Static and Dynamic Sign Sheeting Testing Using In-Vehicle Observers

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ABSTRACT

As is common in many areas of transportation engineering, manufacturers bring new products to market with claims of superior performance, often before industry standards have been established. This results in a need for a method to judge claims among competing manufacturers that their products are equivalent to or better than products currently in use. For the purpose of evaluating sign sheeting material, observational studies using static testing—fixed distance, observer not moving, with a subjective rating the response variable—have been used for this purpose, but are difficult and expensive to perform because the test facility must be traffic free and simulate actual roadway, lighting and sign placement conditions. This paper explores the use of dynamic testing—observer moving at roadway speed, legibility distance the response variable—and directly compares it to static testing in a single observational study. The results suggest that the use of dynamic testing alone for evaluation of sign sheeting materials during nighttime, dry conditions is plausible. This is a useful conclusion because dynamic testing is more economical, as it can be conducted on an open roadway, and potentially could be applied to a much wider variety of actual traffic, lighting and environmental conditions than static testing can replicate.

INTRODUCTION

Limited resources are available to state Departments of Transportation (DOTs) for maintenance, including traffic control signs, because of expanding needs and the current recession (*1, 2, 3, 4*). Because of this, it is important to ensure that resources allocated to a product provide the best combination of safety and price. Technology continues to improve sign sheeting products for use in traffic control devices. At the time of this work, products by at least two manufacturers were noted as “superior” new products by respective manufacturers, marketed to compete directly with a known “superior” product currently in use by the Arizona Department of Transportation (ADOT). However, the manufacturers’ claims regarding these new products are essentially untested. If the claims regarding these new products are true, increased competition will typically result in a reduction in the cost to ADOT for the “superior” type of product they are purchasing. All of these products are advertised as having features beyond current ASTM standards, primarily in retroreflectivity, therefore no standards exist for physically testing the products.

Since no physical testing standards have been established, observational testing was used to compare the new products against the product currently used and believed to be “superior.” While there are two new products purported to be contenders, only one manufacturer ultimately delivered material for testing. Two types of observational testing were used: static and dynamic. In its basic form, static testing locates the observer at different fixed distances from the sign and the observer rates the materials on the sign. Dynamic testing locates the observer in a moving vehicle and the observer states when she or he can first “read” the sign with this distance from the sign being recorded. Both static testing (*5*) and dynamic testing (*6, 8, 8, 9*) have been used to test a variety of parameters regarding the interaction of drivers and signs. But a literature search has found few papers where the two methods were directly compared with the goal of eliminating one or the other. The focus of this paper is to present evidence that dynamic testing could be used as a standalone method without the need to use the more difficult and more expensive static testing.

SITE, SIGNING AND SAMPLING DESCRIPTIONS

Three signs were constructed, all similar but each having a different legend; one sign is shown in FIGURE 1.

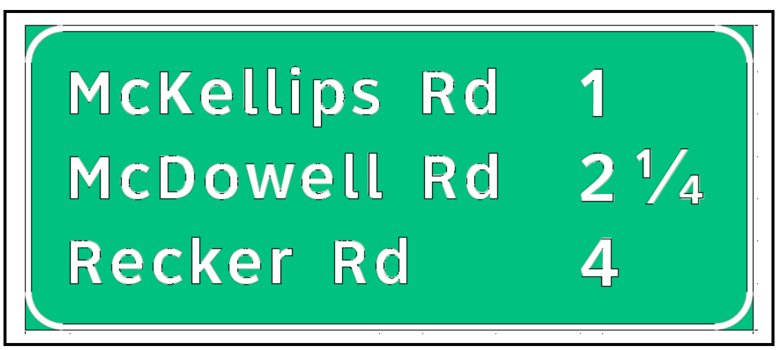


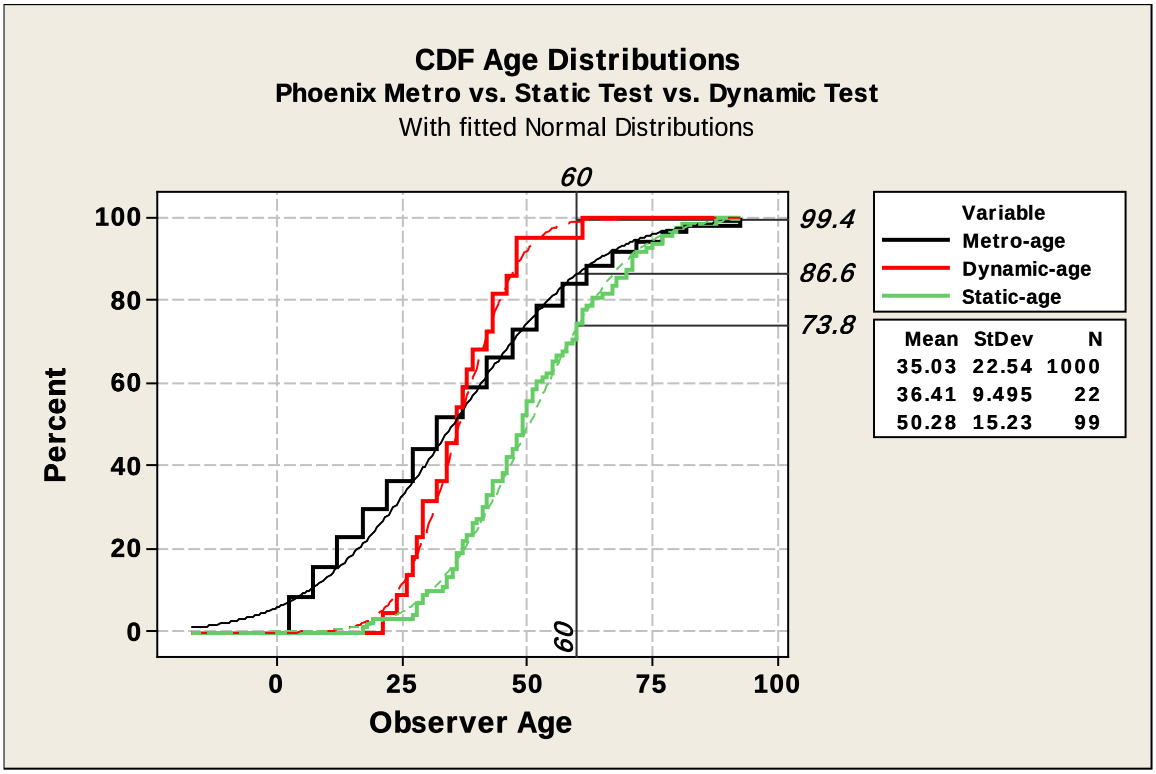
FIGURE 1 Sample of sign used in testing.

The three signs used in testing were located above the roadway, attached to bridges crossing over the roadway. The roadway was a new, completed freeway link that was scheduled to be opened shortly after the testing. The vertical viewing angle varied somewhat depending on the height of the sign, which was at least 18 feet (5.5 m) in height from the pavement. The horizontal viewing angle also varied somewhat due to the curvilinear geometrics of the roadway (see FIGURE 2). The signs were located approximately one mile (1.6 km) apart.

Each sign has three lines of text on them (see FIGURE 1 and FIGURE 2) and each line is made from one of the three test materials, called Material A, B, and C. One of these materials was the current “superior” sheeting ADOT was, and still is, currently using, one was a new material purported to be equivalent, and the third was the material ADOT had been using prior to its current material, which was the previous generation’s “superior” material. There are three signs (SIGN 1, 2, and 3) and three lines on each sign (TEXT LINE 1, 2, and 3). Therefore each material was used on the top line of one sign and the middle and bottom lines on the other two signs. The text was Clearview with a 13.33 inch (33.86 cm) upper case height and a 10 inch (25.40 cm) lower case height.

FIGURE 2 Typical Overhead Sign Location

Since this is an observational study, the samples consist of groups of observers who rate the sign materials. The static testing group of observers numbered 100 after data cleaning was done. A second group of observers was used for the dynamic testing and numbered 22. The ages of the observers in the static testing and dynamic testing data sets were compared to an estimate of the Phoenix metropolitan area demographics (10). This comparison is in the form of graphs shown in FIGURE 3. These graphs include an empirical cumulative distribution function (ecdf) of each sample set as well as its fitted normal cumulative distribution function (cdf), based on the sample's mean and standard deviation.



<u>Footnote</u>: The mean and standard deviation shown for Metro area are imprecise due to use of frequency data versus raw data. The reported actual median age is 33.8 and the standard deviation is unreported.

FIGURE 3 Age distributions of observers versus Phoenix Metro population.

One can observe from FIGURE 3 how the age of the test observers varied from the Phoenix metro area population. A useful comparison is the percentage of people over the age of 60 (the graph marks the reverse of this, i.e., the percentage under 60). Based on the graph, the metro shows 13.4% (100-86.6) of the population age sixty or older but this is imprecise due to the use of frequency data in constructing the graph. The actual raw data from the US Census estimates the component age 60 or older at 15.9%. The static test sample had approximately 26% age 60 or older, a significantly greater proportion. Skewing the test sample age toward the older end of the distribution is believed to better target the desired design driver for purposes of the sign sheeting testing, i.e. older drivers. However, the dynamic test sample was skewed toward the younger end of the distribution. In general, the samples do not appear to cause undue concern regarding bias toward the outcomes. It would, however, be more desirable to have a higher proportion of older drivers in the dynamic testing sample.

STATIC TESTING

Static testing was done at three predetermined stops before each sign. The observer drove her or his own vehicle and often had a front-seat passenger who was also an observer. Each observer rated each of the three lines of text on the sign at each of the three stops. This was repeated for all three signs. The three stops were at 600 ft (183 m) , 450 ft (137 m) and 300 ft (91 m) from the sign, which correspond to Legibility indices of 45.0 ft/in (5.4 m/cm), 33.8 ft/in (4.0 m/cm), and 22.5 ft/in (2.7 m/cm), respectively, for the 13.33 inch (33.86 cm) capital letter height of the Clearview type. The test was conducted during nighttime under dark conditions. No roadway lighting was turned on. The only light illuminating the signs was from the observer's vehicle headlights while she or he was making their rating. The observers rated each line on the sign from 1 to 5, with 1 = Unsatisfactory, 2 = Marginal, 3 = Satisfactory, 4 = Good and 5 = Excellent.

An Analysis of Variance (ANOVA) statistical procedure was used to evaluate the static test results. A balanced design was used with 100 observers forming the data set. The observer's *rating* was the response variable, the *material* and the *distance* from the sign were the factors of interest. The observer was the blocking variable, sometimes called a repeated measures design when using people as the experimental units

Both *material* and *distance* are statistically significant and therefore pairwise comparisons were done using Bonferroni Simultaneous Tests. The mean ratings for all pairs for both *material* (*A* = 4.38, *B* = 2.98 and *C* = 2.88) and *distance* (*Far* = 2.65, *Mid* = 3.57 and *Near* = 4.03) are statistically different. However, whereas all the *material* means differ statistically, they arguably do not all have a practical difference. Obviously material A has a considerable higher mean rating than either materials B or C. However, materials B and C, which are statistically different, are not different enough to have a practical difference. The *distance* means all differ statistically and arguably all have a practical difference as well.

The analysis result from the viewing *distance* is as expected, that is the closer to the sign, the higher the rating for each material. It should be noted, however, that an interaction exists, which means the generalization regarding distance from the sign does not apply in all cases. The exception is for the *Far* distance for materials *B* and *C*, specifically their means are switched for the *far* distance. While notable, this has little practical usefulness.

DYNAMIC TESTING

Dynamic testing was done for each of the same signs that were used in the static testing. An observer rode in the passenger seat and the vehicle was driven at the posted highway speed of 55 mi/h (90 km/h) toward the sign. The observer was instructed to read aloud only the first line on the sign as soon as she or he could. The distance to the sign was captured by a recorder in the back seat using a distance measuring device installed in the vehicle. Three vehicles were used and the nighttime conditions were the same as for static testing, i.e., the only lighting was the vehicle headlights. Each observer observed the first line on each sign only once. Each of the three signs had a different material for the first line of the sign, which yielded one distance reading for each material by each observer.

An Analysis of Variance (ANOVA) statistical procedure was used to evaluate the dynamic test results. A balanced design was used with 22 observers forming the data set, a much smaller sample size than was available for the static testing. The observer's recorded *Legibility-Distance* was the response variable, the *material* was the factor of interest. The observer was the blocking variable.

The *material* is statistically significant and therefore pairwise comparisons were done using Bonferroni Simultaneous Tests, at the 95% confidence interval level. The mean *Legibility Distances* for material *A* (760 ft (232 m)) is statistically and practically different than the means of both materials *B* (615 ft (187 m)) and *C* (610 ft (186 m)). However, the means of *B* and *C* are not significantly different from each other.

The practical interpretation of the results for this dynamic testing is the same as for the static testing. Material *A* has a considerable higher mean rating that either materials *B* or *C*. However, materials B and C, both statistically and practically speaking, reflect essentially the same mean response among the observers and are thereby undistinguishable from each other.

Some potential problems did exist with the dynamic testing conducted for this study. One is the appearance of differing understandings among the observers as to what constituted being able to "read" the sign. It is unknown if this biased the results or if so, in what way it might do so. The data recorders noticed some observers hesitated before stating they could read the sign while others were quick in calling out their response. The instructions to the observers may have been insufficient. It is possible that the words on the sign were unfamiliar to some and they mentally stumbled over them before deciding they could "read" them. Also, each of the three signs had a different material as its first line, which meant that each material was observed from a somewhat different height and viewing angle. Also each sign's first line had a different exit street name and some of its words may have been harder to read, perhaps causing a hesitation resulting in a shorter reading distance being recorded. Conversely, some or all of the hesitations noted may merely be the normal decision process for those people. Finally, the sample size was smaller than desirable and its demographics were not as representative as it could be.

CONCLUSIONS

Two tests were performed, a static test with 100 observers and a dynamic test with 22 observers. In both tests, material *A* showed itself to be superior to materials *B* and *C*, while materials *B* and *C* are practically the same. This is sufficient evidence for ADOT to reject the manufacturer's claim that its material was equivalent to the "superior" material that ADOT is currently using.

But of potentially greater importance is the strong possibility that dynamic testing may be substituted for static testing when evaluating sign sheeting material, as evidenced in this study. This is a useful finding because static testing is both difficult and expensive for a transportation agency to perform as compared to dynamic testing. Static testing requires a test facility that has no traffic on it, yet can plausibly reproduce actual driving conditions and sign placement conditions. Dynamic testing can be performed on existing roadways under various traffic and lighting conditions. Such conditions can be argued to actually provide better testing conditions than those typically used in static testing.

RECOMMENDATIONS

Since the three test signs at the test site are to remain in place for their life span and the roadway is now open to the public, additional dynamic testing can be done that attempts to address some of the potential problems observed. Additionally, other parameters could be added to the dynamic testing such as traffic density and aging. More generally, other agencies could perform dual static and dynamic testing to contribute to a body of evidence to support if one is preferred over the other.

ACKNOWLEDGEMENTS

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