# Evaluation of Lightweight Profilers for Construction Smoothness Evaluation

**Final Report**
**for**
**MLR-02-02**

February 2004

Highway Division

**Iowa Department Of Transportation**

# Evaluation of Lightweight Profilers for Construction Smoothness Evaluation

**Final Report**
**for**
**MLR-02-02**

By
Kevin B. Jones
*Testing Engineer*
*515-239-1237*
*Fax: 515-239-1092*

and

Jason Omundson
*Special Investigations Engineer*
*515-239-1357*
*Fax: 515-239-1092*

Office of Materials
Highway Division
Iowa Department of Transportation
Ames, Iowa 50010

February 2004

## TECHNICAL REPORT TITLE PAGE

**1. REPORT NO.**

MLR-02-02

**2. REPORT DATE**

February 2004

**3. TITLE AND SUBTITLE**

Evaluation of Lightweight Profilers for
Construction Smoothness Evaluation

**4. TYPE OF REPORT & PERIOD COVERED**

Final Report, October 2002 to December 2003

**5. AUTHOR(S)**

Kevin B. Jones
Testing Engineer

Jason Omundson
Special Investigations Engineer

**6. PERFORMING ORGANIZATION ADDRESS**

Iowa Department of Transportation
Office of Materials
800 Lincoln Way
Ames, Iowa 50010

**7. ACKNOWLEDGMENT OF COOPERATING ORGANIZATIONS/INDIVIDUALS**

**8. ABSTRACT**

High-speed non-contact laser profilers have become the standard testing equipment for pavement management ride quality testing. The same technology used in the high-speed profilers is now being used in lightweight profilers for construction smoothness testing. The lightweight profilers have many advantages over the California 25-foot profilograph. Despite the many advantages of the lightweight profilers, there is resistance from the contracting industry toward eliminating the 25-foot profilograph for construction ride testing. One way to reduce or overcome the resistance is to evaluate and demonstrate the advantages/disadvantages of the lightweight profiler in actual field use in Iowa.

The Objective of the study was to purchase a lightweight profiler and to evaluate its suitability for construction smoothness quality verification and quality acceptance on Iowa projects. A lightweight profiler, an Ames Engineering, Inc. LISA single laser unit, was received in February 2003 for the study. Based on the work done during the 2003 construction season, the following conclusions can be made:

1. For HMA surfaces, the LISA correlated well with the contractors' profilographs.

2. LISA results are significantly affected by longitudinal tining on PCC Pavements. Without improvements to the hardware and software, LISA as well as the ICC high-speed profiler will not give accurate results. A laser system upgrade is needed.

3. A significant timesaving was realized by using the LISA. The larger the project, the more the timesavings. The portability of the LISA allowed the District to test a number of locations within a project and to test more than the minimum 10% when the situation warranted.

4. Increasing visibility and reducing time in the construction zone improved safety.

5. Much less physical ability was needed to use the LISA. One person with limited lifting capabilities could set up and operate the unit.

6. With the current Iowa DOT specification, the LISA cannot totally replace the profilograph. Bridges and short segments with no adjoining pavement would still require a profilograph.

**9. KEY WORDS**

Profilograph
Lightweight profiler
Pavement smoothness

**10. NO. OF PAGES**

9

## TABLE OF CONTENTS



## DISCLAIMER

## INTRODUCTION

High-speed non-contact laser profilers have become the standard testing equipment for pavement management ride quality testing. The same technology used in the high-speed profilers is now being used in lightweight profilers for construction smoothness testing. The lightweight profilers have many advantages over the California 25-foot profilograph. Despite the many advantages of the lightweight profilers, there is resistance from the contracting industry toward eliminating the 25-foot profilograph for construction ride testing. One way to reduce or overcome the resistance is to evaluate and demonstrate the advantages/disadvantages of the lightweight profiler in actual field use in Iowa.

Another incentive for evaluating the lightweight profiler is that the current DOT test equipment is nearing the end of its useful life. The manual profilographs have been in operation since the early 1980's and the ProScan reduction units have been in use since the early 1990's. Within the next 3 to 5 years, the DOT is going to need to move toward computerized 25-foot profilographs or the lightweight profilers.

Ride is a very important factor for perceived quality of a pavement by the public and the pavement management system. The pressure to build smooth pavements and the expectation to pay significant incentives for smooth pavements means that measuring the ride quality accurately is going to continue to be vital to both the DOT and the contractors.

## OBJECTIVE

The objective of the project was to purchase a lightweight profiler and to evaluate its suitability for construction smoothness quality verification and quality acceptance on Iowa projects.

## EQUIPMENT

The lightweight profiler, an Ames Engineering, Inc. LISA single laser unit, was received in February 2003 (Figure 1). It was purchased using the results of the Illinois DOT evaluation process for selecting a lightweight profiler. The unit consists of a laser, accelerometer, distance measuring device, automatic start/stop sensor, computer, and printer. A "true" profile is captured by the computer. The unit weighs about 1000 pounds with the operator and travels at 10 to 12 miles per hour when testing.


**Figure 1.** Ames Engineering Inc. LISA

## EQUIPMENT VERIFICATION

To verify the accuracy of the LISA unit, several comparative tests were done.

**Minnesota DOT Certification**
The Minnesota DOT was very helpful in allowing the Iowa LISA to participate in their profilograph/ profiler certification process. The certification track is at the MN/ROAD site northwest of Minneapolis. The Iowa LISA met the Minnesota DOT requirements for repeatability and accuracy.

**High-Speed Profiler to LISA Comparison**
The LISA unit was also compared to the International Cybernetics Corporation (ICC) high-speed inertial profiler used by the Iowa DOT. Figure 2 and 3 show the results of the Profilograph index (P.I.) comparison and the international roughness index (IRI) comparison on dense graded HMA. The forty-five HMA sections represented two new overlays, one of relatively good ride quality and the other of average ride quality.

**Comparisons on Longitudinally tined PCC Pavement**
One area of weakness for the current laser profilers is their inability to simulate a tire footprint on longitudinally tined PCC pavements. The laser footprint is small enough that it will go into the tines rather than bridge them. The standard practice in Iowa has been to use longitudinal tining. Four profilographs and the LISA were run on twenty segments

of a new longitudinally tined PCC pavement. Figures 4 and 5 show the results of that testing. There is a relationship between the profilographs and the LISA. However the LISA profile results in a significantly higher profile index. The results demonstrated that the current LISA is not appropriate for smoothness acceptance on longitudinally tined PCC pavements. Development work is underway to overcome the problem.

The LISA unit was also compared to the ICC profiler on longitudinally tined pavements. Both units were affected by the tining (Table 1). The first section had very deep longitudinally tining. The ICC laser and or software was able to partially average out some of the effect.

**Table 1.** Profiler Comparison on Longitudinally Tined Pavement

| | P.I. 0" (in/mi) | | IRI (m/km) | |
|---|---|---|---|---|
| Location | ICC | LISA | ICC | LISA |
| US 20 MP 176 to 179 | 35.5 | 47.1 | 1.39 | 1.82 |
| US 20 MP 181.3 to 184 | 41.9 | 42.4 | 1.63 | 1.68 |
| US 20 MP 184 to 185.3 | 34.6 | 33.8 | 1.39 | 1.37 |

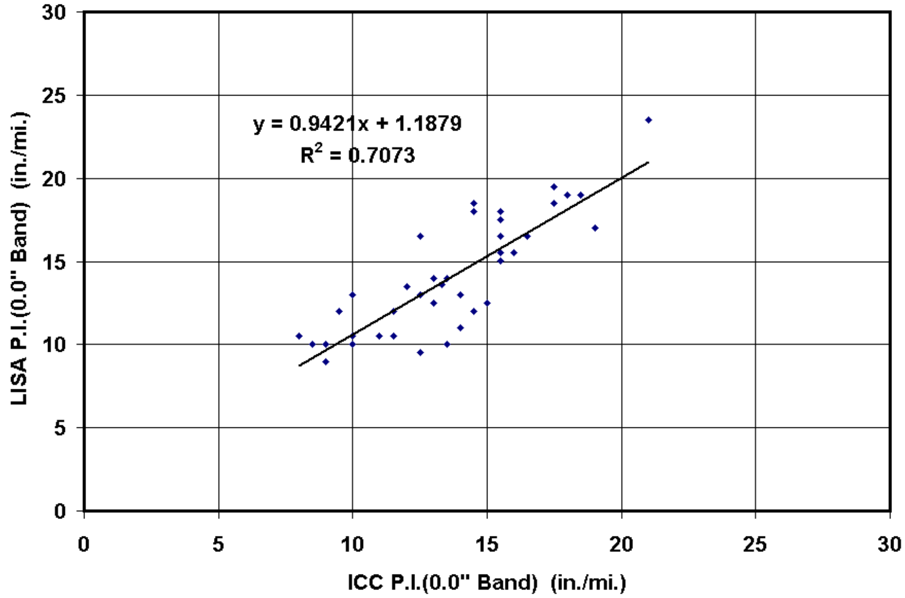


**Figure 2.** Profilograph index comparison between the ICC profiler and the LISA on forty-five 0.1-mile HMA segments.

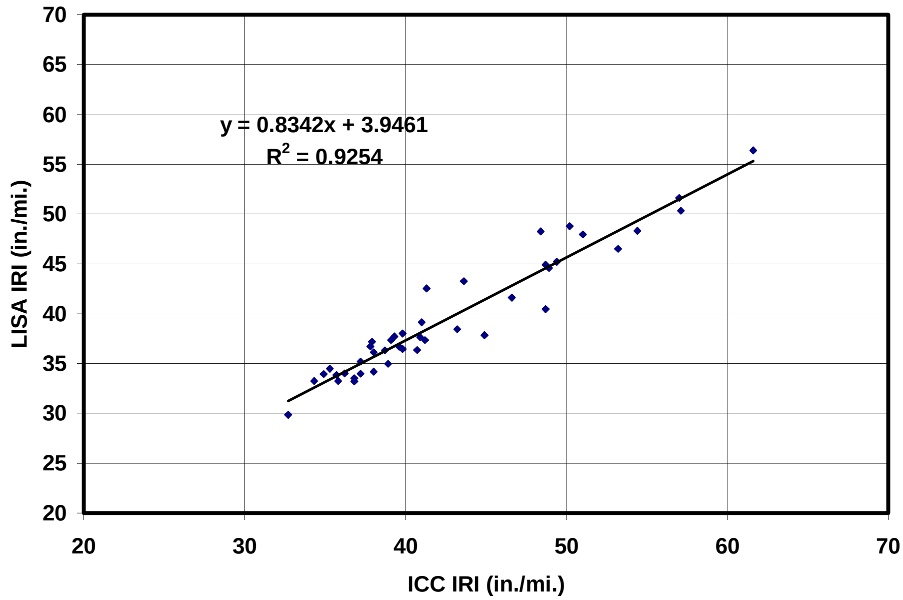


**Figure 3.** International Roughness Index (IRI) comparison between the ICC profiler and the LISA on forty-five 0.1-mile HMA segments.

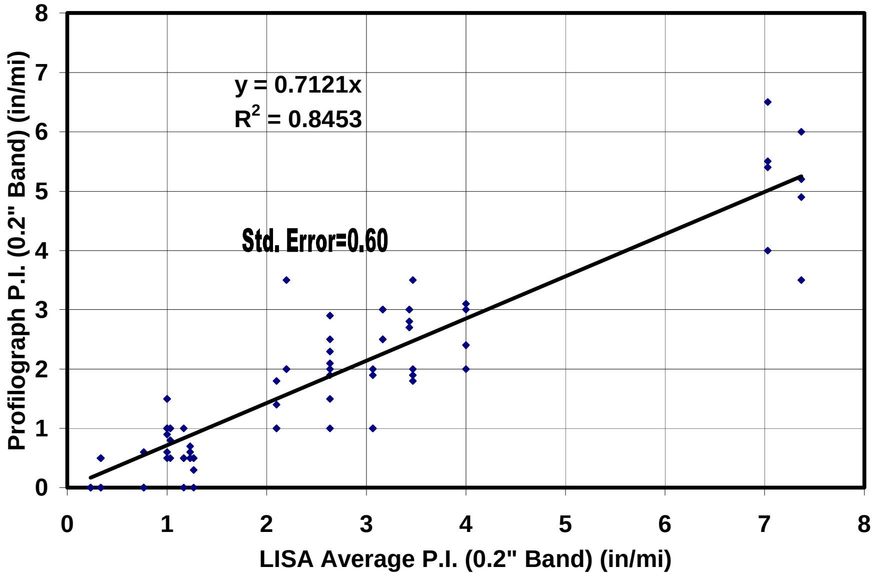


**Figure 4.** Profilograph index comparison between the LISA and four profilographs on twenty 0.1-mile PCC segments with the 0.2" blanking band setting.

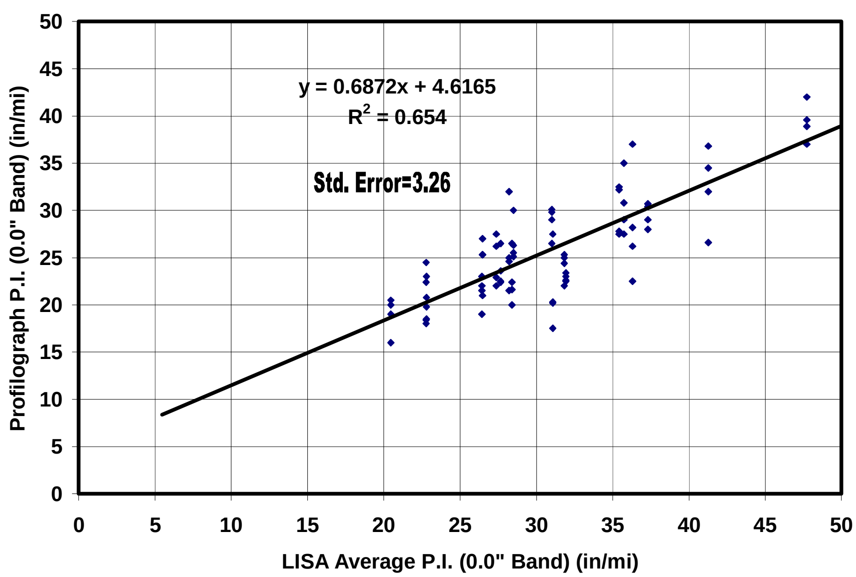


**Figure 5.** Profilograph index comparison between the LISA and four profilographs on twenty 0.1-mile PCC segments with the 0" blanking band setting.

## PROJECT VERIFICATION TESTING

Three Districts used the LISA during the 2003 construction season to perform their ten percent verification of the contractor's test results. The results of that verification testing are in Table 2. Correlation was easily achieved on the HMA pavements.

**Table 2.** District Verification Results for 2003 Construction Projects

| Pavement Type | Contractor P.I. (in/mi) | LISA P.I. (in/mi.) |
|---|---|---|
| PCC | 1.50 | 2.30* |
| PCC | 1.80 | 2.00* |
| PCC | 2.60 | 2.50* |
| PCC | 5.20 | 4.60* |
| HMA | 0.67 | 0.88 |
| HMA | 1.24 | 0.91 |
| PCC | 3.49 | 4.10* |
| PCC | 1.20 | 1.05* |
| PCC | 0.43 | 0.46* |
| HMA | 0.27 | 0.50 |
| HMA | 0.21 | 0.05 |
| HMA | 0.08 | 0.12 |
| HMA | 0.40 | 0.65 |
| HMA | 0.40 | 0.60 |
| HMA | 5.10 | 4.50 |
| HMA | 2.50 | 1.50 |
| HMA | 2.50 | 3.90[1] |
| HMA | 2.80 | 1.29 |
| HMA | 1.90 | 1.14 |
| HMA | 1.23 | 0.88 |
| HMA | 0.89 | 0.75 |
| HMA | 0.86 | 0.69 |

* Correction factor applied to adjust for texture affect.
[1] DOT report covered area not covered by the Contractor.

## OBSERVATIONS FROM LISA EVALUATION

After testing several types of projects through the construction season, the following advantages and disadvantages were noted for the LISA versus the California Profilograph:

**Advantages**

- Increased productivity- The LISA unit was much quicker to setup for testing (5 to 10 minutes vs 20-30 minutes), much faster during testing (10 to 12 mph vs 2 to 3 mph), and much quicker and easier to load up after testing (5 minutes vs 15 to 20 minutes) than a Profilograph. One person could unload, operate, and load the unit with little physical effort needed.

- Increased safety- The LISA spent less time in traffic, was more visible, and more maneuverable than the profilograph. Another aspect of safety is the elimination of bending and lifting that is required for the Profilograph.

- Collected true profile- The LISA collected a true profile, which allows for other ride quality indexes to be calculated.

**Disadvantages**

- Initial Cost- The LISA unit costs $47,000 including the trailer, considerably more than a computerized profilograph. Operating costs are expected to be higher also.

- Longitudinal tining on PCC pavement- None of the currently available lightweight profilers are able to compensate for the tining in PCC pavement. Work is underway to correct the situation.

- Continuous testing- The LISA unit must be moving at a constant speed to collect a good profile. With the profilograph, the operator can stop to move traffic control devices, equipment, and debris or to mark pavement areas for grinding. This is also an issue on 2-lane paving where the lane closure is moving along with the paving.

- Moving start/ lead in- The LISA unit needs to have some lead in profile and must be up to speed to start collecting a good profile. Open headers, bridge approaches, or equipment in the way limit how close the LISA can get to the section end.

## CONCLUSIONS

Based on the work done this construction season by the three Districts, the following conclusions can be made:

1. For HMA surfaces, the LISA correlated well with the contractors' profilographs.

2. LISA results are significantly affected by longitudinal tining on PCC Pavements. Without improvements to the hardware and software, LISA as well as the ICC high-speed profiler will not give accurate results. A laser system upgrade is needed.

3. A significant timesaving was realized by using the LISA. The larger the project, the more the timesavings. The portability of the LISA allowed the District to test a number of locations within a project and to test more than the minimum 10% when the situation warranted.

4. Increasing visibility and reducing time in the construction zone improved safety.

5. Much less physical ability was needed to use the LISA. One person with limited lifting capabilities could set up and operate the unit.

6. With the current Iowa DOT specification, the LISA cannot totally replace the profilograph. Bridges and short segments with no adjoining pavement would still require a profilograph.

## RECOMMENDATIONS FOR STATEWIDE IMPLEMENTATION

A two-step approach is recommended for implementation. It is recommended that a second LISA unit be purchased for two Districts to share during the 2004 construction season. The current unit will be shared between the Ames District and the districts not included in the 2003 evaluation. The additional year of testing will allow for evaluation on the upgraded LISA sensor on PCC texture and additional evaluation into the logistics and costs of sharing units among districts.

The second step of the implementation is to assess the logistics, advantages, disadvantages, and costs of the most practical options. Because of the cost and the efficiency of the LISA, it does not appear to be practical for each District to have a unit. The most practical options identified are:

- Option 1- Central operation of the LISA and high-speed profiler with shared use of new computer profilographs.

- Option 2- Share use of three lightweight profiler units and shared use of new computer profilographs. Use the high-speed profiler for high traffic or very long projects.

- Option 3- Status Quo option of continuing the current operation with only a replacement of the old profilographs and the ProScan scan units.

## ACKNOWLEDGEMENT

The authors wish to extend appreciation to Jeff Brinkman, Mike Magers, and Darrel Carr with the District Materials Offices in Ames, Atlantic, and Sioux City and the Special Investigations Staff for their assistance with the field testing and evaluation of the LISA.