

4/13/06

Motion Records (Any type of motion)

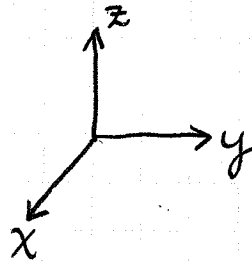
- * tilt of base (ground or floor surface; waves & static/quasi-st. tilts of surface)
- * unknown initial conditions
- * errors in the baseline of the record (noise)
- * instrument glitches (e.g. FBA torqued)

→ velocity and displacements are derived quantities.

Base Tilt:

3 translations + 3 rotations

Let $u_z(t)$ be the vertical displacement of the base over time.



Tilt along x-axis $\frac{\partial u_z(t)}{\partial x}$

along y-axis $\frac{\partial u_z(t)}{\partial y}$

maximum tilt $\theta(t) = \arctan \left[\sqrt{\left(\frac{\partial u_z(t)}{\partial x}\right)^2 + \left(\frac{\partial u_z(t)}{\partial y}\right)^2} \right]$

for small tilt $\theta(t) \approx \sqrt{\left(\frac{\partial u_z(t)}{\partial x}\right)^2 + \left(\frac{\partial u_z(t)}{\partial y}\right)^2}$

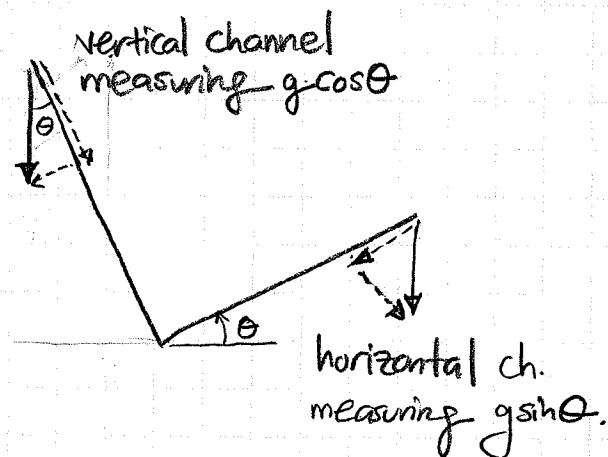
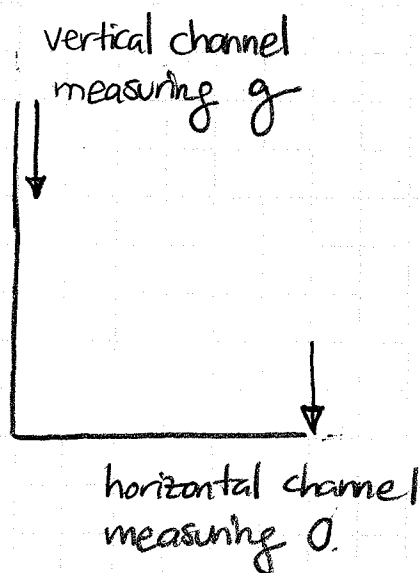
If we include tilt, motion recorder [accelerometer] records:

$$\text{Acc}_{\text{vertical}} = \ddot{u}_z(t) - g \cos \theta(t) \approx \ddot{u}_z(t) - g \leftarrow \begin{array}{l} \text{removed by} \\ \text{datum} \end{array}$$

↑
for small θ

$$\text{Acc}_{\text{horizontal}} = \ddot{u}_x(t) + g \sin \theta_x(t) \approx \ddot{u}_x(t) + g \theta_x(t)$$

↑
for small θ_x



Acc_{vert} : not sensitive to tilt

$\text{Acc}_{\text{horiz}}$: sensitive to tilt

Static Tilt

Ground tilt (static), building floor tilt.

If a constant tilt of θ happens instantaneously at $t=0$ and stays constant

$$\text{Acc}_{\text{horiz}}(t) = g\theta \quad \text{w/ zero I.C.}$$

$$\text{Disp}_{\text{horiz}}(t) = g\theta \frac{t^2}{2}$$

e.g. in 20 sec, 1 m (100 cm) of displacement is recorded.

$$\Rightarrow \theta = \frac{100 \times 2}{981 \times 20^2} = 0.0005 \text{ rad} \approx 0.03 \text{ deg}$$

Aside: Traveling wave filts: strain \propto $\frac{\text{particle velocity}}{\text{Wave velocity}}$

$$\Rightarrow \theta(t) \propto \frac{\dot{u}(t)}{c}$$

0.6 degree tilt over 0.7 sec. Max amp ~ 2% PGA

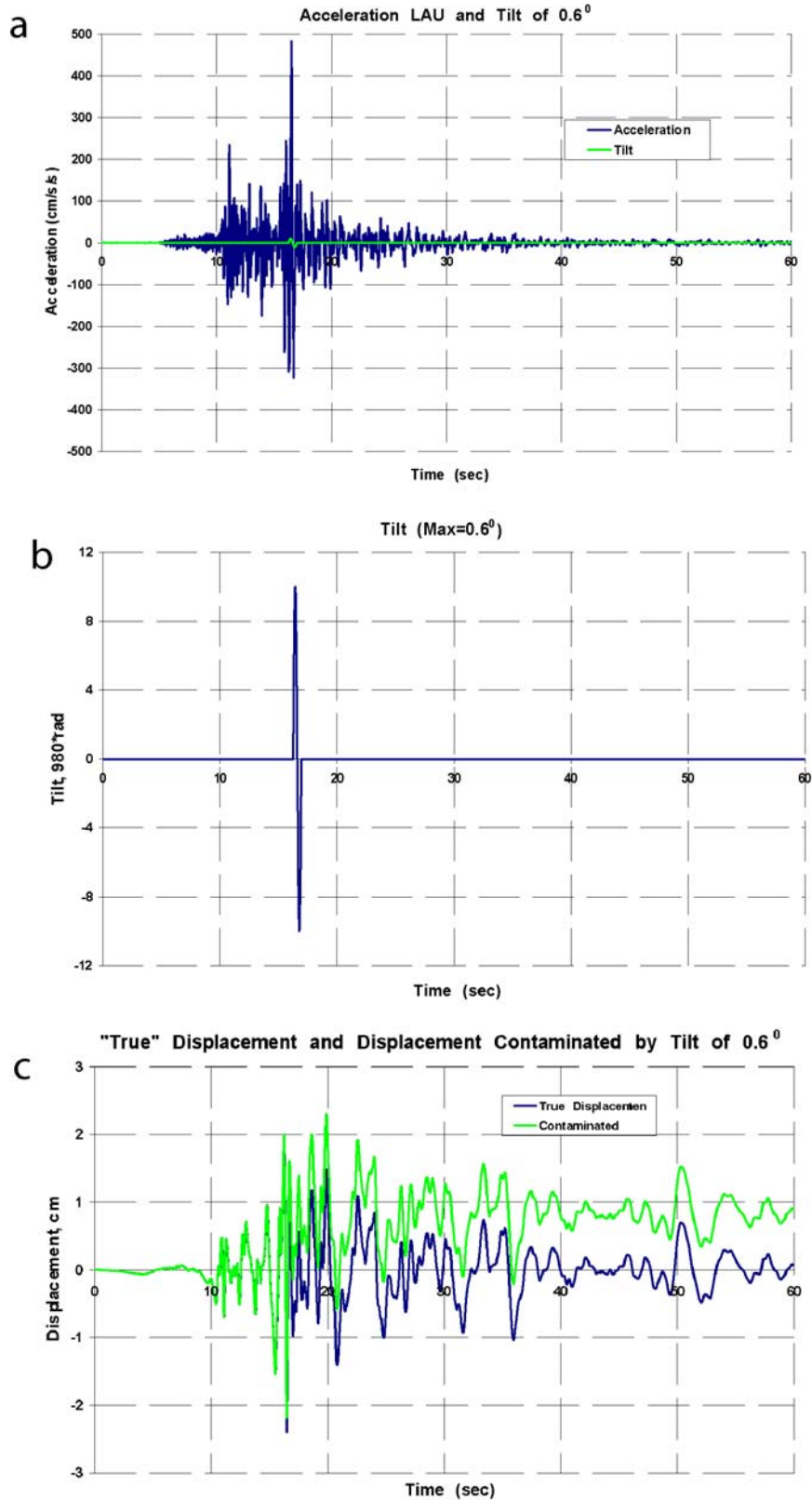


Figure 2. Comparison of the “true” displacement and displacement calculated using accelerogram contaminated by tilt.

0.1 degree max tilt; proportional to ground velocity spectrum. Max amp less than 1% PGA

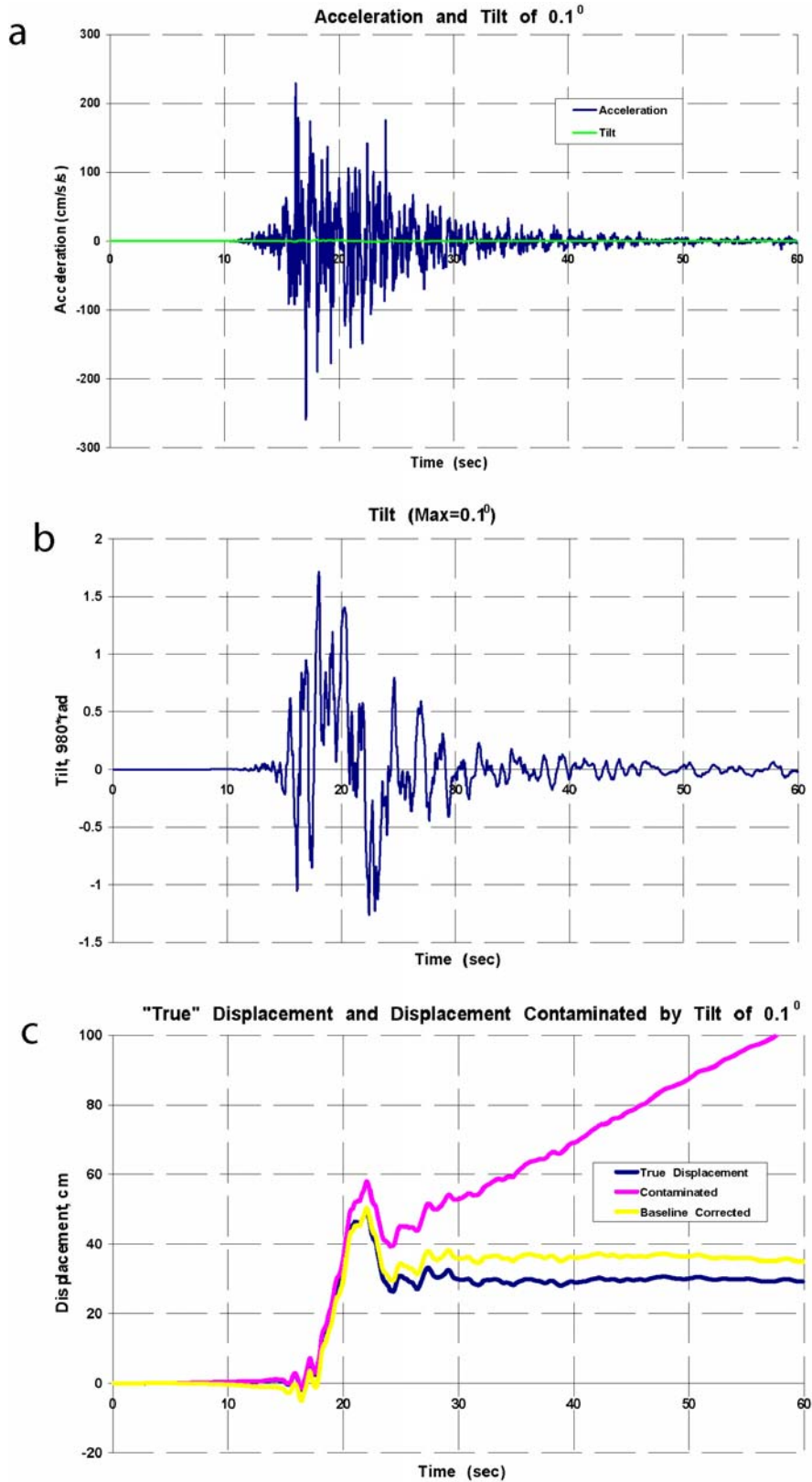


Figure 3. Comparison of the “true” displacement and displacement calculated using accelerogram contaminated by tilt.

Bingol Recording Station Pedastal Tilt at Top (2005 05 01 event)

