

Providing Triangulation of Visibility at Sections and Connections

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Abstract: This article analyzes the main requirements for the organization of intersections and junctions on road networks. In order to ensure safe and efficient movement of traffic, such requirements as geometric parameters of intersections, visibility, equipment with traffic lights and road signs, and convenience for pedestrians are covered in detail. Also, factors that should be taken into account in the design, existing shortcomings and proposals for their elimination are presented. The article is of practical importance in improving road infrastructure.

Keywords: traffic safety, traffic flow, regulated intersection, secondary road, road markings, carriageway, traffic management, road infrastructure, geometric parameters of the road, canalized intersection, reducing the risk of accidents, deceleration and acceleration lanes, engineering solutions, drawings and design, requirements of ShNQ (Urban Planning Norms and Regulations) and GOST (State Standards), conflicting point, junction angles, visibility and artificial lighting, a level crossing, level junction, traffic flow analysis, speed regimes.

The demand for transport in modern cities is increasing. This requires the efficient and safe organization of road and transport infrastructure. In particular, intersections and junctions are the most important elements of the road network. They directly affect the continuity, safety and efficiency of traffic flow.

ShNQ 2.05.02-23, highway intersections and junctions should be placed on the correct parts of intersecting and connecting roads and on empty areas.

Types of level crossings and junctions

Intersections and junctions can be of the following types:

- ✓ single-level connection with three approaches;
- ✓ single-level intersection with four approaches;
- ✓ mixed intersections on the same level;
- ✓ an intersection at the same level as the designated left turns;
- ✓ ring intersection (must be designed in accordance with the requirements for ring intersections).

Intersections and junctions on the same level can be channeled, partially channeled and unchanneled.

It is necessary to simplify single-level intersections with more than four approaches:

- ✓ cancel part of the approaches and connect them in other places;
- ✓ cancellation of turning movements and use of one-way movement modes in approaches;
- ✓ division of intersections.

The following types of traffic control are used at level crossings:

- ✓ without installing priority signs at road intersections of equal importance;
- ✓ by installing priority signs at intersections of roads of equal importance;
- ✓ traffic light regulation.

The type of intersection or junction is selected depending on the class and category of the intersecting roads, as well as the speed of movement on the intersecting roads. When determining the type of intersection or junction, the use of a roundabout should be considered. On category II trunk roads and category IB main roads, it is not recommended to arrange roundabouts outside populated areas.

Intersections and junctions of highways at different levels (transport solutions) should be adopted mainly in the following cases:

- On category Ia roads, with all categories of roads, on category Ib and II roads, with categories II, III and Ic roads;
- At intersections of category III roads, the prospective traffic speed (on all intersecting roads) exceeds 8,000 units/s¹.

When the total traffic volume in the future is less than 2000 units/s, simple intersections and junctions at one level should be designed².

When designing the construction of intersections and junctions, it is recommended to organize intersections and junctions without regulating them with traffic lights.

Distances between intersections and joints

The number of intersections and junctions on roads of categories I-IV should be minimal. On roads of category IB, junctions are allowed to be located at a distance of no more than 5-10 km, and on roads of categories IV and II, junctions and junctions outside the boundaries of settlements are allowed at a distance of no more than 5-10 km. On roads of category III, intersections and junctions are allowed to be located at a distance of no more than 2-5 km, but, as a rule, at a distance of no more than 600 m, taking into account certain conditions (construction, layout of existing road networks, etc.).

^{1,2} - **ShNQ 2.05.02-23. Chapter 7. Intersections and junctions. § 1. Basic requirements.** Pages 35-36

For category IV roads, the distance between intersections and junctions on roads outside populated areas should not exceed 100 m, for category V roads - no more than 50 m from each other. On categories IV and V roads, the distance between intersections and junctions should be sufficient to accommodate a queue of vehicles before the intersection, such a queue should not impede movement at another intersection. To calculate the distance between intersections, it is necessary to take the length of the queue of vehicles, which should not exceed 5%.

Sight distances at intersections or junctions

Intersections and junctions of roads should be designed in places where they are visible on

main and secondary roads. If it is impossible to ensure the required visibility during the overhaul of a road, intersection or junction, the speed of vehicles should be limited to a value corresponding to the permitted speed increased by 10 km/h for the visibility distance.

The following must be provided at an intersection or junction:

- minimum road surface visibility distance for stopping at an intersection or junction on main and secondary roads;
- a warning triangle when entering or crossing a main road;
- minimum sight distance on pedestrian crossings and bicycle lanes and sidewalks (if any).

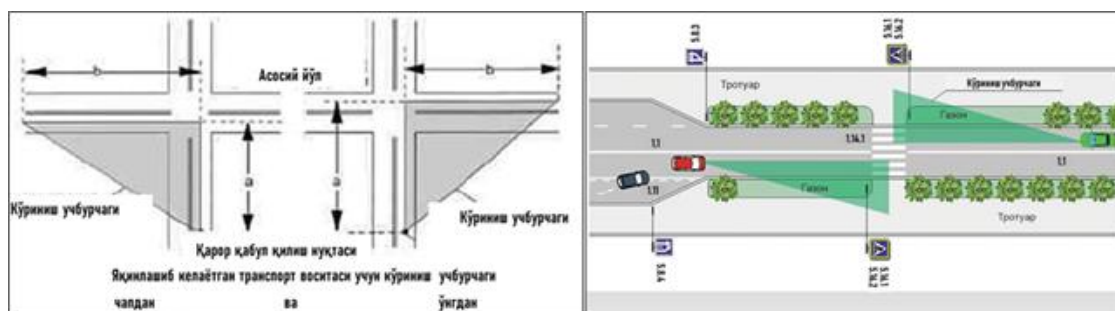


Figure 1. Minimum sight distance at intersections of primary and secondary roads and pedestrian crossings

If it is not possible to ensure visibility in the secondary direction of an unregulated intersection or junction, the sign 2.5 “**Movement without stopping is prohibited**” should be used. If the intersection is located on a convex curve of the longitudinal profile of a secondary road, then it is allowed to ensure visibility only by means of a directional island on the approach to the intersection. The directional island, as a rule, should be raised with a curbstone.

If the planned curve includes an intersection or junction with a turning device on the main road, when approaching the intersection or junction on a secondary road, it is allowed to ensure visibility only of the directional island at a distance sufficient for stopping the vehicle when using the sign 2.5 “**No stopping**”.

At intersections and junctions regulated by traffic lights, the –same visibility conditions as at unregulated intersections must be ensured when there is a traffic light and a conflicting left turn (against the flow of oncoming traffic). If it is impossible to ensure the visibility conditions established for unregulated intersections at a regulated intersection or junction, it is not allowed to turn off the traffic light during periods of low traffic intensity.

When determining visibility, the height of the driver's eyes above the road surface should be 1.2 m for a passenger car.

The visibility triangle must provide a field of view of the road surface and must be free of permanent obstacles in the form of parked vehicles, tall plants, objects other than technical means of traffic control, lighting poles, and the like, at a height of 2.5 m.

When checking the visibility in the vision triangle at a pedestrian crossing, the height of the barrier should be 0.6 m, and at the intersection of traffic flows - 1.0 m.

A driver driving on a main road must see a vehicle waiting to enter the main road and stopping on a secondary road at a distance of 3.0 m from its edge.

A level crossing or junction must be visible to the driver of a vehicle approaching the intersection from a distance that ensures safe braking and stopping before the intersection or

junction.

When approaching an intersection or junction, a driver should see:

- vehicles approaching from other approaches, from a distance that allows him to make a decision to maneuver and to perform this maneuver in a safe mode;
- the road markings on the carriageway at an intersection or junction.

The minimum sight distance for stopping should ensure the visibility of the lines located in the middle of the traffic lane at a height of 1.0 m above the road surface, at the driver's eye level (the height of the barrier is 0 m or more), except on roads with low traffic speeds.

The minimum stopping distance ***S*** is calculated using the following formula:

$$S_{\text{тѣх}} = \frac{V_{\text{хис}} \cdot t_p}{3,6} + \frac{V_{\text{хис}}^2}{254 \cdot \left(\frac{a}{g} \pm i\right)} \quad (1)$$

here: $V_{\text{хис}}$ – calculated speed at the beginning of braking, km/h; a – Acceleration deceleration during braking equal to $t_p - 3.4 \text{ m/s}^2$; calculated reaction time of the driver is 2.5 s; i – longitudinal slope, in decimal form; g – free fall acceleration is equal to 9.81 m/s^2 .

R , m , on vertical convex curves at which an intersection or joint is permitted is calculated by the following formula:

$$R = \frac{S^2}{2h_1}, \quad (2)$$

where: S – sight distance from full stop conditions, m ; h_1 – the height of the driver's eye above the road level – is 1.0 m.

Sight triangle at unregulated intersections where no mandatory stop is required on a secondary road

If it is permitted to pass through an intersection with a secondary road without stopping, a triangular visibility zone must be provided.

On primary and secondary roads, mutual visibility for drivers must be ensured within a triangle with sides equal to:

- on a secondary road – S_b , the minimum sight distance for stopping a vehicle at the intersection of a secondary road moving at the calculated speed and at the junction with a turning radius provided for when entering the main road, but not less than 30 m;
- road – at a constant design speed on the main road, the visibility distance corresponding to the visibility distance for a vehicle on a secondary road at a junction and for stopping, is the minimum visibility distance ***S_b*** on a secondary road calculated by formula (1) within the time required to travel at a constant design speed.

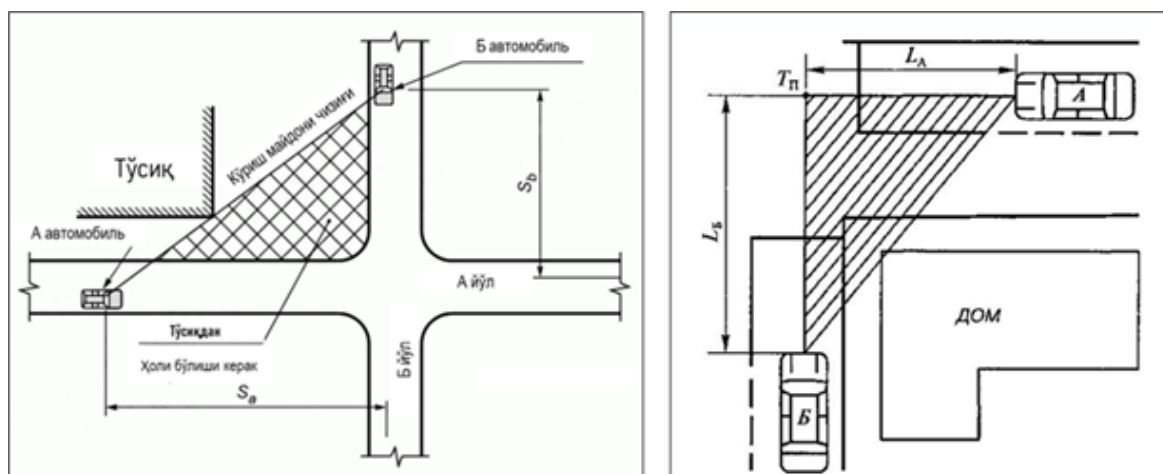


Figure 2. Sight distance along the main road and secondary road

S_a , L_A - visibility distance along the main path; S_b , L_B - visibility distance along the secondary path.

Warning triangle at unregulated intersections with mandatory stopping conditions on secondary roads

At intersections with mandatory stopping on a secondary road, a driver of a vehicle stopped on a secondary road must see the carriageway of the main road at a distance necessary to stop a vehicle approaching from the main road. In this case, the distance from the edge of the carriageway to the driver's eye on the secondary road should be taken as 4.5 m.

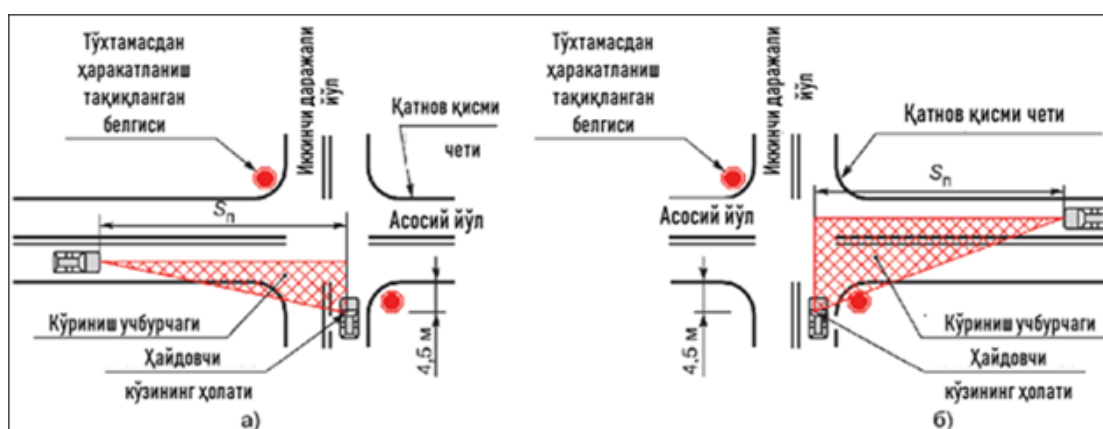


Figure 3. Sight triangle at unregulated intersections where mandatory stopping is required on a secondary road

If there are bicycle lanes on the main road, the distance from the driver's line of sight to the edge of the carriageway of the main road on the secondary road should be increased by the width of the bicycle lane.

Within the visibility triangle, its sides should be provided to those who are considered:

- on a secondary road –to the nearest axis of vehicle movement on the main road when turning right and to the axis of the lane closest to the vehicle approaching from the left when turning left (excluding the deceleration lane for turning right);
- The distance required for a car traveling along a main road to stop. –

Minimum sight distance at intersections with pedestrian crossings and bicycle paths

If there is a pedestrian crossing or intersection with a bicycle path at an intersection or junction, pedestrians and cyclists must be visible to the driver of the vehicle and to the

approaching vehicle.

The minimum visibility distance before a pedestrian crossing, $S_{pedestrian}$, m, is calculated based on the time required for a pedestrian to cross the road using the following formula:

$$S_{пиеда} = \frac{L_{утиш}}{V_{пиеда}} \cdot \frac{V_{хис}}{3,6},$$

here: $L_{утиш}$ - the length of the pedestrian crossing, m; $V_{хис}$ - calculated speed of the car, km/h; $V_{пиеда}$ - speed of pedestrians, 1.1 m/s.

At pedestrian crossings and intersections with bicycle paths, a vision triangle must be provided for drivers, calculated from the vision of a cyclist waiting to cross the road. The side of the vision triangle along the bicycle path must be at least 4 m.

When leaving the road from an adjacent area, if there is a pedestrian walkway or sidewalk, pedestrians moving along the pedestrian walkway or sidewalk must be visible. If the distance from the front bumper of the vehicle to the pedestrian or pedestrian walkway is at least 5.0 m, the side visibility along the sidewalk or pedestrian walkway must be at least 2.0 m.

Requirements for providing a triangle of visibility for pedestrian-vehicle conditions:

Table 1

Speed of movement, km/h	25	30	40	50	60	70	80	90
The parameters of the visibility triangle are, at least, m	8x40	9x43	10x50	11x57	12x64	13x71	14x78	15x85

The maximum required side visibility distance should be determined by the following formula:

$$S_{ен} = \frac{V_{ен}}{V_{авто}} \cdot S_{кўриниш};$$

where: $V_{ен}$ —speed of movement of the pedestrian on the intersecting road, **km/s** ; $V_{авто}$ —calculated speed of the car, **km/s** ; $S_{кўриниш}$ —based on the stopping condition, the calculated visibility distance before the obstacle, **m** .

Recommendations for ensuring visibility triangles at intersections and junctions:

1. Accurately defining the visibility triangle and clearing the area:

All obstructing objects (building elements, trees, advertisements) around intersections and junctions should be removed from the visibility triangle or modified as necessary.

Taking into account the different speeds and directions of vehicles when forming the vision triangle.

2. Clear and correct placement of road signs and signaling:

Ensure that all road signs and traffic control devices are placed within the sight triangle, clearly and timely visible to drivers.

Reducing the sharp corners of the road and widening the edges:

Expand the field of view by softening corners or increasing their radius at intersections and junctions.

3. Traffic speed control:

By limiting speed at intersections and junctions, increasing drivers' attention to visibility and ensuring the ability to stop in emergency situations.

4. Improvement of the lighting system:

Installation of road lights and special lighting elements to improve visibility in the evening and at night.

5. Routine maintenance and control:

The condition of the objects providing the visibility triangle should be regularly checked, the necessary repairs and cleaning should be carried out.

6. Providing information and promotion to road users:

Strengthen efforts to warn drivers about the importance of the warning triangle and their responsibility in traffic.

7. Use of engineering solutions:

It is advisable to use special bridges, tunnels, road corrections and other infrastructural methods to improve visibility during construction.

Conclusion

The visibility triangle at intersections and junctions plays an important role in ensuring road safety. The triangle of vision is the visual field necessary for the driver to see vehicles coming from different directions in time and make safe decisions.

The article describes the regulatory requirements of the visibility triangle at intersections and junctions, the reasons for their formation, and the dangers that arise when these requirements are not observed.

Technical solutions and design principles for the correct provision of the visibility triangle in urban planning, road infrastructure and traffic organization are presented.

Various building elements, trees, advertising banners, improperly positioned vehicles restrict visibility and threaten traffic safety, it was noted.

Engineering measures, legal compliance and regular monitoring are recommended to address existing problems.

The final conclusion is that the correct provision of a warning triangle at intersections and junctions –is a guarantee of safety not only for the driver, but also for all road users. Therefore, urban planners, road engineers and responsible organizations should take this issue seriously, strengthen design and practical control based on standards.

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