

Urban Roadworthiness Adequacy Analysis Using Star Rating for Risk-Based Treatment Prioritization

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Abstract

Growing urban traffic activity and complexity call for a more comprehensive evaluation of road conditions, one that considers safety alongside capacity. Summersari Street- Gajayana Street in Malang City is a strategic corridor linking an educational and residential area with the city center, and is also served by a Bus Rapid Transit line (Trans Jatim Corridor 1), yet an integrated roadworthiness adequacy evaluation of this corridor had never been conducted. This study analyzes the road's roadworthiness adequacy level using the star rating method, referring to Technical Guideline No. 06/P/BM/2024, and develops risk-based treatment priority recommendations. Primary data were collected through field surveys covering 15 consecutive segments of 100 meters each (13 mid-block segments and 2 three-arm intersection segments), capturing geometric attributes, road furniture, pedestrian facilities, and land use, which were processed into a Star Rating Score (SRS) for five motor vehicle crash types. The results show that all 13 mid-block segments (87% of the 15 segments assessed) achieved a 5-star rating (scores of 1.42-2.00), while the 2 intersection segments dropped to a 3-star rating (scores of 6.93 and 9.27), making their average score roughly 5.4 times that of the mid-block segments (based on two intersection segments only). Although the combined average SRS score (2.39) still falls within the 5-star category, a detailed analysis reveals that not a single segment has an adequate sidewalk on both sides of the road, 80% of segments lack pedestrian crossing facilities, and 4 segments near schools have no School Safety Zone. These findings show that the motor vehicle SRS score by design does not capture the facility deficiencies affecting vulnerable road users, so a 5-star motor vehicle rating should not be read as evidence of safety for pedestrians. Nine treatment recommendations were developed based on urgency and risk contribution, prioritizing the provision of sidewalks, pedestrian crossings, intersection channelization, and School Safety Zones.

Keywords: Pedestrian Facilities; Roadworthiness Adequacy; Road Safety; Star Rating; Urban Roads

ARTICLE INFO

Article history:

Received
2026-10-07
Revised
2026-10-17
Accepted
2026-10-17

Published by
ISSN

CV. Creative Tugu Pena
2963-6752

Website

<https://attractivejournal.com/index.php/ajse>

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1. INTRODUCTION

Rising urban mobility demands road infrastructure that is not only adequate in capacity but also meets safety and service standards. A road that fails to meet roadworthiness adequacy requirements (in Indonesian, Laik Fungsi Jalan, LfJ; the formal assessment is the Uji Laik Fungsi Jalan, ULFJ) can lower service levels, raise vehicle operating costs, and increase the potential for traffic accidents. Under Law No. 2 of 2022 on the Second Amendment to Law No. 38 of 2004 on Roads [1] and its implementing regulations [2], every road section must meet technical and administrative requirements before it can be operated at its full capacity, making roadworthiness adequacy evaluation an essential step in ensuring road user safety [3], [4].

In urban areas such as Malang City, growth in educational, commercial, and service activity drives a significant rise in traffic volume every year, and this growth is not always matched by improvements in infrastructure quality [5], [6]. One widely used international approach for assessing road safety is the star rating method developed by the International Road Assessment Programme (iRAP). This method evaluates road risk based on physical attributes that can be observed and measured in the field, without relying on historical crash data, which makes it a proactive way of identifying risk before a crash occurs [7], [8]. In Indonesia, this approach was formally adopted into the regulatory framework for road roadworthiness adequacy testing (ULFJ) through Technical Guideline No. 06/P/BM/2024, which replaced the previous provisions and introduced significant updates to the scoring procedure and implementing institutions [9].

Sumbersari Street, which connects to Gajayana Street, is one of the important corridors in Malang City, linking higher education and residential areas to the city's activity center. The corridor is also served by a Bus Rapid Transit line (Trans Jatim Corridor 1), which connects the greater Malang region [6]. This mass transit service increases the intensity of large-vehicle traffic and passenger boarding and alighting activity along the corridor, which in turn calls for infrastructure that meets safety, comfort, and accessibility standards for all road users.

1.1 Roadworthiness Adequacy Concept

According to Guideline No. 06/P/BM/2024, roadworthiness adequacy is defined as a condition in which a road section meets the technical requirements needed to ensure the safety and security of its users, as well as the administrative requirements that provide legal certainty for both road operators and road users, so that the road can be opened for public use [9]. The technical requirements for ULFJ cover six groups: pavement structure, supporting and connecting structures, road geometry, use of road space, traffic management and engineering, and road furniture [10], [11]. Compliance with these technical requirements is grouped into five star categories based on Star Rating Score (SRS) ranges, as summarized in Table 1, with the minimum star threshold varying by road type. A non-toll road already in operation, such as Summersari Street, for instance, is required to meet at least a 1-star category [9]. Under this criterion alone, all assessed segments (3- to 5-star) would meet the minimum threshold; the deficiencies identified in this study therefore concern the broader technical requirement categories and the safety of vulnerable road users, not formal non-compliance with the SRS threshold.

1.2 Star Rating Method

Road star rating is an approach developed by the International Road Assessment Programme (iRAP) to assess a road section's safety risk level based on physical attributes that can be observed and measured in the field [8]. Its relationship with observed safety performance indicators has been examined in Indonesia [7], roadworthiness assessment results have been related to accident-prone locations identified from crash records [12], and approaches for combining the separate road-user star ratings into a single index have been proposed [13]. Guideline No. 06/P/BM/2024 adopts this approach by defining seven groups of assessment attributes (A.0 through A.6), comprising a total of 46 attributes with 204 field condition codes, covering general segment information, traffic flow, speed, carriageway attributes, roadside attributes, vulnerable road user facilities and land use, and intersections [9]. The SRS score for motor vehicles is calculated using the official formula:

$$SRS = SRS_{Run-off} + SRS_{Ho-Loc} + SRS_{Ho-ot} + SRS_{Int} + SRS_{Pa} \quad (1)$$

where SRS(Run-off) is the risk score for run-off-road crashes, SRS(Ho-Loc) the head-on crash score from loss of control, SRS(Ho-ot) the head-on crash score from overtaking, SRS(Int) the intersection crash score, and SRS(Pa) the property access crash score. Each component is calculated as the product of a likelihood factor and a severity factor determined by the relevant road attributes, taking into account the effect of external traffic flow (traffic volume) and the potential for vehicles to cross the median (median traversability) [9]. This official SRS formula covers only the risk to motor vehicle occupants; the risk to pedestrians and cyclists is calculated separately under the fuller iRAP methodology and is not included in the combined motor vehicle score [13]. This methodological limitation is central to the findings discussed in Sections 3.5 and 3.6.

Table 1. Star Rating Categories Based on SRS Score Range [9]

Star Category	SRS Score Range	Interpretation
5-Star	0.0 to <2.5	Very low risk (safer road)
4-Star	2.5 to <5.0	Low risk (safer road)
3-Star	5.0 to <12.5	Moderate risk (considered acceptable)
2-Star	12.5 to <22.5	High risk (higher-risk category)
1-Star	≥22.5	Very high risk (highest-risk category)

1.3 Previous Studies and Research Novelty

Several studies have examined roadworthiness adequacy assessment and star rating on road sections in Indonesia. Muhammad et al. developed a quantitative, score-based approach for technical roadworthiness adequacy testing and road condition assessment [14]. Sahri and Maulana categorized roadworthiness adequacy test results from a safety perspective on secondary arterial roads in Yogyakarta and related them to accident-prone locations, showing that star rating and risk levels can support treatment prioritization [12]. Fitra applied technical roadworthiness adequacy testing to the Tambu–Tompe national road section in Central Sulawesi using six technical components and classified the section as conditionally adequate [3]. Ratnaningsih et al. evaluated the roadworthiness adequacy of the use of road

space, including sidewalks and the right-of-way, on Soekarno Hatta Street in Malang City, a study that serves as a direct methodological reference for the present research given the shared study city [15]. More recently, Indriastuti et al. applied roadworthiness adequacy testing with star rating to Prof. Dr. Hamka Street in Semarang and obtained an overall 3-star rating with several segments requiring improvement [16], while Husnudzon et al. combined iRAP star rating with road safety inspection on the Kopo–Soreang provincial road and found that the resulting countermeasures favored vehicle occupants over other road users [8]. Taken together, and to the authors' knowledge, these studies concentrate on technical condition scoring, method comparison or countermeasure selection for individual road sections, and none examines how the motor vehicle SRS under the 2024 guideline relates to the facilities available to vulnerable road users.

This review points to two research gaps that motivate the present study: (a) research on roadworthiness adequacy in Malang City has so far focused on Soekarno Hatta Street and has not yet covered Summersari Street, even though this corridor plays a strategic role as an education-area route also served by the Trans Jatim Corridor 1 bus line; and (b) the previous studies reviewed here largely refer to the pre-2024 version of the roadworthiness adequacy testing guideline, and so have not applied the updated technical formulation in Guideline No. 06/P/BM/2024, which introduces significant changes to the scoring procedure and implementing institutions. This study addresses both gaps and, in addition, applies a transparent, risk-based treatment prioritization in which treatments are ranked by the risk contribution of each deficiency and the vulnerability of the road users affected, rather than by budget constraints alone.

Building on this background, the present study aims to (1) analyze the roadworthiness adequacy level of Summersari Street- Gajayana Street in Malang City based on geometric conditions, safety facilities, and the road environment using the star rating method, and (2) develop effective treatment priority recommendations to improve the level of safety and roadworthiness adequacy, particularly along a corridor that supports mass transit operations. The findings are expected to serve as academic input for the Malang City Government in considering asset management and risk-based road treatment priorities.

2. MATERIALS AND METHODS

2.1 Study Location and Scope

The study was conducted along the Summersari Street corridor, which connects to Gajayana Street, in Malang City, East Java Province. This area is known as a center of higher education and student-oriented commercial activity, and is also served by the Trans Jatim Corridor 1 bus line. The corridor (about 1.5 km long) was divided into 15 consecutive coding segments of 100 meters each. Two of these segments (5A at 400-500 m and 11A at 1,000-1,100 m) contain three-arm intersections and were assessed separately from the straight (mid-block) segments because their risk characteristics differ. The roadworthiness adequacy analysis was limited to technical aspects only (administrative requirements were not covered), focusing on the physical condition and safety of the road infrastructure at the time of the survey, and did not include an in-depth pavement structure analysis or a study of driver behavior as a human factor.



Figure 1. Study location: Sumbersari Street – Gajayana Street corridor, Malang City
(Source: Google Maps)

2.2 Variables and Data Sources

The study variables were organized around the six groups of technical requirements for roadworthiness adequacy set out in the PUPR Ministerial Regulation on Roadworthiness Adequacy Guidelines [10], operationalized through the attributes on the Star Rating Technical Inspection Form. Primary data were collected through direct field observation and measurement, covering road geometric data (number and width of lanes, type of direction separator, alignment), median/separator data, pedestrian facilities (sidewalks and crossing facilities), land use along the corridor, property access points, road signs and markings, and peak-hour traffic volume. Secondary data were obtained from relevant agencies, including location maps, road status and classification, Malang City population figures [5].

2.3 Data Collection Procedure

Primary data collection was carried out by a survey team stationed at several strategic points along the study corridor, with roles divided among a team leader (coordinating the survey), surveyors inventorying road geometry and furniture (using measuring tapes and survey forms), traffic counters (using manual counters), and speed surveyors (using speed guns). Measurements were taken during both peak and off-peak hours to capture variation in operating conditions. All collected data were recorded on a Star Rating Technical Inspection Form for each segment and then compiled for analysis.

2.4 Data Analysis Method

Data analysis was carried out by converting the technical attributes recorded for each segment into a Star Rating Score (SRS) following the official formula in Guideline No. 06/P/BM/2024 [9]. The likelihood value was derived from the combination of attributes affecting the probability of a crash (traffic volume, speed, and geometry), while the severity value was derived from attributes affecting crash severity (type of direction separator, roadside object distance, and the other attributes defined for the motor vehicle SRS in Guideline No. 06/P/BM/2024 [9]; facilities for vulnerable road users are not part of this score). The calculation proceeded in two stages: first at the 100-meter segment level, producing an SRS

score and star rating for each segment, and then at the overall road section level, through a length-weighted aggregation of the SRS scores across all segments (as all segments are 100 m long, this equals the arithmetic mean); the section-level result is complemented by the distribution of star categories by length. The resulting SRS scores were then converted into star categories from 1 to 5 following the thresholds in Table 1.

2.5 Treatment Prioritization

Treatment priority recommendations were developed using a risk-based approach through the following steps: (1) identifying the segments with the highest SRS scores (lowest star ratings) as the primary candidates for treatment; (2) identifying the technical deficiencies that contribute most to the risk score in each priority segment; (3) formulating treatment recommendations that specifically target these dominant deficiencies, taking into account ease and estimated cost of implementation; and (4) grouping the recommendations by priority level (high, medium, low) and implementation timeframe (short, medium, long term).

Priority levels were assigned using two criteria: (i) the contribution of the deficiency to the SRS of the segment concerned (for the intersection segments), and (ii) the exposure and severity of the vulnerable road users affected (for pedestrian facility and School Safety Zone deficiencies in the use-of-road-space category, which had the lowest compliance level). Treatments that addressed the segments with the highest SRS, or that addressed deficiencies exposing vulnerable road users in the lowest-compliance category, were assigned high priority; treatments addressing other deficiencies were assigned medium or low priority according to their expected contribution to risk reduction. Implementation timeframes followed the complexity of each treatment: short term for signs and markings, medium term for physical works within the existing right-of-way, and long term for works requiring land acquisition or utility relocation.

3. RESULTS AND DISCUSSION

3.1 General Description and Segment Characteristics

The road section analyzed is the Summersari Street corridor connecting to Gajayana Street in Malang City, an area known as a center of higher education and student-oriented commercial activity (restaurants, convenience stores, boarding houses, and small offices). This high-intensity, mixed-use land pattern gives the corridor high vehicle and pedestrian movement throughout the day. The survey was carried out systematically by dividing the corridor into 15 consecutive segments of 100 meters each, two of which (5A and 11A) are special segments at intersection points that were assessed separately. The traffic survey recorded a corridor-wide average daily traffic (ADT) of 96,247 vehicles/day, and the same value was applied to every segment (see Section 3.3), with land use on both sides of the road entirely classified as commercial or office space within an urban area type.

3.2 Star Rating Results by Segment

Table 2 summarizes the SRS score and star rating for each 100-meter segment along the Summersari Street – Gajayana Street corridor, ordered from the starting point to the end point. The SRS values and the distribution of star categories are also plotted in Figures 2 and 3. The SRS of each segment is the sum of five crash-type

components (run-off, head-on loss of control, head-on overtaking, intersection, and property access).

Table 2. Star Rating Results by Segment

No.	Segment / Location	Length (m)	SRS Score	Star Category
1	Sumbersari Street (0-100)	100	1.56	5-Star
2	Sumbersari Street (100-200)	100	1.46	5-Star
3	Sumbersari Street (200-300)	100	1.49	5-Star
4	Sumbersari Street (300-400)	100	1.55	5-Star
5A*	3-arm intersection (400-500)	100	6.93	3-Star
6	Gajayana Street (500-600)	100	1.49	5-Star
7	Gajayana Street (600-700)	100	1.42	5-Star
8	Gajayana Street (700-800)	100	1.42	5-Star
9	Gajayana Street (800-900)	100	1.42	5-Star
10	Gajayana Street (900-1000)	100	1.49	5-Star
11A*	3-arm intersection (1000-1100)	100	9.27	3-Star
12	Gajayana Street (1100-1200)	100	1.46	5-Star
13	Gajayana Street (1200-1300)	100	1.46	5-Star
14	Gajayana Street (1300-1400)	100	1.46	5-Star
15	Gajayana Street (1400-1500)	100	2.00	5-Star

** Segments 5A and 11A are additional segments at three-arm intersection points, assessed separately from the regular mid-block segment numbering.*

The analysis shows that all 13 mid-block segments (87% of the 15 segments) achieved a 5-star rating with scores of 1.42-2.00, indicating a relatively low risk of fatal or serious crashes, which is likely to be associated with the low recorded operating speed and the straight alignment. The average SRS score for the mid-block segments is 1.51. In contrast, the 2 intersection segments (5A and 11A) dropped sharply to a 3-star rating, with scores of 6.93 and 9.27 and an average of 8.10, or about 5.4 times the mid-block average (based on only two intersection segments, so this ratio is indicative for this corridor only and should not be generalized). This points to a concentration of risk at traffic conflict points. The combined average SRS score across all 15 segments (simple mean of the 15 values in Table 2, as all segments are 100 m long) is 2.39, which numerically still falls within the 5-star threshold shown in Table 1, although this combined figure may mask the real risk concentrated at the intersection segments.

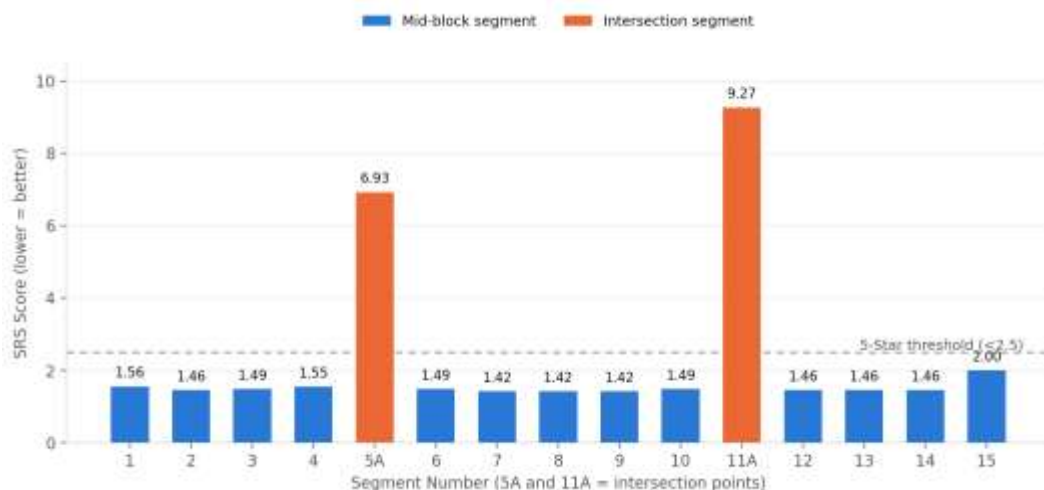


Figure 2. Star Rating Score (SRS) by segment along the Summersari Street – Gajayana Street corridor



Figure 3. Distribution of star categories across the 15 assessed segments

3.3 Detailed Technical Conditions

A few points about the reliability of the operational data deserve attention here. The recorded ADT of 96,247 vehicles/day is identical across all 15 segments, and the recorded operating speed of 30 km/h is uniform across all segments, even though the posted speed limits vary from 40 to 50 km/h. Such identical values across every segment are statistically unusual and suggest that the data may have been entered as a single representative value for the whole section rather than counted segment by segment. Because traffic volume and speed are direct inputs to the SRS, the scores in Table 2 are conditional on these recorded values. Segment-specific re-verification, and a sensitivity analysis in which the SRS is recalculated using the posted speed limits of 40-50 km/h and a plausible range of traffic flows, are needed before the star categories can be regarded as robust, and the results should be interpreted accordingly.

In terms of geometry, all 15 segments (100%) use a single centerline marking as the direction separator, with no physical median, which is the category carrying the highest head-on crash severity value in the SRS risk coefficient table. Despite this highest-severity separator type, the mid-block segments still score 1.42-2.00, which is likely to reflect the low operating speed recorded (30 km/h); the result is therefore sensitive to the speed input [17]. Lane widths are mostly classified as "wide" (≥ 3.25 m) or "medium," except for Segment 4, which is recorded as "narrow" (< 2.75 m). Pavement condition is recorded as "good" with adequate skid resistance across all segments, and street lighting is available in every segment. Both of these are positive findings, since they support braking, vehicle control, and nighttime visibility.

More critical deficiencies emerge on the safety of vulnerable road users. Not one of the 15 segments has a paved shoulder of at least 1 meter on both sides (6 segments, or 40%, have no shoulder at all). Not one segment has an adequate

sidewalk (at least 1 meter) on both sides, and 9 of the 15 segments (60%) have no pedestrian facility at all on either side. In addition, 12 of the 15 segments (80%) have no pedestrian crossing facility whatsoever, while the remaining 3 segments (1, 2, and 7) have only a zebra crossing marking with no supplementary protection. In this study, a crossing facility is considered adequate only if it provides supplementary protection (such as a refuge, signal, or raised crossing) in addition to markings, so zebra markings alone are classified as inadequate. For School Safety Zones (ZoSS), 4 segments (6, 8, 9, and 10) were found to have educational facilities nearby but no ZoSS in place; only Segment 7 is recorded as having a complete ZoSS with signage and markings. At the two intersection points (5A and 11A), both are recorded as three-arm intersections without channelization, with traffic volume on the minor approach reaching 10,000-15,000 vehicles/day. The prevalence of these deficiencies is shown in Figure 4.

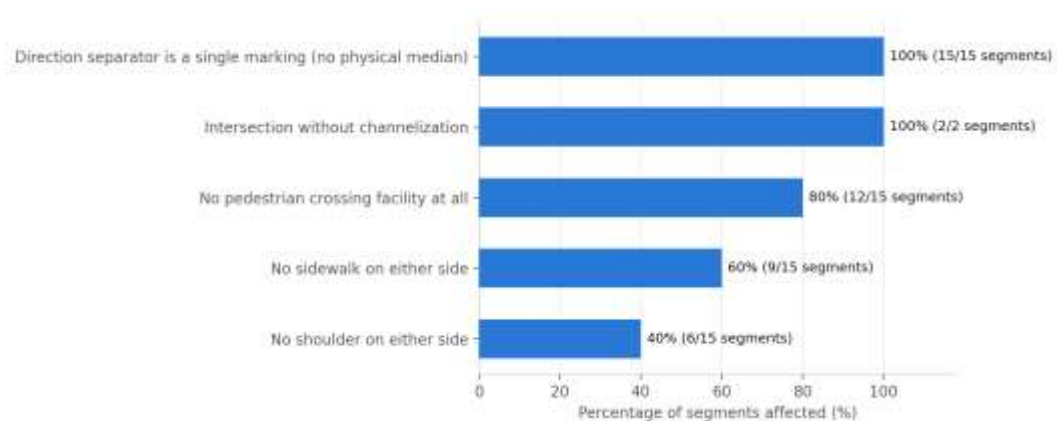


Figure 4. Prevalence of safety infrastructure deficiencies along the study corridor

3.4 Compliance with Technical Requirement Categories

Based on the analysis results, the level of compliance with the technical requirement categories for roadworthiness adequacy [10] (the six groups listed in Section 1.1 are reported as five categories, with traffic management and engineering combined with road furniture) was estimated indicatively, as summarized in Table 3.

Table 3. Estimated Compliance with Roadworthiness Adequacy Technical Requirement Categories

No.	Technical Requirement Category	Estimated Compliance	Status
1	Pavement Structure	≈95%	Compliant
2	Supporting and Connecting Structures	≈90%	Compliant
3	Road Geometry (lanes, median, shoulder, intersections)	≈40%	Non-Compliant
4	Use of Road Space (pedestrian facilities, ZoSS, land use)	≈25%	Non-Compliant
5	Traffic Management and Engineering, and Road Furniture	≈55%	Partially Compliant

The pattern that emerges shows that structural, passive categories (pavement, supporting structures) have high compliance, while categories involving active

interaction among road users (direction-separator geometry, pedestrian facilities, ZoSS) show low compliance (Figure 5). This pattern, in which conditions for motor vehicle occupants are rated more favorably than those for other road users, has also been reported in other Indonesian star rating assessments [8].

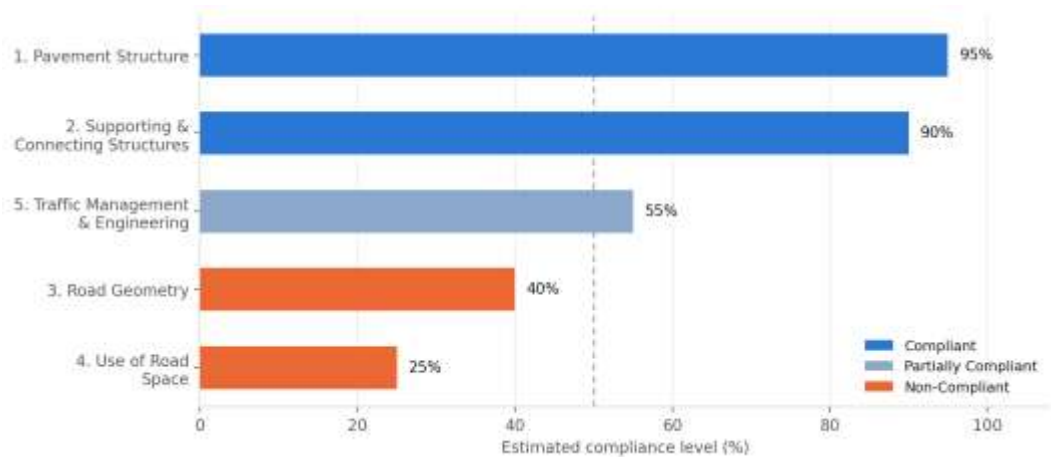


Figure 5. Estimated compliance level with the five roadworthiness adequacy technical requirement categories

Figure 6 summarizes the roadworthiness adequacy profile across six key aspects simultaneously, with indicative scores (0-100) assigned qualitatively by the authors from the findings in Sections 3.3-3.4, not measured values: the closer a line sits to the outer edge, the better the condition of that aspect, while the dashed line marks an indicative minimum adequacy threshold.

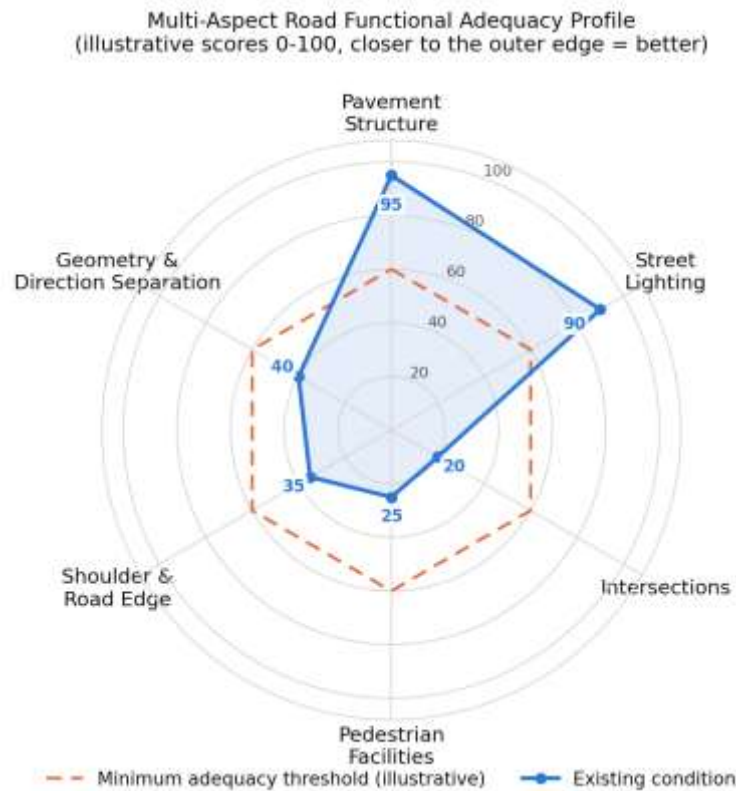


Figure 6. Multi-aspect roadworthiness adequacy profile (indicative scores 0–100, assigned qualitatively from the findings in Sections 3.3–3.4)

The figure makes this pattern clearer: pavement structure and street lighting sit well above the minimum adequacy threshold, while pedestrian facilities, intersections, geometry/direction separation, and shoulders all fall below it. This is the pattern behind the "not yet fully roadworthiness adequate" conclusion in the following subsection.

3.5 Summary of Roadworthiness Adequacy Findings

Based on the field survey data and its mapping against the regulatory framework, the roadworthiness adequacy findings for the Summersari Street-Gajayana Street section can be summarized in layers as follows: (a) the basic structural and geometric aspects are generally adequate, supported by good pavement condition, adequate skid resistance, a relatively straight alignment, and available street lighting; (b) the safety of motor vehicle users on the mid-block segments is adequate, with the caveat that the low SRS scores (1.42-2.00) on the 13 straight segments still coincide with a persistently high head-on crash risk due to the lack of a physical median and the narrow lane width at Segment 4; (c) the intersection aspect is not yet adequate, since the 2 intersection points (5A, 11A) drop to a 3-star rating due to the lack of channelization under high minor-approach volume; and (d) the aspect covering vulnerable road users (pedestrians/cyclists and schoolchildren) is not yet adequate, with 0% of segments having an adequate sidewalk, 80% lacking pedestrian crossing facilities, and 4 school-adjacent segments without a ZoSS. Taken together, then, even though the combined star rating score looks favorable, this assessment indicates that the road section has deficiencies in the geometric category (intersections without channelization) and the use-of-road-space category (pedestrian facilities and ZoSS). Both are categories that, under the regulation, form a mandatory and integral part of the roadworthiness adequacy assessment, not merely a supplementary consideration [10].

3.6 Discussion

These findings point to a gap between the favorable combined star rating score and the actual safety conditions faced by vulnerable road users. The official SRS score in Guideline No. 06/P/BM/2024 is designed to represent risk to motor vehicle occupants across five crash types (run-off, head-on from loss of control, head-on from overtaking, intersection crashes, and property-access crashes), and by design does not account for the specific risk to pedestrians or cyclists [9]. As a result, the 5-star rating on the 13 mid-block segments, which literally means "very low risk," cannot be generalized as a safe condition for all road user groups, given that the same segments show 0% availability of adequate sidewalks and 80% absence of pedestrian crossing facilities along a corridor whose land use is dominated by commercial activity with inherently high pedestrian volume. This finding is consistent with the methodological limitations of the motor vehicle star rating that have been documented in the road safety literature [8], [13], and it underscores the importance of interpreting the combined SRS score layer by layer across technical categories rather than as a single figure.

The comparison between the mid-block and intersection segments (average scores of 1.51 versus 8.10, or about 5.4 times higher) suggests that safety risk on this corridor is concentrated at traffic conflict points (Figure 7), consistent with the principle that an unchannelized intersection with high minor-approach volume is one of the largest risk contributors within the star rating framework [9]. This has

particular relevance for the Trans Jatim Corridor 1 bus service operating along the corridor: passenger boarding and alighting near intersections may heighten conflict between crossing passengers, private vehicles, and large vehicles (buses), especially given that not a single segment on this corridor has an adequate pedestrian crossing facility. However, bus stop locations, bus frequencies, and boarding and alighting volumes are not analyzed in this study, so this interaction remains a hypothesis for future work.

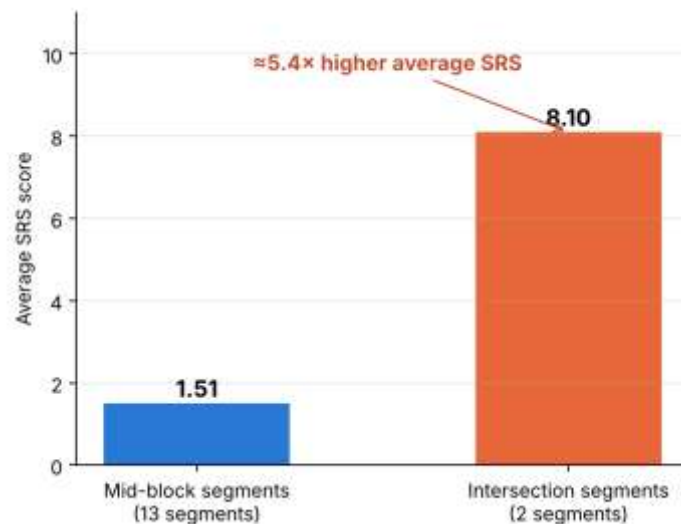


Figure 7. Comparison of average SRS scores: mid-block segments vs. intersection segments

This pattern is consistent with an iRAP-based study on the Kopo–Soreang provincial road, in which 28 countermeasures raised all segments to at least a 3-star rating for all road users and reduced the estimated number of fatalities by 49.91% [8]. Drawing on this precedent, the present study adopts the principle that treatments targeting the largest risk contributors should be implemented first. This principle underlies the nine recommendations set out in Table 4, four of which carry high priority, namely the provision of sidewalks, pedestrian crossings, and School Safety Zones, which directly target the use-of-road-space category (the category with the lowest compliance level, $\approx 25\%$, in Table 3), and the channelization of intersections 5A and 11A, which targets the two segments with the highest SRS.

Table 4. Treatment Recommendations and Priorities

No.	Treatment	Target segment(s)	Deficiency addressed	Priority	Timeframe
1	Provide sidewalks of at least 1 m on both sides	All 15 segments (9 segments have no pedestrian facility at all)	No segment has an adequate sidewalk on both sides	High	Medium term
2	Provide pedestrian crossings with supplementary protection; upgrade existing zebra markings	12 segments without a crossing; segments 1, 2, and 7 (markings only)	80% of segments lack crossing facilities; existing crossings have no supplementary protection	High	Short to medium term
3	Install School Safety Zones (signs, markings, speed management)	Segments 6, 8, 9, and 10	Educational facilities nearby without a ZoSS	High	Short term

4	Channelize the three-arm intersections	Segments 5A and 11A	Unchannelized junctions with 10,000-15,000 vehicles/day on the minor approach; highest SRS (6.93 and 9.27)	High	Medium term
5	Provide paved shoulders of at least 1 m or an equivalent facility	Segments without adequate shoulders on both sides (6 segments have none)	No segment has a paved shoulder of at least 1 m on both sides	Medium	Medium to long term
6	Introduce a physical median or other separator where right-of-way allows	Mid-block segments (single centerline marking in all segments)	Direction-separator type with the highest head-on severity value	Medium	Long term
7	Restore adequate lane width	Segment 4	Lane recorded as narrow (<2.75 m)	Low	Medium term
8	Review bus stop locations and provide safe boarding and crossing areas near intersections	Around segments 5A and 11A	Possible conflict between passengers, private vehicles, and buses (hypothesis, see Section 3.6)	Medium	Short term
9	Speed management: align posted limits (40-50 km/h) with operating conditions; traffic calming at high-pedestrian locations	Mid-block segments	Exposure of vulnerable road users in a mixed-use corridor	Medium	Short term

From a policy standpoint, these findings are particularly relevant to Pillar 2 of the National General Plan for Road Traffic and Transport Safety (RUNK), "Safer Roads" [4], with star rating serving as an operational tool for diagnosing road infrastructure conditions and formulating treatment priorities aligned with national road safety targets. Given that the authority to determine the roadworthiness adequacy of Summersari Street as a city road rests with the Mayor of Malang, the findings of this study, although academic in nature and not an official Roadworthiness Adequacy Test (ULFJ) result, can serve as preliminary input for Malang City's road authority in considering a future review of this section's roadworthiness adequacy [9]. The feasibility of the recommended treatments depends on the available right-of-way, on-street parking and roadside activity, and utilities, none of which were measured in this study; implementation would also require coordination among the city transport, public works, and traffic police agencies, and should be phased according to the priorities in Table 4.

3.7 Limitations

A few limitations of this study should be noted. First, the fact that the recorded ADT and operating speed are identical across all segments suggests a possible limitation in the field data collection stage, so re-verification is needed before this data is used for further technical planning such as volume-to-capacity (V/C) ratio evaluation [18]. Second, this study focuses on technical aspects at a single point in time and does not cover long-term condition changes or road user behavior. Third, a separate pedestrian SRS score, as is customary in the full iRAP methodology, was not calculated in this study; future research is encouraged to calculate this score explicitly to provide a more complete picture of roadworthiness adequacy for all road user groups. Fourth, the star ratings were not validated against observed crash records, so the agreement between the attribute-based risk and the crash experience on this corridor remains untested.

4. CONCLUSION

This study analyzed the roadworthiness adequacy level of Summersari Street – Gajayana Street in Malang City using the star rating method, based on Guideline No. 06/P/BM/2024. The results show that all 13 mid-block segments (87% of the 15 segments) achieved a 5-star rating (SRS scores of 1.42-2.00), while the 2 intersection segments dropped to a 3-star rating (scores of 6.93 and 9.27), or about 5.4 times the mid-block average (based on two intersection segments only). Although the combined average SRS score (2.39) appears to fall within a safe category, a detailed analysis by technical requirement category reveals that this road section shows deficiencies relative to the roadworthiness adequacy technical requirements: the structural category (pavement and supporting structures) shows high compliance (90-95%), the geometric category (unchannelized intersections, lack of a physical median) is only about 40% compliant, and the use-of-road-space category (pedestrian facilities, crossings, and School Safety Zones) is the most critical, with a compliance level of only about 25%.

Regarding the second objective, nine risk-based treatments were prioritized (Table 4); four carry high priority: sidewalks, pedestrian crossings, and School Safety Zones on the mid-block segments, and channelization of intersections 5A and 11A. Because the SRS values depend on traffic volume and speed data that still need segment-level verification, these results should be regarded as provisional. Future research is encouraged to calculate the pedestrian SRS score explicitly, re-verify traffic volume and speed data in the field, and evaluate the quantitative impact of implementing these recommendations on reducing the risk score at the intersection segments.

ACKNOWLEDGEMENTS

The authors would like to thank the State Polytechnic of Malang for funding this research through the 2026 Regular Competitive DIPA Fund scheme.

Data availability: The coded star rating attributes and the SRS calculations for each segment are available from the corresponding author upon reasonable request.

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