

Smart Crosswalk Solution for Urban Intersections with ClairSRS-Wired

Version: 1.0

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1. Background

According to traffic safety regulations, vehicles must slow down when approaching crosswalks and yield to pedestrians. While this improves pedestrian safety, sudden stops by leading vehicles to yield can sometimes cause rear-end collisions if trailing drivers fail to react in time. Additionally, distracted pedestrians ("phone zombies") and jaywalking behaviors often lead to traffic congestion, reducing road efficiency.

Solution:

The **Smart Crosswalk System** enhances safety at both signalized and unsignalized intersections by:

- Pedestrian & Vehicle Detection:
 - **Video sensors** detect crossing demand or red-light violations by pedestrians.
 - **Vehicle sensors** monitor real-time traffic flow, speed, and movement.
- Smart Warning Lights:
 - Embedded LED road markers provide visual alerts to drivers and pedestrians, improving awareness.
- Adaptive Alerts:
 - Dynamic signals adjust based on real-time conditions to prevent sudden stops and reduce collision risks.

Benefits:

- ✓ Reduces rear-end collisions caused by abrupt yielding.
- ✓ Improves traffic flow by minimizing pedestrian-vehicle conflicts.
- ✓ Enhances visibility for distracted pedestrians and drivers.
- ✓ Suitable for high-risk intersections and urban areas.

This system ensures smoother and safer interactions between vehicles and pedestrians while optimizing traffic efficiency.

2. System Overview

The Smart Crosswalk System consists of devices such as **smart stud controllers** and **smart studs**. The architecture of the smart crosswalk system based on **smart studs** is illustrated in the figure below.

The **smart studs** are installed either along the outer edge of the crosswalk or in front of the vehicle stop line, using wired communication to transmit information to nearby vehicles. These studs can emit three colors—green, yellow, and red—depending on their function.

When connected to a network, the operational status of roadside devices can be transmitted in real time to the central management platform via fiber optic links. In offline scenarios, the Smart Crosswalk System can operate independently in standalone mode.

3.Functional Description

This solution delivers a series of crosswalk safety functions, including:

- Pedestrian alert
- Vehicle speed reduction warning
- Pedestrian priority enforcement
- Enhanced nighttime crosswalk visibility

Signalized Intersections

At signalized crossings, the Smart Crosswalk System integrates with the **traffic signal control system**, synchronizing the **smart studs** with traffic lights to reinforce signal compliance. This enhances awareness among drivers and pedestrians, ensuring orderly movement during designated signal phases.

Red-Light Violation Detection

When pedestrians or non-motorized vehicles illegally cross during a red light:

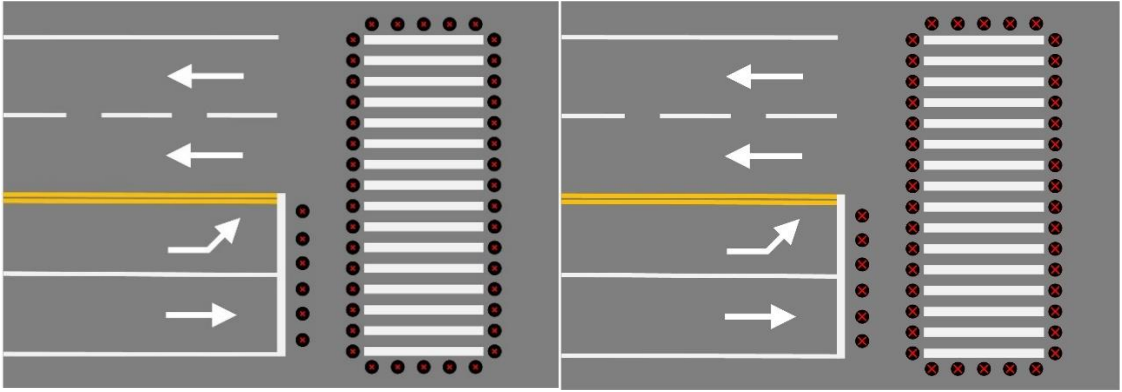
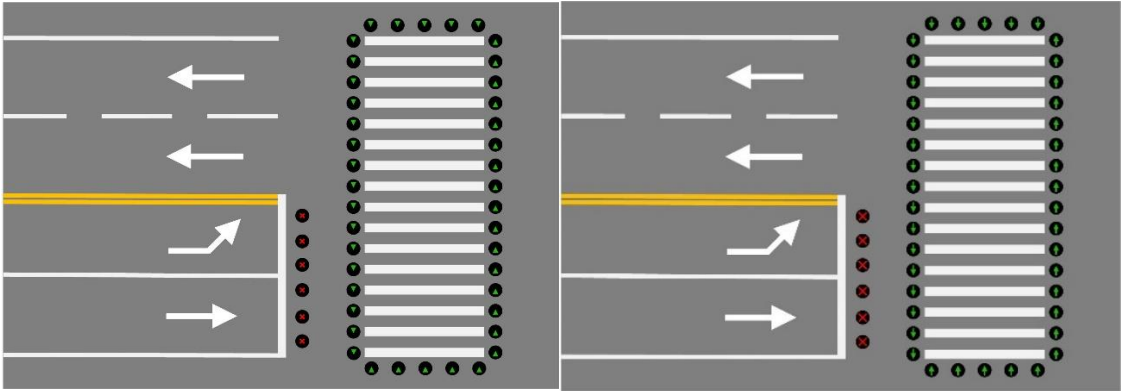
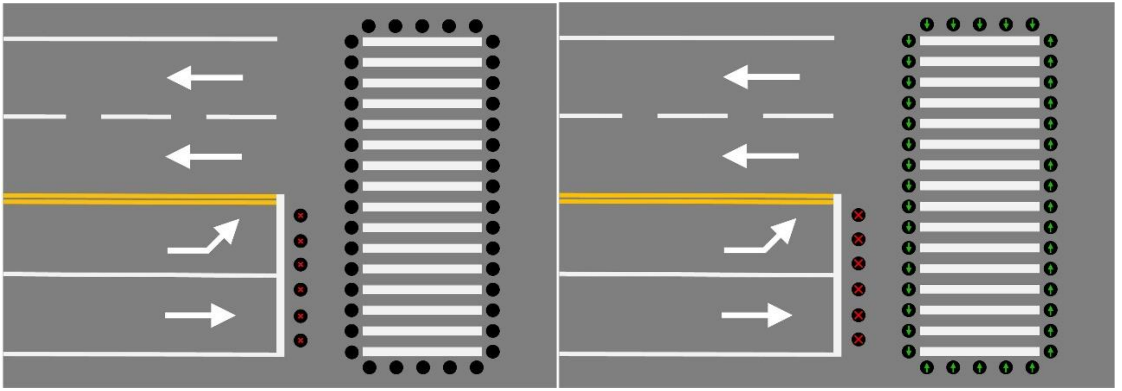
1. **AI cameras** automatically detect the violation.
2. **Smart studs** instantly activate dynamic lighting alerts (e.g., flashing red/yellow).
3. **Real-time warnings** prompt drivers to yield, improving pedestrian safety.

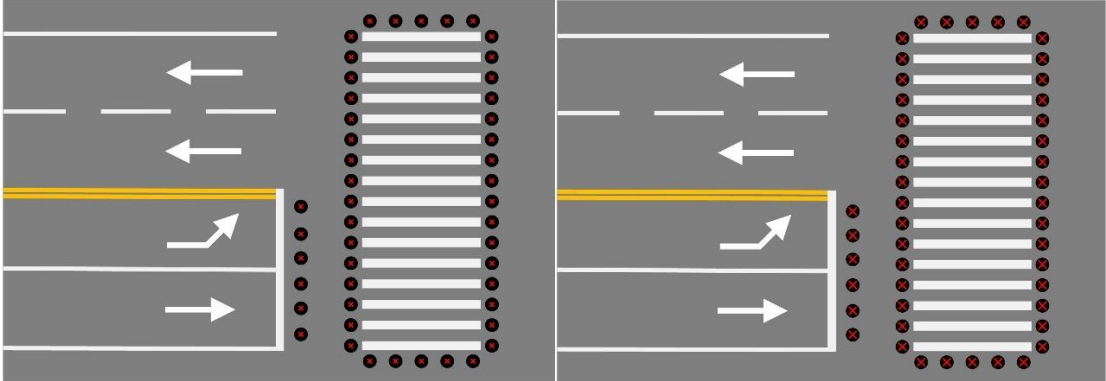
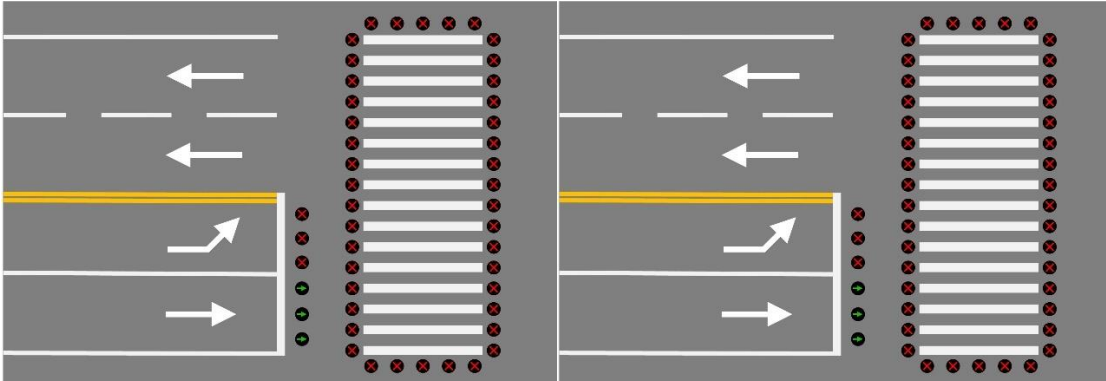
Key Benefits:

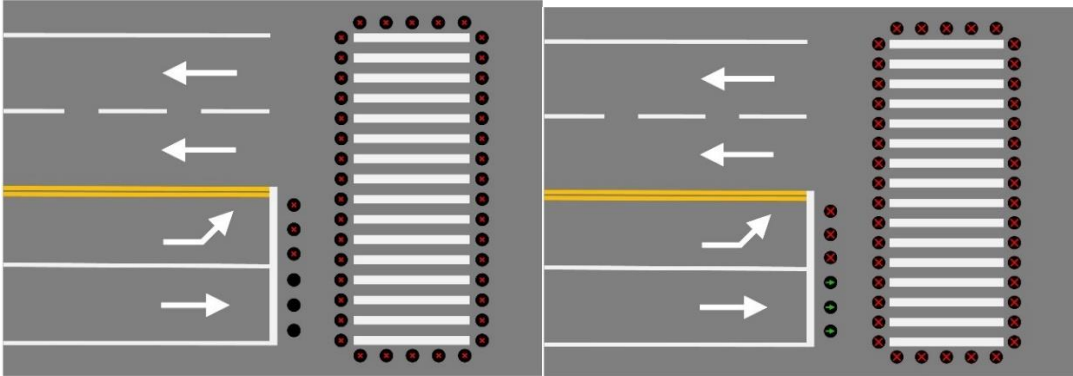
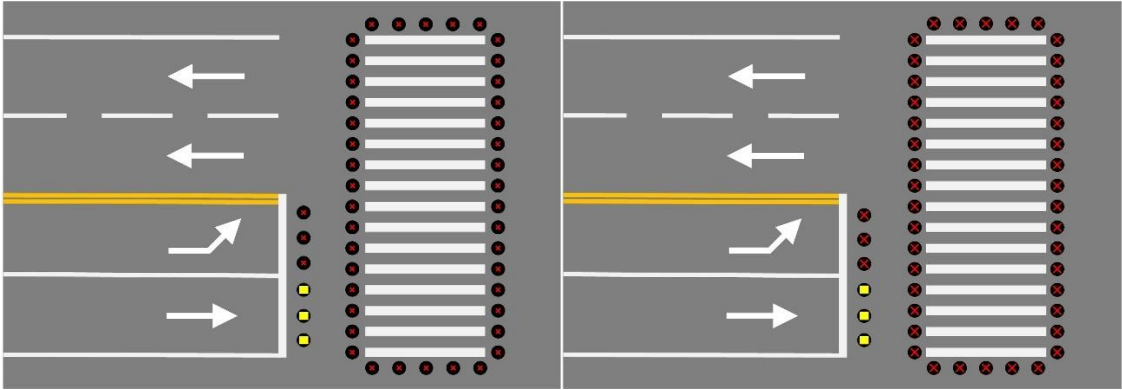
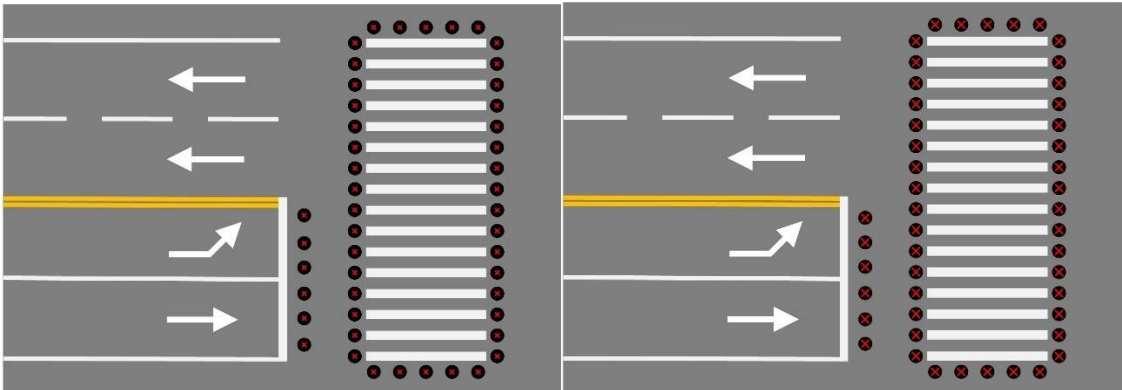
- ✓ **Prevents accidents** by alerting distracted drivers and jaywalkers.
- ✓ **Amplifies signal visibility** under all weather/lighting conditions.
- ✓ **Works standalone or networked**, ensuring reliability.

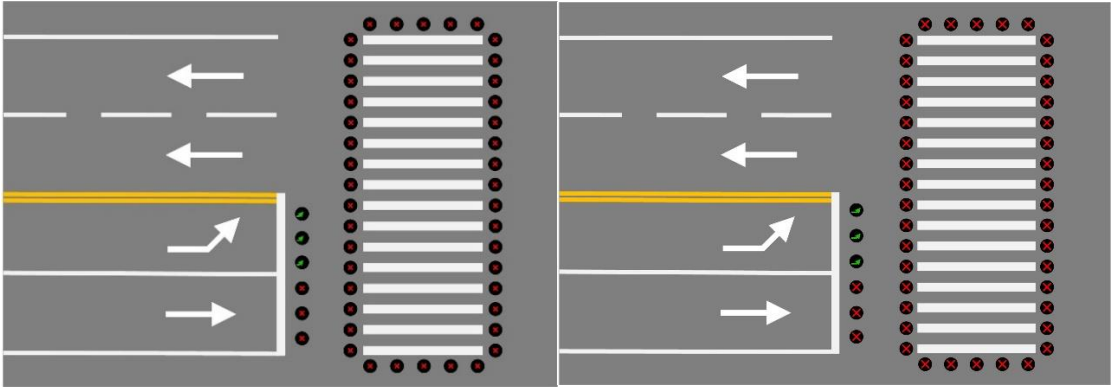
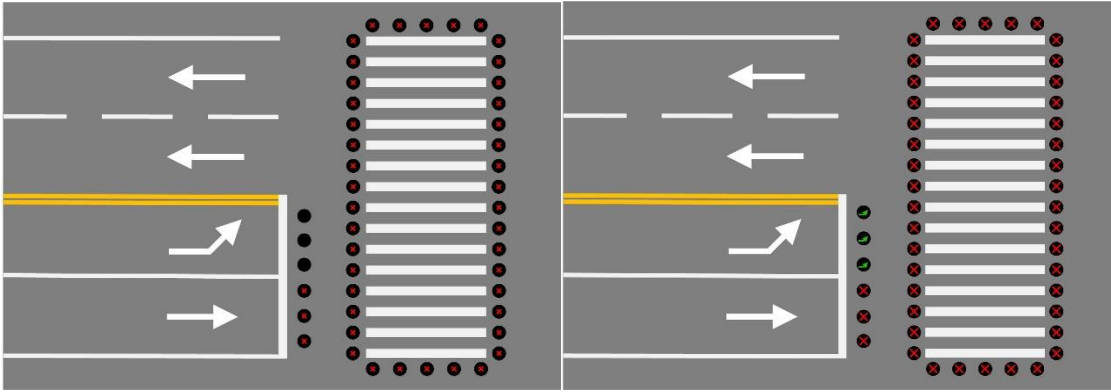
Table 1: Functions of Smart Crosswalk

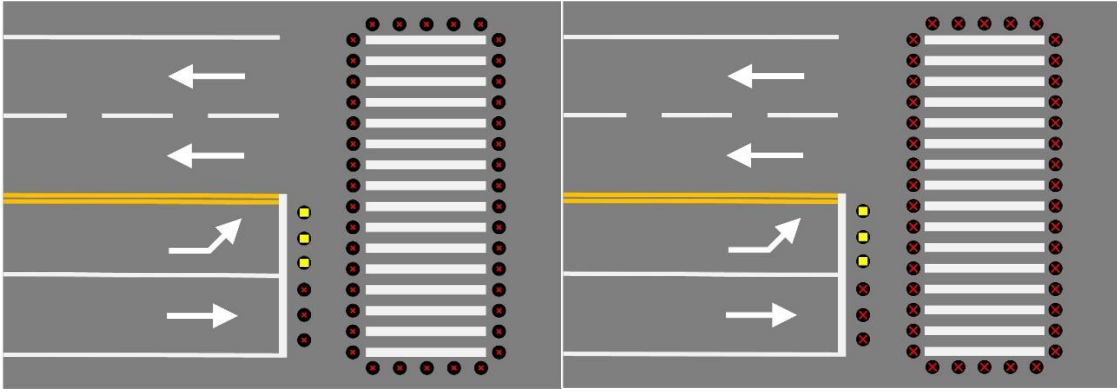
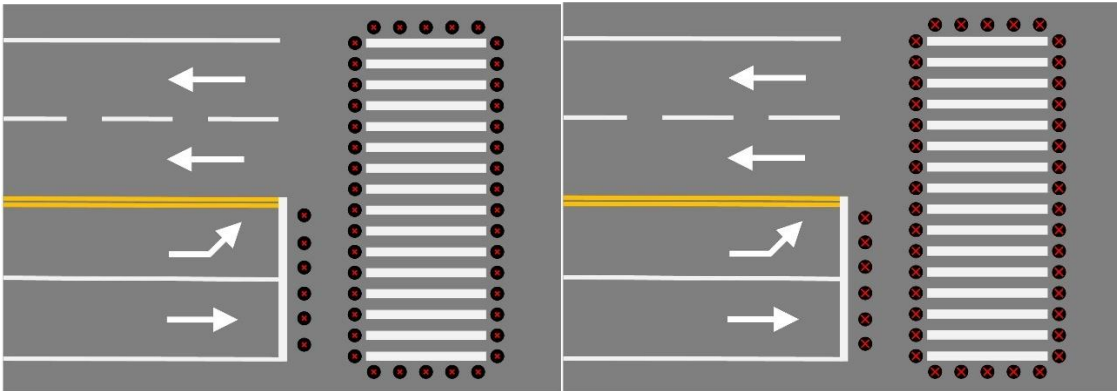
	Scenario & Functions
1	Pedestrian Phase
(1)	According to the traffic signal control scheme, before the pedestrian crossing phase turns green, there must be a full-red state lasting several seconds (typically 1 second, which is the final transitional state of the previous phase). During this full-red state, the smart crosswalk system synchronizes with the traffic signal status, with all warning lights (both around the crosswalk perimeter and in front of vehicle stop lines) displaying red dynamic "X" patterns.

	
(2)	At the end of the all-red phase when entering the pedestrian crossing phase, while the pedestrian signal turns green, the smart crosswalk system's pedestrian-side warning lights (around the crosswalk perimeter) will switch from displaying red dynamic "X" indicators to showing green dynamic arrow patterns. 
(3)	When the pedestrian crossing phase is about to end and the pedestrian traffic signal enters its transition period, it first displays several seconds of flashing green (the duration varies by city and intersection - here using 6 seconds as an example). The smart crosswalk system synchronizes with the traffic signal, making the perimeter warning lights flash green arrow patterns while other indicator lights continue displaying red dynamic "X" patterns. 
(4)	The pedestrian signal transition phase skips the yellow light and directly enters the red

	state. Given pedestrians' slower movement speed, pedestrian signals typically terminate early (switching to red ahead of time). The straight-through vehicle signal (assuming the straight phase follows the pedestrian phase - some intersections may set a left-turn phase instead) must maintain a red state for several seconds (duration varies by city and intersection; this all-red phase ensures pedestrians already crossing can safely clear the crosswalk while preventing new pedestrians from entering - here using 4 seconds as an example). The smart crosswalk system's warning lights synchronize with the traffic signals, displaying red dynamic "X" patterns accordingly. 
2	The straight-through vehicle phase
(1)	At the end of the pedestrian phase transition period, the straight-through vehicle signal turns green, while the smart crosswalk system displays green dynamic arrow patterns at the stop line of straight-through lanes, with all other warning lights maintaining red dynamic "X" patterns. 
(2)	When the straight-through vehicle phase is about to end and enters the transition phase, there will first be several seconds (typically 3 seconds) of flashing green light for straight traffic. During this time, the smart crosswalk system's warning lights at the straight-through lane stop line will flash green arrow patterns, while all other indicator lights maintain the red dynamic "X" pattern.

	
(3)	After the flashing green ends in the straight-through vehicle phase transition, the transition enters its second stage - the yellow light. The traffic signal will display a solid yellow light for several seconds (typically 3 seconds). The smart crosswalk system follows the traffic signal, with the warning lights at the straight-through lane stop line displaying steady yellow lights, while all other indicator lights maintain the red dynamic "X" pattern. 
(4)	Following the yellow light display at the end of the straight-through vehicle phase transition, the system enters its final stage - the all-red phase. During this all-red state, both the crosswalk and vehicle lanes display red signals. The smart crosswalk system synchronizes with the traffic signals, with all warning lights showing red dynamic "X" patterns. 

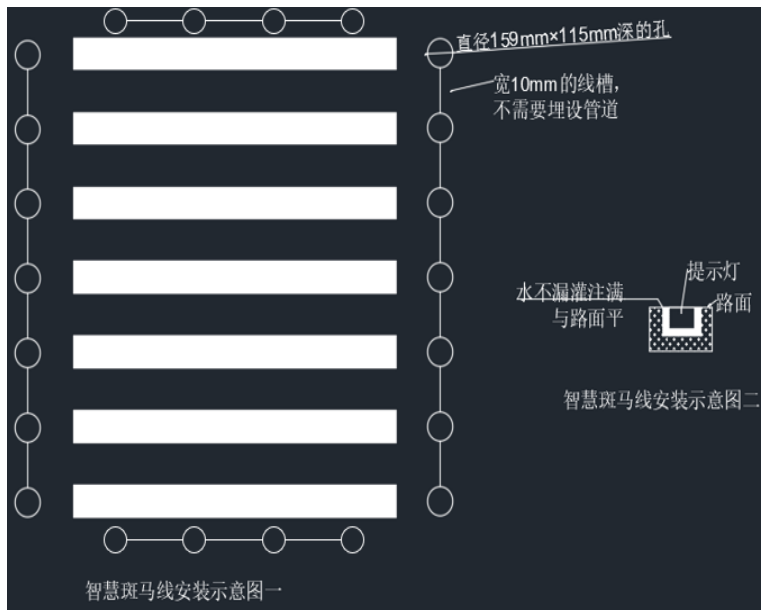
3	The left-turn vehicle phase
(1)	After the straight-through vehicle phase transition ends, the left-turn vehicle phase begins. The left-turn traffic signal turns green, and the smart crosswalk system displays green dynamic left-turn arrow patterns at the left-turn lane stop line while showing red dynamic "X" patterns on all other warning lights. 
(2)	When the left-turn vehicle phase is about to end and enters the transition phase, there will first be several seconds (typically 3 seconds) of flashing green light for left-turning traffic. During this time, the smart crosswalk system's warning lights at the left-turn lane stop line will flash green left-turn arrow patterns, while all other indicator lights maintain the red dynamic "X" pattern. 
(3)	After the flashing green ends in the left-turn vehicle phase transition, the transition enters its second stage - the yellow light. The traffic signal displays a solid yellow light for several seconds (typically 3 seconds). The smart crosswalk system synchronizes with the traffic signal, with the warning lights at the left-turn lane stop line displaying steady yellow lights, while all other indicator lights maintain the red dynamic "X" pattern.

	
(4)	Following the yellow light display at the end of the left-turn vehicle phase transition, the system enters its final stage - the all-red phase. During this all-red state, both the crosswalk and all vehicle lanes display red signals. The smart crosswalk system synchronizes with the traffic signals, with all warning lights showing red dynamic "X" patterns. 

4.Implementation

A ring of smart studs (pedestrian-oriented lighting) shall be installed along the outer perimeter of each crosswalk, aligned with the crosswalk stripes. One row of smart studs (vehicle-oriented lighting) shall be installed at each approach stop line. One control cabinet shall be provided per intersection. The exact quantity of warning lights shall be determined according to actual intersection conditions.

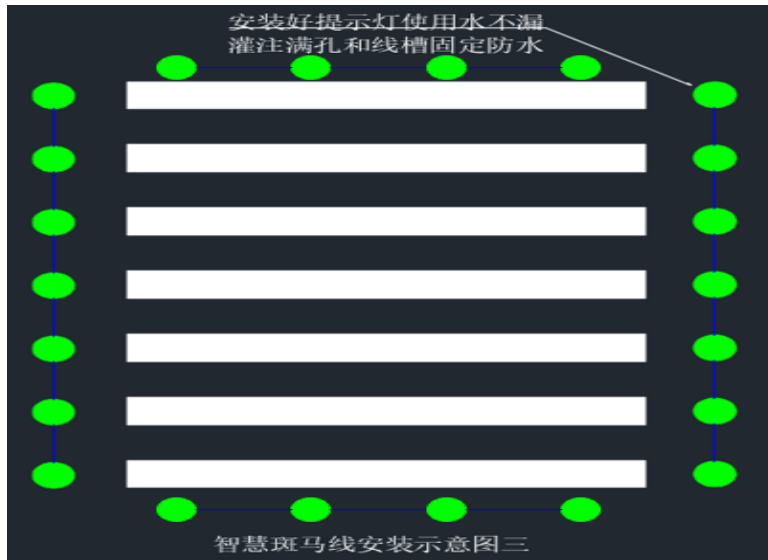
The installation diagram of smart studs is shown below:



Note:

Holes with diameter of 259mm and depth of 115mm.

Cable raceway with width of 10mm. No pipeline burial required



5.Expectation

The implementation of smart crosswalk systems at intersections can significantly reduce the probability of vehicle-pedestrian accidents at crosswalks. By providing vehicle-pedestrian coordination, the system helps mitigate rear-end collisions and traffic congestion caused by pedestrian red-light violations, thereby improving safety for both pedestrians and motorists. The system delivers comprehensive functions including: red-light violation alerts for pedestrians, vehicle crossing warnings, pedestrian priority enforcement, and enhanced nighttime crosswalk visibility.