Sign Effectiveness

• They must be
  – Seen
    • Placement, conspicuity, content
  – Read
    • Legibility
  – Understood
    • Message, comprehension, text/symbol
  – Followed / Abided
    • Adequate distance, PRT
**Signs Must Be Seen: Placement**

- Regulatory
  - At point of regulations
- Warning
  - In advance of hazard
- Guide
  - Usually navigation info, far enough in advance to provide guidelines

**Signs Must Be Seen: Conspicuity & Content**

- Conspicuity
  - Likelihood a sign will be seen, but not much legibility improvement
  - Fluorescent colors improve conspicuity
- Eccentricity
  - Farther sign is from line of sight, the less likely to be seen
- Content
  - Environments and situation where seen
**Signs Visibility – Conspicuity**

- Enhanced by;
  - Size
  - Brightness
  - Boldness, large letters
  - Edge sharpness
  - Contrast between sign & background
  - Visual simplicity, on simple background
  - Nearness to line of sight

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**Legibility of Symbol Signs**

- Word message warnings had legibility distances of 150-200 ft, same study

*Source: Traffic Control Devices Handbook, ITE, 2013*
Important Signing Facts & Errors

• Based on errors seen on technical assistance visits
  – School signing
    • Color – fluorescent yellow green has replaced yellow
    • Crosswalk symbol – student silhouette with downward arrow has replaced student silhouette with crosswalk lines
  – Minimum sign size
    • Stop size – 30x30”
    • Yield size – 30x30x30”
    • Speed limit – 18x24”
    • Do not enter – 30x30”

Source: OSU Technical Assistance Reviews

Errors with Stop Signs

• Stop sign on minor approach facing major road
• Confusing
• Conflicting message
  – conspicuity, good
  – expectancy, wrong
Errors with Stop Signs

- Stop sign shape blocked by backing sign
- “Shape” message is lost
- Shape Message for other directions lost

Not allowed, 2009 MUTCD

Errors with Stop Signs

- 24” STOP sign may only be used:
  - On alleys
  - In parking lots
  - Very low volume roads
- Minimum 2009 MUTCD
  - 30x30”, single lane roads
  - 36x36”, multilane roads
- Why? Need added conspicuity especially for elderly.
  - Not more effective, just more visible
Signing for School Zones

- Uses fluorescent yellow green (FYD) & should not be mixed with old yellow
- Very difficult to get correct
- Two conditions
  - Condition A:
    - adjacent to schools, “7 to 5PM School Days”
  - Condition B:
    - not adjacent to schools, “when children present”
- Confusing to drivers

Source: Oregon MUTCD Supplement

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Signing for School Zones

- Must end school zones with;
  - If only 20 mph speed limit is set
  - If “Fines Higher” zone was imposed

Source: Oregon MUTCD Supplement
What color do you expect for the other approach?

Driver confusion, decreased safety

Higher crash experience with beacon over intersection
More effective with beacons on approach sign posts; eliminate confusion

• This STOP sign was not visible to an elderly male driver with color blindness
  – Red sign indistinguishable from green leaves
• Solution
  – Wider white border or LED lights in border
Signs on Horizontal Curves

- Sign information should be concise and efficient so drivers can:
  - Process the information
  - Alter their speed
- Advance warning signs research efforts differ on most effective means:
  - Text vs symbols
  - Sign placement
  - Sign message
  - Relevant curve radii
  - Driver population

Source: NCHRP #600, p. 6-12
Signs on Horizontal Curves (cont)

- Warning signs for curves should be placed to give adequate PRT.

Table 2C-4. Guidelines for Advance Placement of Warning Signs

| Condition A: Speed reduction and lane changing in heavy traffic |
| Condition B: Deceleration to the listed advisory speed (mph) for the condition |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 0° | 10° | 20° | 30° | 40° | 50° | 60° | 70° |
| 20 mph | 255 ft | 100 ft | N/A | — | — | — | — |
| 25 mph | 325 ft | 100 ft | N/A | N/A | — | — | — |
| 30 mph | 405 ft | 100 ft | N/A | N/A | N/A | — | — |
| 35 mph | 465 ft | 100 ft | N/A | N/A | N/A | — | — |
| 40 mph | 565 ft | 100 ft | N/A | N/A | N/A | — | — |
| 45 mph | 675 ft | 155 ft | 100 ft | 100 ft | 100 ft | N/A | — |
| 50 mph | 775 ft | 175 ft | 125 ft | 100 ft | 100 ft | 100 ft | N/A |
| 55 mph | 885 ft | 250 ft | 200 ft | 175 ft | 125 ft | 100 ft | — |
| 60 mph | 990 ft | 325 ft | 275 ft | 225 ft | 200 ft | 125 ft | N/A |
| 65 mph | 1,100 ft | 400 ft | 350 ft | 300 ft | 275 ft | 200 ft | 100 ft |
| 70 mph | 1,200 ft | 475 ft | 400 ft | 350 ft | 275 ft | 200 ft | 100 ft |
| 75 mph | 1,350 ft | 560 ft | 450 ft | 400 ft | 350 ft | 275 ft | 200 ft |

Note: criteria in MUTCD differs slightly from NCHRP #600

Source: MUTCD p. 108

Turn

Curve
**Signs on Horizontal Curves (cont)**

- Use of chevron signs outside curves to provide additional guidance, as well as warning

Note: Criteria in MUTCD slightly different than NCHRP #600, HFG

Source: MUTCD p. 113

<table>
<thead>
<tr>
<th>Advisory Speed</th>
<th>Curve Radius</th>
<th>Sign Spacing</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 mph or less</td>
<td>Less than 200 feet</td>
<td>40 feet</td>
</tr>
<tr>
<td>20 to 30 mph</td>
<td>200 to 400 feet</td>
<td>80 feet</td>
</tr>
<tr>
<td>35 to 45 mph</td>
<td>401 to 700 feet</td>
<td>120 feet</td>
</tr>
<tr>
<td>50 to 60 mph</td>
<td>701 to 1,250 feet</td>
<td>160 feet</td>
</tr>
<tr>
<td>More than 60 mph</td>
<td>More than 1,250 feet</td>
<td>200 feet</td>
</tr>
</tbody>
</table>

Note: The relationship between the curve radius and the advisory speed shown in this table should not be used to determine the advisory speed.

Chevrons are a “warning” device
Delineators are a “guidance” device

Example Pavement Markings
**Centerline Striping**

- Use widest possible to maximize visibility
  - 4” min width – standard (58% state DOT’s use wider)
  - 6” width, more effective
  - 8” width, no more effective than 6”
- Use highly reflective materials – paint with glass beads or thermoplastic strips

Source: NCHRP #600, p: 6-10
Effect of Marking Width

- Drivers tend to drive in middle of marked lane

Source: F. Rosey et al., 'Impact of Narrower Lane Width. TRR 2138, TRB 2009

Effect of Marking Width

- Standard stripe width – most states use wider than 4-in stripe:
  - Quality of pavement markings have high priority with drivers
- Wider lane lines yield:
  - More centered lateral placement
  - Fewer lane departures on curves
  - Improved lane keeping in low contrast conditions
- Wider striping is beneficial when:
  - Higher definition is needed, e.g., horizontal curves
  - Roads have narrow or no shoulder
  - Construction work zones

Source: NCHRP #600, p. 20-3
Centerline Striping Requirements

- Not required on all roads
- Shall use centerline on continuous 20-ft wide roadways with ADT ≥6000 vpd
- May use centerline on roadways ≥16-ft
- May not use a single stripe on \( C \)
- Must stripe for no-passing if centerline is striped
- May mark the centerline with raised pavement markers (RPMs) and no stripe

Source: MUTCD

Low volume road stripe \( C \) unnecessary
Striping for Passing

Striping for No-Passing; Required if Striped
Solid single stripe not allowed

May be lit with RRPM’s by headlights
Shoulder Stripe or Edgelines

- Not required on narrow roads
- Must use on roadways ≥20-ft and ADT ≥6000
- Use near major crossing roadways and major driveways
- Bicycle lane line must use 8” continuous white stripe, ODOT
- Advisory bicycle lanes use a dashed line

Source: MUTCD & ODOT
Bicycle lane line must be 8” continuous white stripe, ODOT

**Visibility of Lane Markings**

- The ease with which drivers can see and follow longitudinal lane markings
- Design of lane markings
  - Preview time - amount of time drivers look ahead
- Preview time affected by:
  - Distance where lane markings can be seen
  - Marking width
  - Retroreflectivity

*Source: NCHRP #600, p. 20-2*
Preview Time for Markings

- Time to accommodate proper anticipation for:
  - Steering behavior, safe steering on curved roads minimum long-range preview time
    - Drivers don’t increase their speeds much with increased marking visibility

- Recommendation
  - Desirable preview time – 5 s
  - Minimum preview time – 3 s

- Implies need for pavement sight distance, but not to a stop
  - Eye height = 3.50 ft; object height = 0 ft

Source: NCHRP #600, p. 20-3

Markings Retroreflectivity

- Pavement line retroreflectivity affects how far drivers can see markings at night (not presently required)

- Acceptable retroreflectance
  - Young drivers – 93 mcd/m²/lux
  - Older (+60 yrs) drivers - 100 mcd/m²/lux
  - Occluded light, dirty windshields, poor headlights, 121 mcd/m²/lux

Source: NCHRP #600, p. 20-3
**Roadway visibility dramatically enhanced by markings**

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**Estimation of Visibility distance based on Retroreflectivity and Width**

- Visibility distance (D) for longitudinal road markings in high-beam illumination

```
<table>
<thead>
<tr>
<th>Width (in)</th>
<th>Visibility Distance (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 in</td>
<td>495</td>
</tr>
<tr>
<td>12 in</td>
<td>330</td>
</tr>
<tr>
<td>8 in</td>
<td>165</td>
</tr>
<tr>
<td>6 in</td>
<td>120</td>
</tr>
<tr>
<td>4 in</td>
<td>45</td>
</tr>
<tr>
<td>4 in**</td>
<td>30</td>
</tr>
</tbody>
</table>

* *broken line of 2/3 area
** broken line of 1/3 area

Where:
- $R_L$ is the coefficient of retroreflected luminance (and $R_L$ (road) = 15 mcd/m²/flux)
- Luminous intensity is constant towards the road markings (10,000 cd)

- $R_L$ young driver = 93
- $R_L$ elderly = 100

Source: NCHRP #600, p. 20-2
Effectiveness of Symbolic Markings

- “Horizontal signing” is sign text painted on roadways
  - Effective because driver already looking at roadway
  - Ineffective when snow, dirt, leaves can block
  - Ineffective due to wear
- Text “Curve 55 mph” reduced speeds significantly
  - “Curve Ahead” text was not effective
  - “Slow” with curve arrow slowed traffic, not as effective as with speed

Source: NCHRP #600, p. 20-5
Effectiveness of Symbolic Markings

- Transverse line treatments had mixed results:
  - Near middle of road were not effective
  - Near lane edges were effective:
    - Significant on Interstate and arterials
    - Insignificant on rural roads
  - Katz research attempted to create a “visual rumble strip” in drivers peripheral vision

Source: NCHRP #600, p. 20-5
Effectiveness of Symbolic Markings

- Interstate route shield to show exit caused some confusion:
  - Route shield preferred over route name
  - Some drivers thought shield referred to route they were on, not exiting to
- Pavement arrows in exit lane eliminated erratic lane changes in gore area

Source: NCHRP #600, p. 20-5

Effectiveness of Symbolic Markings (pavement arrows)

- Wrong way movements on frontage roads, placed at intersection and 120-ft upstream
  - Lane direction arrow virtually eliminated wrong way driving and conflicts
  - Wrong way driving reduced significantly by pavement arrows where lane selection is confused

Source: NCHRP #600, p. 20-5
Arrows Can Be Used to Enhance Operations & Safety in Oregon

• Section 3.20 (MUTCD, 2009) covers use of pavement word, symbol and arrow markings
  – Support: “Word, symbol and arrow markings used...,” to guide, warn and regulate traffic
  – Standard: Pavement markings..., symbols and arrows shall be installed in accordance with..., ”Standard Highway Signs and Markings“ book

* Arrows are a powerful supplement for safety and operations in finite driving task

Marking Two-Way Left-Turn Lanes (TWLTL)

TWLTL’s shall have paired arrows in both directions

Section 3B-20, MUTCD, p: 392

Source: MUTCD 2009
Marking Two-Way Left-Turn Lanes

- TWLTL markings are dropped and left-turn lane added at major intersection with a single turn arrow

Source: MUTCD 2009
Left Turn Lane Single Arrow

Low Volume Street, Low Classification, No Arrow
Effectiveness of Symbolic Markings

- Major issues are:
  - Visibility of markings
  - Durability of materials
    - White markings may not provide adequate contrast against concrete or worn asphalt surfaces
    - Night time visibility affected by loss of glass beads, due to wear
    - Visibility is limited by congestion
    - Symbols need to be simple and legible
    - Use in critical locations to enhance warnings or caution

Source: NCHRP #600, p. 20-5

Lack of Durability for Marking
Post Mounted Delineators

- Retroreflective marking devices in series along roadway to mark:
  - Curves
  - High fill locations
  - Alignment through short vertical curves without pavement sight distance
  - Provide direction through an expectancy problem location
  - Must have at least 5 sec preview time

Source: NCHRP #600, p. 20-8

Delineators are Guidance Device (MUTCD)

* Works well even under low illumination
Delineator used in a Series are a Warning System

Color of delineator shall match color of edge line

* Drivers are not aware of the difference in color meaning
**Post Mounted Delineators**

* At conscious and unconscious level helps with curvature and speed perception

*Source: NCHRP #600, p. 20-8*

**Color of Delineator Reflectors**

- Delineators shall comply with the color of edge lines
- Delineators on left side of two-lane, two-way shall be white
- Delineators may be red when viewed by a wrong way driver

* Lane markings alone are well under 5-sec preview safety criterion; delineators increase guidance range

*Source: NCHRP #600, p. 20-9*
Is there anything wrong with these delineators?

Markings for Roundabouts

Source: adapted from Robinson et al. (2)

Source: NCHRP #600, p. 20-11
• Yield lines
  – A row of solid white isosceles triangles pointing toward approaching traffic \((\text{section 3B.16, MUTCD})\)
  – Dotted lines
  – Shorter line segments separated by shorter gaps than for broken line. Width of dotted line shall be at least same width of line extended \((\text{section 3A.06, MUTCD})\)

Source: MUTCD 2009, p. 399