Appendix A

Preliminary SEMs

SEM images of various gold tailings samples were taken as a preliminary investigation on the observable fabric and the possibilities with regards to using SEM images. These include SEM images of moist tamped, slurry and in situ gold tailings samples. Backscattered SEM images were also taken of the same samples prepared in a polished section. Images obtained from the SEM are three-dimensional, while Backscattered images are two-dimensional. The use of 2D (backscattered SEM) or 3D (conventional SEM) images will thus need to be decided and evaluated from these preliminary images.

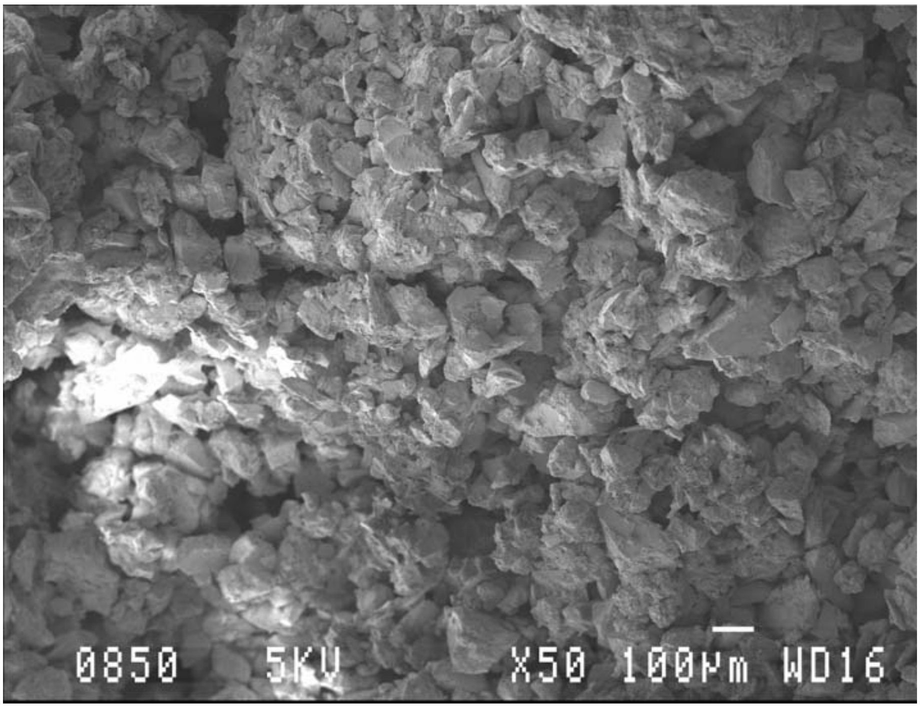

Figure A-1. SEM image of a moist tamped sample at an arbitrary void ratio (50X magnification).

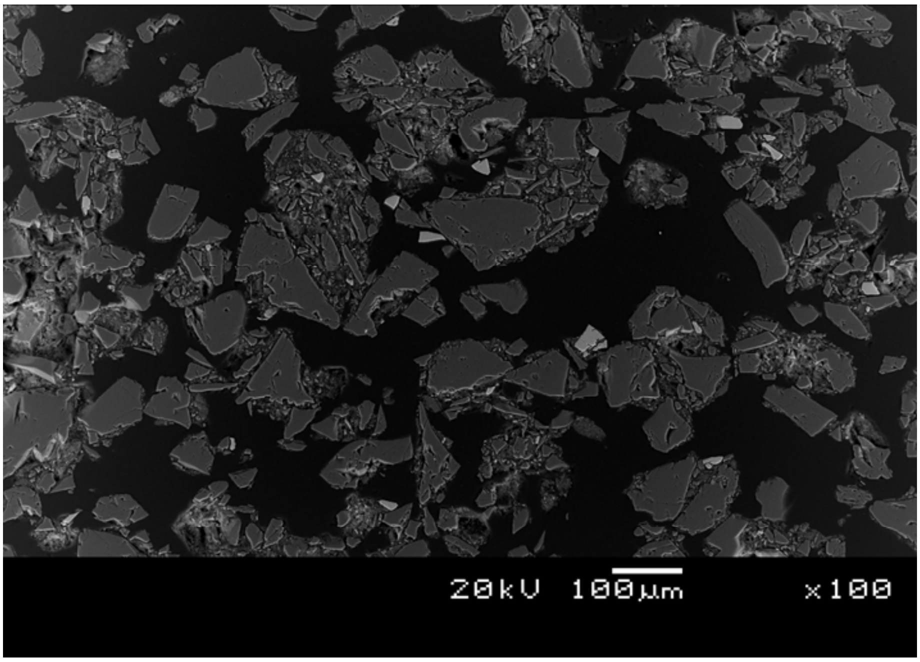

Figure A-2. Backscattered SEM image of a moist tamped sample polished section at an arbitrary void ratio (50X magnification).

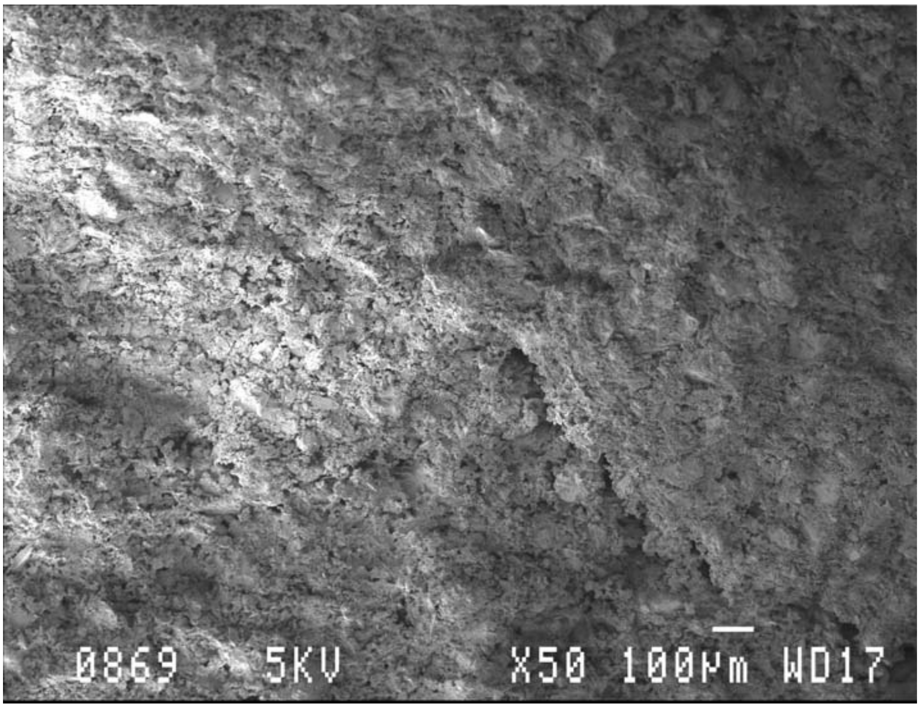

Figure A-3. SEM image of a slurry sample at an arbitrary void ratio (50X magnification).

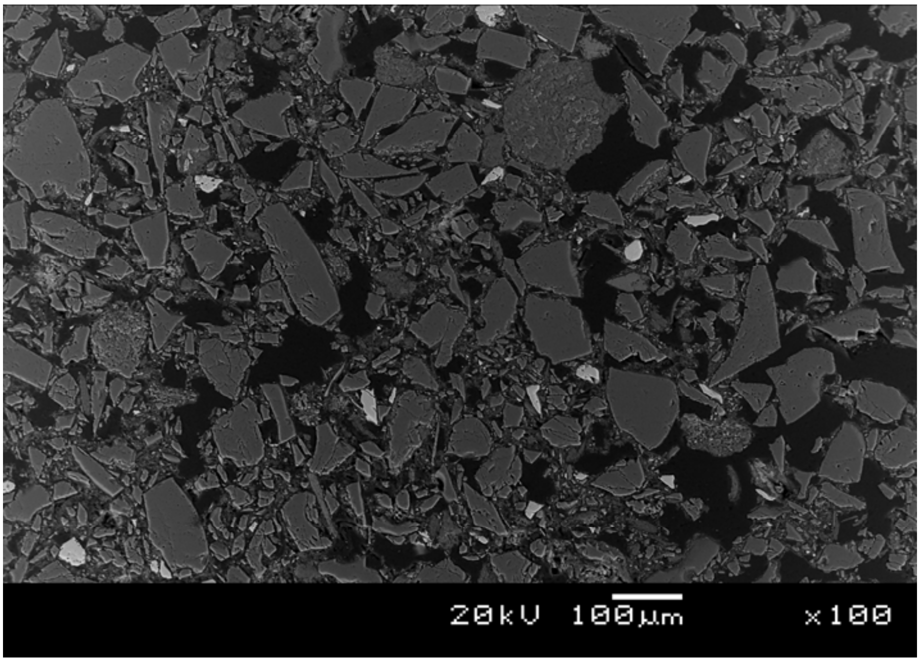

Figure A-4.Backscattered SEM image of a slurry sample polished section at an arbitrary void ratio (50X magnification).

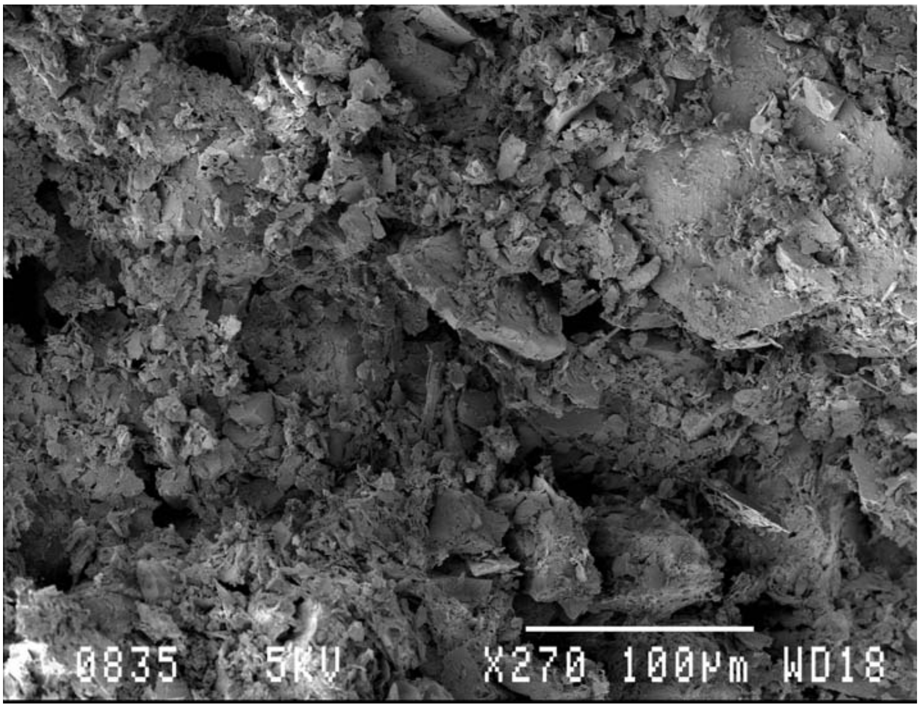

Figure A-5. SEM image of in situ gold tailings (270X magnification).

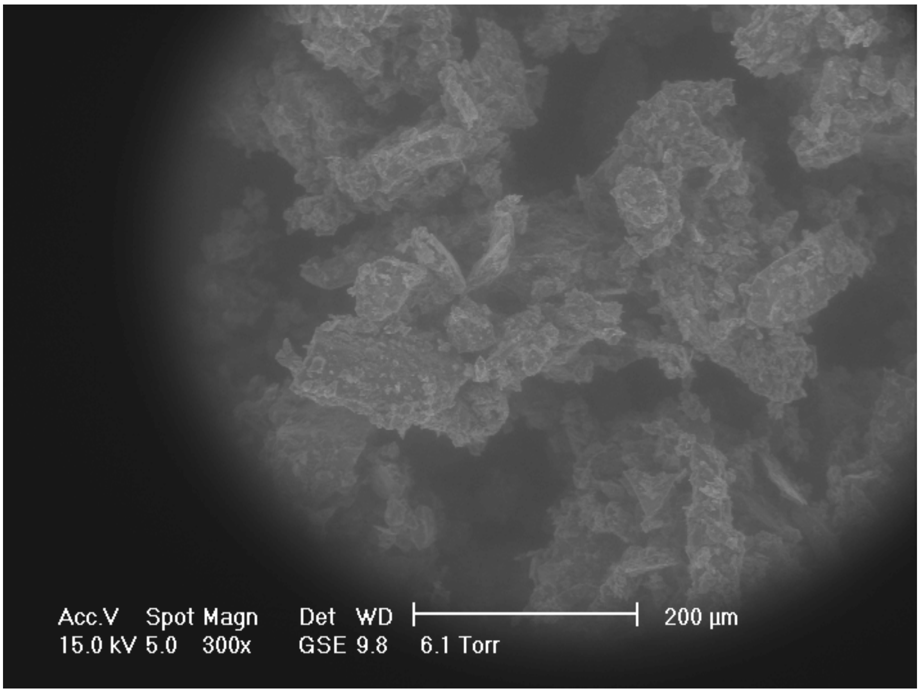

Figure A-6. Environmental SEM image of moist tamped sample (300X magnification).

Appendix B

Instrumentation and Calibration

The calibration methodology used in this thesis has been described in Chapter 3. Appendix B includes the specifications for the instrumentation used, the calibration devices as well as the calibration, error and hysteresis graphs for all instrumentation. An additional armature position test was also included for both LVDTs to investigate the linear range of the apparatus.

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Internal LVDT 1

Calibrated Instrument	RDP 6385 D5/200WRA submissible LVDT/RDP Transducer Amplifier Type S7AC
Department	Civil engineering, University of Pretoria
Instrument no.	6385
Calibration device 1	YGP Tungsten Carbide Gauge Blocks
Department	National Metrology, CSIR
Instrument no.	80112
Certificate no.	DM/1177
Accuracy	±30 nm @ 20°C
Calibration device 2	Mitutoyo ID-F150 Micrometer
Department	Civil Engineering, University of Pretoria
Instrument no.	6049
Accuracy	±1.5 µm
Data acquisition card	National Instruments PCI-6014
Department	Civil Engineering, University of Pretoria
Instrument no.	1044CB9
Certificate no.	70772
Resolution	65536 bit
Absolute accuracy	1 day 0.0154 % of reading
	90 days 0.0174 % of reading
	1 year 0.0196 % of reading
DAQ card settings	
Sensor range	-10V to +10V
Input method	Differential
Channel	0

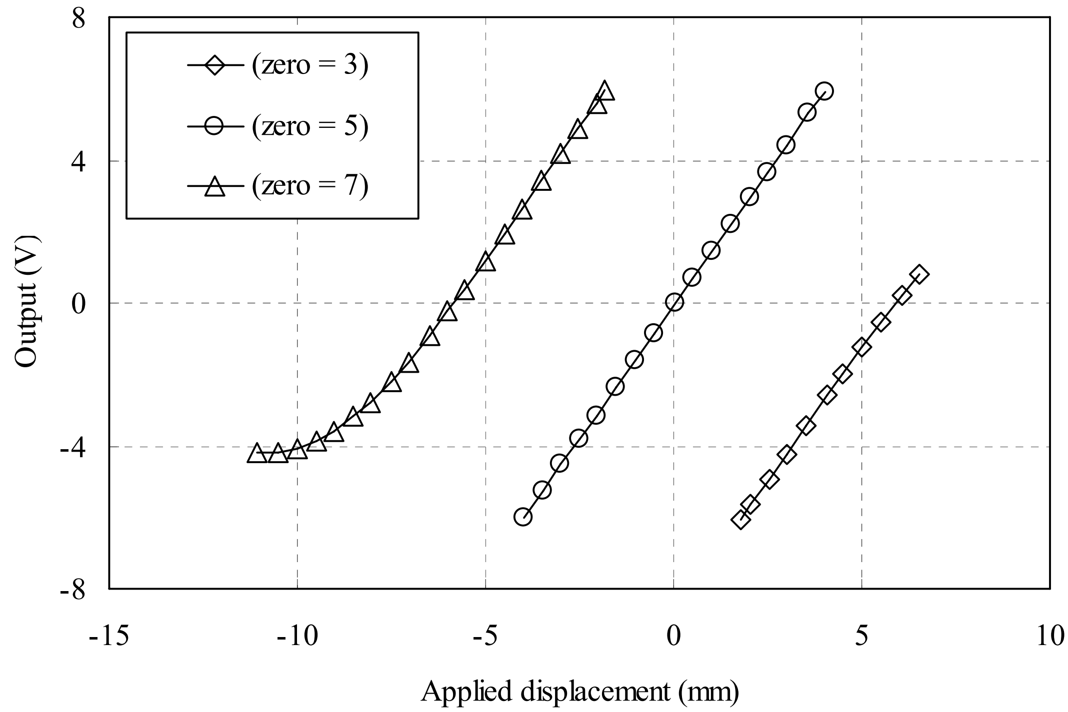

Figure B-1. Armature position test for LVDT1 at gain level 5.

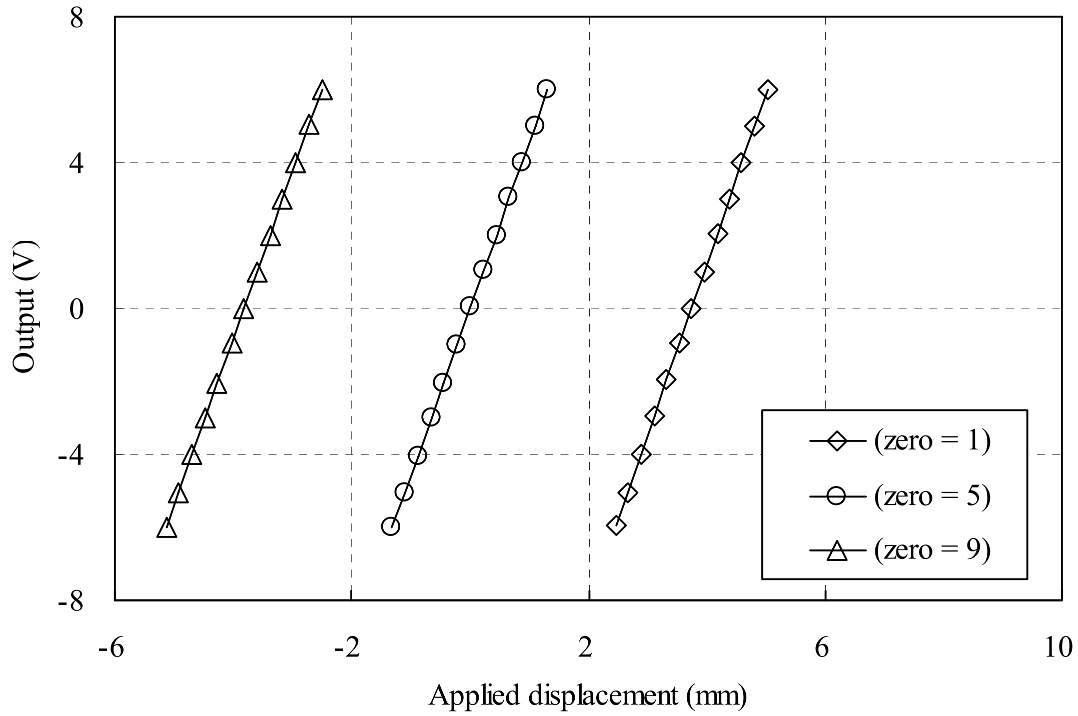

Figure B-2. Armature position test for LVDT1 at gain level 6.

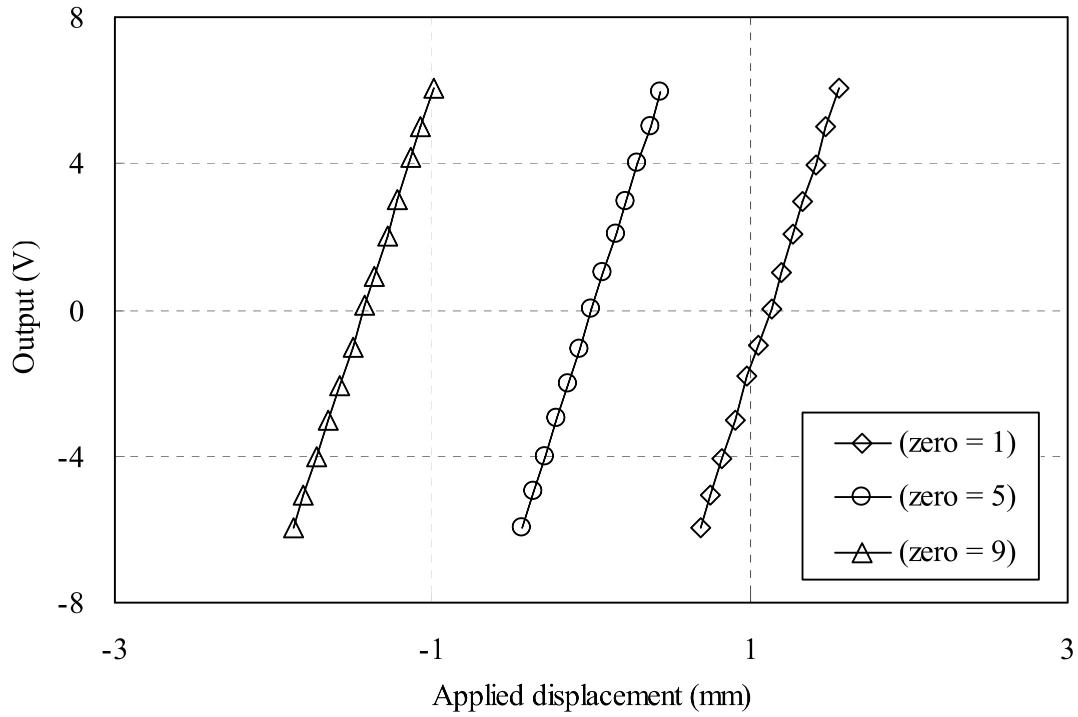

Figure B-3. Armature position test for LVDT1 at gain level 7.

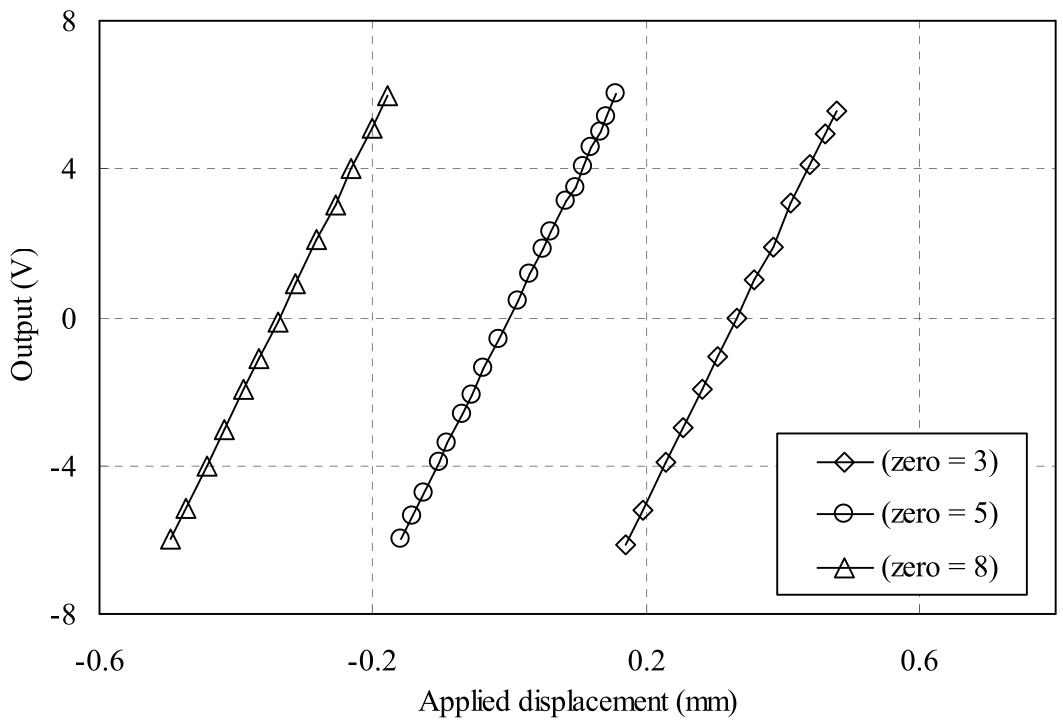

Figure B-4. Armature position test for LVDT1 at gain level 8.

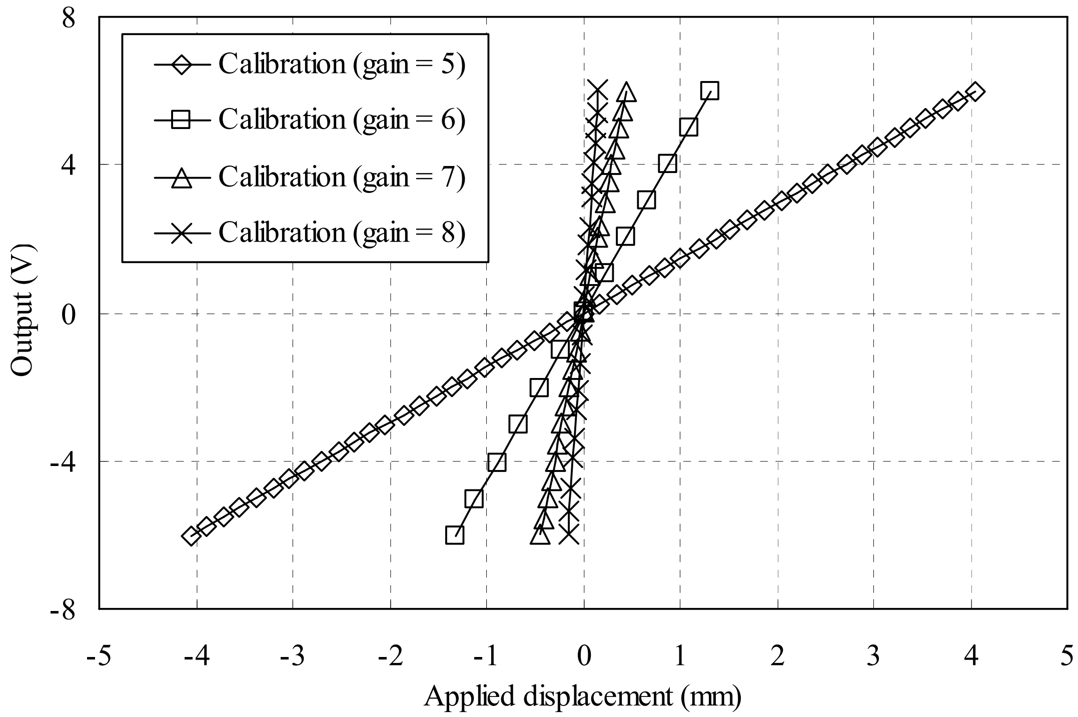

Figure B-5. Calibration graph for LVDT1 at gain levels 5, 6, 7 and 8.

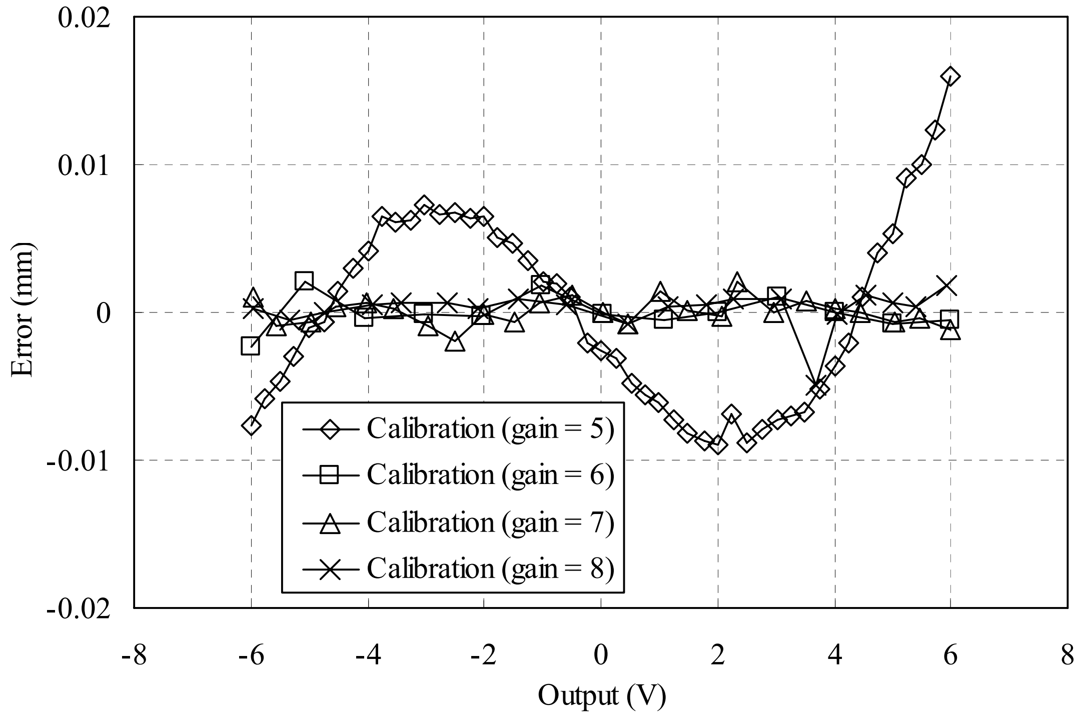

Figure B-6. Error graph for LVDT1 at gain levels 5, 6, 7 and 8.

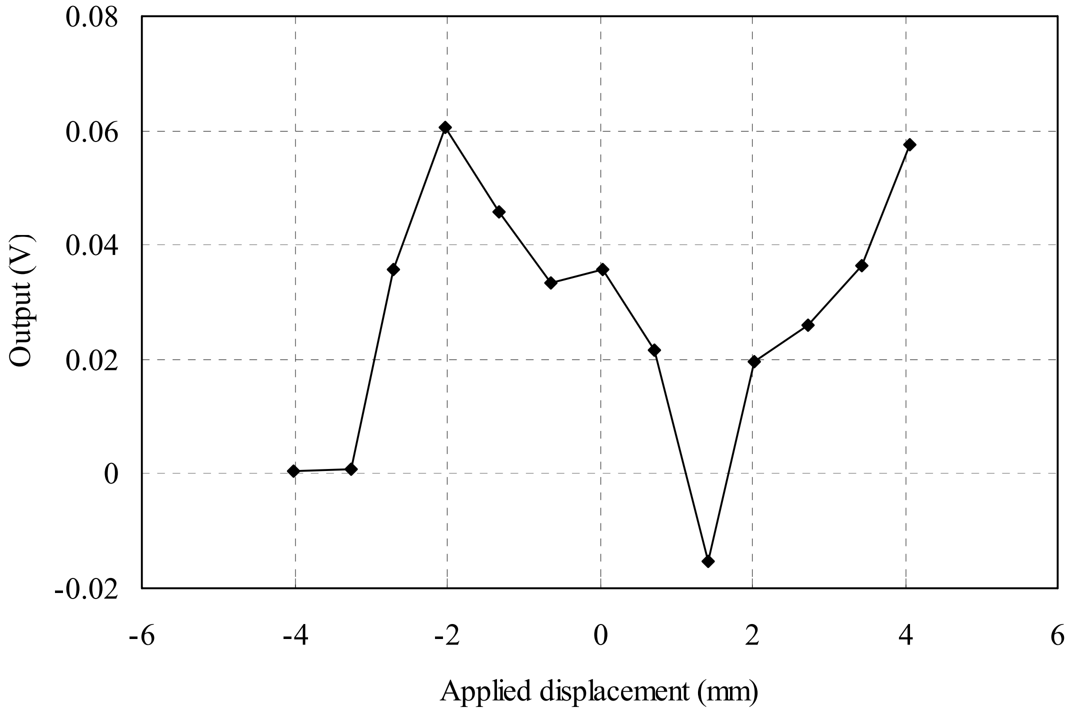

Figure B-7. Hysteresis graph for LVDT1 at gain level 5.

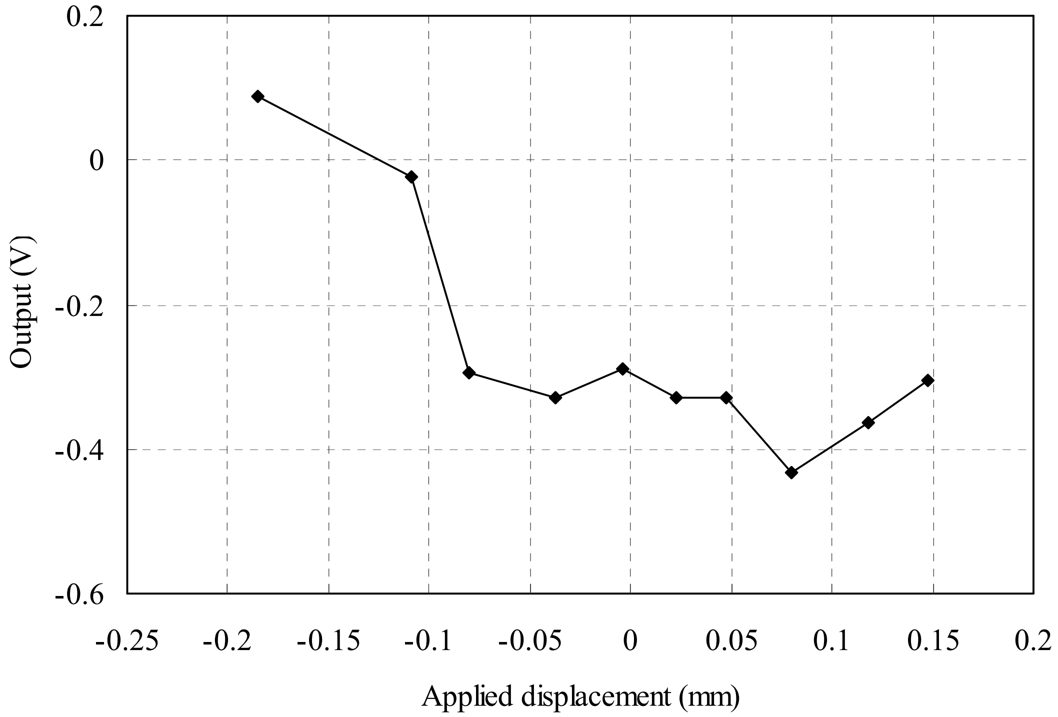

Figure B-8. Hysteresis graph for LVDT1 at gain level 8.

Internal LVDT 2

Calibrated Instrument	RDP 6385 D5/200WRA submissible LVDT/RDP Transducer Amplifier Type S7AC
Department	Civil engineering, University of Pretoria
Instrument no.	6385
Calibration device 1	YGP Tungsten Carbide Gauge Blocks
Department	National Metrology, CSIR
Instrument no.	80112
Certificate no.	DM/1177
Accuracy	±30 nm @ 20°C
Calibration device 2	Mitutoyo ID-F150 Micrometer
Department	Civil Engineering, University of Pretoria
Instrument no.	6049
Accuracy	±1.5 μm
Data acquisition card	National Instruments PCI-6014
Department	Civil Engineering, University of Pretoria
Instrument no.	1044CB9
Certificate no.	70772
Resolution	65536 bit
Absolute accuracy	1 day 0.0154 % of reading
	90 days 0.0174 % of reading
	1 year 0.0196 % of reading
DAQ card settings	
Sensor range	-10V to +10V
Input method	Differential
Channel	1

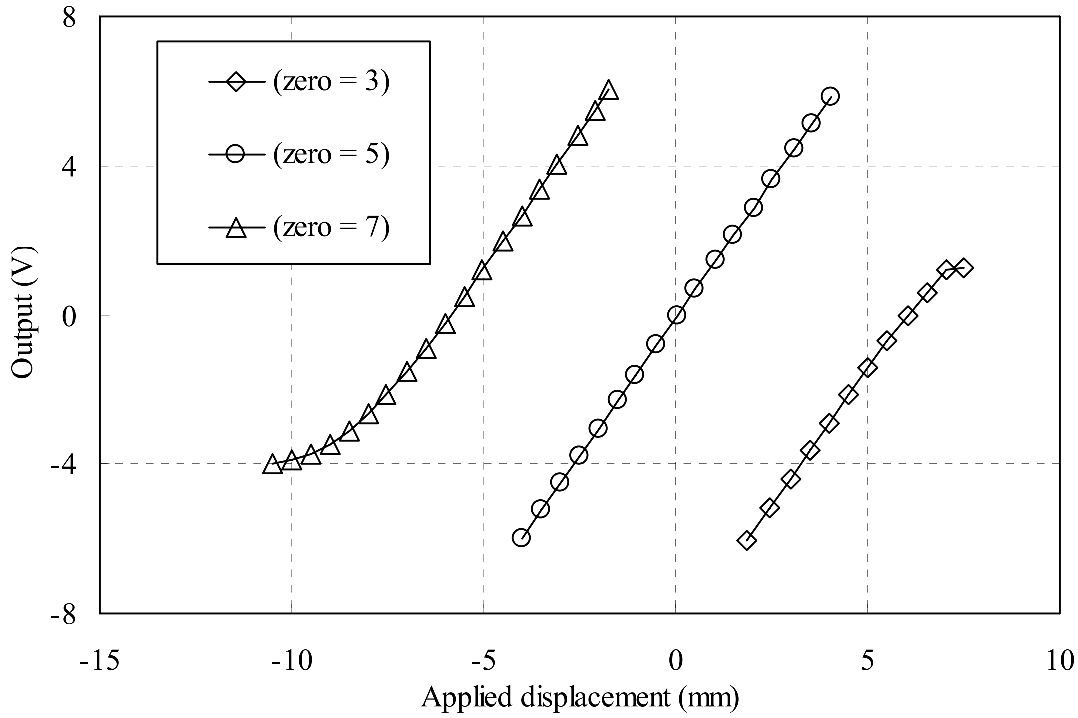

Figure B-9. Armature position test for LVDT2 at gain level 5.

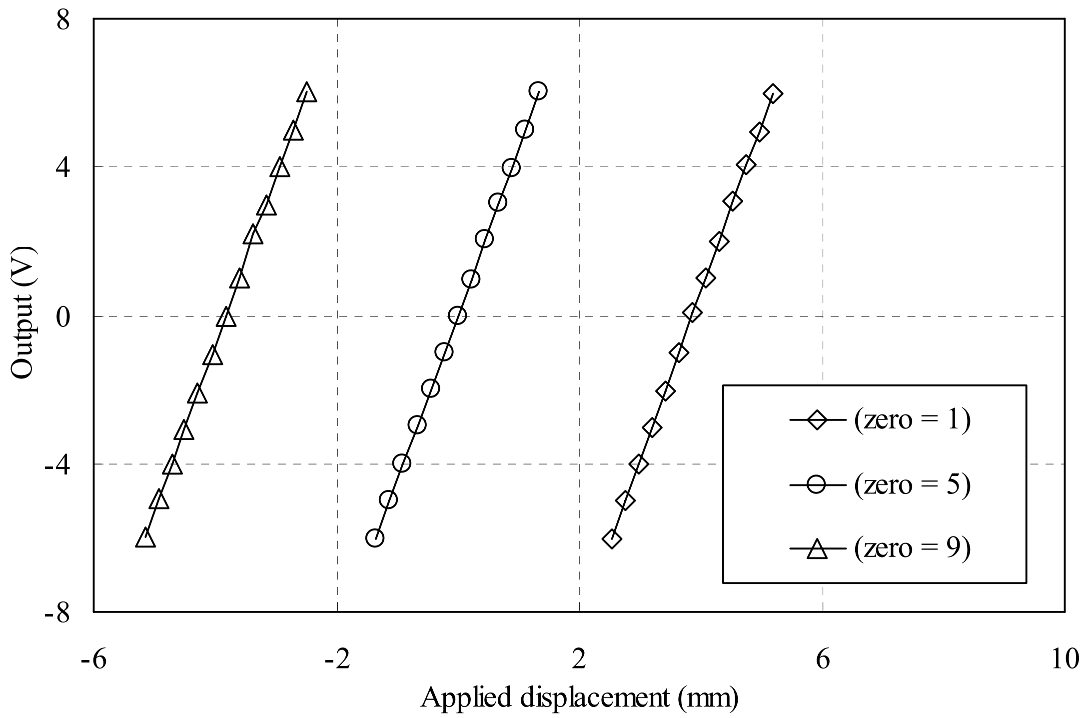

Figure B-10. Armature position test for LVDT2 at gain level 6.

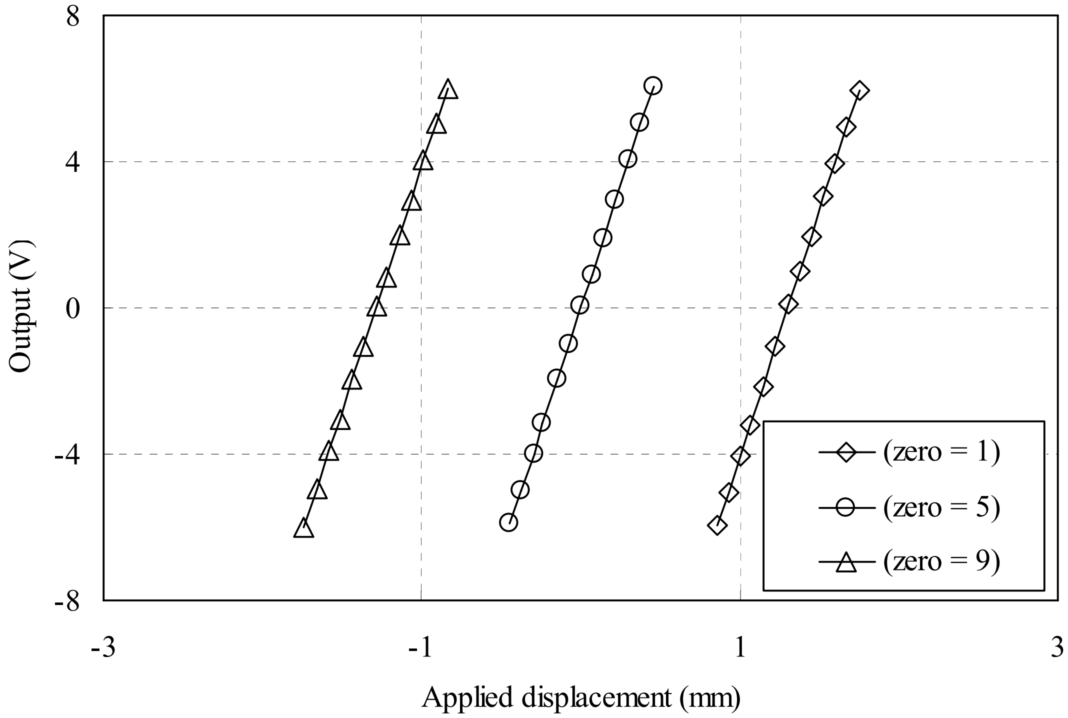

Figure B-11. Armature position test for LVDT2 at gain level 7.

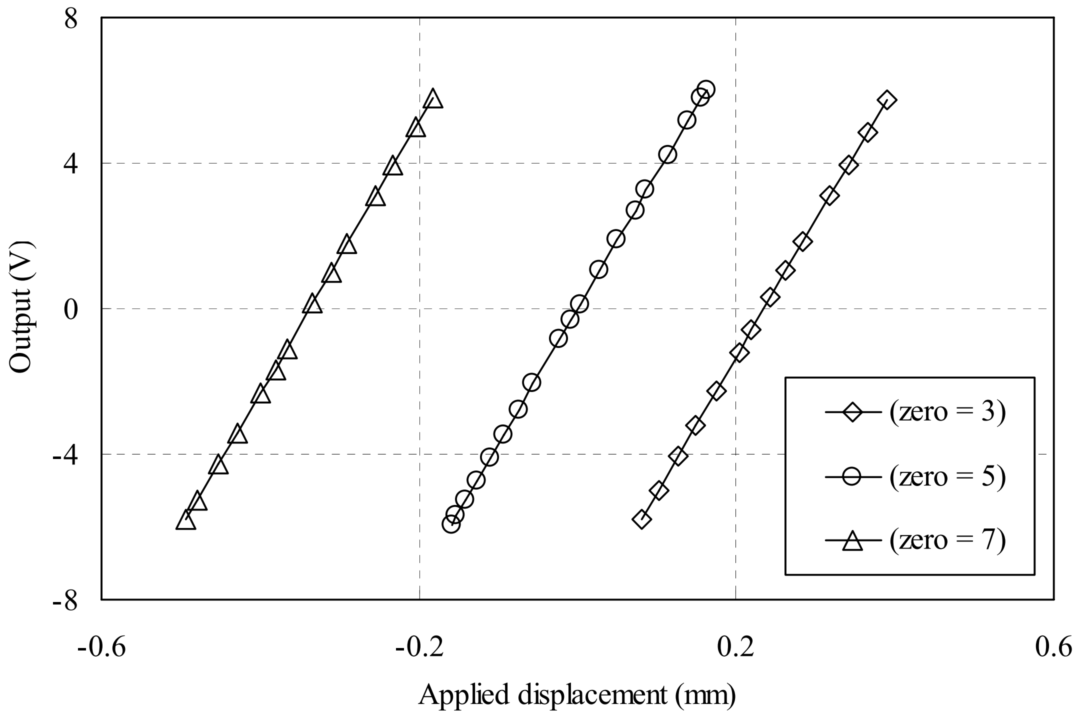

Figure B-12. Armature position test for LVDT2 at gain level 8.

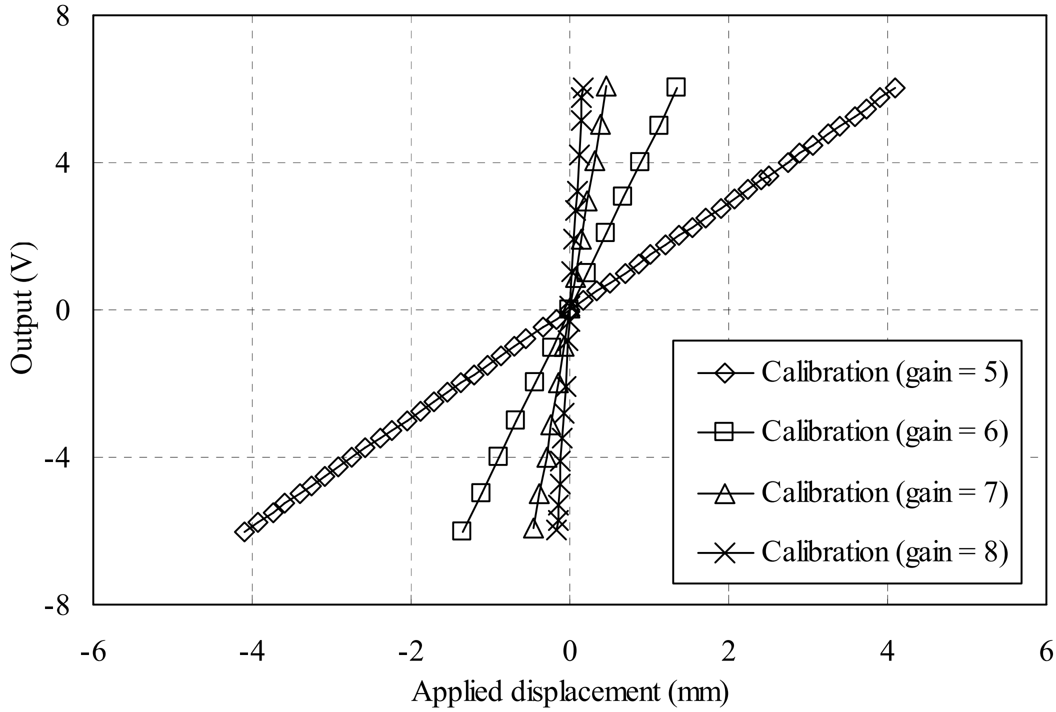

Figure B-13. Calibration graph for LVDT2 at gain levels 5, 6, 7 and 8.

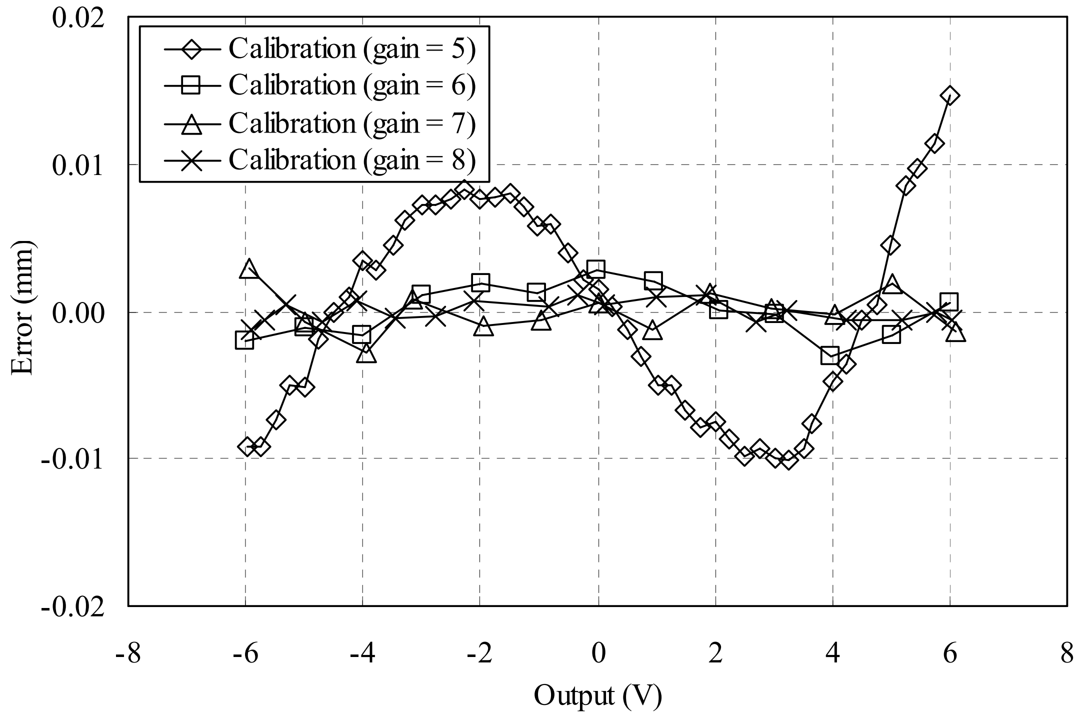

Figure B-14. Error graph for LVDT2 at gain levels 5, 6, 7 and 8.

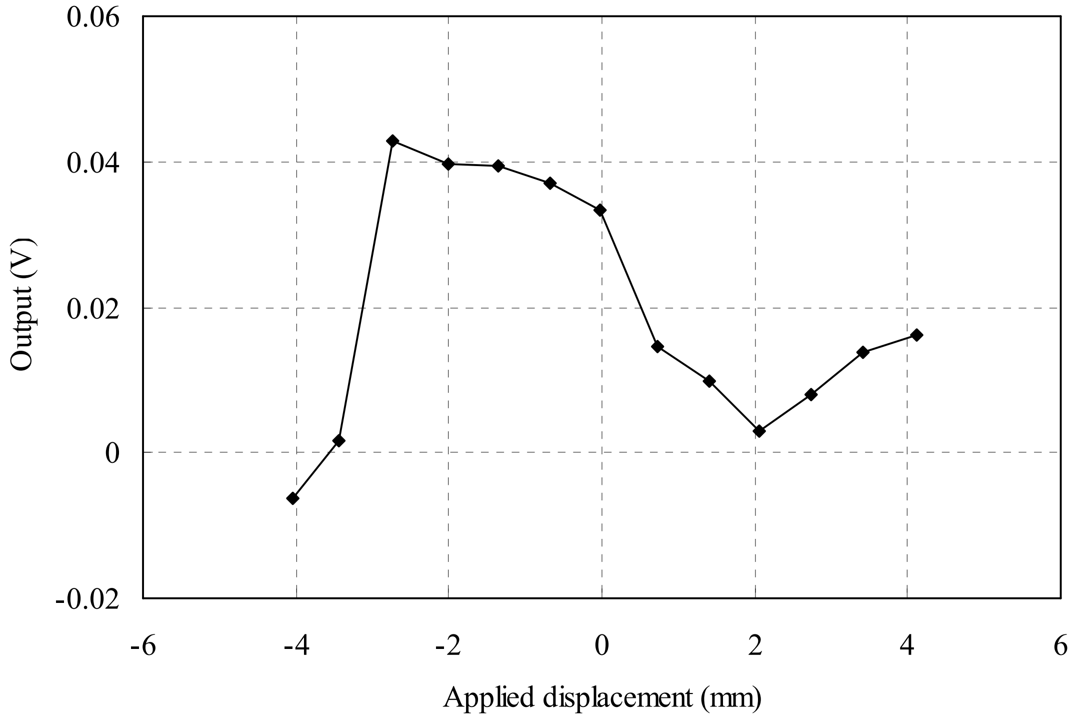

Figure B-15. Hysteresis graph for LVDT2 at gain level 5.

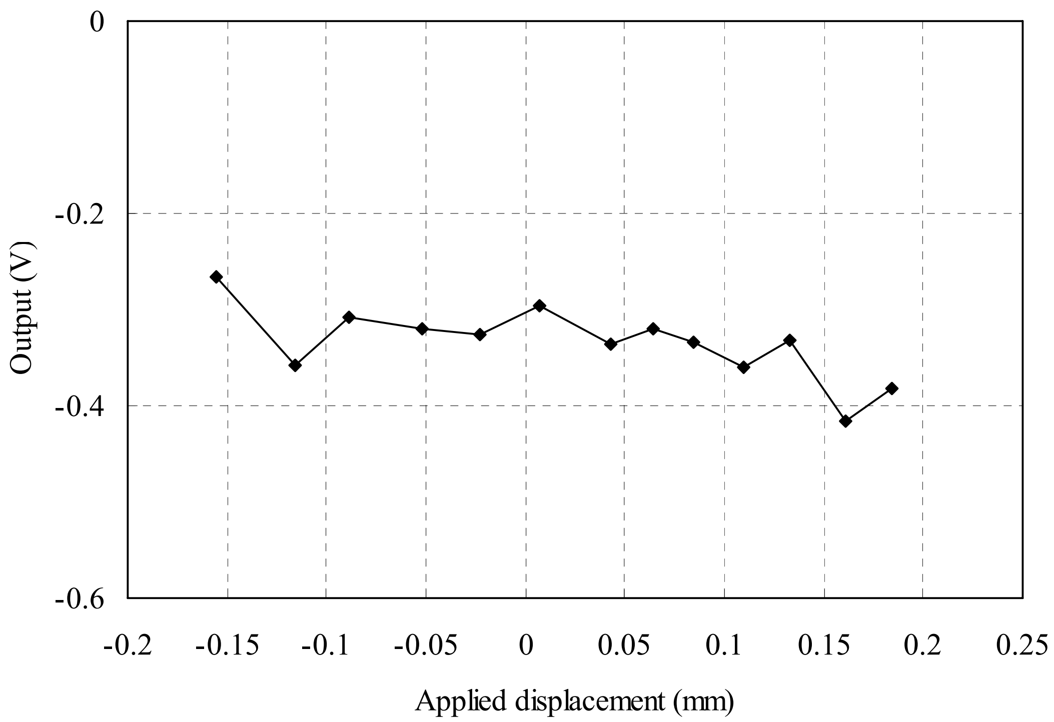

Figure B-16. Hysteresis graph for LVDT2 at gain level 8.

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Linear displacement transducer

Calibrated Instrument	Kyowa linear displacement transducer
Department	Civil engineering, University of Pretoria
Instrument no.	DT-20-D
Serial no.	YB-6279

Calibration device 1	YGP Tungsten Carbide Gauge Blocks
Department	National Metrology, CSIR
Instrument no.	80112
Certificate no.	DM/1177
Accuracy	±30 nm @ 20°C

Calibration device 2	Mitutoyo ID-F150 Micrometer
Department	Civil Engineering, University of Pretoria
Instrument no.	6049
Accuracy	±1.5 μm

Data acquisition card	National Instruments PCI-6014	
Department	Civil Engineering, University of Pretoria	
Instrument no.	1044CB9	
Certificate no.	70772	
Resolution	65536 bit	
Absolute accuracy	1 day	0.0154 % of reading
	90 days	0.0174 % of reading
	1 year	0.0196 % of reading

DAQ card settings	
Sensor range	-10V to +10V
Input method	Differential
Channel	2

Amplifier	HBM KWS 3073
Kal. Signal @ 2mV/V	4983
Measurements @	1mV/V
Channel	1

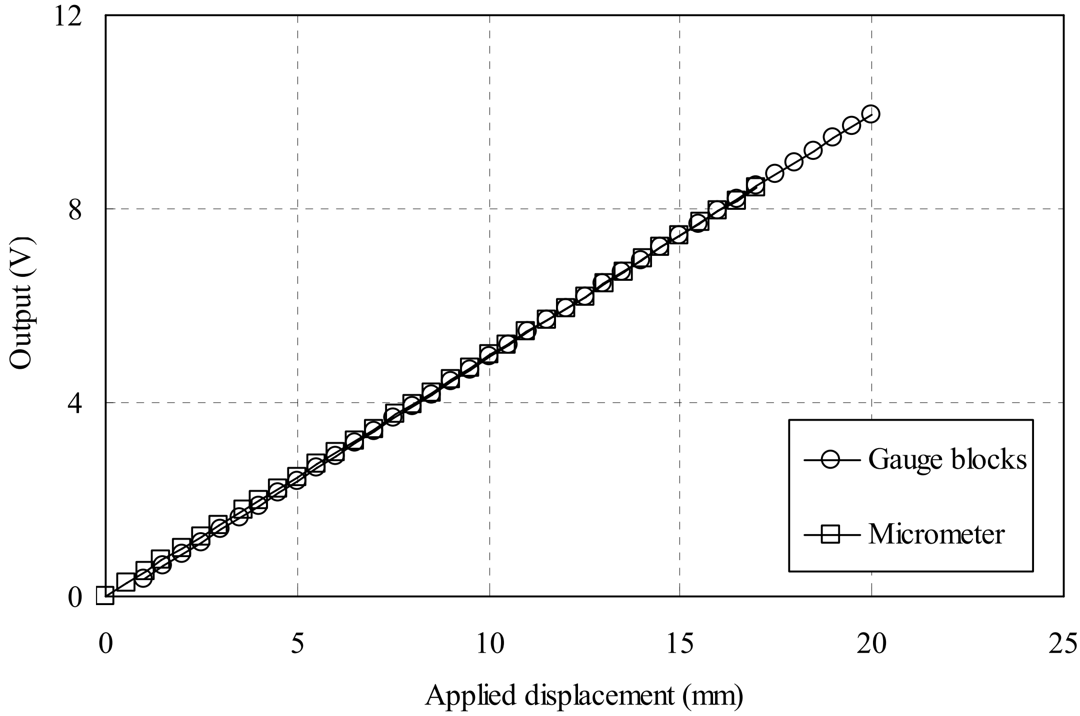


Figure B-17. Calibration graph for external displacement transducer using gauge blocks and micrometer.

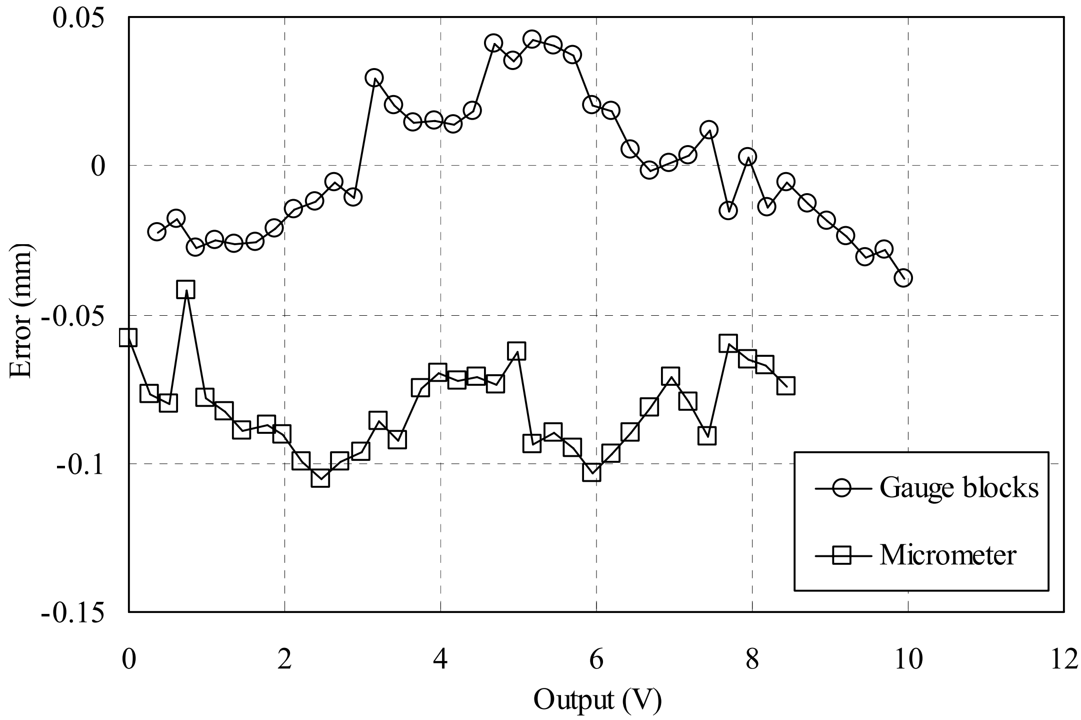


Figure B-18. Error graph for external displacement transducer using gauge blocks and micrometer.

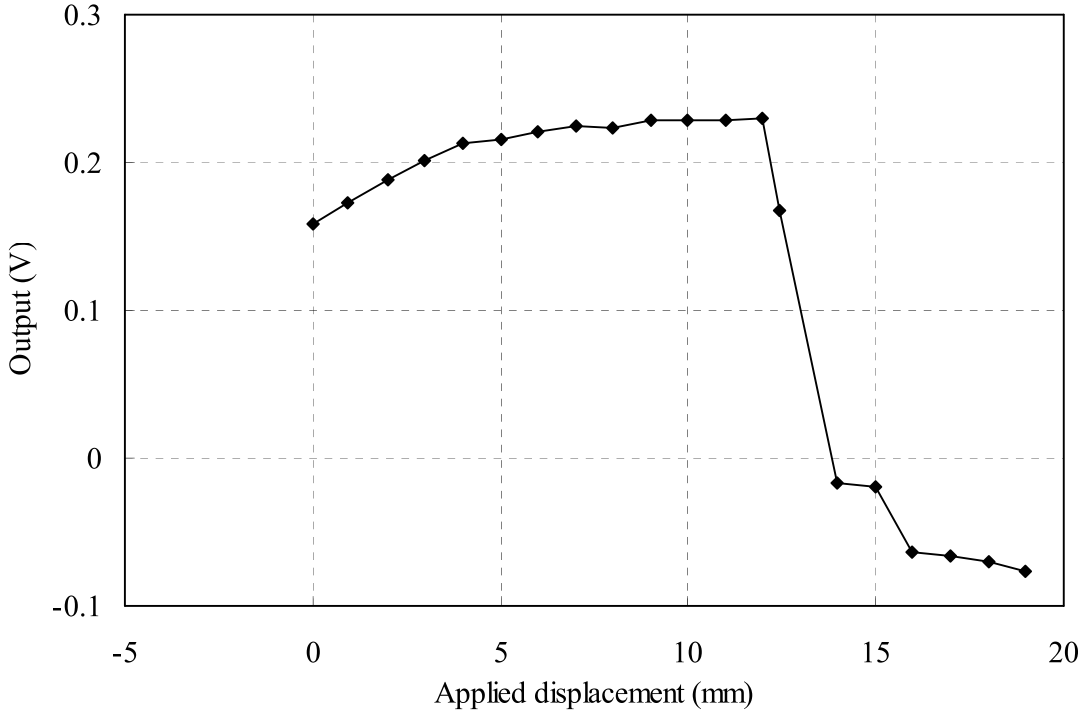


Figure B-19. Hysteresis graph for external displacement transducer using gauge blocks and micrometer.

Internal submersible load cell

Calibrated Instrument	Imperial College type submersible load cell	
Department	Civil engineering, University of Pretoria	
Calibration device	Lloyds LRX Plus single column test system	
Department	Civil engineering, University of Pretoria	
Instrument no.	UNIV VAN PTA 633195	
Certificate no.	UP19222B	
Accuracy	0.5% FS @ 20°C with 95% confidence	
Data acquisition card	National Instruments PCI-6014	
Department	Civil Engineering, University of Pretoria	
Instrument no.	1044CB9	
Certificate no.	70772	
Resolution	65536 bit	
Absolute accuracy	1 day	0.0154 % of reading
	90 days	0.0174 % of reading
	1 year	0.0196 % of reading
DAQ card settings		
Sensor range	-10V to +10V	
Input method	Differential	
Channel	3	
Amplifier	HBM KWS 3073	
Kal. Signal @ 2mV/V	5008	
Measurements @	0.5mV/V	
Channel	2	

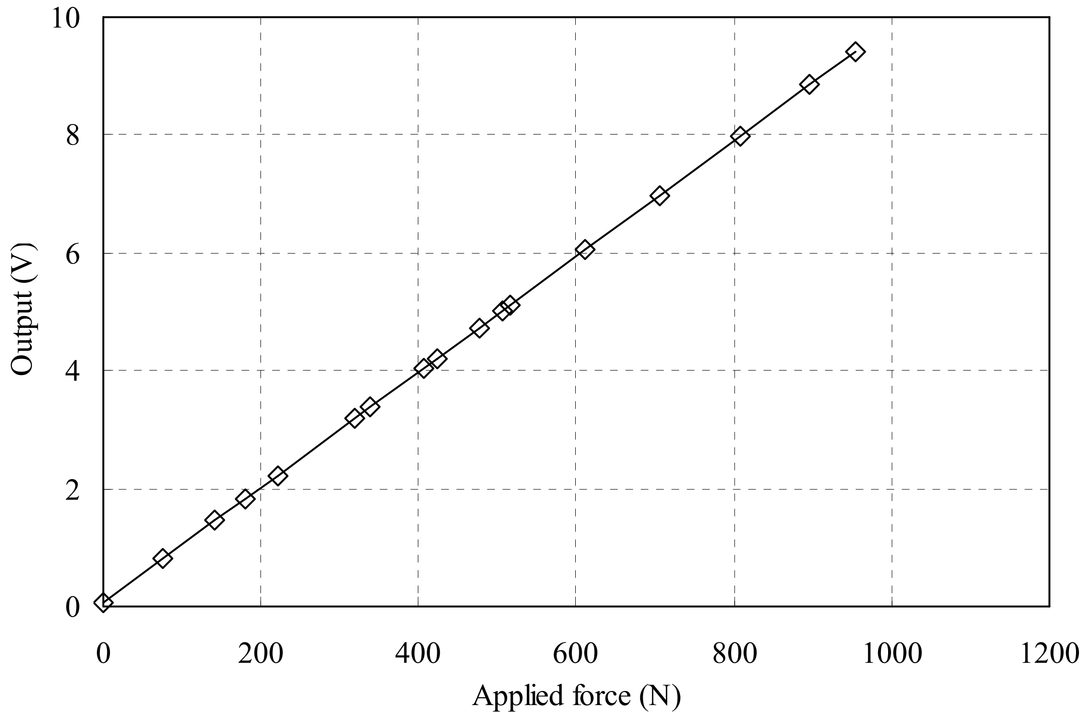


Figure B-20. Calibration graph for submersible load cell.

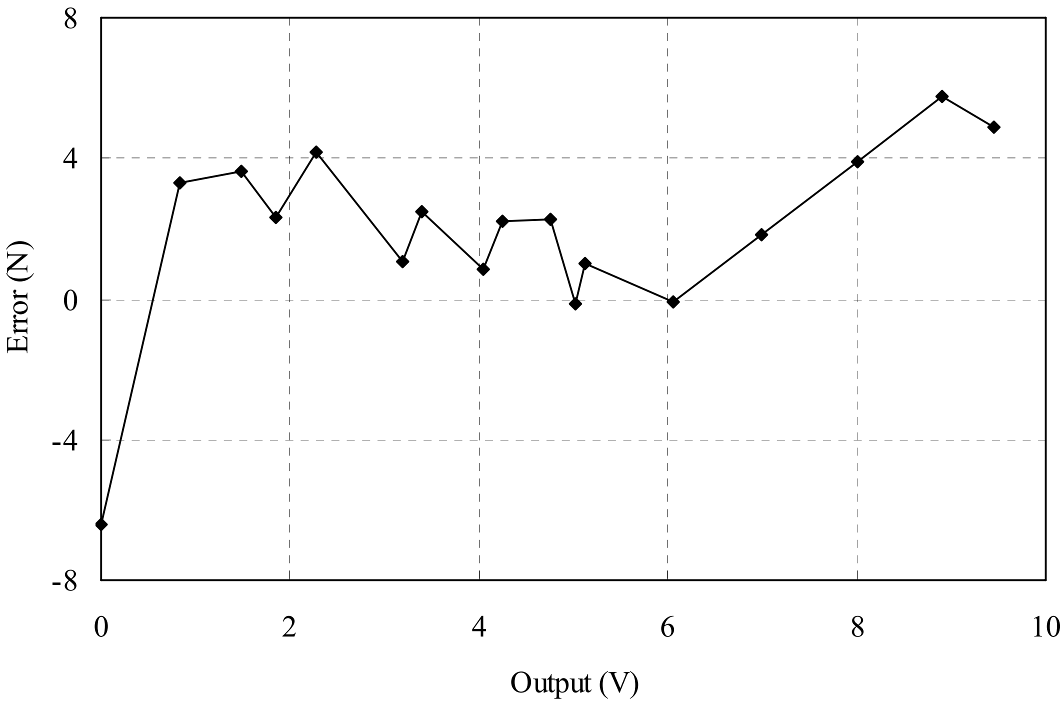


Figure B-21. Error graph for submersible load cell.

Pressure transducers and gauges

Calibrated Instrument 1	Genspec GS4200 pressure transducer
Department	Civil engineering, University of Pretoria

Calibrated Instrument 2	Standard GDS pressure controller
Department	Civil engineering, University of Pretoria

Calibrated Instrument 3	Budenberg standard test gauge
Department	Civil engineering, University of Pretoria

Calibration device	Budenberg 3/500 dead weight system
Department	Civil engineering, University of Pretoria
Instrument no.	UNIV VAN PTA 0473573
Certificate no.	UP19222L
Accuracy	0.02% between 6 and 2600 bars @ 24°C with 95% confidence

Data acquisition card	National Instruments PCI-6014	
Department	Civil Engineering, University of Pretoria	
Instrument no.	1044CB9	
Certificate no.	70772	
Resolution	65536 bit	
Absolute accuracy	1 day	0.0154 % of reading
	90 days	0.0174 % of reading
	1 year	0.0196 % of reading

DAQ card settings	
Sensor range	-10V to +10V
Input method	Differential
Channel	4

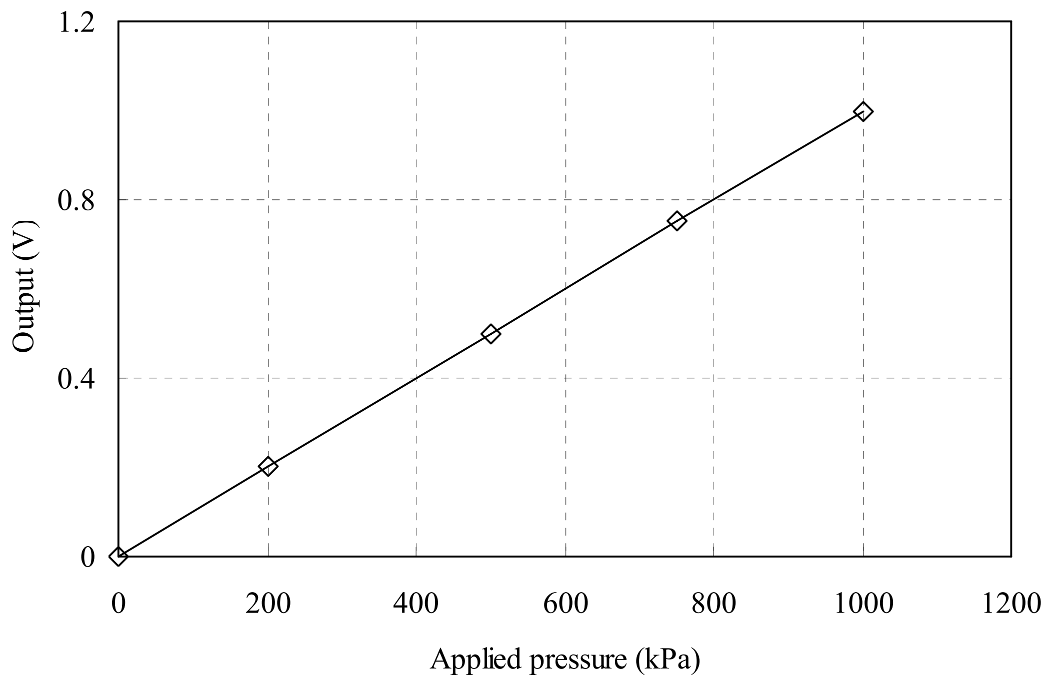


Figure B-22. Calibration graph for pressure transducer.

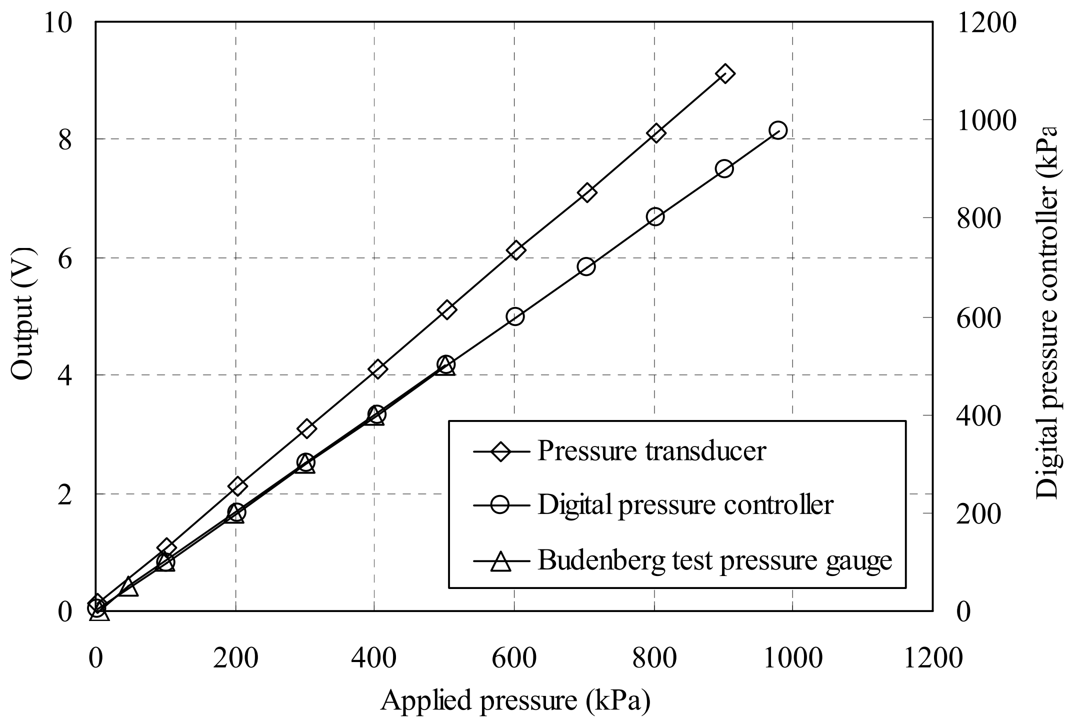


Figure B-23. Calibration graph for pressure transducer, digital pressure controller and Budenberg test pressure gauge.

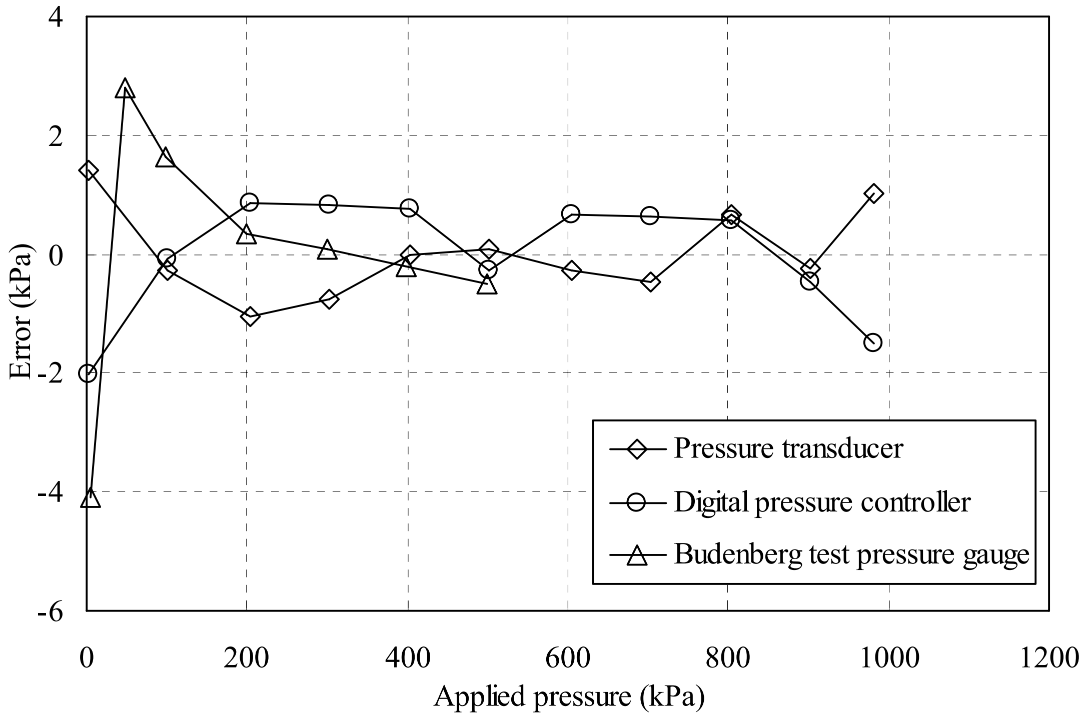


Figure B-24. Error graph for pressure transducer, digital pressure transducer and Budenberg test pressure gauge.

Volume gauge

Calibrated Instrument	Wykeham Ferrance volume gauge
Department	Civil engineering, University of Pretoria
Calibration method	Weight of water expelled at 21 °C
Density of water	0.997968 Mg/m^3
Resolution	0.1g

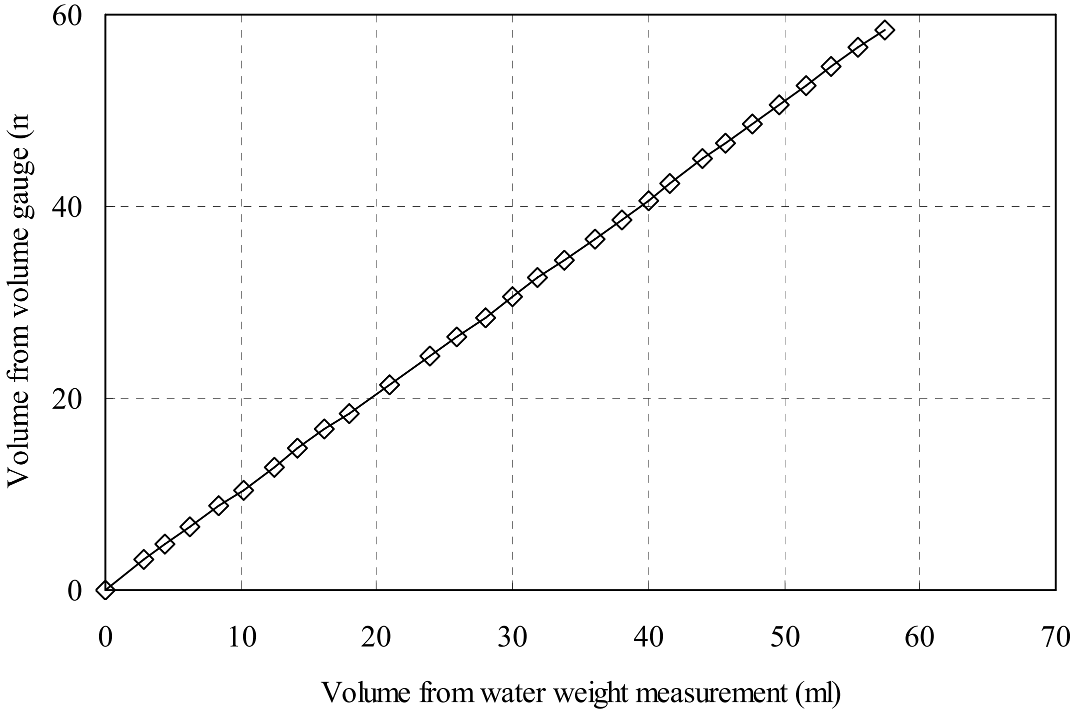


Figure B-25. Calibration graph for the volume gauge.

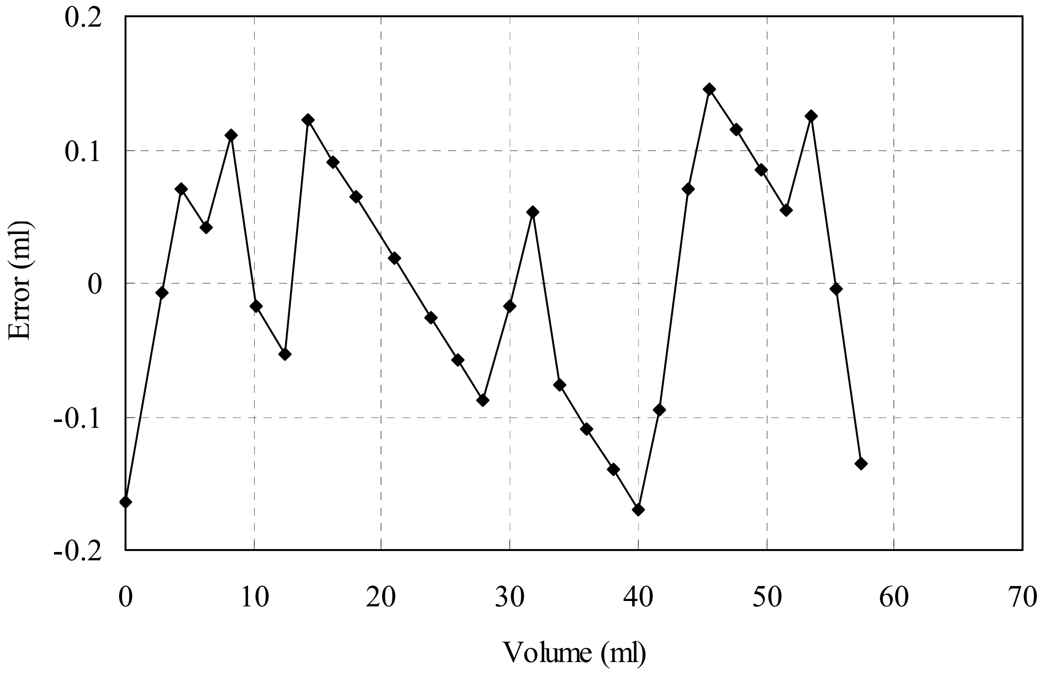


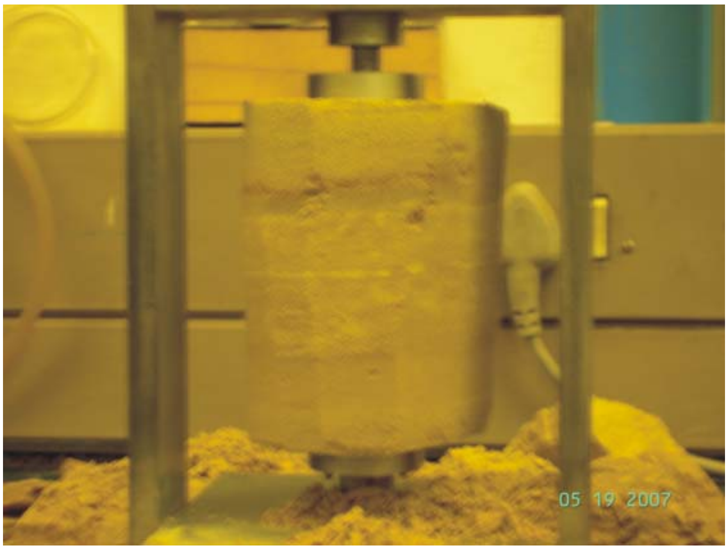
Figure B-26. Error graph for volume gauge.

Appendix C

Sample Preparation

This appendix discusses sample preparation for all samples tested for this research. This includes undisturbed and laboratory prepared samples. Laboratory sample preparation methods include moist tamping and slurry deposition. Both methods were modified to facilitate the preparation process. Photographs are used to aid the description.

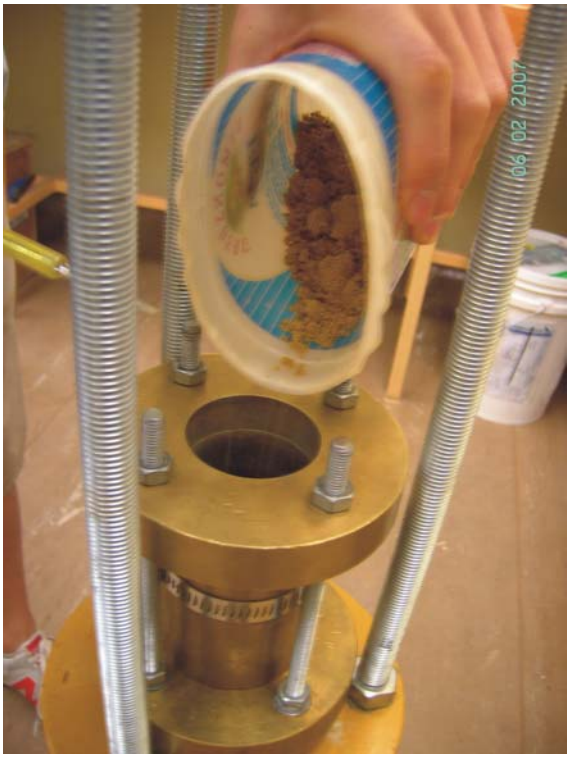
Preparation of undisturbed samples



Undisturbed samples were cut from the in situ blocks. Samples were first cut to the required height and size to fit into the soil lathe, and then shaped using a spatula to the required size (50mm diameter). The sample was then removed from the soil lathe and shaped to the required height.

A porous disk was placed on the base pedestal, followed by the undisturbed sample. It was important that the openings under the porous disk were properly flushed to prevent any airlock. A second porous disk was placed on top of the sample. The membrane was stretched over a membrane stretcher and over the sample. Bottom o-rings were stretched over the membrane on the base pedestal. The top cap was then positioned above the top porous disk. The membrane was pulled over the top cap and secured via two o-rings. Procedures for the installation of LVDTS are described later in the Appendix.

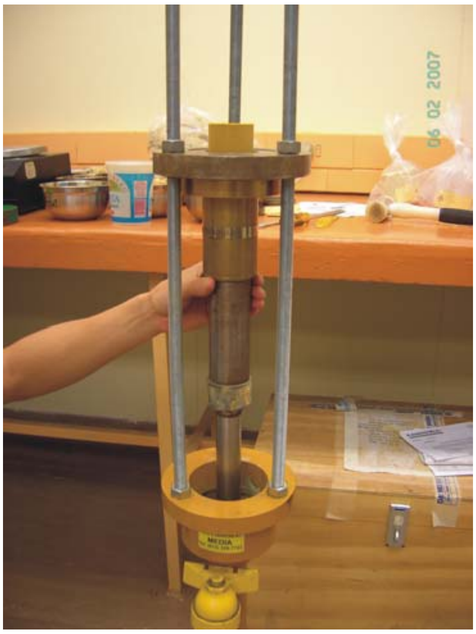
Preparation of moist tamped samples



The split mould used for preparing moist tamped samples was modified to include a top ring and a base to hold the mould together. The top ring and the base were held together using threaded rods and bolts. The modified mould assembly was placed on the hydraulic jack. Material was prepared to the required moisture content 24 hours before preparation to allow the moisture to equalize throughout the material. The sample mass was determined from the target void ratio, the volume of the mould and the moisture content of the material. Material was compacted in five 20mm layers to yield a uniform sample. The sample mass was divided by 5 to obtain the mass of material required per layer. Material was placed in the mould as shown in the figure. Before compaction, the material was stirred to prevent excess compaction on one side.

The compaction rod was inserted into the mould and a stopper was placed on top of the compaction rod. Compaction was done by raising the mould into the compaction rod as shown in the figure. Grading marks on the compaction rod indicate when the layer has reached the required height. The first 3 layers were under-compacted to lesser extents to prevent over-compaction due to compaction of the subsequent layers. A moist cloth was placed on the mould in between compactions to prevent loss of moisture. The compacted layer was scratched before the material for the subsequent layer was added to minimize layering. The process was continued until the entire sample was constructed.

After the sample was completed, the bolts were unscrewed and the base of the mould was removed. The mould and sample assembly was placed on the compaction rod as shown in the figure. The sample was extruded by raising the compaction rod. The use of a hydraulic jack was required to prepare samples at high density, such as the pond material. Preparation of MB and UB moist tamped samples was probably possible with the mould, but for consistency all moist tamped samples were prepared using the hydraulic jack. The extrusion also prevented cracking of the sample when the mould was removed, as is often seen in samples compacted to high densities. Samples were then placed on the pedestal in the same manner as with undisturbed samples.



Preparation of slurry samples

The preparation of slurry samples involved preparation on the triaxial pedestal. After preparation to the required moisture content, the slurry was de-aired for 30 minutes in a desiccator. Preparation of the mould involved first stretching the membrane over the pedestal and securing it with two o-rings as shown in the figure. A customized seal was made to seal the suction applied by the vacuum pump. This vacuum seal was also stretched over the membrane, as seen above the o-rings in the figure. A circular clamp used to clamp the mould was also put in place in advance.

A mould stand was used to raise the split mould to the required height to be clamped against the vacuum seal. The two halves of the split mould were brought together and clamped as shown in the figure. The clamp was tightened around the two spacers. A second, temporary clamp was used to clamp the top of the mould. Caution was exercised so the two split moulds did not to pinch the membrane when clamped, as this will cause leakage. It was also important to ensure that the mould clamps the vacuum seal and that vacuum could be maintained in the chamber between the mould and the membrane.

Insulation tape was used to seal the contact between the two halves of the split mould. Once the tape is in place, a third clamp was used to clamp the mould at mid-height as shown in the figure. The second clamp was removed to make room for the membrane. The membrane was pulled over the top of the mould to create an air-tight chamber between the mould and the membrane. It was important that the membrane was vertical and tight to prevent deformations of the sample.

Once the setup was complete, vacuum was switched on. The vacuum pulled the membrane against the inside of the split mould within which material was deposited. It was important at this stage to ensure the drainage leads were properly flushed, as any air trapped under the porous disk would cause an airlock. A 50mm porous disk was first placed, followed by a 50mm diameter filter paper to prevent material entering the pores of the porous disk. Deposition of slurry involved spooning in layers. Each layer was stirred before the following layer was placed to prevent segregation. Segregation was not observed, as the material was either in a near plastic state (in the case of pond and upper beach samples) or in a flocculated state (in the case of middle beach samples). Stirring also allowed trapped air bubbles to escape. Slurry was deposited to the brim, where after a second filter paper followed by the top porous disk was placed on top of the deposited slurry. The top cap was positioned in place and the membrane was pulled over the top cap and secured via two o-rings. A 10kPa suction was then applied through the top valve, whilst keeping the surrounding suction on. It was also important that the gap between the membrane and the top of the mould was not sealed. This allowed some one-dimensional consolidation to take place. The tube connecting the top cap and the base pedestal was supported to keep the top cap in an upright position. The suction was applied until the 10kpa suction was registered by the pore pressure transducer.

Removal of the mould was done in steps, as some suction drop was encountered during each step. After the entire mould setup was removed, the suction was maintained until a -10kPa was again registered by the pore pressure transducer. The sample was now ready and LVDTs could be installed. During installation of the LVDTs, any slight disturbance caused a drop in the suction in the sample, and it was important that the suction was maintained. If the suction drops below -3kPa, all processes were halted to allow the suction to recover.

Installation of LVDTs

LVDTs were mounted onto clamps and secured onto the membrane using superglue on opposite ends of the sample. Clamps used were similar to that used by Heymann (1998). Clamps were installed at distance of 50mm in the middle half of the sample. The position for the LVDTs were first measured and marked on the membrane. The LVDTs were first mounted on to the top clamp and glued to the sample. The LVDT pins were then held in place while the bottom clamp was glued in place. The pins rested on a flat-headed screw in the bottom clamp. The screws could be used to adjust the initial position of the armature and therefore the initial output of the LVDTs. This was required to accommodate for volume changes before shear so that shearing could start in the range of the highest gain (8). Installation of LVDTs was done in this manner for all samples tested.