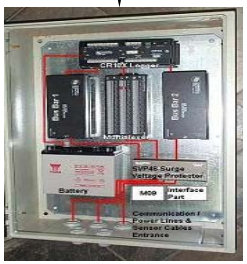
Ground Monitoring System 地面监测系统

Inclinometer
倾斜测量仪

Vibrating Wire Piezometer
孔隙水压力计

Borehole Rod Extensometer
多点位移计

VW Settlement Cell
弦式 沉降传感器



Acquisition Logging System
数据采集系统

Alarm messages sent by emails
邮件告警

Alarm Alert System
告警系统

Real Time Visualization
实时可视化系统

Alarm messages on mobile phone or pagers
短信或书面告警

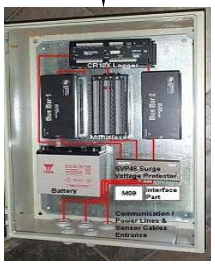
Structure Monitoring System 结构化的监测系统

EL Beam Sensor
电子水平尺

EL Tilt Sensor
EL 倾斜探测器

Vibrating Wire Crack Meter
测缝仪

Vibrating Wire Strain Gauge
悬式应变计



Acquisition Logging System
数据采集系统

Alarm messages sent by emails

邮件告警

Alarm Alert System

告警系统

Real Time Visualization

实时可视化系统

Alarm messages on mobile phone or pagers
短信或书面告警

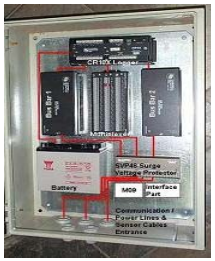
Corrosion Monitoring System 腐蚀监测系统

Corrosion Sensor
腐蚀传感器

Corrosion Sensor
腐蚀传感器

Corrosion Sensor
腐蚀传感器

Corrosion Sensor
腐蚀传感器



Acquisition Logging System
数据采集系统

Alarm messages sent by emails
邮件告警

Alarm Alert System
告警系统

Real Time Visualization
实时可视化系统

Alarm messages on mobile phone or pagers
短信或书面告警

Vibration Monitoring System 振动监测系统

Vibration Monitor
振动监测仪

Vibration Monitor
振动监测仪

Vibration Monitor
振动监测仪

Vibration Monitor
振动监测仪

Alarm Alert System

告警系统

Real Time Visualization
实时可视化系统

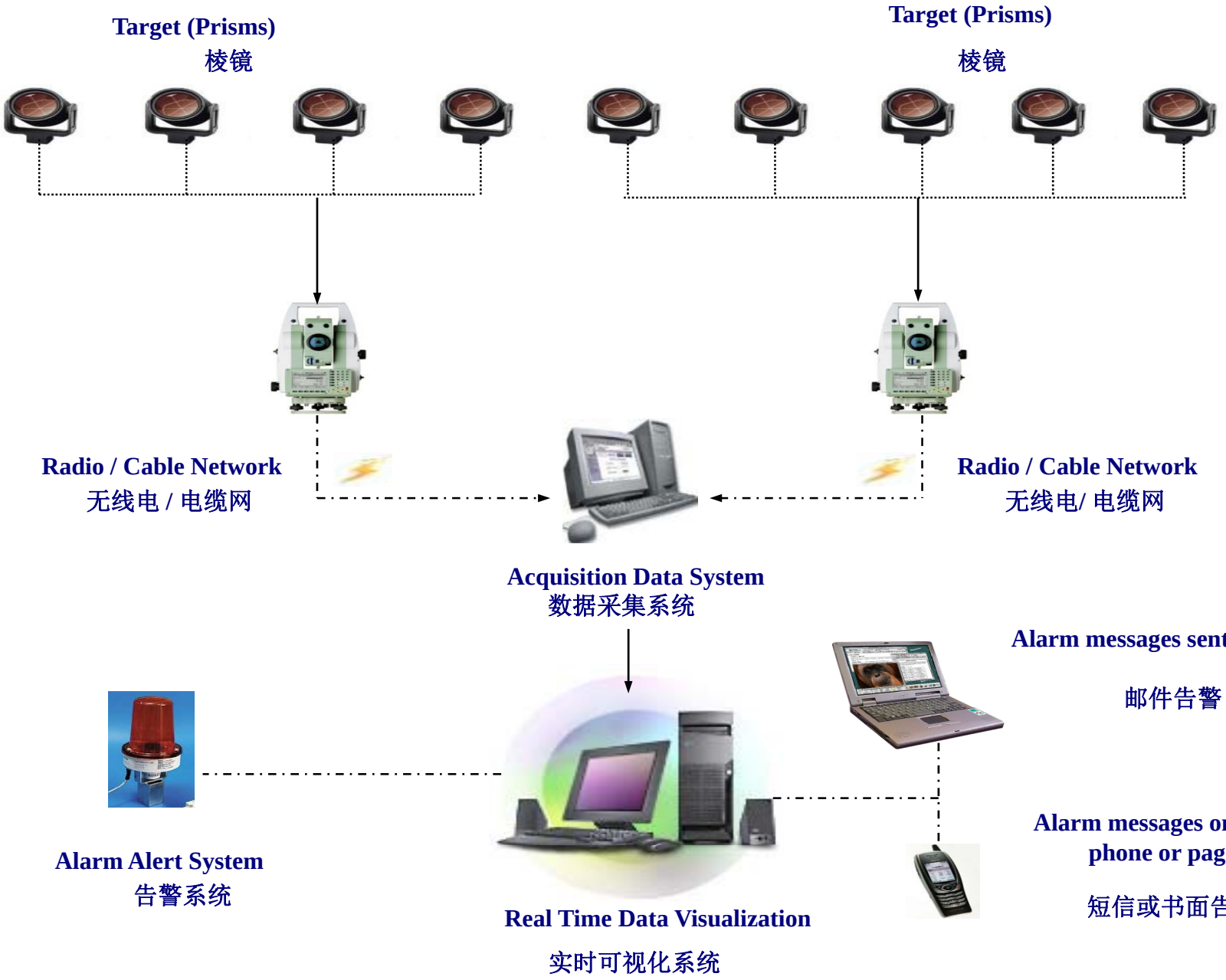
Alarm messages sent by emails

邮件告警

Alarm messages on mobile phone or pagers

短信或书面告警

Automated Survey Monitoring System自动全站仪观测系统



Project Picture

工程图集

CCL Line -1

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CCL Line -2

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CCL Line -3

CCL Line -4

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CCL Line -5

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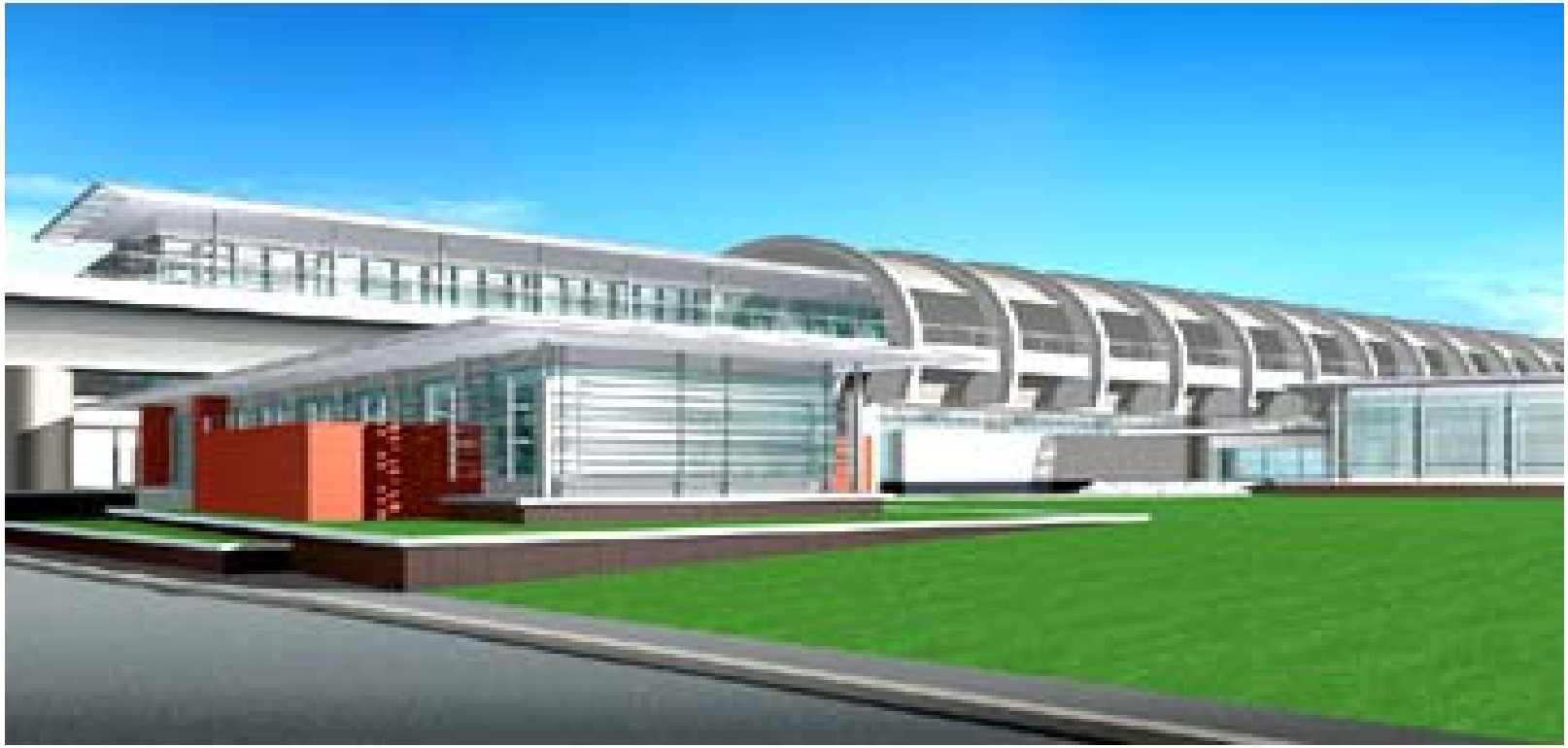
CCL Line - 6



CCL Line - 7

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CCL Line - 8

CCL Line - 9

CCL Line - 10

CCL Line – C855A

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CCL Line – C851A

Side View- Real Time EL Beam System
侧面图 – 实时测斜仪系统

Real Time EL Beam Monitoring system
实时倾斜监测系统

智弘庫圖 BLUEPRINT BRAINTRUST

CCL Line – C852

Auto Tunnel Survey System
隧道自动监测系统

Real Time Track Monitoring

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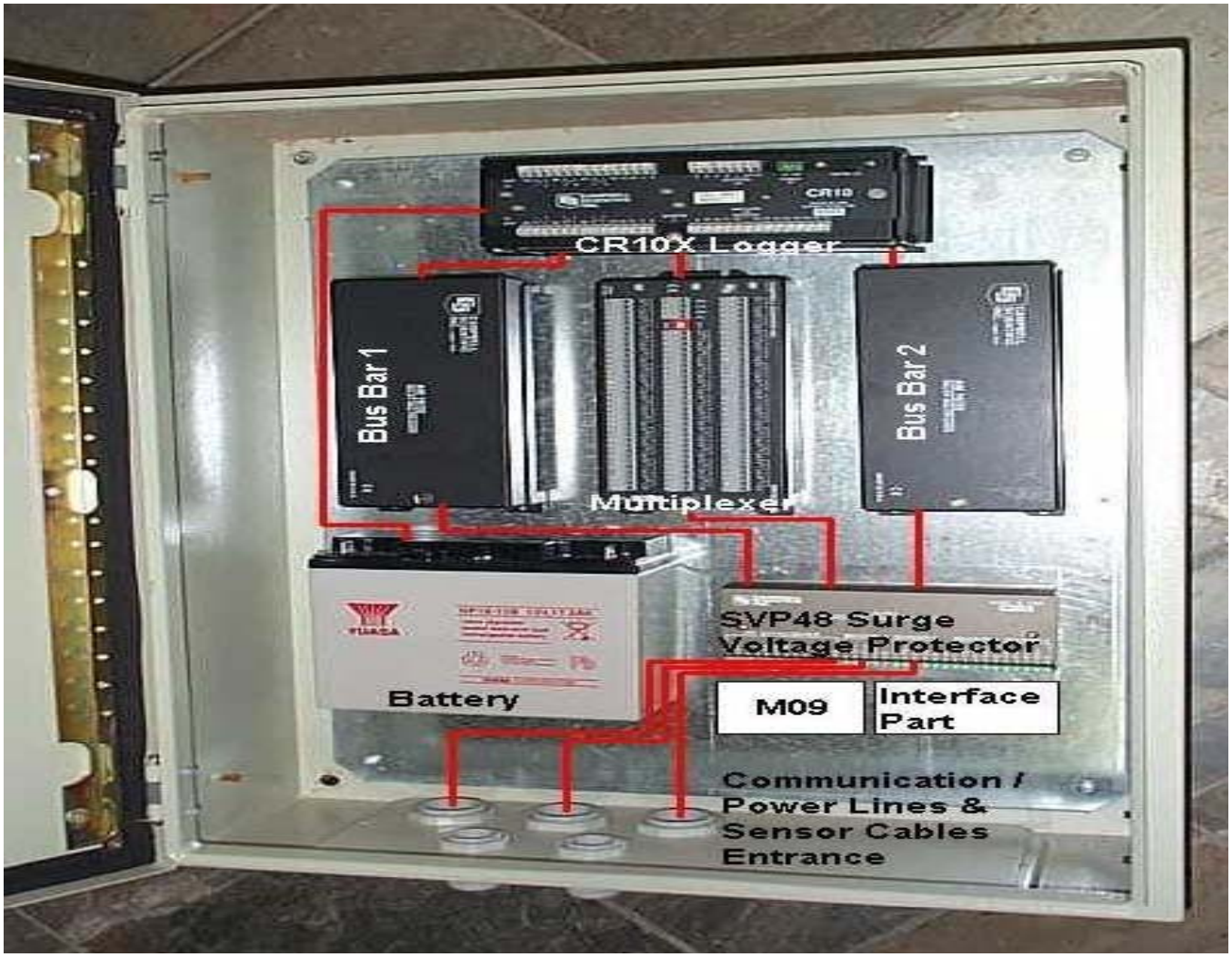
Auto Logger System

Auto Logger System



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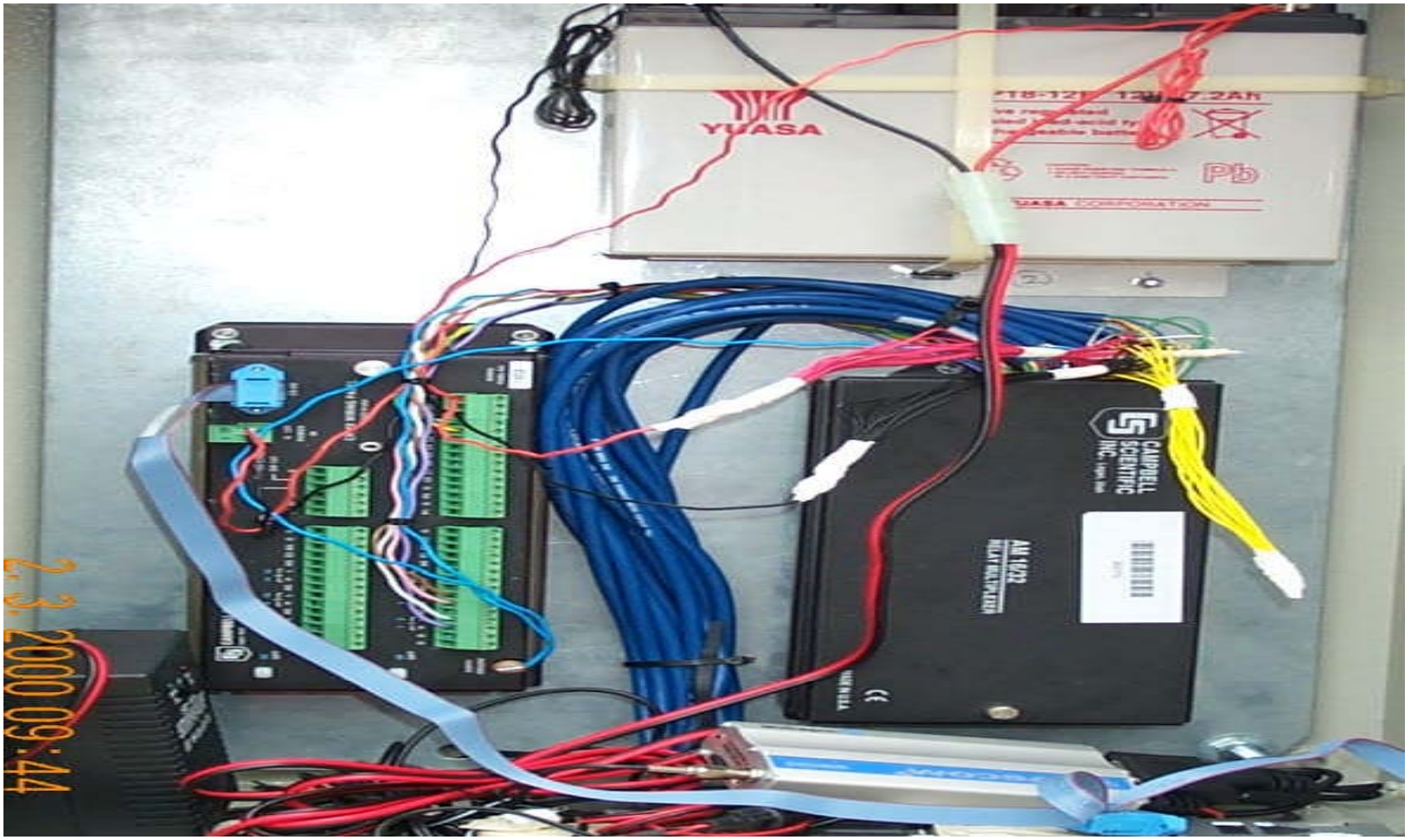
Wire Connection of Auto Logger



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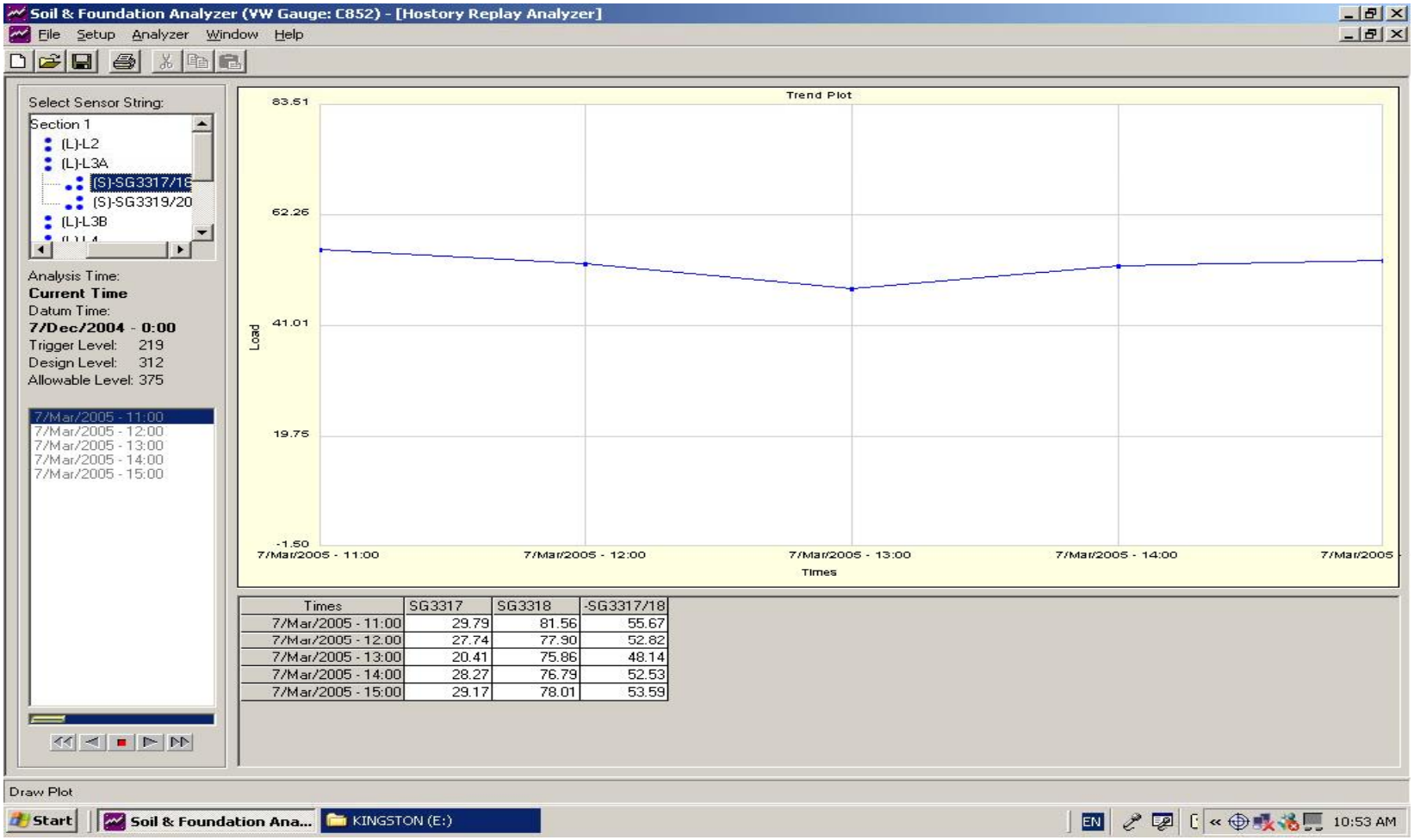
VWSG for Strut Load Monitoring



Times	SG3317	SG3318	-SG3317/18
7/Mar/2005 - 11:00	29.79	81.56	55.67
7/Mar/2005 - 12:00	27.74	77.90	52.82
7/Mar/2005 - 13:00	20.41	75.86	48.14
7/Mar/2005 - 14:00	28.27	76.79	52.53
7/Mar/2005 - 15:00	29.17	78.01	53.59

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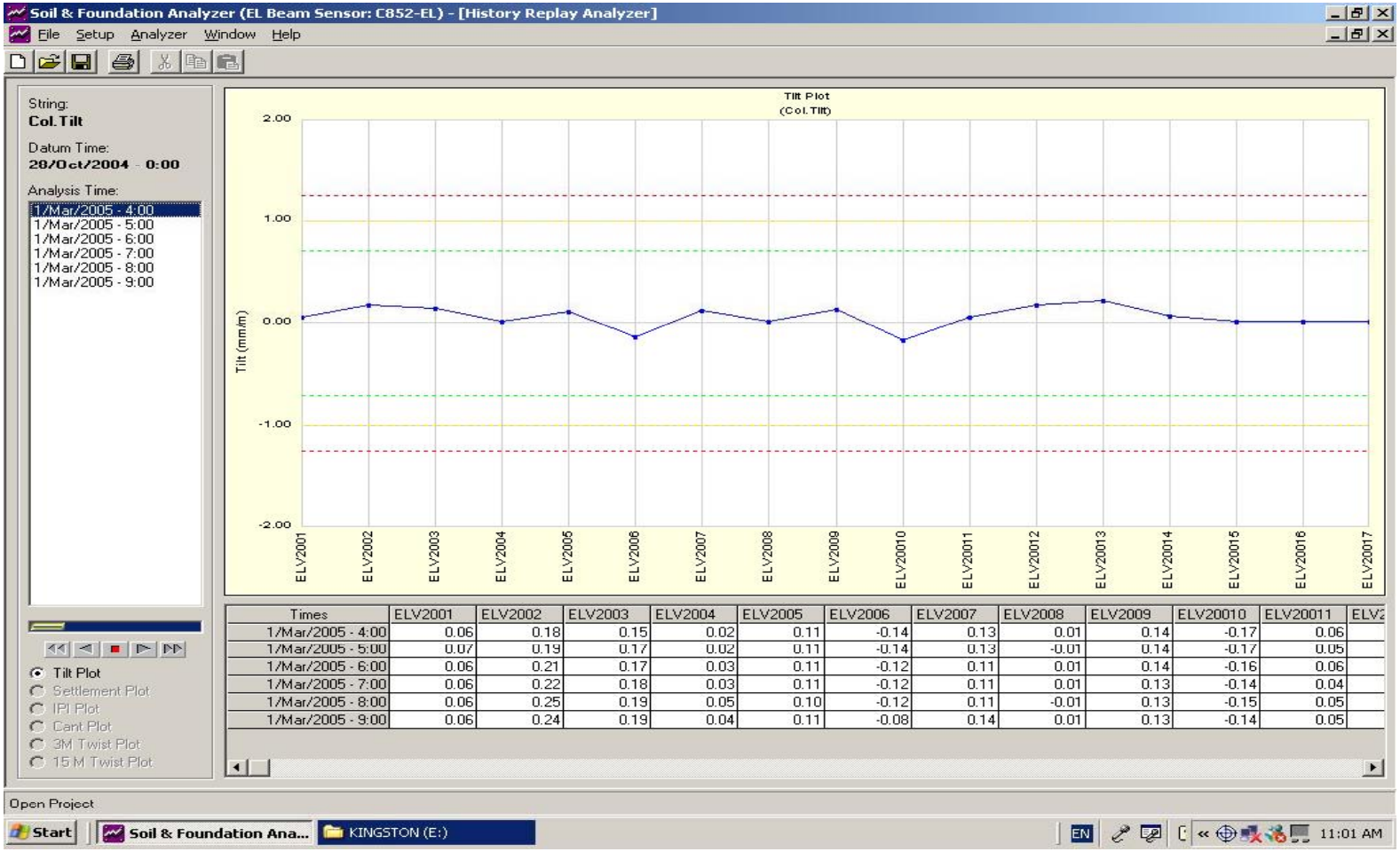
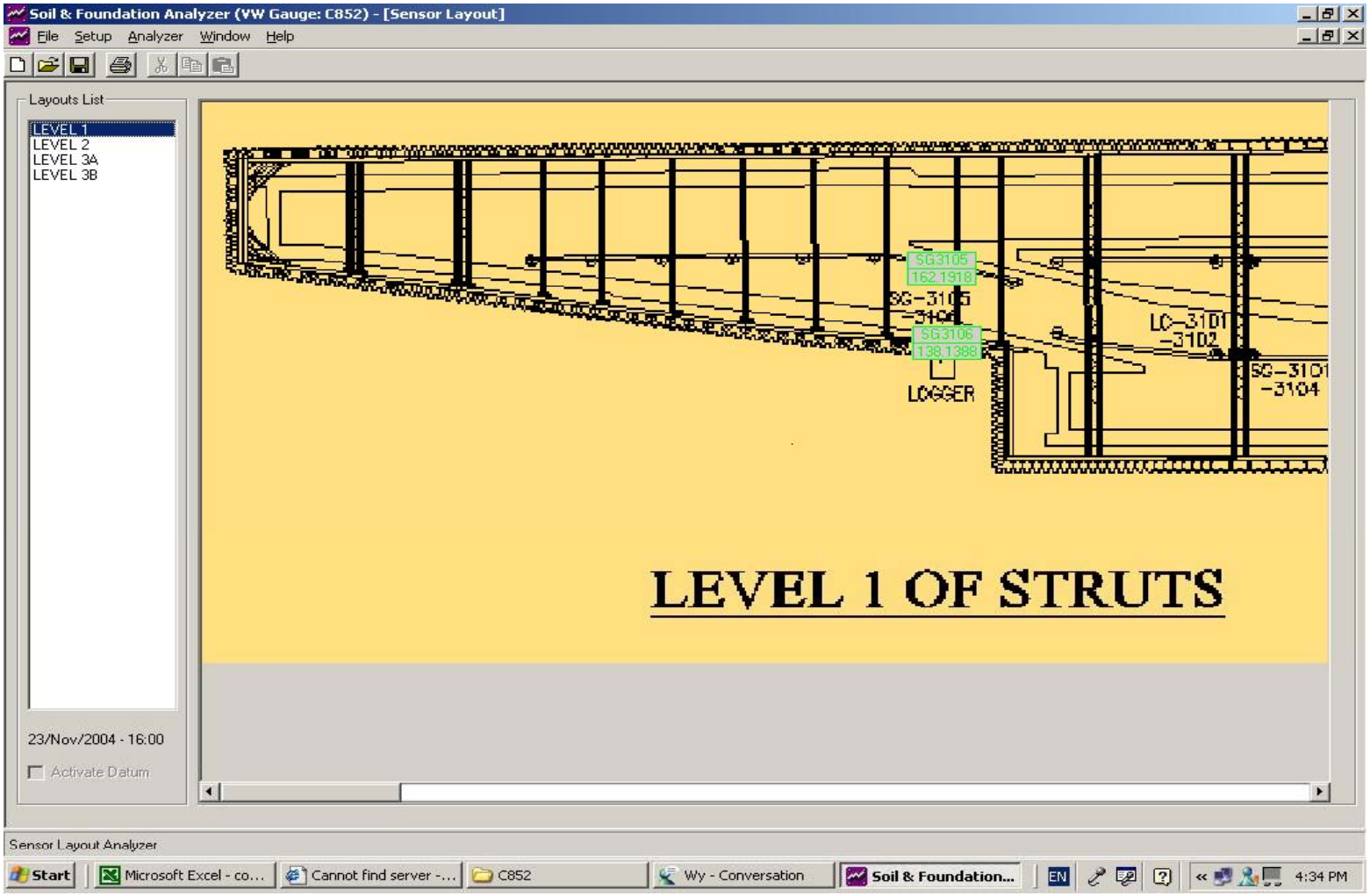
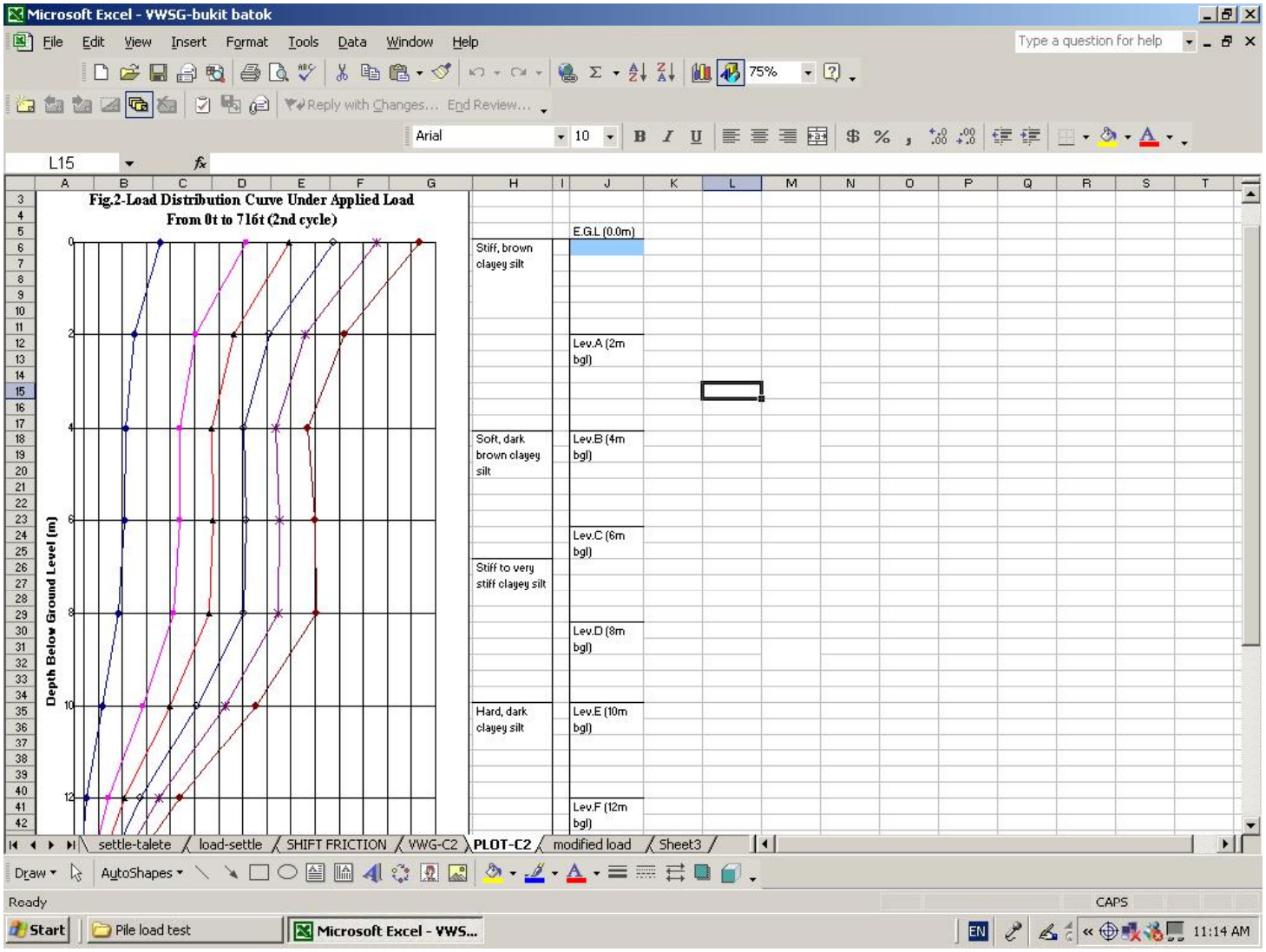
EL Tilt Monitoring
倾斜仪监测系统



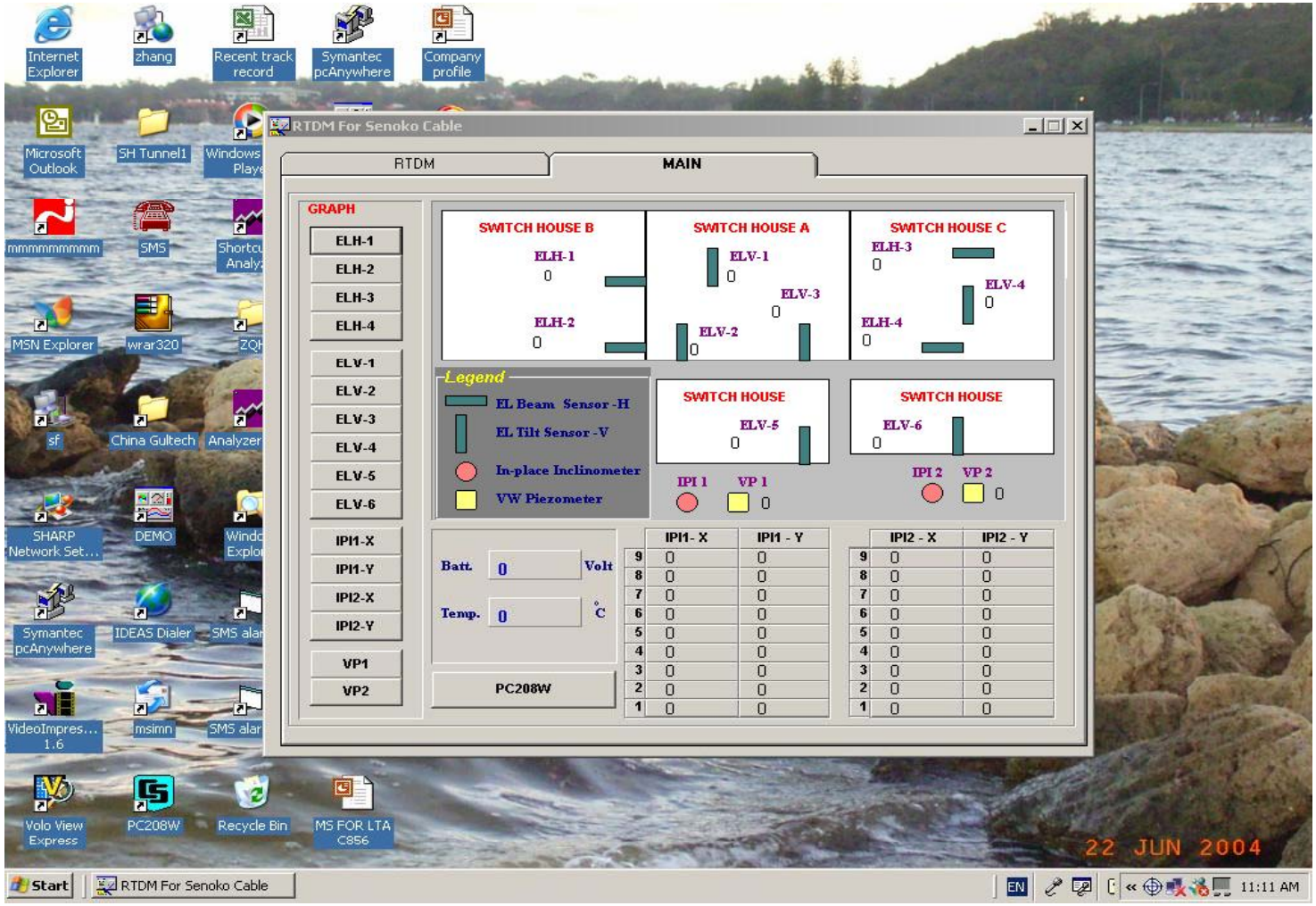
VWSG for Strut Load Monitoring



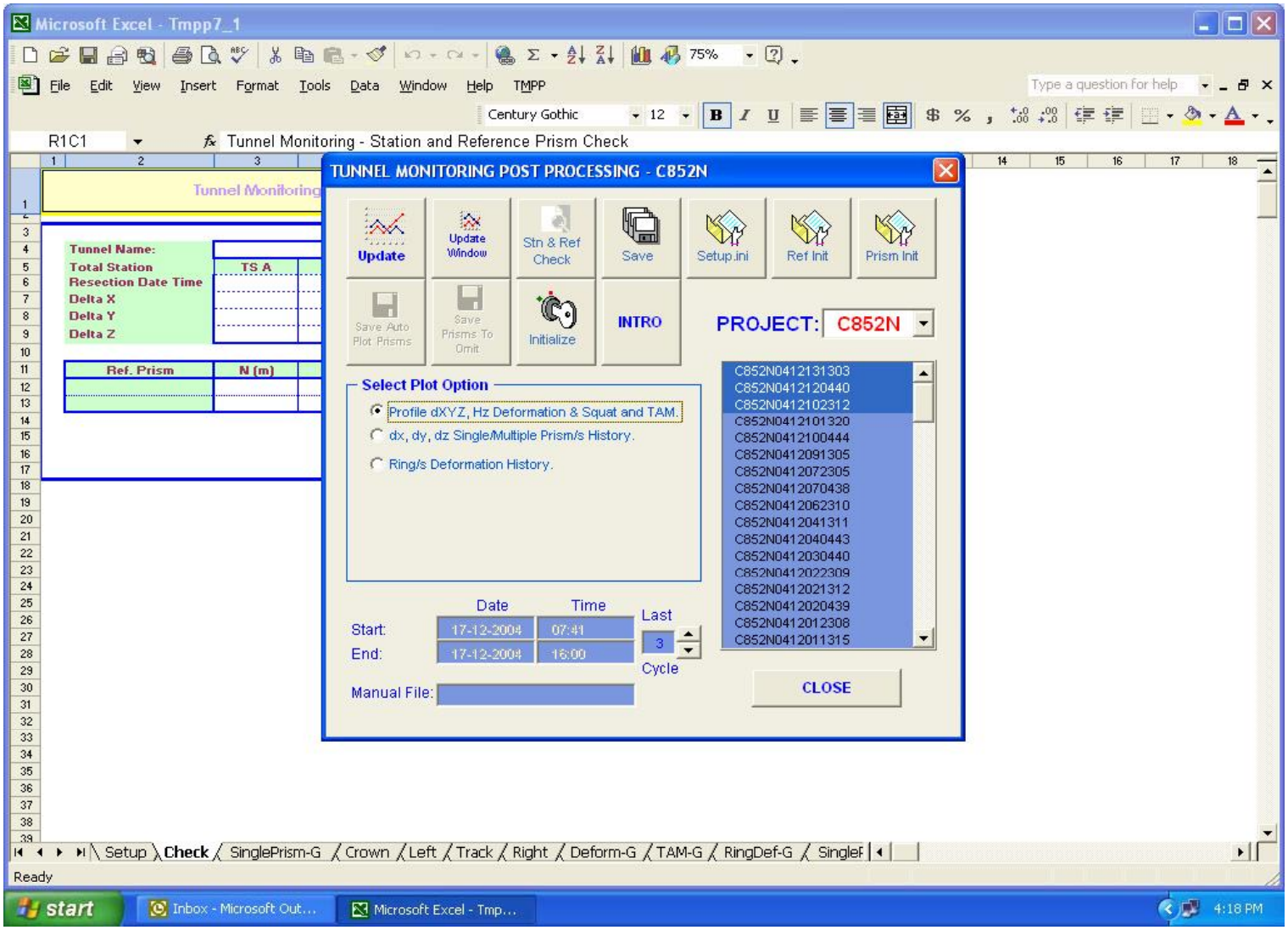
Pile Load Test Graph



Real Time Data Monitoring Program
实时数据监测软件



Automated MRT Survey



THANK YOU!