Tall Tales: Poles, Heads and Arms

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1. Introduction

At the Aldridge Signals Barbecue on the Tuesday evening of the 2021 Signals Symposium, Chris Kennett took the first stand on the 'JCT Signals Soapbox' and railed against the overuse of tall poles at signal installations. Few people heard him as they were otherwise engaged in the sort of informal discussions these occasions promote. Later in the evening, I had a chat with him about the subject.

One of his main gripes was the obsession some road safety auditors appeared to have about using them. Another was that they were perceived as being a 'National Highways standard' when they are not. This might be a product of working, living or driving in an area where either an individual or small group of people influence what gets installed on the highway, or it might be an indication of a design philosophy that has lost touch with the basic requirements of signal visibility.

Against this backdrop, the aim of this paper, therefore, is to explore the topic of High-Level Signal Heads (HLSHs):

- What advice currently exists?
- What are the implications?
- When should you consider tall poles?
- When shouldn't you?
- Where *can* you stick your head?

2. Advice

My starting point was that there is very little specific advice regarding high level signal heads. You could find the odd mention, but nothing particularly specific. Some highway authorities or operators may have their own standard details, possibly policies on use, but this could be considered 'advice', rather than 'regulation'. How accurate was that as an opinion?

2.1 Design Manual for Roads and Bridges (DMRB)

2.1.1 CD 109 Highway Link Design

Stopping Sight Distance is shown in Table 2.10 'Design speed related parameters' for the relevant design speed, that is identified in Table 2.5 'Urban roads speed limit/ design speed relationship' for urban roads. Rural roads are dealt with earlier in the document with Figure 2.1 'Selection of design speed (rural roads)' and Table 2.3 'Layout constraint' used to determine the design speed, which can then be used in Table 2.10.

Clause 3.1 in Section 3 defines how the Stopping sight distance is measured in the vertical plane and shows the Measurement of stopping sight distance Envelope of visibility in Figure 3.1. For a stretch of carriageway,

the desirable minimum stopping sight distance shall be available between any two points in the centre of each lane within the horizontal extents of the visible envelope.

2.1.2 CD 116 Geometric Design of Roundabouts

Clauses 4.7 to 4.8 cover visibility to the signals at a roundabout, whilst 4.9 covers the junction intervisibility zone. Clause 4.8 makes a succinct reference to CD 109 (Ref 3.N) and reproduces the Envelope of Visibility in Stopping Sight Distance. Clause 4.7 provides the most specific advice:

On an external approach to a signal-controlled roundabout, each traffic lane shall have clear visibility of at least one primary traffic signal associated with its particular movement, from a distance equivalent to the desirable minimum SSD of the approach road.

It then points the reader to Section 3 for 'Circulatory visibility' and CD 123 (Ref 2.N) for requirements and advice on the provision of additional signal heads.

Section 3, namely Clause 3.49 requires drivers on the circulatory carriageway to be able to see its full width ahead of them for a visibility distance shown in Table 3.43 and shows Figure 3.48 to illustrate the required visibility distance and limit of visibility splay.

2.1.3 CD122 Geometric design of grade separated junctions

This has no specific references to traffic signals in terms of visibility, though Table 5.4 'Connector road design speed' can be used to determine the design speed for use in CD 109 to identify the Desirable Minimum Sight Stopping Distance. Whilst there may be traffic signal control at a grade separated junction, the actual grade separation is between the through movements of each route, whereas the point at which the conflict needs to be managed is effectively an at-grade junction, the design of which follows next in the CD sequence.

2.1.4 CD123 Geometric design of at-grade priority and signal-controlled junctions

Section 7 covers the visibility of signals and opens with Clause 7.1 requiring each traffic lane to have clear visibility of at least one primary signal associated with its particular movement from a distance equivalent to the desirable minimum stopping sight distance of the approach road. Clause 7.1.1 recommends duplicate primary signals for approaches with a speed of 85 kilometres per hour or more.

Clause 7.2 refers the reader back to CD 109 (Ref 5.N, interesting because that is for vertical alignment) for the visibility envelope but with the high object height amended 'where this exceeds 2 metres.' Figure 7.2 'Visibility requirements on approach to junction' is a version of CD 109 Figure 3.1 'Measurement of stopping sight distance' amended to show a signal head. The next few clauses involve the idea of signal heads that are suddenly something more interesting in the context of this paper:

7.2.1 Where multiple lanes are provided on the approach, a signal-controlled junction may have offside primary, double-headed or overhead additional signals to ensure visibility of the signals from all lanes.

7.2.2 A minimum of 2 signals should be visible from each approach arm and each stop-line.

NOTE The 2 signals usually comprise a primary and a secondary signal. Does that imply that the secondary signal counts towards visibility?

7.2.3 Additional signal heads may be provided, where a driver's vision of the signal head could be obscured, for example, by a lorry in the lane adjacent to the signal.

2.2 Traffic Signs Regulations and General Directions (TSRGD)

2.2.1 Part 6 The Schedule 14 General Directions

This is fundamental in terms of traffic signals being a sign.

Clause 4. The traffic light signals may be placed to face traffic proceeding in a particular direction if and only if –

(a) At least two identical sets of signals are placed so as to face traffic proceeding in that direction; and

(b) At least one of those sets of signals is a set of primary signals

2.3 Traffic Signs Manual (TSM)

2.3.1 Chapter 6

Section 2 covers layout requirements

2.1.4 states that the primary considerations for traffic signal design and placement are visibility and clarity, with road users approaching a junction clear what is required of them.

Section 3 Location of Signals starts with the requirement of a minimum of two signal heads visible per approach, at least one of which must be a primary signal, unless the traffic only consists of pedal cycles.

3.4.1 and 3.4.4 cover the permitted range of mounting heights as they relate to the centre of the amber aspect.

3.4.3 and 3.4.4 mention situations that may justify providing more than the statutory two traffic signal heads: multi-lane approaches; where large numbers of heavy goods vehicles or buses are present; or where poor sight lines compromise the visibility. The use of taller poles and mast arms is covered in 3.4.4.

3.4.5 briefly discusses, the installation and maintenance challenges higher-level signal heads present.

3.4.6 has some rather telling content. It states that the use of signal heads beyond the minimum number required by the Regulations at stand-alone crossings has become almost a matter of course in some places. They are often unnecessary, create extra clutter and should be avoided except where necessary to address a particular safety problem.

2.3.2 Chapter 1

However, right at the start of the Traffic Signs Manual, in Chapter 1 (thanks to Chris Kennett alerting me to it) we find Clause 2.4.2 with the following:

At traffic signals and signal controlled pedestrian crossings, TSRGD requires two signal heads per approach, one of which must be a primary signal head. At most sites, this should suffice. Some complex junction layouts may require extra signal heads (for example on multilane approaches) but designers should always start from a position of providing the minimum number of heads necessary. The routine use of ‘tall poles’ to provide an extra signal head mounted at height should be avoided.

2.4 Subsequent state of my assumption

Based upon the above, my assumption that there is little advice on the use of HLSH has been proven to some extent. There are certainly requirements in terms of visibility, but DMRB CD 116 and CD123, TSRGD, TSM Chapters 1 and 6 consistently require at least one primary signal for the relevant movement to be visible and for a minimum of two signals to be provided, the second of which is a secondary. The way this is achieved is up to the designer. In addition, there is also a consistent inference to keep the number of signals provided to a minimum.

3. Implications

Before the situations that might be appropriate for using HLSHs are considered, the implications of including them within a design should be examined. If they are included in a design, they will have to be installed and maintained.

3.1 Installation

The means of mounting an HLSH such as a pole or mast arm may require a larger foundation than a regular traffic signal pole. A mast arm might use a large cube of concrete, or perhaps an inverted pedestal with reinforcement bars. This would compete for space against any buried services and may need to extend beneath the carriageway to achieve the required head position. The foundation would need to accommodate a cable route to the assembly. A gantry would double or quadruple those concerns and potentially require a bespoke design of a structure.

Tall poles are less of a challenge in terms of foundation as NAL provide advice in their installation guides for 6 metre (m) poles. However, if the pole needs to be more than 6m long, more work will be required to design an appropriate foundation.

How will the pole or mast arm be installed in its foundation? Some form of lifting device will be required such as a HIAB. And the installers will need access.

3.2 Maintenance

If it counts as a structure, it will require periodic inspections. How will you access the aspects to replace a lamp or clean them?

A cherry picker would be the most obvious way to access an HLSH, but that then requires traffic management to secure road space. It may be possible to have an area off-carriageway for the vehicle to position itself, but not every site has that luxury.

If a site has more than one HLSH, the opportunity might be taken to replace all the lamps and clean all the aspects once one lamp has failed. However, the access elements need to be organised: the road space; the cherry picker and the weather. If a red lamp has failed, surely there would be some urgency to have it replaced. The presence of the signal head may still contribute to awareness of the stop line, or a change in stage, but how necessary is the HLSH if a delay of more than a few days is acceptable? How does your maintenance contract deal with these situations?

There are some options that address access issues. There are poles that have internal pivot points, allowing the upper half to be lowered so anything mounted on it can be accessed from ground level. These may require an amount of traffic management, or at least a policy of not lowering the upper half of the pole during peak periods unless a faulty red lamp was considered an emergency. Positioning such poles needs to give due regard to the surrounding area to prevent unwanted interactions with the pedestrian and cycle routes, carriageway, other street furniture, vegetation and land boundaries. A further option is a mast arm that has a mechanism to rotate the cantilevered arm away from the carriageway to reduce the need to cone off the middle lane for cherry picker access.

For all of these taller assemblies, access to cable termination points can be kept at an easily accessible height with low-level access plates/ doors or min-pillars. Facilitating those low-level termination points would preferably require some cabling work prior to erection of the structure. That or some higher-risk, high-level cabling and termination work. The risk assessments and method statements would hopefully lead to the former, rather than the latter.

Whilst passively safe tall poles, including those that can be lowered, are readily available, a mast arm will almost certainly require protection if sited in a higher-speed location, unless it can be set well back and not require an extremely long outreach arm

4. When should you?

There are many things that could be said, but phrases like ‘visibility’ and ‘emphasise’ will tend to dominate the prose from a designer or reviewer justifying a HLSH. The essence of using tall poles is hopefully to satisfy the visibility requirements of CD 109, CD 116, CD 123 and Traffic Signs Manual Chapter 6 Table 2.1, that is, for a primary signal to be visible. So the aim is to meet or exceed the Desirable Minimum Stopping Sight Distance or Recommended Stopping Sight Distance appropriate for the speed situation on each approach to your site.

If that is not possible with a regular pole, then the tall pole/ mast arm/ gantry is supposed to solve that position by letting a head be positioned higher up.

However, visibility also has a horizontal component. And that tends to be the one that is most frequently interrupted by:

1. Buildings
2. Vegetation
3. Street furniture such as signs or lighting columns
4. Road alignment bringing 1, 2 and 3 into play

A tall pole will not necessarily help that, though you might be able to mount the head on lighting column if it can be appropriately positioned and all sorts of other wrangling stomached. A mast arm could be of more assistance, with the HLSH being out over the carriageway.

The vertical element involves the visibility envelope, which is probably not satisfied if you need the head to be higher. The hump in the road would probably make it difficult to see queuing traffic on the approach.

So why use a tall pole at all?

A review of my previous designs shows multiple approach lanes, from which it may be inferred that the aim has been to make sure one primary is always visible, especially if there are vulnerable pedestrians to protect on a high-speed approach. Many of the tall poles in my designs have been positioned on the offside of an approach. This is because most of the situations are approaches to roundabouts, where the nearside primary pole position tends to be tucked just around the bend of the kerb line where the flare opens up. Those primaries would often have to be 12m tall to be visible, but probably not at a point that is relevant to a driver. The overall aim was to avoid a high-sided vehicle blocking visibility to a primary red, if the vehicle was in the outer lane. In those situations, the offside primary and even the secondary can appear to be in the same position as a nearside primary when viewed from further upstream from the stop line. Yet would the secondary count towards visibility? It could be listed as a mitigation, but the requirement is for a primary to be visible. Unless CD 123 Clause 7.2.2 permits a secondary signal to be considered in terms of satisfying a visibility requirement.

When I started at Hampshire County Council in the 1990s, there was an unwritten rule that a three-lane approach required a mast arm and one with four lanes required a gantry. At that time, Hampshire had no four-lane approaches, with the possible exception of some of the circulatory sections of larger roundabouts. None of the grade separated interchanges with full or part-time signal control had tall poles, though from memory, none of the entry arms had three lane approaches.

In practice, an approach with multiple lanes could have islands to keep the maximum number of lanes between kerbs below three. A number of roundabouts around the country that have four lanes have a splitter island between the second and fourth lanes, neatly side-stepping the problem on entry arms and circulatory sections. The luxury of such width is not always available.

At various times I have undertaken designs for Highway Authorities that had very different interpretations of the regulations and advice in place at the time. One wanted a mast arm for a four lane circulatory section, whilst another did not want tall poles for a three lane main road approach. However, there were reasons for this:

- The circulatory approach was around 30m long, had four lanes and the entry arm immediately upstream also had four lanes and a mast arm. There was obviously a concern that traffic proceeding around the roundabout could find the regular primary poles obscured by high-sided vehicles legitimately in the first of or fourth lanes.
- The three lane main road approach was on a route that consistently had that number of lanes and no HLSH, so the Highway Authority had confidence that they were not needed.

5. When shouldn't you?

As has been shown for the 'When' considerations, there is no clear-cut situation where a HLSH should be used, only situations where they might be beneficial. Similarly, defining the 'shouldn't' is difficult, apart from the official instruction to not use them routinely.

One reason to not provide a HLSH, particularly one on a tall pole, would be for the sake of symmetry. It would be hard to make a case for providing a nearside tall pole to compliment the one you have decided is necessary for the offside solely on the basis of appearance.

To what extent can the anticipated behaviour of drivers form part of a justification to not provide HLSH? Is it reasonable to expect a driver knowingly approaching a set of traffic signals, who cannot see any of the signal heads due to high-sided vehicles, to brake when drivers in the other lanes brake? Or should the designer assume the driver will require more evidence before following suit? Perhaps the driver's workload is higher in those situations: being satisfied they are in the correct lane for their destination; staying in their lane and watching for others who may change lane. The high-sided vehicles may have obscured any Diagram 543 warning signs, reducing their awareness of an imminent signal junction. And yet, whatever the situation, if the vehicle ahead brakes, would not most drivers would tend to do the same?

6. Where *can* you stick your head?

As designer, you should be the one identifying when a HLSH is required and be able to substantiate it. Not just beneficial, but required. If you are designing a complex gyratory with four circulating lanes near a port or bus station, maybe that gantry is justifiable. Your colleagues designing the destination signs may already be considering overhead options. But just because your site is on a dual carriageway? That is hard to justify. Someone may decide to impose use of a HLSH, but make it clear they have taken design responsibility for that, noting that road safety audit is outside of the design process.

An element of Chris Kennett's original concern was that use of tall poles was effectively imposed by those not immediately responsible for a design. A safety auditor might propose one in response to a concern, or a client may have had a poor experience at a different site where a HLSH was not provided. As designer, you need to be satisfied with what you have proposed based on the standards, best practice and information available to you. It may be melodramatic to say that you could end up in court following an incident, though a design may come under official scrutiny either internally or externally in the event of a serious or fatal incident. An accident can be defined as a 'rare, random, multi-factor event in which one or more people fail to cope with their environment'. The 'rare' and 'random' elements of that may be particularly relevant. You as designer need to have used the design standards, best practice and advice from colleagues to minimise the 'rare' element and mitigated for the 'random'.

Considering the advice in DMRB, TSRGD and TSM, designers should concentrate on using HLSH to provide the greatest chance of keeping one primary signal visible, rather than over-using them. And resist the urge for symmetry.

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