

# Markings at Signalized Intersections in Japan and Germany

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## 1. Introduction

Intersection design and layout have significant impacts on driver behavior and traffic flows. One of the most important measures to define the layout of intersections are pavement markings, which are usually used to provide visual guidance, to make situations easily to be understood, to gather attention and to divide roads into separate segments. The amount of markings is likely to increase in large and complicated intersections with higher vehicle speeds and increasing degree of freedom for drivers.

Existing guidelines propose some general information on where to apply markings and in what visual characteristics. In Japan, the “Manual on Road Markings” (JSTE, 1991)<sup>1)</sup> is published and revision works are currently going on. For this, some updated knowledge regarding more effective and rational markings is requested. On the other hand, a guideline for road marking (FGSV, 1993<sup>2)</sup>, 1980<sup>3)</sup>) defines details of road markings in Germany. This paper aims to highlight the differences in pavement markings at signalized intersections between Japan and Germany. It is a part of a study to define more rational and reasonable specifications for markings at signalized intersections considering various geometric and traffic conditions.

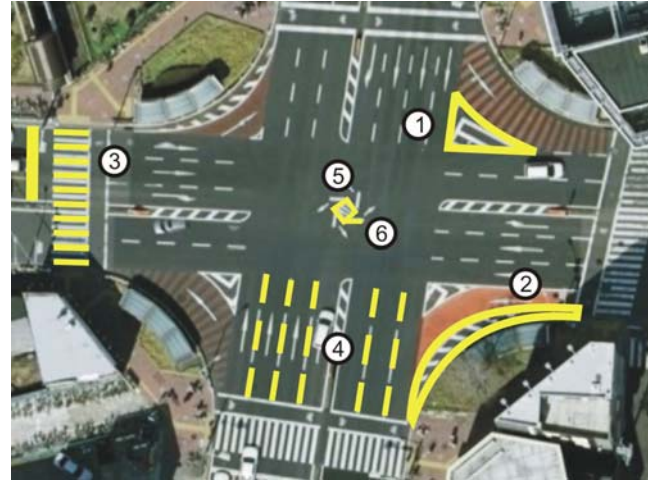
## 2. Literature review

On pavement markings, most existing studies have been conducted regarding their durability or retroreflexion rather than their effects on driver behavior. However, several works attempted to study the effects of marking on driver behavior at road segments. Miller (1993)<sup>4)</sup> found that markings are cost effective, since they can improve safety and mobility performance with very low cost. Brüning (1998)<sup>5)</sup> concluded from the analysis of crash records that markings improve traffic safety especially at nighttime. These studies have shown that pavement markings can have an effect on driver behaviors at road segments. Although it may be reasonable to assume that markings at signalized intersections have similar effects, works to quantify these effects are still missing.

## 3. Methodology

In order to provide a comprehensive comparison on road markings in both countries, existing markings at signalized intersections should first be categorized dependent on their functions. This helps to identify the markings with apparent differences for further research on their effects on driver behavior. The proposed marking categories are:

1) Channelization (Japanese left-/German right turn) using either island markings or raised triangle island to separate left turning vehicles from other traffic movements.



**Fig. 1: Japan – (1) channelization, (2) curb marking, (3) vehicle stop line and crosswalk, (4) straight lane markings, (5) right turn marking and (6) attention marking (Taiko-dori 3, Nagoya)**

- 2) Curb markings used at left turns (German right turn)
- 3) Vehicle stop line and crosswalks
- 4) Straight lane markings to direct through vehicles.
- 5) Right turn markings (German left turn) provides drivers with a trajectory to follow.
- 6) Attention markings inside the intersection to make aware of upcoming traffic – stop if necessary

Note that information on intersection layout comes from Google Earth, while driver behavior was observed from video footage available at Nakamura Lab, Nagoya University.

## 4. Comparison

### 4.1 Channelization

Channelization is utilized to separate left turners from through traffic and possibly to guide drivers with a proper trajectory. In Japan, channelization is often made by pavement markings instead of raised islands (**Fig. 1 (1)**). Due to this it can be observed that left turners overrun island markings. This can end up with two left turning vehicles next to each other, waiting for a pedestrian to cross. Drivers' trajectories can widely vary.

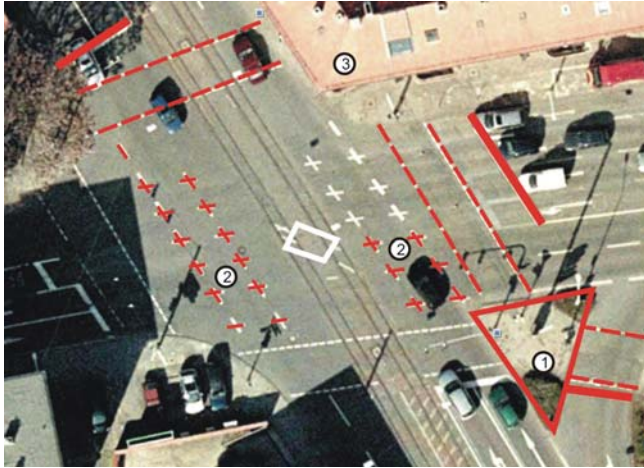
In contrast, German intersections use raised islands for channelization (**Fig. 2 (1)**), which force drivers to follow a certain trajectory through a physical treatment. Additionally to the function of pavement markings, raised islands can also serve as refugee islands for pedestrians.

### 4.2 Curb markings

In both countries, curb markings serve the same general purpose; to guide drivers through the turn and control vehicle speeds through the radius. At Japanese

intersections the curbs are often designed with large radius. These large curb radii are provided for large vehicles to turn, even though smaller radii seem feasible. By intending to slow down smaller vehicles, markings are often used to reduce turning radius (**Fig. 1 (2)**), however their effects are questionable.

In Germany, the curb itself is the guiding line; no markings are applied, which is achieved through a smaller curb radius, in which large vehicles are considered, sometimes with very low speeds.



**Fig. 2: Germany – (1) channelization, (2) straight lane markings, and (3) vehicle stop line and crosswalk (Darmstadt)**

#### 4.3 Vehicle stop lines and crosswalks

In general, the functions of vehicle stop lines and crosswalks are similar in both countries, which are to stop vehicles at red signals and let pedestrians cross roads safely. The major difference is the position of markings. Hence curb radii are rather large in Japan, stop lines and crosswalks are generally positioned further upstream (**Fig. 1 (3)**). This layout might encourage drivers to stop and wait after the crosswalk. Clearance time will increase, resulting in large cycle length and possibly in longer vehicle delays.

However, guidelines in Germany<sup>6)</sup> mention clearly that pedestrian crossings should not be positioned farther than 5 to 6 meters from the edge of the carriageway. Furthermore, signalized crosswalks are marked by showing the outer border of crossings only (**Fig. 2 (3)**). Zebra marking is used at unsignalized crosswalks only.

#### 4.4 Straight lane markings:

Straight lane markings are used to guide drivers through the intersection. Since crosswalks at Japanese intersections are applied far upstream, straight lane markings are used, particularly in case of large intersections, to guide through vehicles from the crosswalk to the point where the two streets intersect (**Fig. 1 (4)**).

In Germany, dashed markings are applied throughout the intersection usually only for the major street (**Fig. 2 (2)**). If markings appear to be necessary for minor streets little dashes intersecting the major lane markings are applied.

#### 4.5 Right turn markings:

In most Japanese intersections, right turn markings are diamond shaped (**Fig. 1 (5)**). Dashed lines can be found in few intersections to indicate the turn. In contrast, the diamond shape can seldom be found in Germany. Whereas drivers will encounter dashed lines that mark the border of

the turning lane throughout the intersection (**Fig. 3**) at the major street and less often little dashes at the minor street.

The diamond shape is applied to plot the outer border of turning lanes. If drivers face upcoming traffic they are supposed to stop at the diamond shape. Because continuous markings for turning lanes are not used, it was observed that drivers tend to go with shortcuts without reaching the diamond shaped marking. This can result in higher turning speed. Dashed lines and dashes in Germany provide drivers with an outline of the turning lane. Viewed from drivers position lanes can clearly be recognized. This can prevent dangerous scenarios due to shortcut vehicles.



**Fig. 3: Turn marking (left) and attention marking (right) in Germany (Darmstadt)**

#### 4.6 Attention markings:

Attention markings in Japan are solid or dotted lines in the middle of intersections (**Fig. 1 (6)**). German intersections sometimes are featured with wide dashed lines (**Fig. 3**) where lanes intersect with upcoming traffic. Both markings imply a waiting point to let upcoming traffic pass. Differences in driver behavior cannot be derived from the video footage available.

### 5. Concluding remarks

By comparing pavement markings at Japanese and German signalized intersections significant differences can be found particularly in channelization, curb markings and right turn markings. To discuss which pavement markings have advantages over others is not possible currently, due to a lack of surveys. An empirical analysis on the effects of marked or raised channelization on driver behavior has to be conducted since drivers might neglect marked islands. Furthermore, the rationality of curb markings has to be analyzed empirically. Marking both sides of turning lanes continuously throughout intersections might be more effective than the usage of diamond shaped markings, due to more consistent driver behavior. Further research is necessary to be done to find rational guidelines, which consider various traffic and geometric conditions.

#### References:

- 1) Japan Society of Traffic Engineers (JSTE) (1991): Manual on Road Markings
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