Behavior and Design of Cast-in-Place Anchors under Simulated Seismic Loading

Phase I– Cyclic Tests of Cast-in Place Anchors in Plain Concrete

Instrumentation Plan

String pots and linear variable differential transformers (LVDT's) were used to measure the anchor displacements relative to the test block in shear and tension directions respectively. For tension, the high strength tie-down rod located after the test anchor at the center of the block was used to mount the LVDT's to measure the vertical movement of the load plate relative to the test block as shown in Figure 1. The Trans-Tek model 245 DC-DC LVDT's used had a stroke of ± 2 inches with a voltage output of ± 10 Volts.

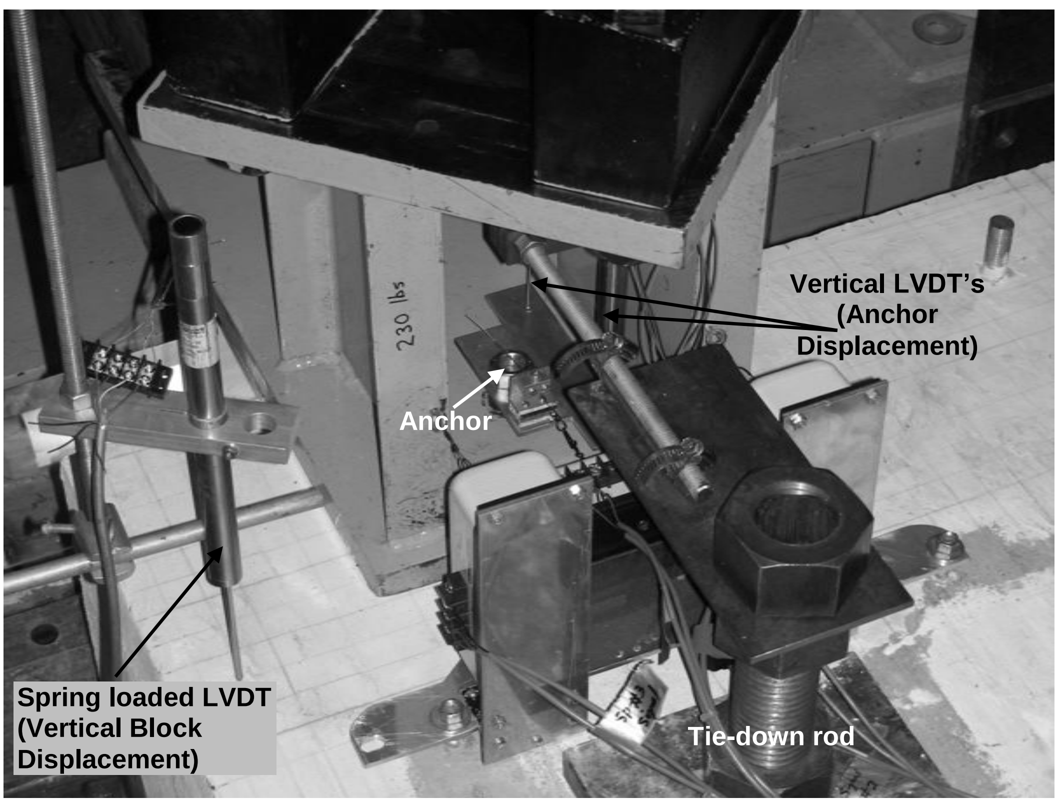

Figure 1: LVDT's for measuring vertical anchor displacement

The apparatus shown in Figure 1 was attached to the threaded rod and cantilevered into the load plate where the LVDTs were mounted at equal distances of two inches from the anchor in the plane of applied shear load. Using this technique, any vertical movement of the test block was negated leaving only relative vertical movement between the LVDTs and the anchor. Initial tests used a thin (1/8 inch thick) plate that was attached between two nuts on the anchor, on which to rest the vertical LVDTs. This allowed for the tilt of the anchor to be calculated during shear tests. However, during tension tests, it proved to be detrimental because anchor displacements were small for concrete failure modes. The measured tilt of the anchors under tension masked actual vertical movement of the anchors themselves so the small plate was removed and the vertical LVDTs rested on the load plate itself. Because the load plate was assumed to be in contact with the nut located on the anchor at all times, any vertical movement of the load plate was in turn equal to the vertical movement of the anchor. Resting the vertical LVDTs on the load plate eliminated the measurement of anchor tilt, and effectively corrected the accuracy of the vertical anchor displacements.

Horizontal displacements of anchors were measured using three Celesco PT510 DC string pots shown in Figure 2. Each string pot has a total stroke of two inches with a voltage output of 0-10 Volts. All three string pots were mounted on a custom made mounting bracket that was in turn suspended on top of the lift bolts provided on the top surface of the test blocks. The mounting bracket was suspended on the lift bolts using a nut on the top and bottom of the plate and was situated to provide 1/16 inch clearance between the surface of the concrete and the bracket itself to deter interference of horizontal measurements caused by possible contact with concrete tensile breakout cones. Connection of the string pot mounting bracket to the lift bolts provided a secure fastening to the concrete block which allowed for measurements of horizontal anchor movements with respect to the test block to be taken directly through the sting pots.

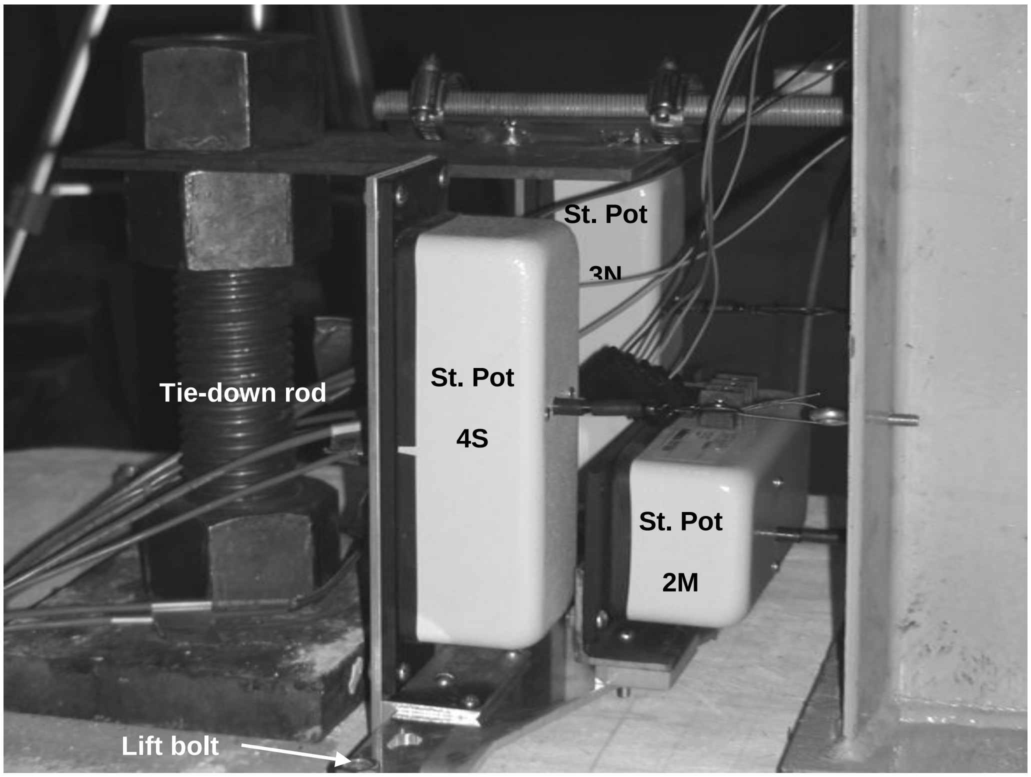

Figure 2: Three string pots for measuring horizontal anchor displacement

The middle string pot was attached to the anchor itself to provide a direct measurement of the horizontal displacement of the anchor. However, because it was impossible to locate the point of attachment to the anchor at the surface of the concrete test block, the string pot was ultimately mounted a distance of 1.5 inches above concrete surface for 0.75 inch diameter anchors and two inches above the concrete surface for 1.0 inch diameter anchors. For this reason, the measurements taken from the string pot attached to the anchor contain a combination of the actual horizontal movement of the anchor at the concrete surface as well as some amount of bending displacement at the point of connection. The degree of error for these measurements depends on the hole clearances allowing the anchor to rotate as well as other unforeseen behaviors.

Two additional string pots were attached to the load plate itself on the North and South sides of the anchor. Because the load plate acts as a rigid body whose contact with the anchor is responsible for any displacements and imparted loads on the anchor, measurements taken from the load plate can be assumed to be a direct measurement of displacements of the anchor with some exceptions. During testing, a hole clearance was present between the anchor and the load plate. Such clearances produced a lag in displacement measurement between the instances where both the load plate and anchor were moving in unison during cyclic tests. Shim rings were used to surround the anchor which minimized the lag effects with no measurable effect on shear capacity of the anchor. The data from these two string pots was averaged and used to produce all shear load versus displacement graphs displayed in this document.

Two Sensotec spring loaded LVDTs were used to monitor the horizontal and/or vertical displacement of the specimens during testing as shown in Figure 1. The horizontal spring loaded LVDT was positioned on the back side of the test block directly in line with the applied shear load to isolate any potential rotation of the block. The movement of the horizontal load frame was measured using a dial gauge. Vertical block movements were monitored using a second spring loaded LVDT located at the side edge of the block and oriented equidistant from the loaded edge as the anchor.

Data Acquisition and Filtering

An IO Tech DaqBook 2000 was used to collect data from all instrumentation as well as force and displacement output channels from the actuators. The DaqBook system was consists of four DBK43A strain gauge modules and a single 16 channel DBK85 module for voltage inputs. The readouts of the DBK43A strain gauge modules were filtered by an internal hardware filter while the DBK85 module does not provide signal filtration. A Matlab program was used to filter the obtained data.

The data acquisition system used for this research does not possess a sample and hold function necessary of collecting perfectly time-synchronized data. However, with an inherent physical internal sampling rate of 2 kHz, the lag difference between individual channel recordings was deemed insignificant.

Data Filtering Program

```
% read in Tets data files.
[Filename,Pathname]=uigetfile('*.txt','IOTech data file');
if isempty(Filename)==1 | Filename==0
    msg=['Cannot loacate the file!']
    return;
end

finname=strcat(Pathname,Filename);

rawdata=load(finname);
[nlines,nchannels]=size(rawdata);
filtereddata=zeros(nlines,nchannels);
if nlines==0 | nchannels==0
    msg = ['No data in the file!!']
    return;
end

%filtering out data: 2nd-order Butterworth filter with 0.1 Hz cutoff frequency
b=[0.0201,0.0402,0.0201];
a=[1,-1.5610,0.6414];
for i=1:nchannels
    x=rawdata(:,i);
    y=filter(b,a,x);
    filtereddata(:,i)=y;
end

%save filtered data back
finname=[Pathname,'DFed_',Filename];
fio=fopen(finname,'w');
format1='%f';
for i=2:nchannels
    format1=[format1,' %f'];
end
format1=[format1,'\n'];
fprintf(fio,format1,filtereddata');
fclose(fio);

clear filtereddata;
filtereddata=load(finname);
figure;
plot(rawdata(:,9),rawdata(:,4)); hold on;
plot(filtereddata(:,9),filtereddata(:,4),'r--');
```