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## ModShock™, Pole Test Version



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By J.S.Higgs and D.J.Tongue of Integrity Testing Pty. Ltd.

The Modified Shock test has been in existence since the early 80's, when Davis and Dunn {a} and Higgs et al {b} developed a system to test concrete piles as a substitute for their vibration test systems. The problem with the vibration system being that it was expensive and required interpretation by extremely skilled personnel. The idea was therefore formed that the basis of the vibration test was to produce a Mechanical Admittance plot of the pile's responses to excitation from a mechanical source. They therefore adopted a heavy blow from a hammer or drop weight to substitute the forced vibration. A heavy hammer blow has a broad spectrum of frequencies which with correct processing could produce a similar Mechanical Admittance plot as a vibration test. As stated before the early development was by Davis and Dunn, but the more concentrated efforts for continued development was by Higgs et al {c} in Asia and Australia. In all of the developments, the Modified Shock test systems were used on concrete and steel piles, both having generally homogeneous materials to deal with and as the velocity of the materials is an important part of the analysis, in physical terms quite easy.

In the mid 90's the Australian office of Materials Consultants, Integrity Testing Pty. Ltd. was approached to see if their pile test system could test timber marine piles. Being a commercial consultancy the company agreed to try and after a number of poor attempts and with the help of the then Port of Melbourne Authority {d} the results became acceptable. With numerous modifications the testing of marine timber piles became a major factor in the growth of the company and still to this day up to 10,000 timber marine piles are tested annually.

In early 1998 Integrity Testing Pty. Ltd. was invited by the Electrical Association of New South Wales to participate in a controlled trial {e} to determine if there was a suitable Non Destructive test which could test utility timber poles to determine certain properties of the poles, with a strong bias towards determining the loss of cross section in the vicinity of the ground line. There were over 300 timber utility poles re erected on a prepared site and numerous NDE practitioners and researchers were required to test and report on their findings. We were the first to test the poles and at this stage none of the poles had been excavated around the ground line, this being required by the majority of the other N.D.E. systems under test, so ground line dimensions were obtained from the clients measurements.

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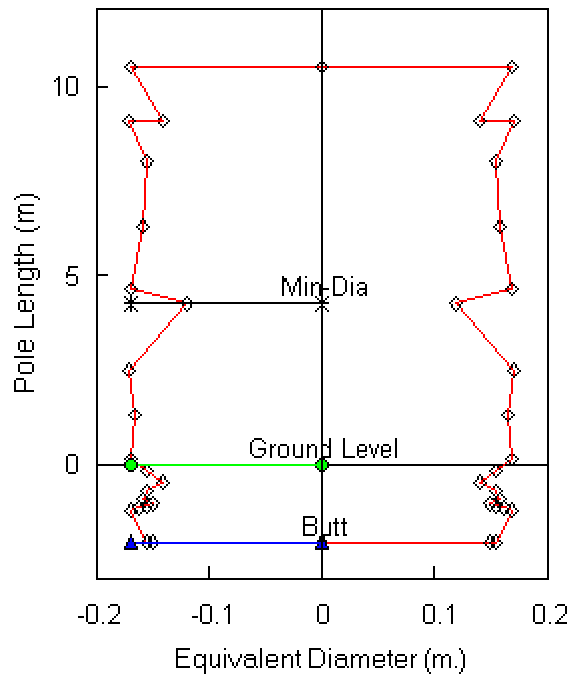
We completed the data capture within 8 hours, even experimenting with various locations for the data capture. Processing followed and was by the then normal pile test program and all the data was processed in three working days, a total time of 32 to 36 hours for both data capture and processing.

Even when we received the first 50% of the results we did not change any of our results, mainly due to be able to see how we fared in a real time situation, as would be required for the system to be used commercially and as also we are a commercial consultancy we could not afford the time to analyse the results in depth. Finally we received the report on our findings in July 2001 {f}, I think this time span indicates the complexity of the research and how difficult it was to assess the different results from the different systems used. On the basis of the findings we did not fair very well in assessing the "Z" modulus in the vicinity of the ground line, but if other results close to the ground line were considered we were a bit better. The calculations for "Z" modulus are dependent on where the section loss occurs either internal or external and we found this to be responsible for a large volume of our errors, as we only measure equivalent diameter. We compared our measured diameters to a calculated diameter from the measured cross sectional area from the report and found that we were very close in this aspect, better than 85% correct to within 10% of the diameters. We therefore deemed a large percentage of our errors were the inability of the system to determine whether the loss of section was internal or external.

In our measured Bending moments we were much better and compared favourably with all the other techniques, which used the "Z" modulus to determine Remaining Strength. Our assessment of these results would indicate that we had problems in determining the precise location of the ground line, but that the diameters compared well with the diameters from the measured cross sectional area. That the Bending Moment calculations were as good or if not better than current practice.

As we stated before the results of the research were time consuming and in the interim period a number of companies expressed interest in the ModShock™ system for the testing of poles, later being designated as the Pole Test system to distinguish it from the pile test programs. The first of the continued research was under the direction of Associate professor Keith Crews acting as tutor to Mr. Bill Woods for his degree at the U.T.S. [Keith Crews was the leader of the research project by EA of NSW]. The research {g} highlighted numerous bugs in the program, as well as a need to define the ground line, though generally the report concluded that the system showed promise. Further research continued with Enerserve, through Mr. Terry Lampard's division and after over 13 months of continued research and development the system now produces the following proven criteria.

The ground line position as well as the total length of the pole can now be measured to within 300mm, that is plus or minus 150mm and has been consistent over a large number of samples. This allows better positioning when trying to determine where the defective areas are on the pole and referenced to the ground line. Though this was a minor aspect of the work with Energy, the measurement of the loss of section was within 10% of the actual loss at any location on the pole.



**2D RESULT Fig:1**

The major research and development with Energy was the proving of the Bending Moment or as it became later referenced to was, how accurate was the Mod-Shock in predicting the bending failure of the pole. Extensive work was carried out with an end result whereby the Mod-Shock could predict within 12% or better of the ultimate failure of the poles tested. The poles were of a large cross section and very representative of poles in the Energy area in Sydney. This was a major breakthrough for the Mod-Shock system and gave an extra dimension for the system and a form of QA for the defect location and dimensioning.

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At present the Mod-shock is operated through a notebook computer and as such is seen to be somewhat outdated with the advent of PDA's into the industry. A further development program, about to commence, is for the program to be developed so it can be operated from PDA's or other similar more robust equipment. Though still at present the system on the Notebooks produces all the correct results and the only possible draw back being the relatively fragile nature of the Notebooks. One authority wanted to strap a Notebook to a Quad bike and go Bush bashing, which essentially a Notebook is not designed to do. We have tested over 50,000 piles and poles using Notebooks and obtained excellent results, but we realise that you must look after your Notebooks and cannot abuse them too much.



**Exposed Pole from 2D result Fig:2**

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At the same time as the Sydney research was going on we continued our research efforts, when time and money allowed, particularly with the assistance of Powerlines Management Systems in Melbourne, ably assisted by Mr. Dennis Clarke and Mr. Tony Veling. The research went off track somewhat due to a lack of the correct hardware and trying to produce a fully automatic system based on a specialised one off P.C. package. We got back on track with new hardware and the acceptance of a semi automatic system, rather than a fully automatic system, based on standard Notebook computers. Results to date with the system in its present state indicates that it can determine faults ANYWHERE on the pole and that the diameters at these defects are comparable to the actual loss of cross section.

With the development of the system on Notebook computers we tried various ways to determine if we could install an acceptance criteria for the poles based on the industry standards. The basic standard used being the minimal circumference allowed for various classes of poles. This worked well for the better timber for class 1 and 2 poles, but failed with the class 3 and lower class poles, particularly for the lower grade timbers such as the Messmates and stringy Barks etc. After testing probably over 3,000 poles we developed an Artificial Intelligence {AI} technique even with the class three poles that indicated which poles were defective, though to what degree we could not ascertain.

In summary we developed the system to be used to give positive results on where the defects were and to what extent the defects had as far as compliance for class 1 and 2 poles were concerned. For the class three and lower class poles we were able to identify the defective poles, but not in all cases the actual loss of section dimensions and tended to exaggerate the loss of section by 10 to 20 %. The end result being, conservative assessments on lower class poles with accurate results for class 1 and 2 poles. The system can be used to test over 100 poles per day, by if required a one man team. The outputs from the results are in a standard text file portable by any system to the clients operating systems with outputs in clear tables and models if required.

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## Perceived Advantages of ModShock™ System.

Probably the biggest advantage is that poles can be inspected, without digging and without drilling and the volume of poles tested per day is easily 100, even higher in Urban areas. We understand that digging is a general requirement for some utilities, but we suggest that as the system identifies any ground line problems, then only preventative anti termite measures would be required if the system does not identify any problems. There is currently research being undertaken on preventative anti termite treatments and we are also testing such a product for long term preventative treatments. We consider that this will be the way to go in the future for even greater economies, but still at present economies exist generally due to the large numbers of poles inspected each day.

Our development has indicated that using the ModShock™ system the results identify a large number of potentially dangerous defects not found in the standard inspections. Failures of poles due to the lack of incorrect inspections are expensive and we believe that with the ModShock™ system these failures would be eliminated. We suggest you visit our web site [www.integritytesting.com.au](http://www.integritytesting.com.au) and select “ Poles “ and you will see one example of a serious defect not found with the standard inspection methods. The ability of the system to find defective areas anywhere on the pole adds a dimension not found before with conventional inspections or any other NDT type system.

After five years of research and development, including extensive field trials we consider the system to be ready to be used by the industry. We already have embarked on a program of testing for one of the large utility companies in Victoria and we are ready to continue with other companies.

Should you require any additional information please contact either David Tongue or John Higgs on 03 54440782, Fax 03 54413810, or E-mail [info@integritytesting.com.au](mailto:info@integritytesting.com.au). or web site [www.integritytesting.com.au](http://www.integritytesting.com.au)

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## Developments

At the Project report stage of the N.D.E. research {f} in June 2001, there was a very positive response that the ModShock™ Pole Test system showed sufficient promise to pursue with the finalisation of its development. The system to be used to inspect a large volume of poles in a short time, to determine which poles require further inspection either, manually or at ground level by one of the N.D.E. systems good at determining location of loss of section. We would consider that 100 to 150 poles could be inspected in a standard working day and that a one man, semi skilled operator could produce the necessary information required. These thoughts were reinforced by Associate Professor Keith Crews from the academia and from industry Mr. Terry Westlake and others from Enerserve. In all a very positive response from the research side as well as the commercial side of the industry.

With the continued development the system has proven the thoughts of both the academia and the industry and is now ready to be utilised and introduced into the industry to be the only method to test utility poles.

### DATA CAPTURE.

- Data capture is a one man operation, using a standard Notebook computer, an A to D interface, a horizontal transducer and a 2Kg lump hammer.
- After booting the program the location of the pole is entered, the diameter of the pole at the test location and strength category for the timber.

The system is armed and via a delay the operator has time to place the transducer on the side of the pole. The pole is then struck three or four sharp blows with the hammer and the resultant reflected seismic waves captured by the transducer and via a cable stored in the NoteBook computer.

### Pole Test

Lastly to enlighten anybody who does not know what is produced from ModShock™, Pole Test, system, we attach a printout of the results, both from the Energy work and the Powerlines work, from poles tested in the recent projects.

Most of the information on the sheet is self explanatory, but we summarise the information below and explain the simplicity in the test operation:-

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## ANALYSIS.

- Analysis can now commence and is either fully automatic or performed by inserting the approximate length of the pole, this can vary up to plus or minus ONE metre of the actual length and the program still obtains the correct information.
- Analysis is now complete and for the defect location system a RATING table is seen on the screen, see attached form on the top left hand side of the form. The rating values can be suited for the various client's requirements, but generally any value 3 and above requires further investigations. The depth to the defects are noted in the same table, so it is easy to determine the location to be inspected for further investigation. In addition to the Defect location in the capacity system the Tip Bending Moment is displayed, as well as the Bending Moment at other locations on the pole.
- Also on the form is a 2D model of the pole with the diameter and lengths identified, on the top right hand side of the form.
- At this point the operator can decide whether the pole requires further inspection or not. If the client requires the decision on acceptance or not, to be carried out by a supervisor the information can be dispatched to the office by electronic or other means for decisions to be made by others.
- Total time for the test is estimated to be 2 to 3 minutes, if the computer is already booted, and the operator is ready to move to the next pole to repeat the test.

## Conclusion

It can be seen that the system is an ideal tool to inspect a large volume of assets in a short period of time, eliminating any digging as in the traditional methods and the other N.D.E. techniques used in the trial. The system is also easy to use in a friendly work environment with no bending at difficult angles. We therefore believe the answer and the technical way forward to minimise inspection costs and to save on costly pole failures, particularly on pole failures above ground is to utilise the ModShock™ Pole Test system for routine pole inspections.

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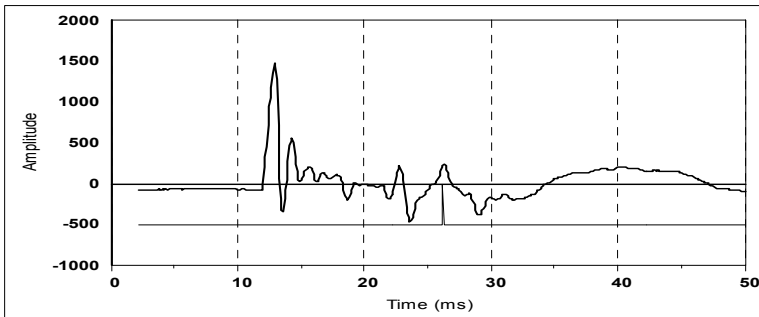
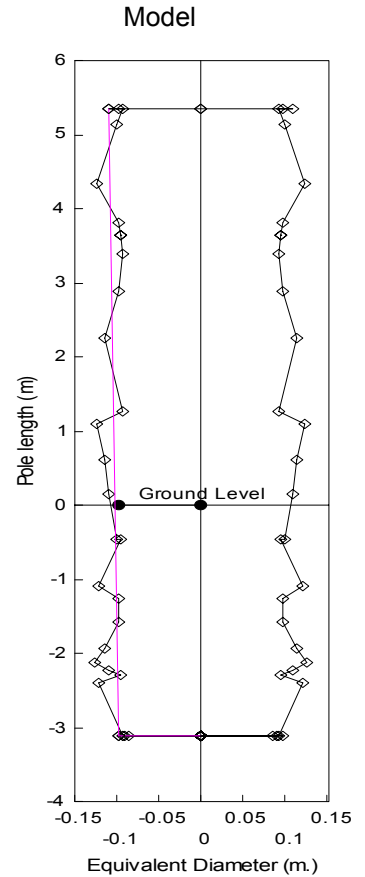
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## Example Mod-Shock™ Pole Test results

### Mod-Shock™ Pole

Test No: 9e      Pole No: MP009  
**Pole Capacity**      **9 Kn**      **7 Kn BM**      **59**

Depth	Diameter	Corrected	Rating	Cor %	True %	Cap kN
5.36	0.19	0.18	2	0.84	0.92	11
5.36	0.22	0.20	1	0.94	1.03	11
5.36	0.19	0.17	2	0.81	0.89	11
5.15	0.20	0.18	1	0.85	0.94	11
4.34	0.25	0.22	1	1.07	1.18	14
3.83	0.19	0.18	2	0.84	0.92	15
3.66	0.19	0.17	2	0.82	0.90	16
3.66	0.19	0.17	2	0.81	0.89	16
3.40	0.19	0.17	2	0.81	0.89	17
2.89	0.19	0.18	2	0.84	0.92	20
2.27	0.23	0.21	1	0.98	1.08	26
1.27	0.19	0.17	2	0.81	0.89	---
1.10	0.25	0.22	1	1.07	1.18	---
0.61	0.23	0.21	1	0.98	1.08	---
0.16	0.22	0.20	1	0.94	1.03	---
-0.45	0.20	0.18	1	0.86	0.94	---
-0.46	0.19	0.17	2	0.82	0.90	---
-1.09	0.24	0.22	1	1.03	1.14	---
-1.25	0.20	0.18	2	0.85	0.93	---
-1.56	0.19	0.18	2	0.84	0.93	---
-1.93	0.23	0.21	1	0.99	1.08	---
-2.12	0.25	0.23	1	1.08	1.18	---



Deflection mm	Load KN.
0.00	0.00
2.06	3.15
3.49	6.65
4.39	8.18
25.00	43.25

