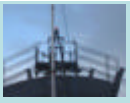
Using GPS to Monitor the Forth Road Bridge

G W Roberts[1], C J Brown[2], X Meng[1]
[1] IESSG, The University of Nottingham
[2] Brunel University

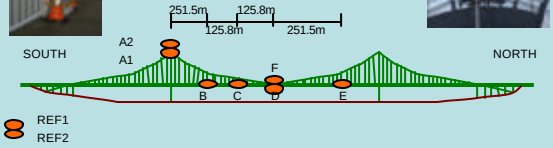
www.nottingham.ac.uk/iessg
Gethin.roberts@nottingham.ac.uk

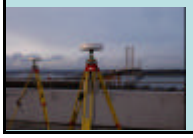
- Introduction and Background
- Forth trials on 8th – 10th February 2005
  - 46 hrs continuous data
  - General review of data
    - Detailed analysis of sections of data
  - Unusual occurrences
    - 100 t lorry (by accident)
    - High wind loading
  - Lorry trials with 2 x 40t lorries
- Concluding comments

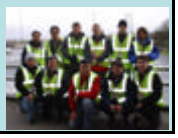
Antenna Locations



Instrument layout for the bridge test

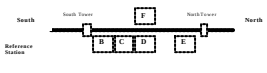


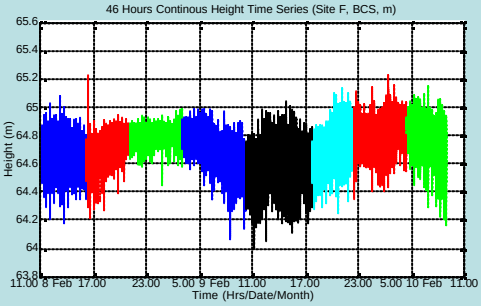


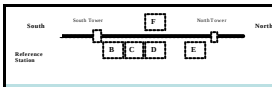


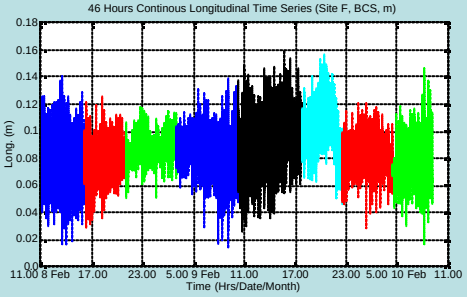
Processing Strategy

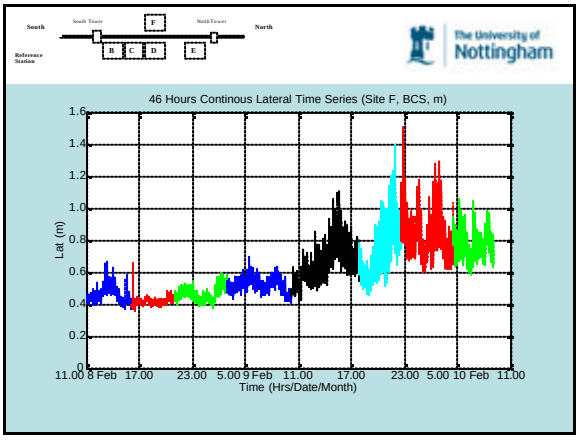
- Lots of data; focussed on specific occurrences
- GPS processing Analysis of the GPS characteristics
- Typical magnitude deflections during the period
- Temperature effects
- Change in deflections during rush hour
- Analysis of the 100t lorry data
- Lateral movement and wind speeds
- Frequencies (tower and deck frequencies)
- Vibrations
- Lorry trials

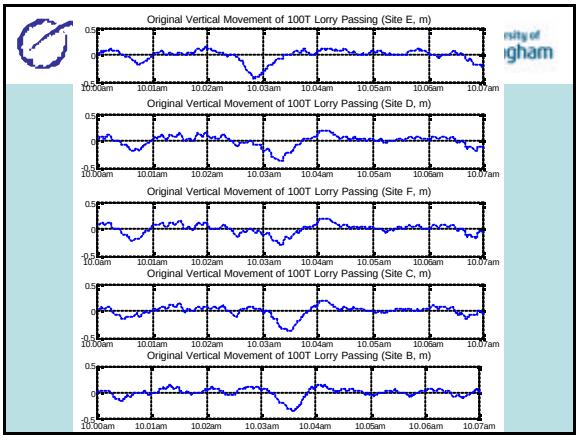


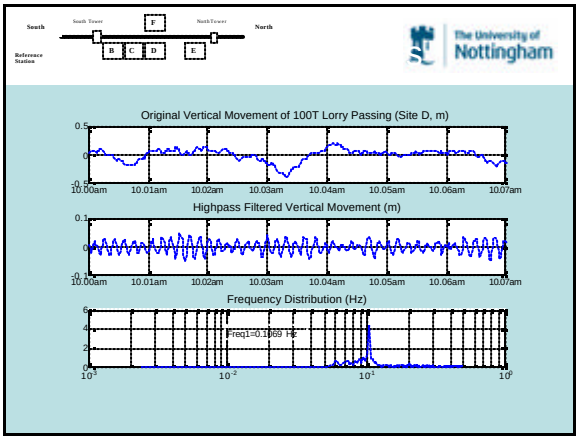


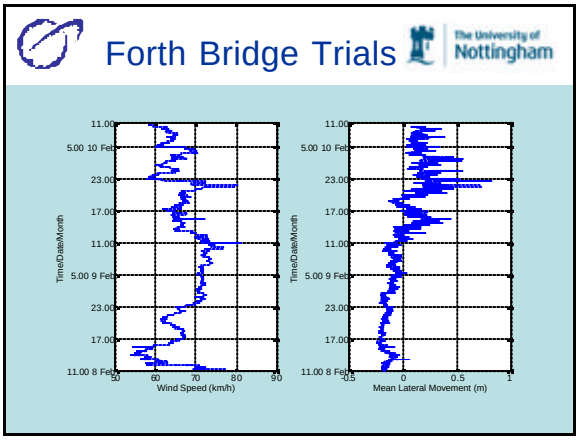


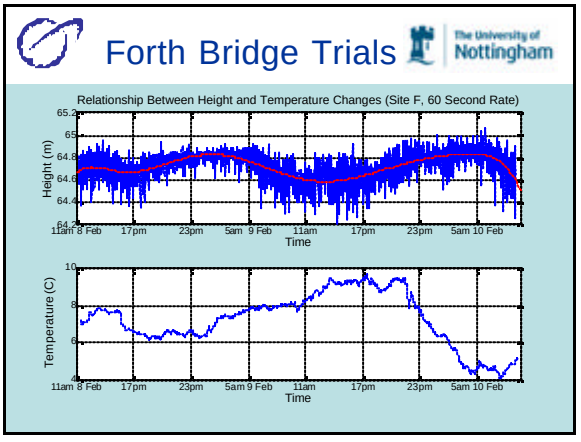


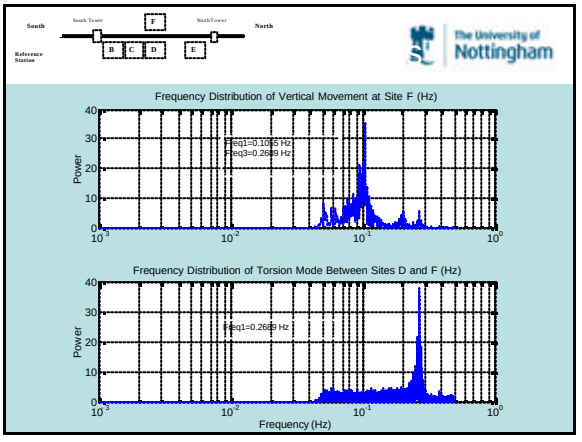

South
South Tower
F
North Tower
North
Reference Station
B
C
D
E
The University of Nottingham
46 Hours Continous Lateral Time Series (Site F, BCS, m)
Lat (m)
Time (Hrs/Date/Month)
11.00 8 Feb
17.00
23.00
5.00 9 Feb
11.00
17.00
23.00
5.00 10 Feb
11.00

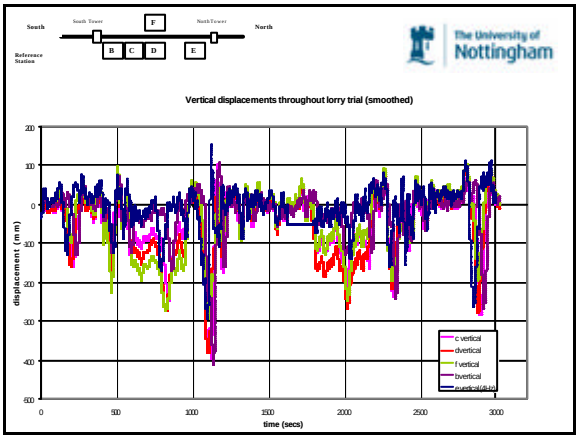

Original Vertical Movement of 100T Lorry Passing (Site E, m)
Original Vertical Movement of 100T Lorry Passing (Site D, m)
Original Vertical Movement of 100T Lorry Passing (Site F, m)
Original Vertical Movement of 100T Lorry Passing (Site C, m)
Original Vertical Movement of 100T Lorry Passing (Site B, m)
10.00am
10.01am
10.02am
10.03am
10.04am
10.05am
10.06am
10.07am

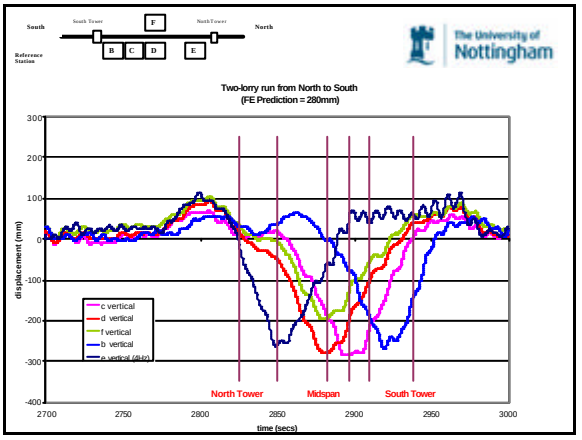

South
South Tower
F
North Tower
North
Reference Station
B
C
D
E
The University of Nottingham
Original Vertical Movement of 100T Lorry Passing (Site D, m)
Highpass Filtered Vertical Movement (m)
Frequency Distribution (Hz)
Freq1=0.1069 Hz


Forth Bridge Trials
The University of Nottingham
Time/Date/Month
11.00 8 Feb
5.00 9 Feb
5.00 10 Feb
Wind Speed (km/h)
Mean Lateral Movement (m)


Forth Bridge Trials
The University of Nottingham
Relationship Between Height and Temperature Changes (Site F, 60 Second Rate)
Height (m)
Temperature (C)
Time
11am 8 Feb
17pm
23pm
5am 9 Feb
11am
17pm
23pm
5am 10 Feb


South
South Tower
F
North Tower
North
Reference Station
B
C
D
E
The University of Nottingham
Frequency Distribution of Vertical Movement at Site F (Hz)
Freq1=0.1065 Hz
Freq3=0.2689 Hz
Frequency Distribution of Torsion Mode Between Sites D and F (Hz)
Freq1=0.2689 Hz
Power
Frequency (Hz)





Concluding Comments

The University of Nottingham

- Successful Monitoring Exercise
- Sub cm 10Hz (possibly 100 Hz) 3-d, absolute
- No other way
- Synchronous measurements
- Multipath mitigation
- Gives useful information
- Real time feedback possible
- Gives response to loads
- Quasi-static and dynamic response
- Displacement under load, vibration under excitation
- Response to temperature change

Acknowledgements

The University of Nottingham

- Forth Estuary Transport Authority and staff
- and

Brunel UNIVERSITY WEST LONDON

The University of Nottingham

Using GPS to Monitor the Forth Road Bridge

G W Roberts[1], C J Brown[2], X Meng[1]

[1] IESSG, The University of Nottingham

[2] Brunel University