# A Review of Statnamic Literature: 1989–1994

by

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## 1. Introduction

The concept of Statnamic testing first came to the attention of the piling community in 1989. By the end of 1994, a total of twenty-five papers and articles dealing with this subject (Appendix A) were published in journals and conference proceedings.

Until the end of 1993, all authors, without exception, thought it necessary to introduce each publication with a description of the system and a historical review. This comes as no surprise, since 75% of these publications include the word "innovative" (or one of its synonyms) in their title.

From the beginning, the large majority of published work has focused on case histories, mainly comparing the results of Statnamic tests with those of conventional methods. Paucity of case histories at the early stages, together with understandable marketing zeal, led to much publication duplication: in fact, a few of the references in Appendix A are essentially identical.

Early publications claimed that Statnamic results showed good agreement with conventional tests. However, users soon began to suspect that Statnamic results needed some form of adjustment before they could be used to predict static behavior. The first hint in this direction was given in 1992, when two distinct approaches to the problem were published. A third method was added in 1994. It is now generally accepted that Statnamic test results do *not* represent static pile behavior.

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## 2. Statistics

### 2.1. Annual Output

In the year 1989, Statnamic testing was mentioned in only one publication. During the next four years (1990–1993), the annual harvest leveled-off at between three and five publications. The year 1994 saw a marked increase at nine, and 1995 will bring a new record at around 30 papers (mostly presented at this seminar). With the continuation of this trend, an elementary extrapolation to the year 2000 gives a predicted number of more than 120 publications!

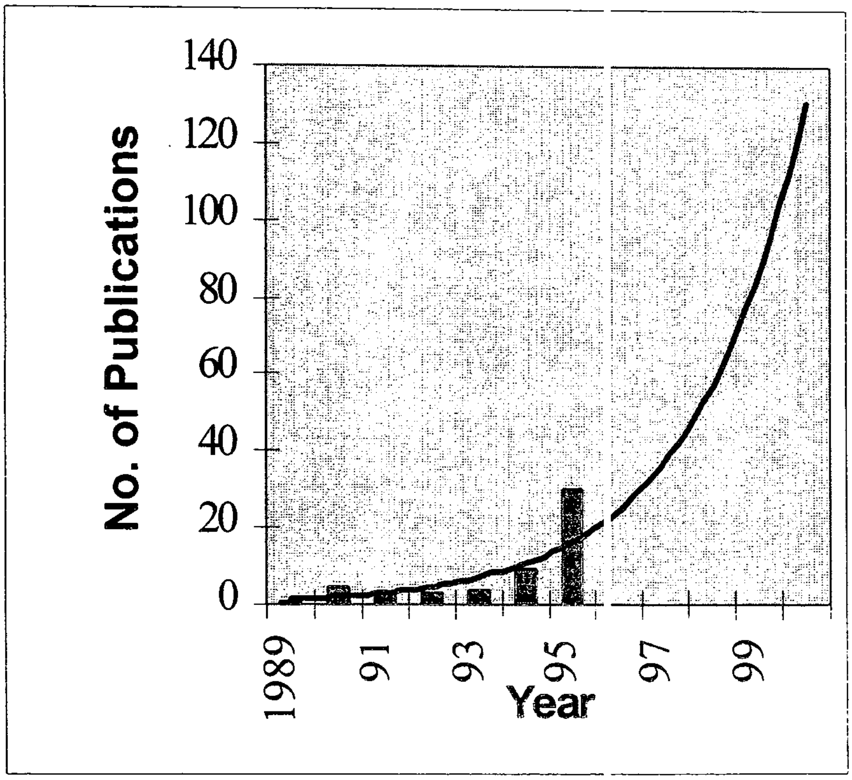


Fig. 1: Annual Output of Statnamic Literature

### 2.2. Subject Matter

Clearly, the most popular subject is case-histories, presented in not less than twenty papers. A brief historical review is given in fifteen, while only six papers are of analytical character.

### 2.3. Authorship

Understandably, Patrick Bermingham is the champion author, with eight publications to his credit. Bob Horvath and Matthew Janes are a close second with seven each, while Peter Middendorp is the author of four. Nineteen other authors, each with one or two publications to his credit, share an aggregate output of fifteen papers.

## 3. Case Histories

Making comparisons between pile loading tests is a difficult task at best. On one hand there is the variability inherent to all geotechnical testing, while on the other hand (because of the high expense involved) there are never enough tests to form a significant statistical sample. However, what makes things really difficult is the lack of an established standard for comparison: it is well known that pile behavior under initial loading is totally different from its behavior upon subsequent reloading. Subjecting a given pile to a series of tests of different nature leads, therefore, to unavoidable complications.

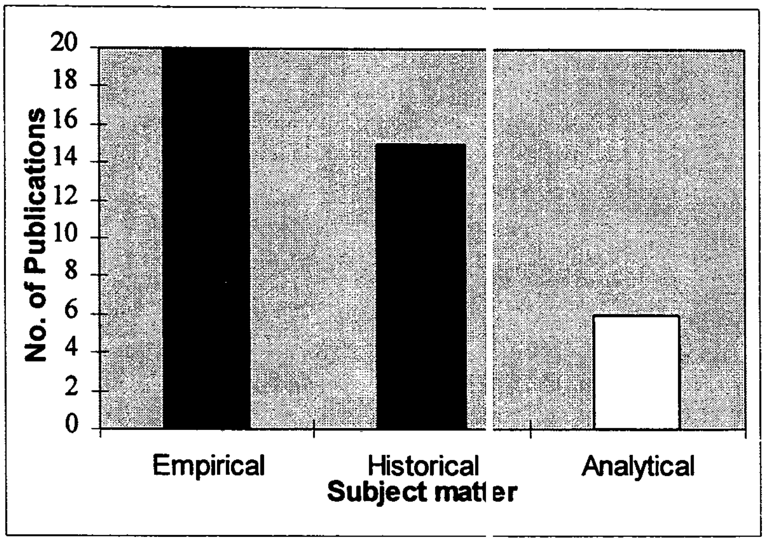


Fig. 2: Subject Matter of Publications

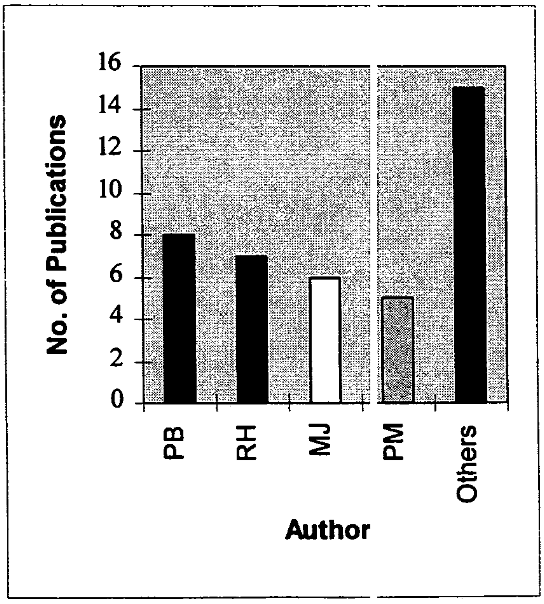


Fig. 3: Distribution of Authorship

The results from twenty-one test sites are reported in the publications. The most popular is the McMaster site, leading with seven quotations, followed by Texas A&M, Ottawa and Burlington with four each. Later, when more case histories had been accumulated, individual sites were mentioned not more than once or twice.

Looking at the records from these sites, one encounters all possible combinations of tests:

- In 55 percent of the cases reported, the same piles were subjected first to static tests, and then to Statnamic loading. In some instances, the static tests included cyclic loading or both compression and tension.
- In 27 percent of the sites, static tests were performed on different piles, or not done at all.
- In the remaining 18 percent, the Statnamic loading was applied first, followed by static (or in one case dynamic) loading.

Obviously, with such data one can prove anything (or nothing at all), depending upon ones' point of view.

In addition, there is also a lack of uniformity in the reporting format: forces, displacements, velocities and accelerations are all vectors, and should be plotted pointing in the right direction. Since, during a given test, at least some of them will change direction, following this rule is extremely important.

To make life even more complex, certain authors still prefer to use Imperial units. While this practice may causes certain difficulties in static analysis, it becomes virtually impossible when dealing with dynamic problems: when force is reported in kips and displacement in inches, the units of mass become kips $sec^2$ per inch, which may be rather mysterious even to educated people.

## 4. Modeling

The model suggested by El Naggar & Novak (10,17) is no more than an enhanced Smith model (Smith 1960), in which the parameters are obtainable from routine geotechnical tests. The parameters, however, are iteratively modified by some curve-fitting technique and in the process may lose their original geotechnical significance. The method is applicable to either clay or sand, but provides no solution to complex soil profiles or rock.

The model proposed by Middendorp *et al.* (11) consists of modifying the load-displacement curve: the difference between the maximum applied force and the force acting at the lowest point of the curve (zero-velocity point) is wholly attributed to damping. It is further assumed that the damping force is directly proportional to the velocity throughout the test. After the damping constant C is calculated, all points on the load-displacement curve are moved leftward by the product of the velocity at that point v(t) and the damping constant C.

This approach has certain weaknesses:

- It ignores strong evidence (Litkouhi and Poskitt 1980) that damping in piles is rather non-linear.
- In certain cases (such as massive concrete piles), inertia effects may become very important. In the Middendorp model, however, these are totally disregarded.

The load-displacement curve (Fig. 4) is not always smooth, and a certain error is inherent in each value measured from the graph. The following example will illuminate this: imagine the maximum force is 6 MN and the force at maximum displacement is 5.5 MN. Say that both values are determined with an accuracy of 3%. The difference is 0.5 MN, with a standard deviation of $0.03 \times (6+5.5) = 0.35$ MN, or 70 percent. Clearly under similar circumstances, the resulting C is rather inaccurate.

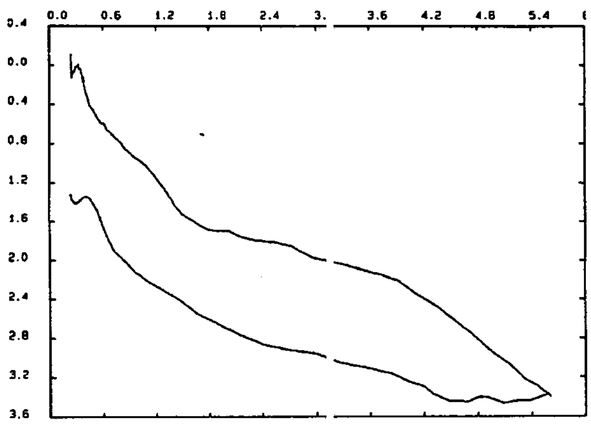


Fig. 4: A typical (?) Statnamic test result

Yamashita *et al.* (24) utilized finite element techniques to predict Statnamic behavior. This is a powerful, though somewhat cumbersome, approach. The main obstacle, as usual, lies with deciding the correct material properties.

## 5. Conclusions

Considering all work published to date, the following items appear as most desirable future developments:

- A widely accepted standard for the Statnamic test procedure (preferably by ASTM), which will also dictate the right testing sequence when a given pile is subject to more than one type of test. The standard shall also specify which units to use and the direction of axes to be used to present the results.
- A comprehensive compilation of Statnamic results and Statnamic literature, including comparisons with other methods (case histories showing discrepancies should be specially encouraged)!
- Development of user-friendly, public domain software that can directly read Statnamic files and analyze them by all available methods. This will introduce the necessary redundancy in the system and enable the engineer to base his judgment on better data.
- Production of an annually updated disk (perhaps a CD-ROM) including cumulative literature and a test-result database as well as pertinent software. Interim data should be available to all interested parties via the Internet.

## 6. References

Litkouhi, S and Poskitt, T.J (1980): Damping Constants for Pile Driveability Calculations. *Geotechnique*, 30:77–86

Smith, E.A.L. (1960): Pile Driving Analysis by the Wave Equation. *J. Soil Mech. and Found Div. ASCE*, 86 (SM4), pp. 35–61

## Appendix A
## A List of Statnamic Publications (1989–94)

1. Bermingham, P., Janes, M.: "An Innovative Approach to Load Testing of High Capacity Piles", *Proceedings of the International Conference on Piling and Deep Foundations,* London, May 15–18, 1989, pp. 409–413.
2. Horvath, R.G.: "**STAT***NAMIC*: An Accurate and Innovative Load Test Method for High Capacity Deep Foundations", *Foundation Drilling,* March/April 1990, pp. 8–12.
3. Janes, M.: "**STAT***NAMIC*: An Innovative Test Method for Pile Foundations", *Advanced In-Situ Monitoring,* (Seminar) Canadian Geotechnical Society, Southern Ontario, September 1990.
4. "Pieux de Fondation: Nouvelle Technique de Vérification", *Chantiers,* Novembre 1990, Volume 7, No 8, pp. 10–13.
5. Horvath, R.G., Bermingham, P., Janes, M.: "The **STAT***NAMIC* Test. An Innovative Method for Testing Deep Foundations", *CSCE Annual Conference,* 1990.
6. Horvath, R.G., Bermingham, P., Janes, M.: "The **STAT***NAMIC* Loading Test. An Innovative Method for Predicting Capacity of Deep Foundations", *43rd Canadian Geotechnical Conference,* 1990.
7. Janes, M., Bermingham, P., Horvath, R.: "Pile Load Test Results Using the **STAT***NAMIC* Method", *Proceedings of the 4th International Conference on Piling and Deep Foundations,* Stresa, Italy, April 7–12, 1991, pp. 481–489.
8. Middendorp, P., Reiding, F.J.: "**STAT***NAMIC*: A Cost Effective Alternative for Test Loading Piles and Caissons", *Proceedings of the 9th Asian Regional Conference on Soil Mechanics and Foundation Engineering,* Bangkok, Thailand, December 9–13, 1991.
9. Janes, M.C., Bermingham, P.D., Horvath, R.G.: "An Innovative Dynamic Test Method for Piles", *Proceedings: 2nd International Conference on Recent Advances in Geotechnical Earthquake Engineering and Soil Dynamics,* St. Louis, Missouri, March 11–15, 1991, pp. 253–261.
10. El Naggar, M.H., Novak, M.: "Analytical Model For An Innovative Pile Test", *Canadian Geotechnical Journal,* vol. 29, 1992, pp. 569–579.
11. Middendorp, P., Bermingham, P., Kuiper, B.: "**STAT***NAMIC* Load Testing of Foundation Piles", *Proceedings of the 4th International Stress Wave Conference,* The Hague, September 21–24, 1992.

12. Middendorp, P.: "The First **STAT**_NAMIC_ Load Testing of Foundation Piles in Europe", _Evolution in Experimentation for Constructions,_ Centro Comune di Ricera di Ispra (VA), Italy, October 1992.

13. Horvath, R.G.: "**STAT**_NAMIC_ Load Tests in Drilled Foundations in Sand: I-40 Rio Grande River", _Foundation Drilling,_ December/January 1993, pp. 21–24.

14. Randy Quinn.: "Engineers are Impressed with High-Capacity Pile Test", _Engineering News Record_, September 13, 1993, page 25. (Article)

15. "Evaluation of Static Capacity of Deep Foundations from **STAT**_NAMIC_ Testing", Brown, D.A., _Proceedings of the South East Transportation and Geotechnical Engineering Conference,_ Natches, Mississippi, October 4–8, 1993.

16. Horvath, R.G., Bermingham, P., Middendorp, P.: The Equilibrium Point Method of Analysis for the **STAT**_NAMIC_ Loading Test with Supporting Case Histories", _Proceedings of the Deep Foundations Conference,_ Pittsburgh, Pennsylvania, October 18–20, 1993.

17. El Naggar, M.H., Novak, M.: "Non-Linear Model for Dynamic Axial Pile Response", _Journal of Geotechnical Engineering,_ Vol 120, No. 2, February, 1994.

18. Janes, M., Sy, A., Campanella, R.G.: "A Comparison of **STAT**_NAMIC_ and Static Pile Load Tests on Steel Pipe Piles in the Fraser Delta", Vancouver Geotechnical Society Symposium on Deep Foundations, Vancouver, British Columbia, May 1994.

19. Yamashita, K., Fukuhara, T.: "Kinetic and Dynamic Loading Tests of a Cast-In-Place Concrete Pile", _Proceedings of the Fifth DFI International Conference_, Bruges, Belgium, June 13–15, 1994.

20. Komornik, A., Amir, J.M.: "Quality Control at Pier MB-2", _Proceedings of the Fifth DFI International Conference_, Bruges, Belgium, June 13–15, 1994, pp 4.1.1–4.1.8.

21. de Kruijff, H., Vinks, T.N.J.: "Installation and Testing of a New Vibration-Free Piling System, The Europile", _Proceedings of the Fifth DFI International Conference_, Bruges, Belgium, June 13–15, 1994,. pp 4.9.1–4.9.8.

22. Matsumoto, T., Tsuzuki, M., Michi, Y.: "Comparative Study of Static Loading Test and **STAT**_NAMIC_ on a Steel Pipe Pile Driven in a Soft Rock", _Proceedings of the Fifth DFI International Conference_, Bruges, Belgium, June 13–15, 1994, pp 5.3.1–5.3.7.

23. Matsumoto, T., Tsuzuki, M.: "**STAT**_NAMIC_ Tests on Steel Pipe Piles Driven in a Soft Rock", _Proceedings of the International Conference on Design and Construction of Deep Foundations_, Orlando, Florida, December 6–8, 1994.

24. Yamashita, K., Tsubakihara, Y., Kakurai, M., Fukuhara, T.: "Analytical Study of **STAT**_NAMIC_ Test of a Cast-In-Place Concrete Pile", _Proceedings of the International Conference on Design and Construction of Deep Foundations_, Orlando, Florida, December 6–8, 1994.

25. Bermingham, P., Ealy, C.D., White, J.K.: "A Comparison of **STAT**_NAMIC_ and Static Field Tests at Seven FHWA Sites", _Proceedings of the International Conference on Design and Construction of Deep Foundations_, Orlando, Florida, December 6–8, 1994.