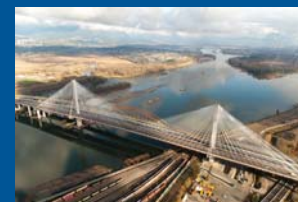


KEY FEATURES:

- Distributed Systems
- Centralized Systems

APPLICATIONS:

- Structural Monitoring of:
 - Dams
 - Bridges
 - Buildings



REF TEK STRUCTURAL MONITORING SYSTEMS

Solutions to Meet Building Codes

Installation of earthquake recording instrumentation in every building over six stories with floor area over 60,000 square feet, or every building over ten stories is required by the Building Codes of several US cities (Los Angeles, San Francisco, etc.). The minimum required instrumentation is three accelerographs, interconnected for common triggering and timing. These are located in the basement, mid-height and near the top of the building.

REF TEK's low-cost strong motion accelerograph, model 130-SMA, is an ideal solution for monitoring three levels in a building. The REF TEK system designed for this application is the nine channel accelerograph 130-SMA/9, (with internal accelerometer) located at the basement of the building, the triaxial accelerometer model 131B-01/3 located at mid-height and at the top of the

building. The 130-MC12 (12 channel) is the best solution if a free field stand-alone unit is also needed.

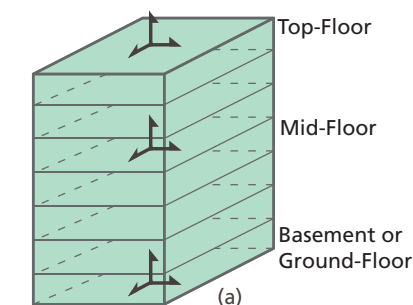
The 130-MC, 12 or 18 channel system with accelerometers located at different levels and connected to the central recording unit is designed to monitor more than three levels in a building.

REF TEK's Borehole Accelerometer, model 131A-02/BH is used to measure acceleration at different depths below the surface (e.g. deep foundation structures). An optional clamping mechanism and internal digital compass to monitor the orientation are also offered.

Compass interactive strong motion analysis software, processes the recorded signal and obtains all of the normally required structure status parameters.

Location of Earthquake Recording Instrumentation in a Building

Building Codes Recommendations:
Typical Accelerometer Deployment

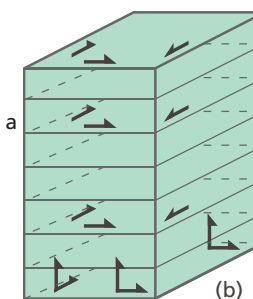


At Levels Where:
(a) higher modes contribute most
(b) change of stiffness

Two parallel sensors at a distance to evaluate torsion (all to evaluate translation).

Vertical sensors in the basement to evaluate rocking.

Ideal Extensive Instrumentation



Free-Field

From: A.F. Shakal, M.J. Huang, Current Building Instrumentation: Programs and Guidelines (Section 1-2, p.g 19. Fig. 1)

Related Sub-systems:

- 3rd Generation Seismic Recorders, 130S-01
- Strong Motion Accelerographs, 130-SMA, 130-SMHR
- Multi-Channel Accelerograph, 130-MC
- Accelerometers, 147-01 & 131B
- Miniature Seismic Recorders, 125A "Texan"

Geophysical Monitoring Solutions

There are three basic REF TEK Seismic and Earthquake Engineering System concepts for structural instrumentation:

- Distributed Seismic Recorders
- Centralized Seismic Recorders
- A combination of both distributed and centralized

A distributed system is one that deploys multiple 130-SMA Accelerographs in different parts of the building. Each system has from 3 to 9 channels. The 3-channel system contains a triaxial accelerometer with 1 or 2 external input 3-channel connectors connected to either surface triaxial or uniaxial accelerometers or underground borehole accelerometers.

A centralized structure instrumentation system is one that deploys either the 130-MC12 or 130-MC18 Recorder. The 130-MC Accelerograph can be connected to triaxial, uniaxial or borehole accelerometers.

Accommodating the large scale needs of today's market, the 130-MCs, with fully featured network capabilities, can be installed in and around the structure, whether it be a campus, a single building, a bridge or a dam.

A system that deploys both centralized and distributed seismic data recorders is one that has a 130-MC for the main structure and deploys a 130-SMA in a wing of the building. The design of the structure and the engineering preferences determine which system to select.

130-SMA Accelerographs for Distributed Systems

The 130-SMA provides accurate and timely data and information by continuously monitoring and recording seismic events, including the effect on ground sites, buildings and critical structures.

The 130-SMA has three channels connected to an internal triaxial accelerometer. When ordered as a 6 or 9 channel unit, the additional channels can be connected to external sensors.

REF TEK 130-SMA Accelerograph



130-MC Multichannel for Centralized Systems

Built-in communication facilities allow for real-time and on-demand data collection. The 130-MC is available in a 12 or 18 channel recording scheme with advanced telemetry built-in for real-time data collection for every channel.



REF TEK 130-MC Multi-Channel Accelerograph

The low cost 130-SMA and 130-MC use "command line" firmware specifically designed for structural monitoring applications. The firmware controls three relay closure contacts for external alarm activation and can automatically dial the optional modem for remote notification of events and alarms. Set-up and control is accomplished using the strong motion GUI (Graphic User Interface) that runs on multiple platforms. The user can program and examine the instrument's operating parameters and perform important diagnostic functions.

To satisfy the common triggering requirement of the US Building Codes, the recorders can be triggered to collect data with a Level or Vote Trigger on user-selected levels (0.0001 to 4g). Timing is maintained by a precision TCXO disciplined by an external GPS receiver/clock. Sending an alarm signal is an available option. The recorder data is transmittable through built in internet capability, or by telephone lines using the optional internal modem. Data is recorded to the built-in CF II compact flash and is retrievable by physically removing it if normal communication is down or if operation is in the standalone mode.

Accelerometers

The REF TEK 131B-01/3 Triaxial Accelerometer provides excellent dynamic range. It is easily connected to the REF TEK 130 Series 24-Bit digitizer. These accelerometers use a Micro-Electro-Mechanical System (MEMS) variable capacitance displacement sensor.

The 131B-01/3 model is a $\pm 4g$ full scale accelerometer with $2\mu g/Hz$ noise level and is specially suited for structural applications (building, bridge, dam monitoring). When the project requires accelerometers to be deployed in uniaxial configuration, the REF TEK 131B-01/1 Accelerograph is appropriate.



REF TEK 131B-01/3 Triaxial Accelerometer

REF TEK 131B-01/1 Uniaxial Accelerometer



REF TEK 131A-02/BH Accelerometer

Close up view of wedging cleft

REF TEK 131A-02/BH/CLAMP Borehole Clamp

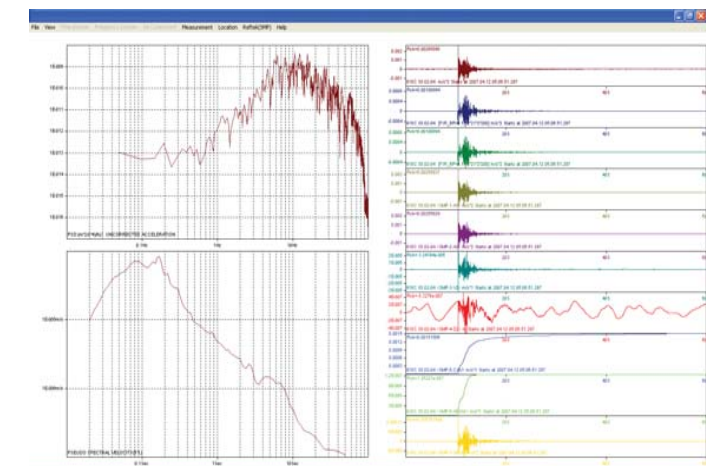
Borehole package with clamp assembled

REF TEK 131A-02/BH Borehole Accelerometer

COMPASS Data Processing Software

The interactive Compass program works with distributed and centralized systems. It makes initial and quick analysis of seismic waveform data and creates reports and graphic displays. Advanced seismic signal processing algorithms include: offset removal, reverse sign, apply filters, apply smoothing functions, perform integration and differentiation, FFT, etc. The simultaneous results are the following standard strong motion parametric data:

- Maximum Acceleration
- Spectral intensity for 5% damping. It is defined as the integral of the pseudo-spectral velocity curve within 0.1-2.5 seconds
- Predominant Period - Period corresponding to the peak value of FFT acceleration spectrum
- Mean Period - Period corresponding to the average of the weighted value of acceleration spectrum
- Maximum Velocity - Peak Ground Velocity
- Maximum Displacement - Peak Ground Displacement
- Cumulative Absolute Velocity
- Arias Intensity
- Arias Duration of strong motion within 5 - 75% of Arias' Charging Curve
- Arias Duration of strong motion within 5 - 95% of Arias' Charging Curve
- JMA Intensity - as Instantaneous Instrumental Seismic Intensity
- MMI Intensity



Examples of processing and graphic capabilities of the Compass Software