

- c. at a location where a traffic signal is warranted for only short periods of the day; or
- d. at a location where turning movements occur often only during specific time periods and do not occur during the remainder of the time.

The advantages of the fully-actuated mode are as follows.

- a. It can efficiently control high traffic volume.
- b. It is efficient at an isolated intersection.
- c. It can handle varying traffic demands such as a complex intersection where one or more movements are sporadic or subject to wide variations in traffic volume.
- d. It can count traffic volume for all detected movements.

The disadvantage of the fully-actuated mode is the additional costs of installing and maintaining detection equipment on all of the approaches.

#### **502-3.03(02) Pedestrian Control [Rev. Jan. 2016]**

The pedestrian feature works in conjunction with the signal controller. This feature allows for the timing of the “Walk” and “Don’t Walk” cycles and can be actuated by pedestrian push buttons. *IMUTCD Chapter 4E describes pedestrian control features. See Section 502-3.04(05) for information on the use of pedestrian signals and accessible pedestrian signals.*

Advantages of the pedestrian feature include the following.

- 1. It provides additional time for crossing pedestrians.
- 2. Where there is minimal pedestrian demand, disruption to the vehicular phases can be minimized.

Disadvantages of the pedestrian feature are as follows.

- 1. Where pedestrian push buttons are required, they must be located in a convenient, accessible location.
- 2. Pedestrian cycles concurrent with green time can delay right-turning vehicles.
- 3. It can increase the required minimum green time on the minor street if the major street is wider than the minor street.

#### **502-3.03(03) Preemption**

Preemption is the modification of a signal's normal operation to accommodate an occurrence such as the approach of an emergency vehicle, the passage of a train through a nearby grade crossing, priority passage of transit vehicles, or the opening of a moveable bridge. With a microprocessor-based controller, all preemption routines are performed by the controller software. The only necessary external equipment is the preemption call detection device.

Preemption sequences should be shown in the plans or in the special provisions. For information on preemption equipment, the designer should contact the manufacturer. The following describes situations where preemption is used.

1. Railroad-Crossing Preemption. The purpose of the preemption is to clear vehicles from the railroad crossing before the arrival of a train. Where a signalized intersection is within 200 ft of a railroad grade crossing with active warning devices, preemption is required. Where this distance is between 200 ft and 600 ft, a queue analysis should be performed to determine if a highway-traffic queue has the potential for extending across a nearby rail crossing. If the analysis indicates that this potential exists, the traffic signal should be interconnected with active warning devices at the railroad crossing. The Federal *MUTCD*, the Indiana *MUTCD*, and the *FHWA Railroad-Highway Grade Crossing Handbook* describe preemption strategies and define the requirements for grade-crossing preemption.

Railroad-crossing preemption requires interconnection between the traffic-signal controller and the grade-crossing signal equipment. The preemption routine at the traffic-signal controller is initiated by the approach of a train, as detected by the railroad's controller, and starts with a transition from the current phase into the Track Clear Green interval (TCG). The TCG interval is used to clear vehicles which can be stopped between the railroad-crossing stop line and the intersection. Subsequent signal displays include only those that are not in conflict with the occupied grade crossing. Once the railroad preemption call is cleared, after the train has passed, the traffic signal is returned to normal operations. On a state route, this type of preemption requires an agreement between the State and the Railroad.

Railroad-crossing preemption shall be designed using either simultaneous or advance preemption sufficient to provide for Right-of-Way Transfer Time (RTT) to transition into the TCG interval. The TCG interval shall be sufficient to clear the last vehicle in the queue past the Minimum Track Clear Distance (MTCD), avoid vehicle-gate interaction, and provide separation time as required. Traffic-control signals with railroad preemption should be provided with a back-up power supply.

Best- and worst-case scenarios shall be considered with regard to the signal phase state and all known preemption traps, such as the advance, second train, failed circuit, and vehicular-

yellow preemption traps. Pre-signals, queue-cutter signals, and not-to-exceed timers should be considered as options where an engineering study determines that the queue extends into the track area.

Other options to consider for railroad preemption are blank-out signs for protected or permitted left turns, optically programmable heads for pre-signals, and pavement markings and signage to prevent vehicles from stopping on the tracks if inadequate storage distance exists for the design vehicle.

2. **Fire-Station or Fire-Route Preemption**. The most common preemption method is the activation of the preemption sequence at a fixed point, e.g., a push button located within the fire station. On a state route, this type of preemption requires an agreement between the State and the appropriate local public agency.

The simplest form of fire-station preemption is the installation of a traffic signal, at the fire-station driveway intersection with a major through street. The signal remains in the through-street green display until called by an actuation in the fire station. The signal then provides a timed green indication to the driveway to allow emergency vehicles to enter the major street.

Where the fire station is near a signalized intersection, a preemption sequence can be designed to display a movement permitting the passage of emergency equipment through the intersection.

Where emergency vehicles frequently follow the same route through more than one nearby signal, a fire-route-preemption operation should be provided. Actuation of the fire-station push button will be transmitted to all of the signals along the route and, after a variable timed delay, each signal will provide a preempt movement display. This will provide a one-way green wave away from the fire station, allowing the optimal movement of emergency equipment.

3. **Emergency-Vehicle Preemption**. The preemption equipment causes the signals to advance to a preempt movement display. On a state route, this type of preemption requires an agreement between the State and the appropriate local governmental agency.

The system used on a state route for identifying the presence of the approaching emergency vehicle uses a light emitter on the emergency vehicle and a photocell receiver for each approach to the intersection. The emitter outputs an intense strobe light flash sequence, coded to distinguish the flash from lightning or other light sources. The

electronics package in the receiver identifies the coded flash and generates an output that causes the controller unit to advance through to the desired preempt sequence.

This system requires a specialized transmitting device on each vehicle for which preemption is desired, and it requires that an emergency-vehicle driver activate the transmitters during the run and turns off the transmitter after arriving at the scene. This system also provides directionality of approach and a confirmation light at the signal that notifies the approaching emergency vehicle that the preemption call has been received by the equipment in the traffic-controller cabinet.

4. **Transit-Vehicle Priority**. Most transit-priority systems are designed to extend an existing green indication for an approaching bus and do not cause the immediate termination of conflicting phases, as occurs for emergency-vehicle preemption. On a state route, this type of preemption requires an agreement between the State and the appropriate local public agency.

One system is a light emitter and receiver system, using the coded, flash-strobe light emitter. An infrared filter is placed over the emitter, so that the flash is invisible to the human eye, and a flash code is used to distinguish the transit preemption call from that for an emergency vehicle. The intersection receiver can be configured to provide both emergency-vehicle preemption and transit priority with the same equipment. Another system uses the same type of radio transmitter and receiver equipment as used for emergency-vehicle preemption.

Two other types of transit vehicle detectors have been used and are available. One, a passive detector, can identify the electrical signature of a bus traveling over an inductive loop detector. The other, an active detector, requires a vehicle-mounted transponder that replies to a roadside polling detector.

#### **502-3.03(04) Controller Cabinet**

A controller cabinet is an enclosure designed to house the controller unit and its associated equipment, providing for its security and environmental protection. Each controller cabinet must satisfy the INDOT *Standard Specifications*. Section [502-3.04\(04\)](#) provides roadside-safety considerations for the placement of the cabinet. Foundation requirements for each cabinet type are shown on the INDOT *Standard Drawings*. The following cabinet types are used by the Department.

1. P-1 Cabinet. The P-1 cabinet is a ground-mounted cabinet. This cabinet is the preferred Department cabinet.
2. R-1 Cabinet. The R-1 cabinet is a taller version of the P-1 cabinet. It is used only where equipment needs dictate the additional space.
3. M Cabinet. The M cabinet is a ground-mounted cabinet. This cabinet should be used where space limitations or sight restrictions are a factor at the intersection.
4. M Stretch Cabinet. The M stretch cabinet is a ground-mounted cabinet installed on a type M foundation. This cabinet should be used where space limitations or sight restrictions are a factor at the intersection and where equipment needs dictate additional space.
5. G Cabinet. The G cabinet is a pedestal-mounted or pole-mounted cabinet. The Department no longer uses this cabinet due to its limited size. However, this cabinet type may be used, if practical, for matching or upgrading existing local signals.

#### **502-3.03(05) Detector [Rev. Jan. 2016]**

1. Operation. The purpose of a detector is to determine the presence or the passage of a vehicle, bicyclist, or pedestrian. This presence or passage detection is sent back to the controller which adjusts the signal accordingly. There are many types of detectors available that can detect the presence or passage of a vehicle. INDOT uses only inductive loop detectors in its signal design. The inductive loop detector is preferred because it can be used for passage or presence detection, vehicular counts, and speed determinations. It is accurate and easy to maintain. Although the inductive loop detector is the system of choice, this does not prevent recommendation of the use of new devices in the future. If, in the designer's opinion, a different detector should be considered, its use must first be coordinated with the district Traffic Engineer and the Traffic Control Systems Division to determine the acceptability of the recommended device and to determine maintenance requirements or equipment needs.

The detection device can operate in the modes as follows.

- a. Passage, or Pulse, Detection. A passage detector detects the passage of a vehicle moving through the detection zone and ignores the presence of a vehicle stopped within the detection zone. The detector produces a short output pulse once the vehicle enters the detection zone. The loop is a single loop with a

diameter of 6 ft, or a regular octagon shape with sides of 2.5-ft length at a spot location upstream of the stop line.

- b. **Presence Detection**. A presence detector is capable of detecting the presence of a standing or moving vehicle in the detection zone. A signal output is generated for as long as the detected vehicle is within the detection zone, subject to the eventual tuning out of the call by some types of detectors. The long loop design for a long detection area is considered to be a presence detector.
- c. **Locking Mode**. The controller memory holds the call once a vehicle arrives during the red or yellow display after the vehicle leaves the detection zone, until the call has been satisfied by a green display.
- d. **Non-Locking Mode**. For a non-locking operation, the call is held only while the detector is occupied. The call is voided once the vehicle leaves the detection area. The non-locking mode is used with a presence detector.
- e. **Delayed Detection**. Delayed detection requires a vehicle to be located in the detection area for a certain set time before detection is recorded. If a vehicle leaves the area before the time limit is reached, no detection is registered. This application is appropriate where a right-turn-on-red is allowed.
- f. **Extended-Call or Stretch Detection**. With extended-call detection, the detection is held by the detector after a vehicle has left the detection area. This operation is performed to hold the call until the passing vehicle has had time to reach a predetermined point beyond the detection zone. With a solid-state controller, the extended-call detection is handled by the controller software.

Where the controller is part of a coordinated signal system design, extended or delayed detection should be used to ensure that the local controller will not adversely affect the timing of the system.

- 2. **Inductive Loop Detector**. An inductive loop detector consists of four or more turns of wire embedded in the pavement surface. As a vehicle passes over the loop, it changes the inductance of the wire. This change is recorded by an amplifier and is transmitted to the controller as a vehicular detection. NEMA criteria define the requirements for detector units and the *Approved Products List of Traffic Signal and ITS Control Equipment* identifies the detector units approved for use.

The advantages of a loop detector are as follows:

- a. it can detect vehicles in both presence and passage modes;
- b. it can be used for vehicular counts and speed determination; and
- c. it can be designed to satisfy the various site conditions.

A disadvantage of the loop detector is that it is vulnerable to pavement surface problems, e.g., potholes, which can cause breaks in the loops. To alleviate this problem, a sequence of loops should be used.

The types of loop detectors are the long loop, which is rectangular at 6 ft x 20 ft to 65 ft and the short loop, that can be of regular octagon or circular shape. INDOT uses the short loop. The long loop, as a single entity, is being supplanted by a sequence of short loops which emulate the long loop. The INDOT *Standard Drawings* illustrate typical loop layout and installation details. The layout shown in the INDOT *Standard Drawings* is for illustrative purposes only. Each intersection should be designed individually to satisfy local site conditions.

A sequence of loops is used at an intersection for presence detection of vehicles stopped at the traffic signal. A set of loops before the intersection is used to determine the passage of vehicles. The distance from the stop line to these loops is based on the posted speed limit. Section [502-3.04\(10\)](#) provides additional information on detector locations. Section [502-3.04\(11\)](#) provides information on loops set up to count traffic.

A preformed loop is a detector loop constructed of the designated number of turns of wire contained inside a protective jacket. It is paved over with concrete or asphalt pavement. A preformed loop may be installed in a 1-, 2-, 3-, or 4-loop configuration. Wires from preformed loops are spliced to the 2-conductor lead-in cable in a handhole or detector housing. The *Approved Products List of Traffic Signal and ITS Control Equipment* identifies the preformed loops approved for use.

3. Other Detector Types. INDOT uses the inductive-loop detector. However, the following other detector types are also available.
  - a. Magnetic Detector. A magnetic detector consists of a small coil of wires located inside a protective housing embedded into the roadway surface. As vehicles pass over the device, the detector registers the change in the magnetic field surrounding the device. This signal is recorded by an amplifier and relayed back to the controller as a vehicular detection. A problem with this detector is that it can detect only the passage of a vehicle traveling at a speed of 3 mph or higher. It

cannot be used to determine a stopped vehicle's presence. The advantages are ease of installation and resistance to pavement-surfacing problems.

- b. **Magnetometer Detector**. A magnetometer detector consists of a magnetic metal core with wrapped windings, similar to a transformer. This core is sealed in a cylinder with a diameter of 1 in. and length of 4 in. The detector is placed in a drilled vertical hole about 1 ft into the pavement. A magnetometer detector senses the variation between the magnetic fields caused by the passage or presence of a vehicle. The signal is recorded by an amplifier and is relayed to the controller as a passage or presence vehicle. A magnetometer detector is sufficiently sensitive to detect a bicyclist or to be used as a counting device. A problem with the magnetometer detector is that it does not provide a sharp cutoff at the perimeter of the detection vehicle, i.e., it can detect vehicles in adjacent lanes.
- c. **Wireless Vehicle Detector**. A wireless vehicle detector is similar to a magnetometer detector except that it uses a low-power radio to transmit the signal to a wireless repeater or receiver processor. The signal is recorded by an amplifier and is relayed to the controller as a passage or presence vehicle. The detector is placed in a drilled vertical hole of 0.2 ft depth into the pavement. The wireless repeater and receiver processor should be mounted to the signal structures. The ethernet cable for the receiver processor may be placed across the span wire on a span and strain pole installation. A wireless vehicle detector is sufficiently sensitive to detect a bicyclist or to be used as a counting device. A disadvantage is that it must be replaced at least every 10 years and the wireless repeater's batteries must be replaced every 2 years. See Figures [502-3A](#) and [502-3B](#) for installation details.
- d. **Microloop Detector**. A microloop detector is similar to a magnetometer detector. The microloop is installed by drilling a hole of 3 in. diameter to a depth of 1'-6" into the pavement structure, by securing it to the underside of a bridge deck, or inserting a conduit of 3 in. diameter under the pavement to accommodate a non-invasive microloop system. A disadvantage is that it requires motion to activate the triggering circuitry of the detector and it does not detect a stopped vehicle. This type of detector requires two detectors placed side-by-side per lane due to its limited field of detection.
- e. **Video-Image Detector**. The video-image detector consists of one to six video cameras, an automatic control unit, and a supervisor computer. The computer detects a vehicle by comparing the images from the cameras to those stored in

memory. The detector can work in both the presence and passage modes. This detector also allows the images to be used for counting and vehicular classification. A housing is required to protect the camera from environmental elements. Problems have been experienced with video detection during adverse weather conditions, e.g., fog, rain, or snow. INDOT allows video detection only for a temporary signal.

4. **Pedestrian Detector.** The most common pedestrian detector is the pushbutton. Where pedestrian signals are provided at pedestrian street crossings, they shall include pedestrian pushbuttons complying with section 4E.08 of the *MUTCD*.

For an accessible pedestrian signal (APS), the pedestrian pushbutton assembly is an integrated device that communicates information about the “Walk” and “Don’t Walk” intervals at signalized intersections in non-visual formats, i.e., audible tones and vibrotactile surfaces, to pedestrians who are blind or have low vision.

Pedestrian pushbutton detectors must be a minimum of 2 in. across in one dimension and contrast visually with their housing or mounting to meet the requirements of the *Americans with Disabilities Act* (ADA).

See Section 502-3.04(05) for information on the use of a pedestrian signals.

5. **Bicycle Detector.** The following methods are used for bicycle detection.
  - a. **Pushbutton Detector.** With the pushbutton detector, the bicyclist must stop and push the detector button for the controller to record the detection. This can require the bicyclist to leave the roadway and proceed on the sidewalk to reach the detector.
  - b. **Inductive-Loop Detector.** The inductive-loop detector can detect the bicycle without the bicyclist’s interaction. For the detector to be most sensitive, the bicycle should be ridden directly over the wire. A problem with a bicycle inductive-loop detector is that it requires metal to be activated. A bicycle tends to include more non-magnetic, man-made materials to increase its strength and reduce its weight. This has reduced the metal content that can be detected.
6. **Decision-Making Criteria for Consideration of Another Type of Detection.** A detection system other than inductive loops requires plans details. See Figures [502-3A](#) and [502-3B](#) for typical plans details. To use a type of detection other than inductive loops, the

designer must provide and submit documentation that one or more of the following conditions have been satisfied.

- a. An inductive loop design will not function because of a physical limitation, e.g., right of way, geometrics, pavement conditions, or obstructed conduit paths.
- b. A full inductive loop design has been considered and there is a post-design lifecycle cost advantage to using a detection system other than loops. No design time cost or labor savings will be considered in lifecycle cost calculations.
- c. A hybrid design using loops at the stop line and wireless magnetometers for advance vehicle detection has been considered and evaluated where a wireless magnetometer has been evaluated for advance vehicle detection only, and the hybrid design is the most cost effective for post-design lifecycle cost.

Written concurrence is required from the Office of Traffic Control Systems or the district Traffic Engineer, or the local agency for a local project, before another type of detection may be used at a specific location.

#### **502-3.03(06) Traffic Signal-Head Components**

The traffic-signal head consists of the signal head, signal face, optical unit, visors, etc. The criteria set forth in *IMUTCD* Part 4, the INDOT *Standard Specifications*, and ITE's *Equipment and Material Standards of the Institute of Transportation Engineers* should be followed in determining appropriate signal display arrangements and equipment. The following additional guidance is provided for the selection of the signal display equipment.

1. Signal-Head Housing. The signal head housing is made from polycarbonate plastic. For new traffic signal installations on the state highway system, the signal-head housing should have a black color. For traffic signal modernization projects on the state highway system, the existing yellow signal heads may be reused if approved by the district Traffic Engineer.
2. Signal Faces and Flashing Yellow Arrow Indications. Section [502-3.04\(01\)](#) provides the face arrangement for use on a state highway. The signal lenses should be placed in a vertical line rather than horizontally except where an overhead obstruction can limit visibility. Where protected left turns are followed by permissive left turns, the four-section signal head with a flashing yellow arrow indication should be used. *IMUTCD* Part 4 provides additional information on the arrangement of signal heads.

Considerations when specifying a flashing yellow arrow (FYA) signal indication include:

- a. Offset. Lateral position signal heads that include FYA for PPLT will be offset 4 ft right from the extension of left side of the left turn lane.
- b. Number of Sections and Alignment. The signal head display should be a four-section signal face that is aligned vertically. Vertically aligned heads should be top justified, that is the red or top indication should be at the same elevation and towards the upper span cable.

Where signal head height limitations exist so that it is not feasible to use a vertical four-section signal head, consideration may be given to mounting the head horizontally.

- c. Wiring. A 7C-14 signal cable is needed from each four-section head to the disconnect hanger, and a 9C-14 cable should be specified from the disconnect hanger to the controller.
- d. Supplemental Sign. To supplement traffic signal control, a “Left Turn Yield On Flashing Yellow Arrow” sign should be provided adjacent to the left-turn signal face when a FYA is used.
- e. Modernizations and Additional Heads for Through Movements. When converting a PPLT to a four-section FYA head, additional heads for the through movement may be needed to satisfy *IMUTCD* requirements for the number of through heads as follows:
  - 1) one for each through lane for approaches with multiple through lanes.
  - 2) two heads for approaches with a single through lane.

3. Lens Size. Only lenses having diameter of 12 in. should be used.
4. Signal Illumination. Light-emitting diodes should be used for all signal heads.
5. Visors. A visor should be used with each signal face. These visors are used to direct the signal indication to the appropriate approaching traffic and to reduce sun phantom. A tunnel visor provides a complete circle around the lens. A cutaway visor is a partial visor, with the bottom cut away. A partial visor reduces water and snow accumulation, and does not let birds build nests within the visor. The decision on which visor type

should be used is determined on a site-by-site basis. For a department installation, partial visors should be used. Visors are made of the same material as the housing.

6. Louvers. Louvers can be used to direct the signal indication to a specific lane. Louvers are used where signal heads can cause confusion for an approaching motorist. One example of this problem is where an intersection has its approaches at an acute angle and the signal indications can be seen from both approaches. The decision on whether to use louvers depends on site conditions and will be determined on a project-by-project basis.
7. Optically-Programmable Signals. Like louvers, optically programmable signals are designed to direct the signal indication to specific approach lanes and for specific distances. An advantage is that they can be narrowly aligned so that motorists from other approaches cannot see the indications. Applications include closely-spaced intersections and intersections where the approaches are at an acute angle. Optically-programmable signals should be mounted to keep the signal indication properly aligned. The cost is higher than louvers but the improved visibility can offset the cost. The decision on whether to use an optically-programmable signal depends on site conditions and will be determined on a project-by-project basis.

The lanes and limits of where optically-programmed heads are to be visible to motorists should be shown on the plans. This may be done by means of shading or other technique.

8. Backplate. A signal indication loses some of its contrast value if viewed against a bright sky or other intensive background lighting, e.g., advertising lighting. A backplate placed around a signal assembly enhances the signal's visibility and has been shown to provide a benefit in reducing crashes. However, a backplate also adds weight to the signal head and can increase the effect of wind loading on the signal. Normally backplates should be used on all signal heads unless directed otherwise by the district Traffic Engineer. A backplate is required by the INDOT *Standard Specifications* on all overhead 3-section signal heads for through lanes. Backplates to be installed with heads other than 3-section through movement should be identified on the plans.

Backplates for heads installed on existing cantilever structures should be specified to have louvers (slotted openings) to reduce wind load. Louvers should comprise no more than 40% of the backplate area.

The INDOT *Standard Specifications* require backplates to include a 2-in. yellow retroreflective strip around the perimeter of the backplate to enhance the conspicuity of the signal head at night. For non-INDOT projects where the reflectorized surface is not desired, the plans or special provisions should so indicate.

Backplates may be retrofitted onto existing traffic signal heads when the existing LEDs have some service life remaining and should be reused but backplates are needed. Currently LED indicators have a service life of about 6 years. The INDOT *Standard Specifications* require a retrofit to include a new signal housing along with the backplate. Retrofits should be indicated on the plans and are paid for under the Traffic Signal Head Retrofit pay item.

9. Pedestrian-Signal Head. A pedestrian-signal head controls the movement of pedestrians across designated approaches of a signalized intersection. Pedestrian signal heads with lenses of 18 in. x 18 in., are used with international symbols and pedestrian clearance interval countdown displays.

### **502-3.03(07) Signal-Support Structure**

Traffic-signal heads are installed using span, catenary, and tether cables on four steel strain poles, or with cantilever structures on all four corners. Pedestal or pole-mounted supplemental signals may be used if necessary. Pedestrian-signal heads are mounted on pedestals or poles.

*IMUTCD* Section 4E.08 provides guidance on the location of pedestrian pushbuttons.

A post-mounted signal has the following advantages:

1. low installation costs;
2. ease of maintenance, with no roadway interference;
3. considered most aesthetically acceptable;
4. acceptable locations for pedestrian signals and pushbuttons; and
5. provides visibility where a wide median with left-turn lanes and phasing exist.

A post-mounted signal has the following disadvantages:

1. requires underground wiring which can offset low installation costs;
2. does not provide visibility of signal indications for a motorist due to lateral placement of signal heads;
3. signal indications can be blocked by signs or trees;
4. may not provide a mounting location such that a display with understandable meaning is provided;
5. height limitations can be a problem where the approach is on a vertical curve; and
6. is subject to vehicular impact if installed close to the roadway, particularly in a median.

A cable-span-mounted signal has the following advantages:

1. ease of installation, with less underground work required;
2. allows lateral placement of signal heads for maximum visibility;
3. allows for future adjustments to signal heads;
4. allows signal placement with respect to the stop line;
5. can provide convenient post locations for supplemental signal heads and pedestrian signals and pushbuttons;
6. permits bridles to reduce distance from the stop line at a wide intersection as shown on Figure [502-3C](#); and
7. allows for proper placement of signs.

A cable-span mounted signal has the following disadvantages:

1. seen by some users as aesthetically unpleasing;
2. requires periodic maintenance for span tightening; and
3. prevents passage of over-height vehicles.

A cantilever-mounted signal has the following advantages:

1. allows lateral placement of signal heads and placement relative to the stop line for maximum visibility of signal indications;
2. may provide post locations for supplementary signals or pedestrian signals and pushbuttons;
3. accepted as an aesthetically pleasing method for installing overhead signals in a developed area;
4. rigid mountings provide the most positive control of signal movement in wind; and
5. allows better clearance to an overhead obstruction.

A cantilever-mounted signal has the following disadvantages:

1. costs are the highest;
2. on a wide approach, it can be difficult to properly place signal heads; and
3. limited flexibility for addition of new signal heads or signs on an existing cantilever.

For the span, steel strain poles provide greater strength, are easier to maintain, and require less space. Wood poles are limited to temporary installations and require the use of down-guy cables.

Each traffic signal cantilever structure shall be designed to satisfy the AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals*. Signal cantilever structures and foundations should be as shown on the INDOT *Standard Drawings*. See Section [502-3.03\(08\)](#) for design criteria for a non-standard structure.

At a rural signalized intersection, overhead highway lighting may be provided where warranted; see Section [502-4.02\(03\)](#). A traffic signal cantilever structure may be used for the overhead highway lighting. Figure [502-3D](#) provides an illustration of a combination signal-luminaire cantilever structure.

### **502-3.03(08) Signal Cantilever Structure Selection Guidance and Design Criteria**

1. Selection Guidance. The INDOT *Standard Drawings* provide details for standardized signal-cantilever structures, pole section 2, combination arm, and both drilled-shaft and spread foundations.

If soil-borings information is available for a roadwork project that the signalized intersection is part of, it should be used to determine whether the soil is cohesive or sand, the soil-bearing capacity, and the friction coefficient. Otherwise, the designer should contact the Office of Geotechnical Services. If soil-properties information is unavailable, one boring should be made at the intersection to be signalized. Once the soil properties are known, and the values are equal to or higher than those shown in Figure [502-3EE](#), the foundation type can be determined as shown in Figure [502-3EE](#).

If the soil properties are such that the values are lower than those shown in Figure [502-3EE](#), the foundation should be designed, and its details should be shown on the plans.

A signal cantilever structure should be designed to provide a minimum clearance of 17.5 ft under each signal head or sign. Clearance should be the vertical distance from the lowest point of the signal head or sign to a horizontal plane to the pavement surface below the signal head or sign.

A 3-section signal head may be placed where a 5-section signal head is shown on the INDOT *Standard Drawings*.

The structure should be provided with vibration-mitigation devices if either of the following conditions applies:

- a. structure has an arm length in excess of 50 ft; or
- b. structure is located where the speed limit exceeds 35 mph and the ADT exceeds 10,000, or the ADTT exceeds 1000. ADT and ADTT are for one direction regardless of the number of lanes.

The foundation location and type, pole height, arm length, and sign designations and messages should be shown on the plans. The true arm length should be shown from the center of the pole to the end of the arm. Such length, for pay item determination purposes, should be rounded to the higher 5-ft increment. The plans should show ADT and ADTT for each direction.

2. **Design Criteria.** If a structure shown on the INDOT *Standard Drawings* cannot be used, its foundation, pole, arm, and connections should be designed utilizing the following design conditions:

- a. wind speed of 90 mph;
- b. service life of 50 yr;
- c. Fatigue Category II;
- d. galloping considered;
- e. wind gusts considered with truck speed of 60 mph;
- f. backplates included for signal heads; and
- g.  $C_d$  for structure members = 1.1 for fatigue and in accordance with AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals*, Table 3-6 for working loads.

The device weights and areas are listed in Figure [502-3FF](#).

If necessary, the combination arm can be added by including pole section 2 of diameter of either 17 in. or 24 in. Where used, the combination arm length should be equal to or less than the length of the signal cantilever arm.

The pole's maximum allowable horizontal deflection should be limited to 2.5% of the structure height in accordance with AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals*, Section 10.4.2, group 1 load combination.

#### **502-3.04 Traffic Signal Design**

## **502-3.04(01) Design Criteria**

INDOT has adopted the *IMUTCD* criteria for the placement and design of traffic and pedestrian signals. The INDOT *Standard Specifications*, *Standard Drawings* and the following provide additional information.

1. All electrical service should be metered.
2. All parking regulations should be reviewed for a distance of at least 150 ft from the stop line or back to a detector.
3. All signal heads should be placed in accordance with *IMUTCD* Section 4D-15.
4. The necessary signal heads should be verified for the traffic movements as shown in the phase diagram.
5. All signal equipment should satisfy the lateral clearances as specified in Chapter 49.
6. Placement of signal structures and indications should consider the requirements of the Americans with Disabilities Act (ADA), with regard to the placement of pedestrian features.
7. Steel strain pole support height is 30 ft or 36 ft.
8. Preformed loop detection should be used where new pavement is constructed or pavement is to be replaced. The designer should contact the district Traffic Engineer before specifying preformed loops.
9. All existing signal components should be field-verified.
10. Position and direction of aiming for all signal heads should be in accordance with Section [502-3.04\(02\)](#).
11. Count loops should be provided in each travel lane approaching an INDOT project signalized intersection. The count loops shall be identified in the loop tagging table.
12. The location of detectors for the indecision zone is discussed in Section [502-3.04\(10\)](#).
13. For a signal cantilever structure, see Section [502-3.03\(08\)](#).

## **502-3.04(02) Signal Displays**

The *IMUTCD* requires that there be at least two signal heads for each through approach to an intersection or other signalized location. A single head is permitted for control of an exclusive turn lane, provided that this single head is in addition to the minimum two for through movements. For multiple left turn lanes, one head per lane shall be provided.

Supplemental signal indications may be used if the two signal indications are marginally visible or detectable. One signal head per approach lane has been shown to provide a benefit in reducing crashes. Situations where supplemental indications can improve visibility include the following:

1. approach in excess of two through lanes;
2. location where there can be driver uncertainty;
3. where there is a high percentage of trucks which can block the signal indications; or
4. where the approach alignment affects the continuous visibility of normally-positioned signal indications.

The following figures illustrate the placement of signal heads.

1. Figure [502-3E](#), Rural Two-Lane Road with Obstructed Sight Distance
2. Figure [502-3F](#), Offsetting Intersection
3. Figure [502-3G](#), Rural Two-Lane Road with Truck Blocking View of Signal Heads
4. Figure [502-3H](#), Approaching Lanes with Permissible Phase and Parking on Near Side
5. Figure [502-3 I](#), Approaching Lanes with Left-Turn Lane with Permissible Phase and Parking on Far Side
6. Figure [502-3J](#), Approaching Lanes with Left-Turn Lane with Protected Phase
7. Figure [502-3K](#), Approaching Lanes with Left-Turn Lane with Permissible Phase
8. Figure [502-3L](#), Approaching Lanes with Left-Turn Lane with Protected/Permissible Phase
9. Figure [502-3M](#) – Multi-Lane Roadway Approaching Lanes with Left-Turn Lane Protected Phase
10. Figure [502-3N](#), Approaching Lanes with Two Left-Turn Lanes with Protected Phase
11. Figure [502-3 O](#), Approaching Lanes with Right-Turn Overlaps

#### **502-3.04(03) Visibility Requirements**

The minimum visibility for a traffic signal is defined as the distance from the stop line at which a signal should be continuously visible for various approach speeds. *IMUTCD* Section 4D-15 discusses the number and location of signal indications by approach.

Signal heads for one approach should be mounted no less than 10 ft apart between the centers of the heads, measured perpendicular to the direction of travel.

#### **502-3.04(04) Placement of Signal Equipment**

Available options are limited in determining acceptable locations for the placement of signal pedestals, signal poles, pedestrian detectors, and controller cabinets. Considering roadside safety, these elements should be placed as far back from the roadway as practical. However, due to visibility requirements, limited signal cantilever structure arm lengths, limited right of

way, restrictive geometrics, pedestrian requirements, or overhead or underground utility conflicts, traffic signal equipment must be placed relatively close to the travelway. The following should be considered in determining the placement of traffic signal equipment.

1. **Traffic Signal Support.** A traffic signal support should be placed to provide the lateral clearance as specified in Chapter 49.
2. **Controller Cabinet.** In determining the location of the controller cabinet, the following should be considered.
  - a. The controller cabinet should be placed in a position so that it is unlikely to be struck by an errant vehicle. It should be outside the obstruction-free zone.
  - b. The controller cabinet should be located where it can be accessed by maintenance personnel.
  - c. The controller cabinet should be located so that a technician working in the cabinet can see the signal indications in at least one direction.
  - d. The controller cabinet should be located where the potential for water damage is minimized.
  - e. The controller cabinet should not obstruct intersection visibility.
  - f. The power service connect should be close to the controller cabinet.
  - g. Where a utility must perform additional work to provide power to the service point, such information should be included in the contract special provisions.
3. **Pedestrians.** If the signal pole must be located in the sidewalk, it should be placed to minimize pedestrian conflicts. The signal pole shall not be placed so as to restrict wheelchair access to curb ramps. Pedestrian pushbuttons must be conveniently located. *IMUTCD* Sections 4E.08 through 4E.13 provide criteria for ADA accessibility.

#### **502-3.04(05) Pedestrian Signal [Rev. Jan. 2016]**

Pedestrian signal indications should be provided on a new or modernized traffic-signal installation in accordance with *IMUTCD* Section 4E.03.

An INDOT pedestrian signal installation should satisfy the INDOT *Standard Specifications*. For a local-agency facility, a pedestrian signal installation should satisfy ITE criteria and local practice. *IMUTCD* Section 4E.04 provides additional information regarding the location of pedestrian-signal indications.

The use of an accessible pedestrian signal (APS) at a location will be based on an APS study conducted by the designer or the district Traffic Engineer. An editable version of the APS Study Report Form is available from the Department's Editable Documents webpage at <http://www.in.gov/dot/div/contracts/design/dmforms/>, under Traffic. When an APS is used, the percussive tone should be specified for APS when the pushbuttons at a curb ramp are separated by 10 ft or more. The speech walk message should be specified for APS when the pushbuttons at a curb ramp are separated by less than 10 ft. The speech walk message should normally be patterned after the model, "Broadway. Walk sign is on to cross Broadway." The speech walk message must not include commands or tell pedestrians that it is safe to cross. The speech walk message should also avoid superfluous street name terms such as "street" or "avenue" unless necessary to avoid confusion. When a speech walk message is required the Accessible Pedestrian Signals with Speech Walk Messages recurring special provision should be completed and inserted into the contract.

Where crosswalks are longer or the ambient noise level is greater, it may be necessary to specify speakers or baffling for the APS. A 7C/14 signal cable should be specified from the controller to each corner with APS.

#### **502-3.04(06) Signing and Pavement Markings**

Signal structures such as signal overhead structures, cantilevers, and span cables, can include regulatory and informational signs, e.g., left-turn lane only sign or street-name sign. See IMUTCD Tables 2B-1 and 2C-2. The effects on the signal overhead structure of wind loading and the weight of the sign should be considered. The number of signs should be limited on a traffic signal structure. Section [502-1.0](#) provides additional guidance on the placement and design of signs.

For a cable-span signal installation, lane-use-control signs should be placed over the lane on the near-side span. Street-name signs should be placed on right side of the far-side span.

Internally-illuminated street-name signs provide increased visibility at night. INDOT does not install these signs, but a local agency may request their installation along with an INDOT-controlled traffic signal. Their installation requires a contract between INDOT and the local agency.

Section [502-2.0](#) provides the criteria for the application of pavement markings at an intersection. Pavement markings are used to supplement the traffic-signal indication and lane-use signs.