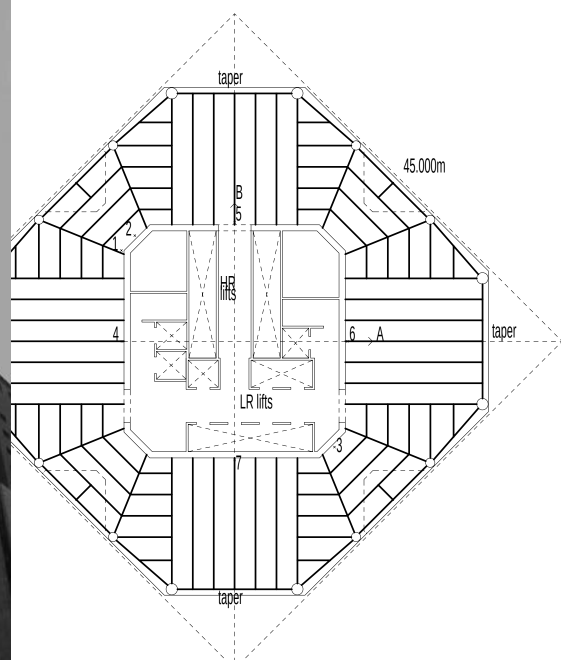
Republic Plaza - Singapore

Project Description:

Republic Plaza is one of the three tallest buildings in Singapore, at 280m. Monitoring, for the purpose of tracking wind and seismic loads and developing an understanding of the structural and loading mechanisms at work in such a structure, has included

- manual readings of stress and strain during and after construction,
- periodic measurements of natural frequencies during construction,
- recording of level 65 (building top) vibrations,
- addition of wind sensors and basement accelerometers,
- development of data logger for collecting response characteristics and capturing the small number of high quality waveforms,
- installation of synchronised dual-rover GPS system
- comprehensive ambient vibration survey
- finite element model (FEM) updating

Elevation and section through building at level 18



Quick Facts:

- **Name and Location:** Republic Plaza, Singapore
- **Timing of SHM:** 2/1994 - present
- **Owner:** City Developments Limited
- **Structure category:** Tall building
- **Height:** 280m
- **Structural system:** RC shear core, ring of concrete filled steel columns and horizontal framing system for vertical loads
- **Start of SHM:** September, 1994
- **Number of sensors installed:** 56 static +14 dynamic +2 GPS
- **Sensor configuration and monitoring system:** see below
- **Instrumentation design by:** NTU Singapore. Leica, SysEng (S) Pte Ltd.
- **Engineer in Chief:** JMW Brownjohn

Description of Structure:

A RC core of variable thickness extends from basement 1 (B1) the full building height. A horizontal steel framing system is simply supported at the core and spans to a perimeter of steel tubes (filled with concrete up to level 49) that transfer vertical loads to the deep caisson foundation. Outriggers are installed at two M&E levels to control wind-induced drift. A cladding system was installed with a storey lag behind the main structure.

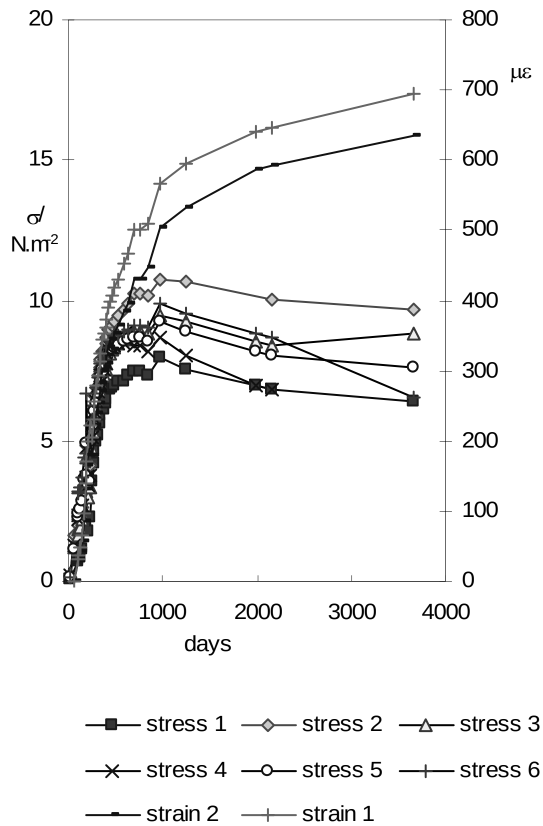
Purpose of Monitoring:

Static monitoring was installed to track the load sharing between structural components and to identify creep. Dynamic monitoring was installed to monitor the wind loading and effects, and proved highly capable of recording earthquakes originating from hundreds of thousands of km distant. Recently a GPS system has been installed to identify the relative contributions of static and dynamic wind-induced response. Hence the focus has been more on using the building as a wind and earthquake 'super-sensor'.

Sensor Details:

Type of sensors	Number	Location
Strain gauges	46	At levels 18 to 19 in core, columns and beams
Stress gauges	10	In core wall and columns
Accelerometers	4	At B1 and level 65
Anemometers	2	At roof top on east and west corners
GPS rovers	2	At roof top on east and west corners

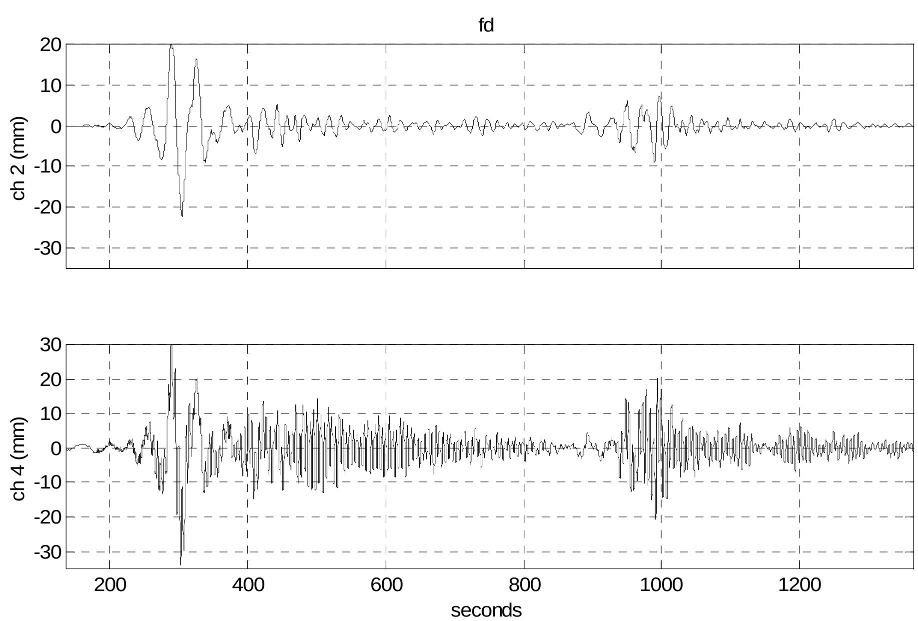
Examples of results:



Static monitoring over ten years has shown distinct load transfer and creep tendencies in the structural system. After steady changes of modal parameters during construction, minor changes were observed during installation of cladding, water tanks and interior fittings. Subsequently, frequencies have slowly dropped.

Effects of distance tremors have been captured and compared with those due to strong winds. It has been shown that seismic load is the dominant effect for medium to tall buildings in Singapore. When the GPS system has been able to identify the relative effects of mean and turbulent components of wind it is likely that (attitudes of authorities permitting), there could be impact on local design against lateral loads, possibly via design codes or guides.

Above: Stresses and strains in core wall



Basement and roof displacements during Bengkulu ‘great’ earthquake of 2004

Benefits of using SHM technologies in the project:

Identification of structural mechanisms, loading effects and slow changes in building performance over time. Calibration of loading codes. Validation of GPS technology.

References:

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