

Post Construction iRAP Assessment, India



Belgaum – Yaragatti SH-20, Karnataka
April 2019

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iRAP works in partnership with government and non-government organisations to:

- inspect high-risk roads and develop Star Ratings and Safer Roads Investment Plans
- provide training, technology and support that will build and sustain national, regional and local capability
- track road safety performance so that funding agencies can assess the benefits of their investments.

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1 Introduction

As part of efforts to curb road deaths and serious injuries, the World Bank Global Road Safety Facility (GRSF) invited the International Road Assessment Programme (iRAP) to work with the Ministry of Road Transport and Highways (MoRTH), public works departments, research institutes, and local engineering firms. The Ministry of Road Transport and Highways (MoRTH) and the State Public Works Departments (PWDs) of Kerala, Andhra Pradesh, Karnataka and Gujarat prepared road improvement projects financed by World Bank loans, and the iRAP road safety assessments were undertaken as part of these projects in year 2012-2013. The iRAP assessments were conducted for major state highway network in these states at two stages, (1) before improvement (baseline), and (2) during design stage. The iRAP assessment at design stage served a tool to ensure that proven and cost-effective road safety treatments are included in the designs.

The Belgaum – Yaragatti road (SH-20) was assessed post-construction in April 2019. This brief report shows the baseline and as built Star Ratings and comparison of key road infrastructure risk attributes.

Belgaum – Yaragatti SH-20 is part of the Belgaum-Bagalkot highway, and it is the Safe Corridor Demonstration Project (SCDP) of Second Karnataka State Highway Improvement Program (KSHIP-II). SH20 Belgaum-Yaragatti has been improved with safe facilities for pedestrian crossing and walking along in the urban areas and intersection improvements. The road safety engineering interventions were completed by end of 2016. In addition to the engineering measures other non-engineering measures have been implemented as part of the SCDP which include enforcement, enhanced road safety education and improved post-crash medical response having a holistic approach to road safety.

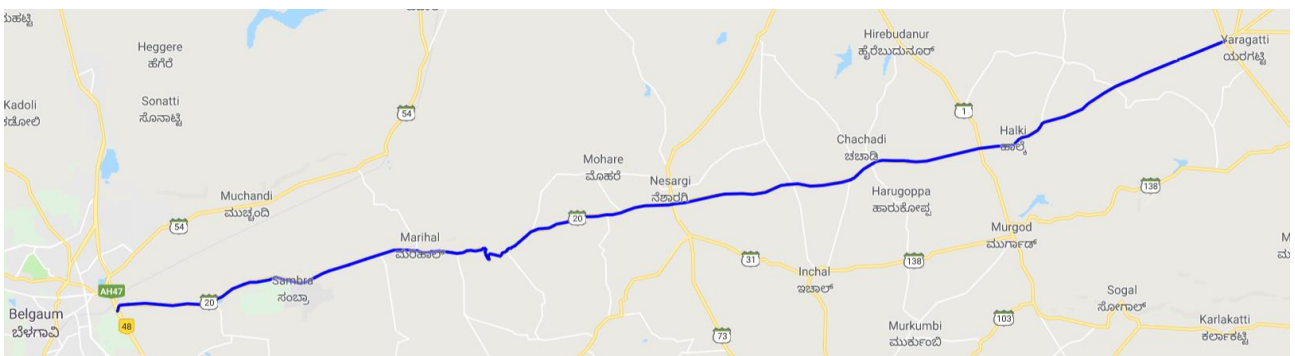


Figure 1 Belgaum – Yaragatti SH-20 key map

Prior to this post-construction assessment, iRAP did safety assessment of SH-20 in August 2016 when some road construction activities were still under progress (e.g. intersection improvement). A brief report of the post-construction assessment conducted in 2016 is available in Appendix-A of this report.

2 Key road attributes

The road has been improved with safety features as shown in the form of charts below.

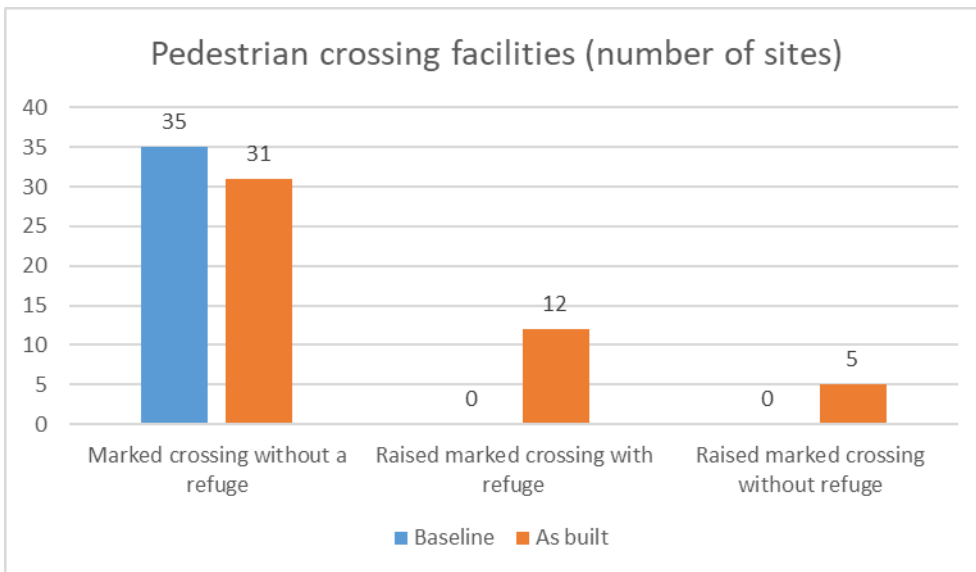


Figure 2 Pedestrian crossing facility type

The improved SH20 includes raised (or table-top type) pedestrian crossings near major intersections and areas where frequent pedestrian cross flow occurs. This gives pedestrians a safe way to cross the road and also act as a traffic calming measure as the approaching vehicles slow down.

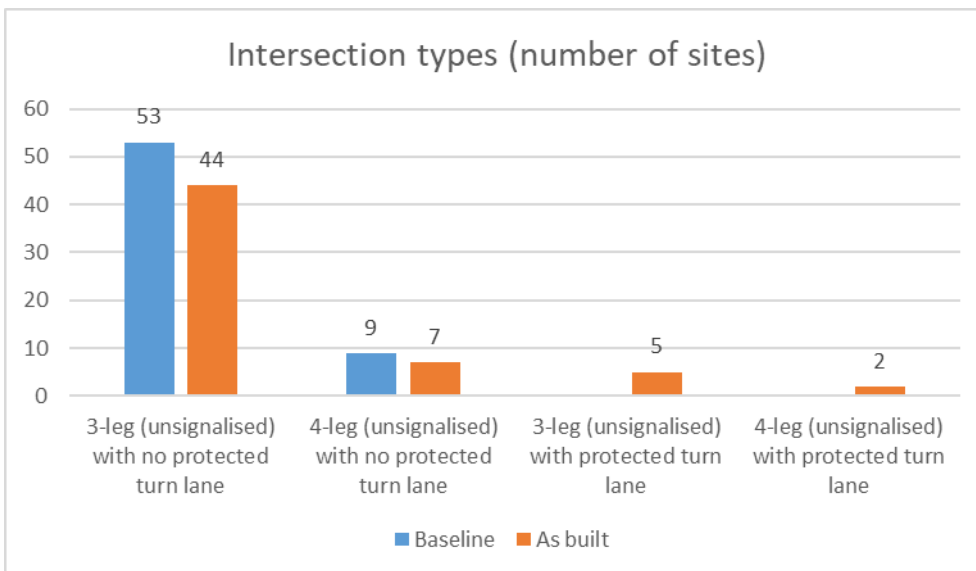


Figure 3 Intersection type

Seven major intersections on this road have been redesigned with a right turning lane and channelization (median in the intersection area). The turn lane reduces the risk for turning vehicles being hit from the rear while waiting to take a right turn. The physical median on the main road in the intersection area helps to channelize the flow.

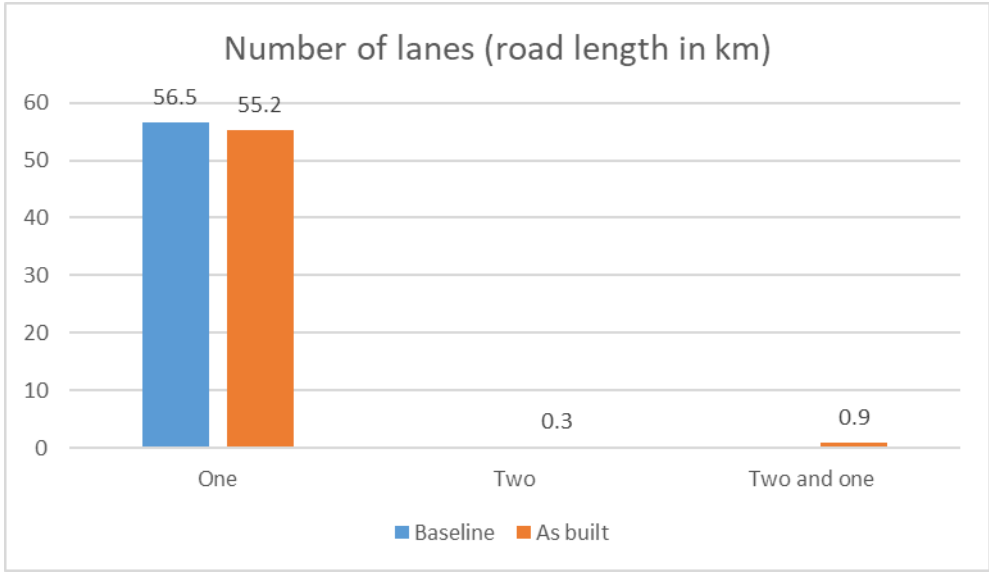


Figure 4 Number of lanes

The hill road section has been provided with 2+1 lanes so that it gives enough opportunity to fast vehicles to overtake the slow-moving/heavy vehicles. Some portion of the road in urban area has got 2 lanes in each direction to cater for slow-moving vehicles like bicycles, rickshaws, etc.

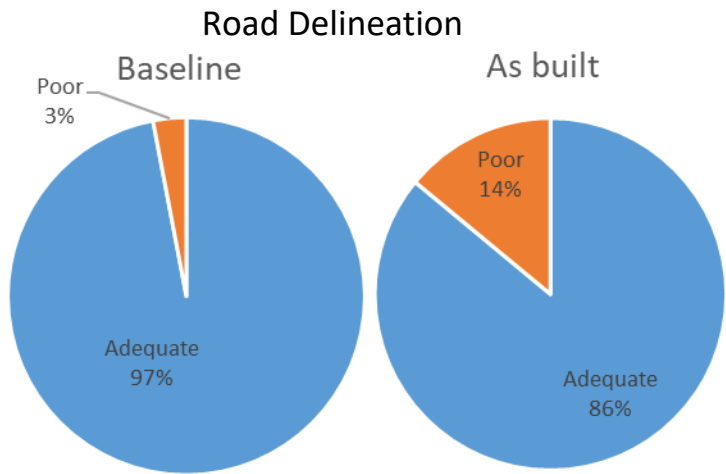


Figure 5 Road delineation

The road delineation that mainly includes road markings and signs is of adequate quality for 86% of the road length compared to 97% of road length in baseline. This seems to be contrary to the road improvement. This is mainly because the road surface and lane markings of few sections of the road were not improved as part of the project. The stretches listed below have medium/poor road surface condition and/or poor delineation,

- Km 15.1 - 17.8;
- Km 22.2 - 24.4; and
- Km 26.2 - 28.1

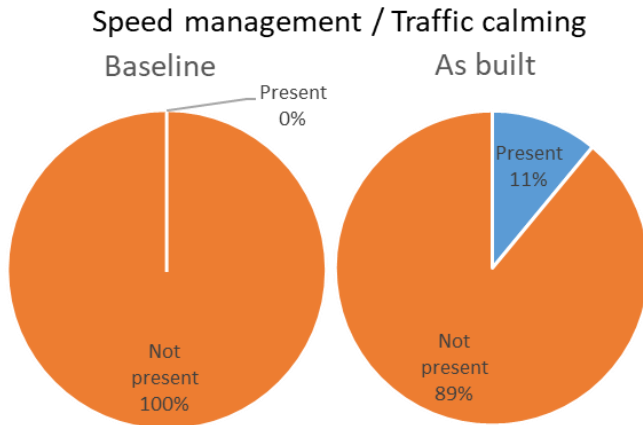


Figure 6 Speed management measures

The improved road has traffic calming measures like painted yellow stripes across the road and raised pedestrian crossing. These are effective in making the drivers alert of the road situation and to slow down. Major intersections have been provided with yellow painted strips and raised (table-top) crossings on both sides which effectively reduces the vehicle speeds to around 40kmph in such zones.

The figure below shows yellow painted strips across the road on approach of a major intersection and the table-top crossing acting as a traffic calming measure reduces the vehicle speed to around 40kmph in the intersection area. The painted strips and markings on the raised pedestrian crossing should be inspected and renewed periodically if worn. The markings in image given below shows slightly worn which may need to be renewed soon.



Figure 7 Effective speed management on major intersections

Vehicle Operating Speed

The safety of infrastructure is heavily influenced by the speed of traffic and without an understanding of the operating speeds it is difficult to assess the safety performance of infrastructure at a given location. All iRAP assessments are based on vehicle operating speeds to ensure that the Star Rating is based on how the road is actively functioning, which in some cases can be above the posted speed limit. The Star Ratings are produced based on the higher value of (1) Posted speed limit, and (2) 85th percentile operating speed. The comparison of these two speeds before and after road improvement is given below.

Table 1 Posted speed limit for baseline and as built road

Posted speed limit	Baseline (% road length)	As built (% road length)
<30kmph	-	49%
50kmph	7%	-
60kmph	93%	7%
80kmph	-	43%

Table 2 85th percentile operating speeds for baseline and as built road

85 th percentile speed	Baseline (% road length)	As built (% road length)
50kmph	-	26%
60kmph	7%	1%
70kmph	-	26%
80kmph	93%	
85kmph	-	47%

The above two tables reveal that the new road has got slightly higher posted speed limit than before however the 85th percentile speed decreased mainly because of the traffic calming measures in urban and intersection areas. The basis on which the 85th percentile speeds were adopted are given below,

- The 85th percentile speed (as built road) of 85kmph was estimated based on the spot speed survey conducted at one location (rural section with posted speed limit of 80kmph) during the post-construction assessment.
- The 85th percentile speed of 70kmph was adopted based on the observed survey vehicle speed in the rural/semi-urban area with lower speed limits.
- The 85th percentile speed of 50kmph was adopted based on the observed survey vehicle speed in the major intersection area with lower speed limits and traffic calming measures present on both approaches.

3 Star Ratings

The Star Ratings of baseline road were conducted in year 2012. A comparison of the baseline and post construction (as built) Star Ratings are shown in the table below.

Table 3 Baseline and as built road Star Ratings

Star Ratings	Vehicle Occupant		Motorcyclist		Pedestrian		Bicyclist	
	Baseline	As built	Baseline	As built	Baseline	As built	Baseline	As built
5 Stars	0%	0%	0%	0%	0%	0%	0%	0%
4 Stars	0%	8%	0%	4%	0%	0%	0%	0%
3 Stars	1%	71%	0%	40%	0%	10%	0%	26%
2 Stars	33%	21%	18%	56%	7%	23%	0%	55%
1 Star	66%	0%	82%	0%	93%	65%	100%	20%
Totals	100%	100%	100%	100%	100%	97%	100%	100%

Note: Smoothed star ratings

The Star Ratings show significant improvement in the 3-star or better road length for all road users except pedestrian. The road sections where significant pedestrian movement is present is the urban area and major intersections where treatments like pedestrian crossings, footpath and speed management have been provided to improve safety. The chart given below compares % road length with 3-star or better ratings for SH20 before and after improvement.

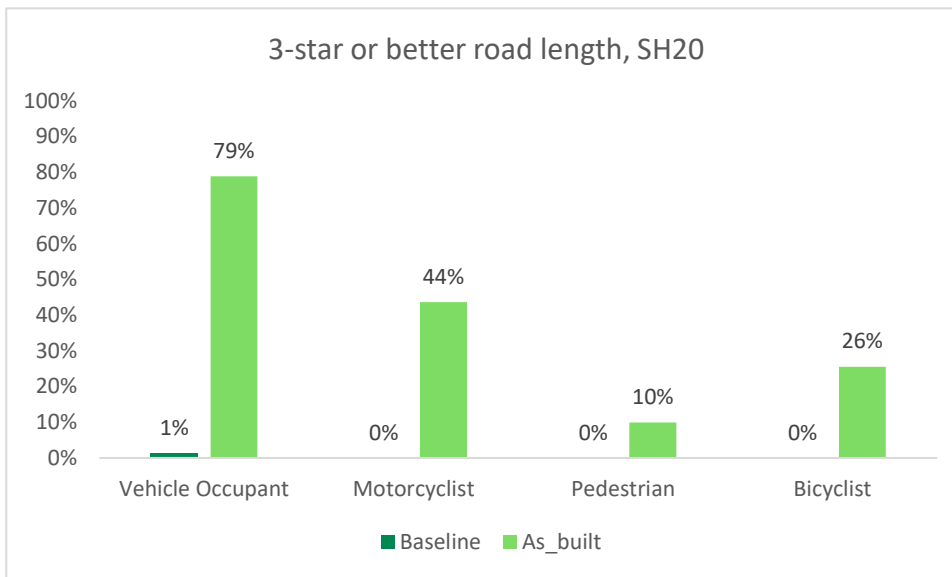


Figure 8 % road length with 3-star or better ratings

The chart given below shows improvement in safety of pedestrian in the urban area and sections where significant pedestrian movement is present by comparing the road length with 3-star or better ratings before and after improvement of road.

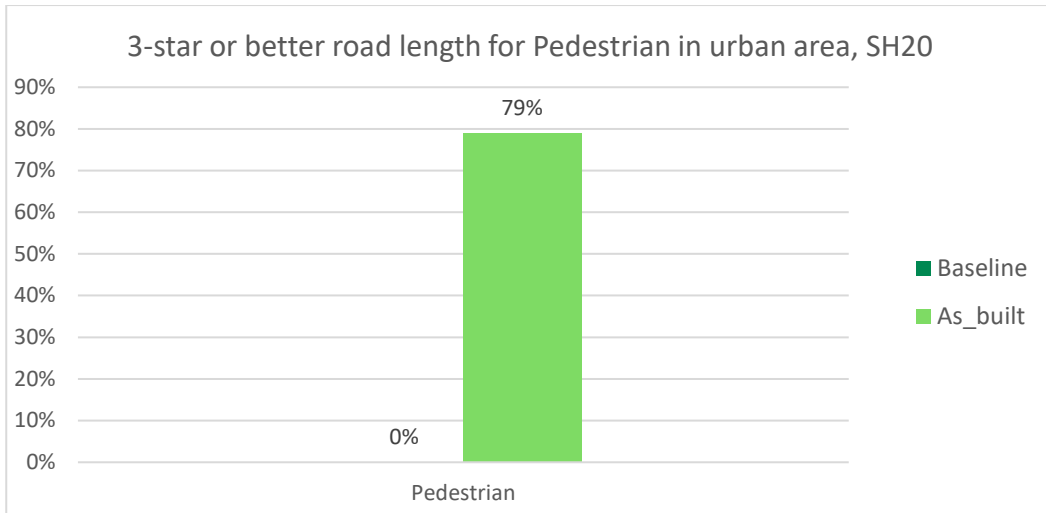
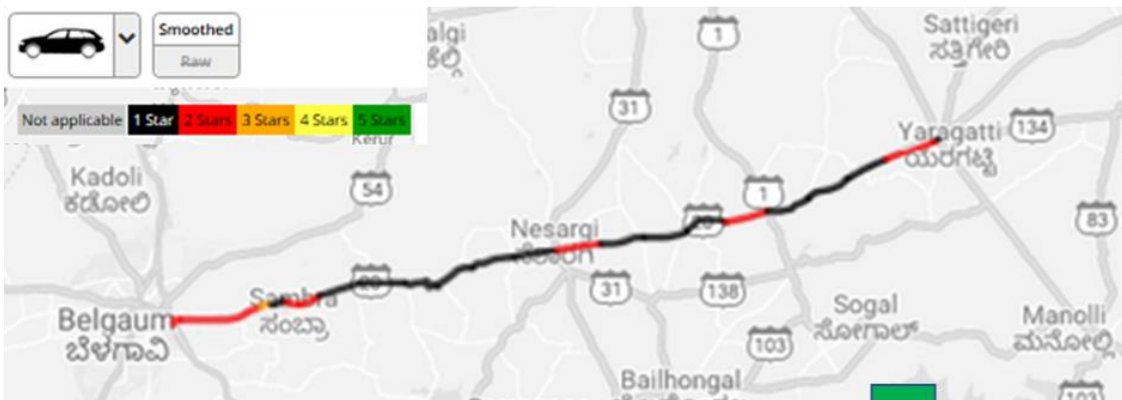


Figure 9 % road length with 3-star or better ratings for pedestrian in urban area

The Star Rating maps of vehicle occupant given below compares before improvement and after improvement situation.

Star Rating map of baseline road (before improvement)



Star Rating map of as built road (after improvement)

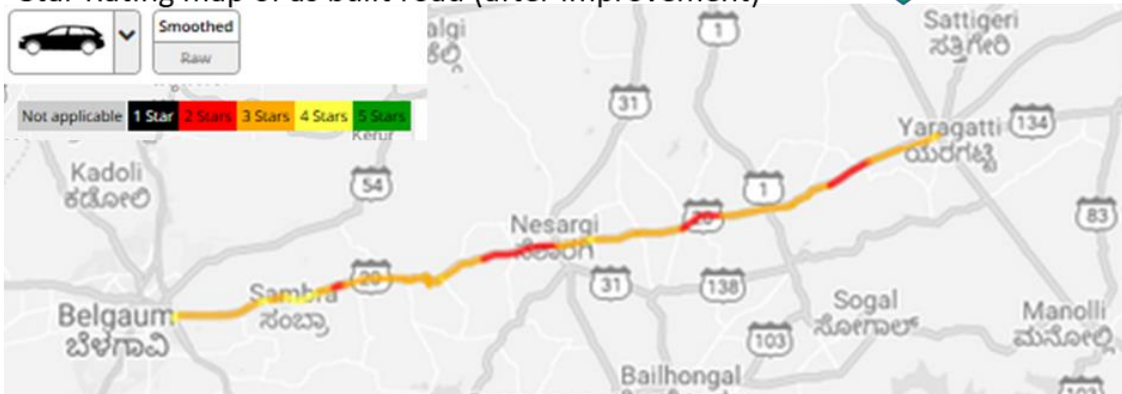


Figure 10 Star Rating map of baseline and as built road for vehicle occupant

A Star Rating Score (SRS) was calculated for each 100metre segment of SH20 for vehicles occupants, motorcyclists, pedestrians and bicyclists. These scores were then allocated to Star Rating bands to determine the Star Rating for each 100metre of road. However, for the purposes of producing a network level map showing Star Ratings, 100metre is too much detail. Hence, Star Ratings were smoothed (or averaged) over longer lengths in order to produce more meaningful results. The chart (risk worm) with smoothed SRS for

vehicle occupant before and after road improvement is given below which shows significant reduction in risk after road improvement.

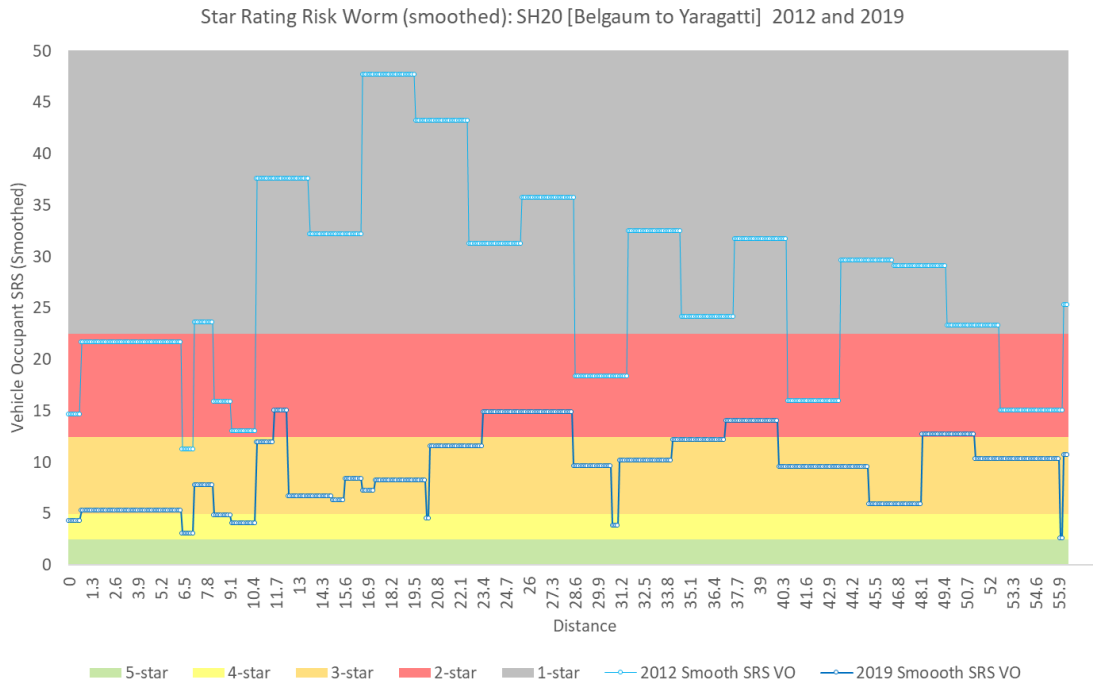


Figure 11 Risk worm showing Star Rating Score for vehicle occupant before and after road improvement

Similarly, risk worm prepared for pedestrian shows significant reduction in the risk for pedestrian after improvement of the road given below.

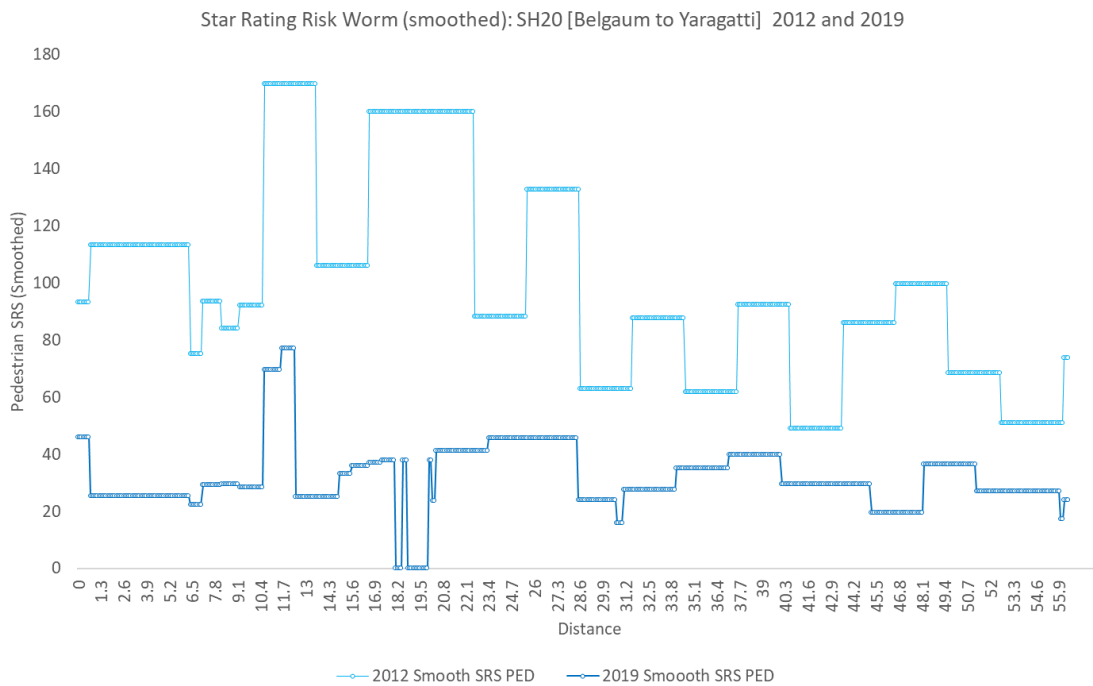


Figure 12 Risk worm showing Star Rating Score for pedestrian before and after road improvement

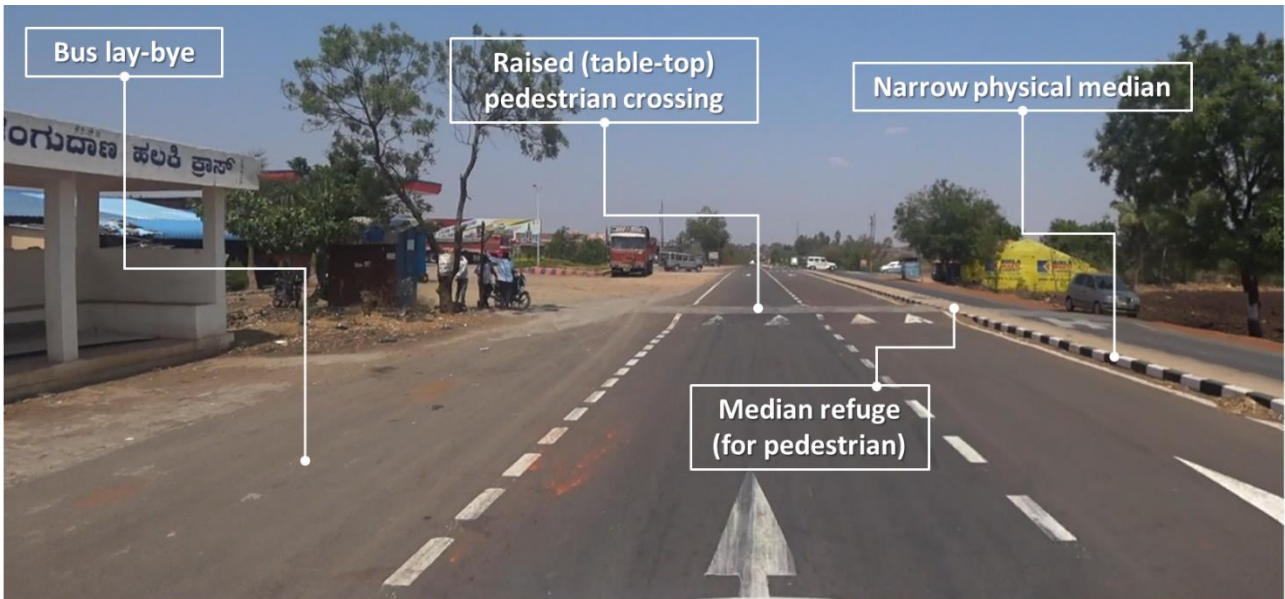
4 Before and after road images

Select images of the baseline road (year 2012) and post-construction (year 2019) with Star Ratings are given in this section.



Figure 13 Before and after road improvement image, Km 22.2

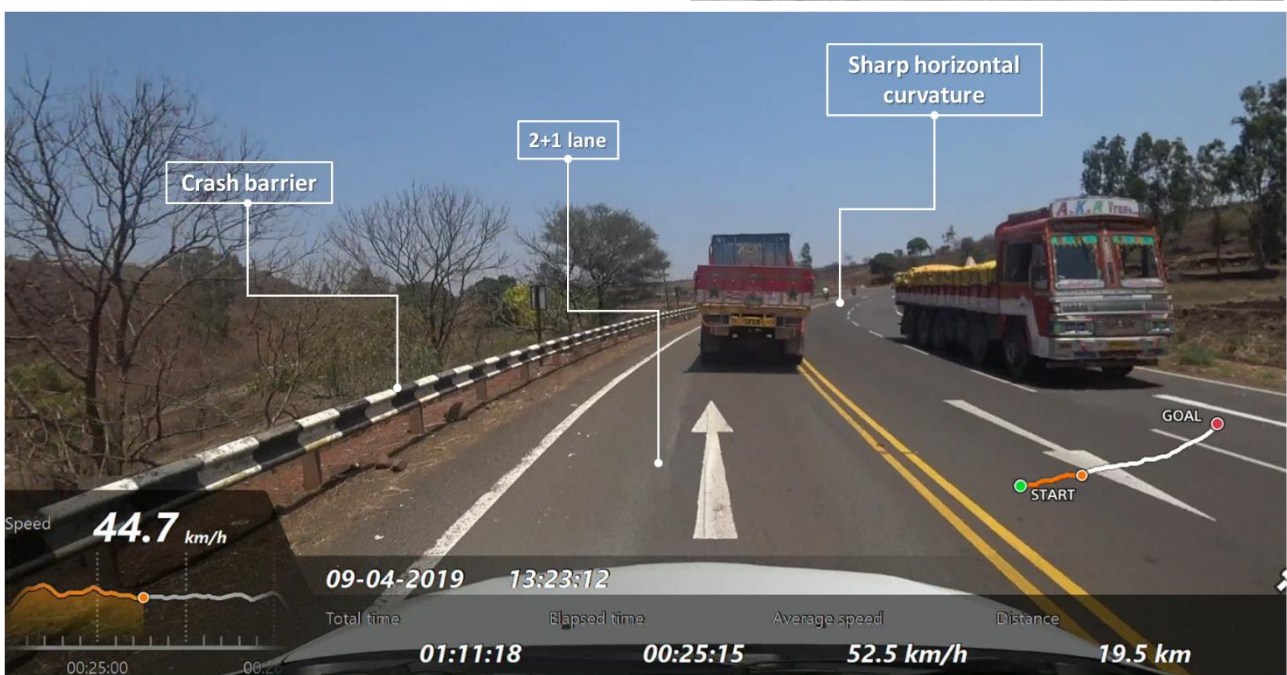
The image (before improvement) given above shows broken bridge parapet which poses very high risk of severity in case of a run-off crash. This broken parapet has been fixed and the metal crash barrier has been provided before the bridge parapet. This improves vehicle occupant and motorcyclist Star Rating from 1-star to 3-star. The poor delineation (edge line and centreline markings) was observed at this location and the KSHIP team was informed for improvement under the road maintenance activity.



Key road conditions	Before improvement	After improvement
Facilities for pedestrian	None	Bus lay-bye and Raised pedestrian crossing with refuge space in the median
Road markings	Poor	Adequate
Type of intersection	4-leg intersection	4-leg intersection with additional lane for right-turning vehicles
Intersection markings and signages	Poor	Adequate
Star Ratings	★ ★ ★★ ★★	★★★ ★★★ ★★★ ★★★★

Figure 14 Improved intersection and pedestrian facility, Km 43.5

The image given above shows improved facility for pedestrian that includes a bus stop with lay-bye and raised pedestrian crossing with refuge space in the median. The 4-leg intersection at this location has been improved by providing additional lane for right turning vehicles and median/splitter islands. The raised/table-top crossing on each side of intersection and the yellow painted strips across the road proves to be effective speed management measure that brings down the vehicle speeds in intersection area to about 40kmph. The before and after improvement Star Ratings shown above are smooth Star Ratings of the road stretch from Km 43.4 to 43.9 which indicates improved road gets 3-star or better for all four road user groups.



Key road conditions	Before improvement	After improvement
Road and curvature markings	Poor	Adequate
Number of lanes	1 in each direction	2+1
Roadside hazards	Trees and steep slope	Metal crash barrier
Star Ratings	★★  ★★ 	★★★  ★★★ 

Figure 15 Improved road with 2+1 lane and curve delineation, Km 19.5

The road section from Km 18 to 20 is hill road with bends and sharp horizontal curvatures. This part of road has been improved with improved road and curvature delineation and provision of 2+1 lanes. The smooth Star Ratings of this section shows improvement from 2-star to 3-star for vehicle occupant and motorcyclist. Due to very low numbers of pedestrian and bicyclist in this section, Star Rating results are not produced for them.

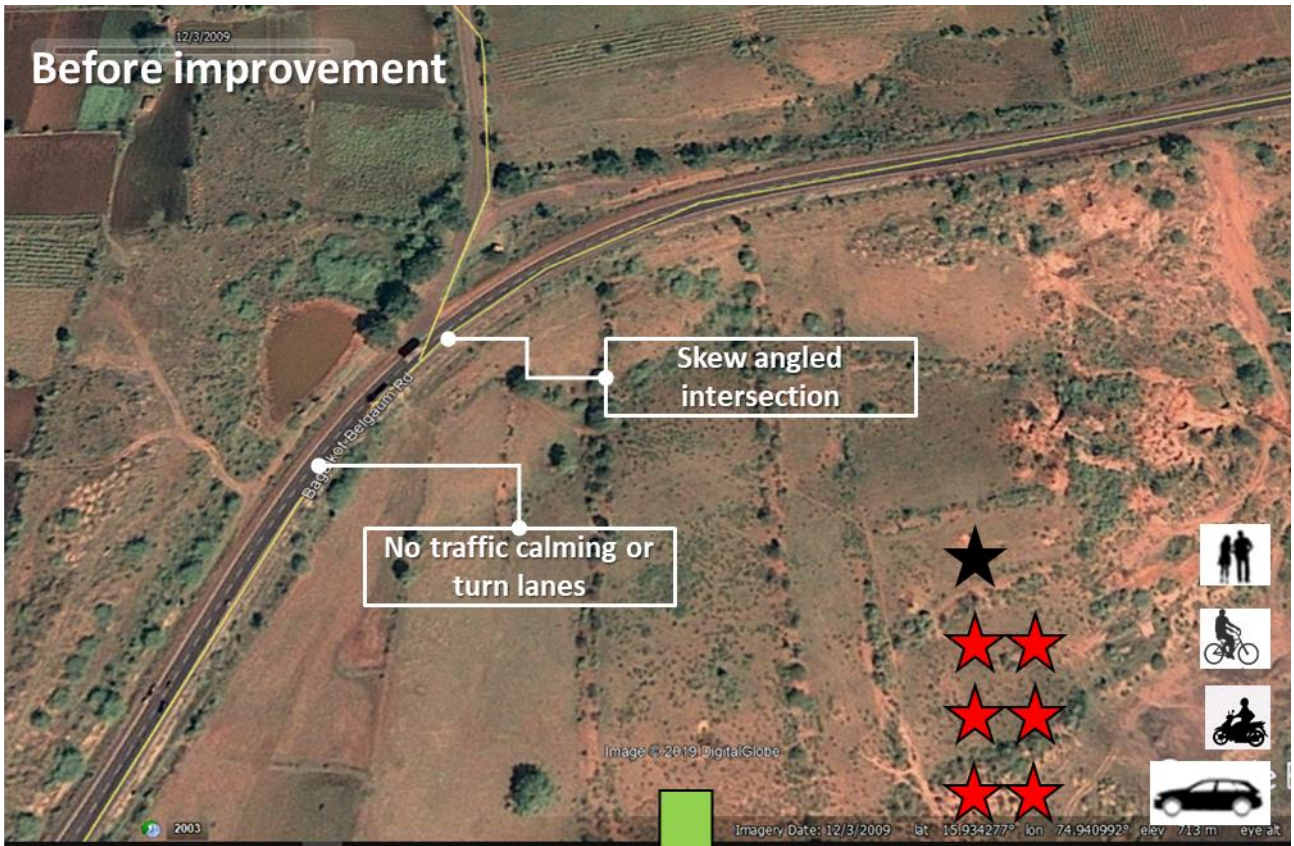


Figure 16 Before and after Improvement image of intersection, Km 46.9

Major intersections on SH20 are improved by providing the traffic calming measures, right-turn lane, physical median (splitter islands), adequate road markings and signs, and pedestrian crossing facilities as shown in the image above. The Star Ratings for all road users increased to 3-star for intersection at Km 46.9.



Figure 17 Intersection at Km 46.9

The photograph of improved intersection at Km 46.9 shows features such as right-turn lane, splitter islands, and road markings.

On both the approaches of such major intersections, 4-sets of yellow painted rumble strips and a raised pedestrian crossing are provided as traffic calming measures. This set of treatment seems to be effective as the vehicle speeds in such intersection area was observed to be around 40kmph. The uniform application of such traffic calming measures on all major intersections of SH20 helps the driver to recognize the given road situation and adapt to it by reducing the speed of vehicle.

5 Road Crash Data¹

KSHIP, the implementing road authority, collected road crash data for this corridor and compared the number of crashes and number of deaths before the improvement and after improvement. The number of crashes and persons killed from January 2017 to December 2017 was compared with the previous year data i.e., from January 2016 to December 2016 and it was observed that,

- the number of crashes reduced from 162 to 107, and
- the number of persons killed reduced from 49 to 20,

This shows over 50% reduction in fatalities. This achievement in reduction of crashes and saving lives is achieved due to implementing targeted road safety interventions and the non-engineering measures adopted.

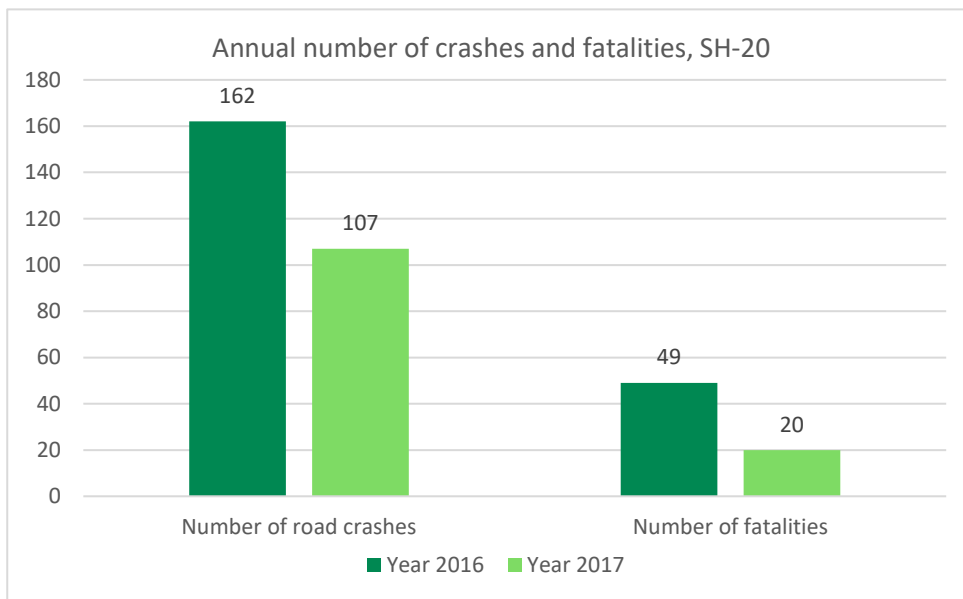


Figure 18 Reduction in number of crashes and fatalities after improvement of SH-20

¹ “Implementation of Safe Corridor Demonstration Program in Stretch of SH-20 from Yaragatti to Belgaum”, Paper No. 682, Journal of the Indian Roads Congress, Vol. 79-3, July-September 2018. Author: Dr. Masood Sharief and Dr. K.S. Krishna Reddy.

6 Summary

The road safety improvements implemented on SH20 include improvement of intersections, parking facilities for freight vehicles, overtaking zones (2+1 lane in hill road section), metal crash barrier to manage the roadside hazard related risk, traffic calming measures, footpath, pedestrian crossings, bus bays and improved road delineation. These safety improvements are also eminent as comparison of the baseline and post-construction Star Ratings show significant increase in the 3-star or better road length for all road users. The targeted road safety interventions have yielded significant reduction in road deaths thereby saving precious human lives lost on the road. In addition to the engineering measures, the non-engineering measures like enforcement, enhanced road safety education and improved post-crash medical response have also been implemented. Given below are the suggestions to sustain this achievement.

Road maintenance: The road must undergo continuous maintenance to keep the road markings and other safety devices in good condition. Evidence of broken crash barriers, pedestrian fence and footpath are shown in images below which must be maintained or replaced.

Road surface and delineation improvement: Improve road surface condition, road markings, shoulders and footpath (wherever exists) in the road sections which are not already included in this road improvement project.



Broken crash barrier Km 42.5, SH-20



Poor condition of footpath and broken pedestrian fence Km 5.1, SH-20




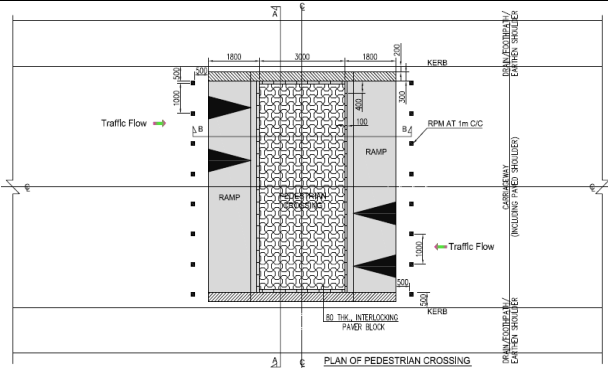


Night-time delineation: The raised pedestrian crossings, speed humps and splitter islands in the intersection area must be maintained with good road markings and road studs so that it becomes visible during the night-time. If not well maintained, the traffic calming measures such as raised pedestrian crossings and speed humps may require the approaching vehicles to sudden application of breaks which may result into rear-end collisions. The streetlights must be lit during evening/night time. Major intersections and urban areas must have working streetlights. In absence of continuous electricity supply, the streetlights may be powered by solar electricity.




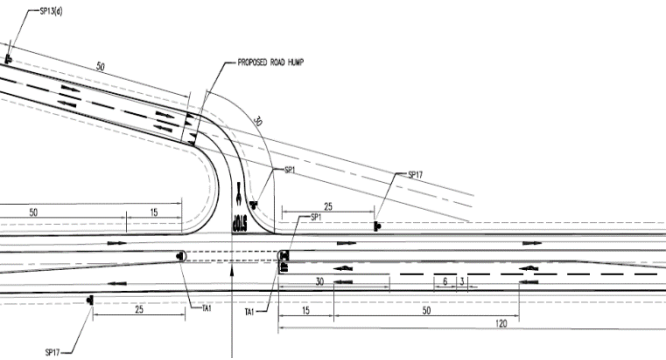





‘Hold your Stars high’: The Belgaum – Yaragatti SH20 has been developed as Safe Corridor Demonstration Project. With engineering and non-engineering safety measures more than 50% reduction in fatalities has been achieved. This is a big achievement which can become inspiration for other road safety improvement projects and must sustain with proper maintenance of the safety features. The post-construction Star Ratings shows significant increase in the length of road which gets 3-star or better ratings and a continuous monitoring (say every year) should be practiced. The road crash data should also be continuously monitored so that reactive actions may be taken if the trend shows any increment in the road crashes or fall in the 3-star or better ratings.



Appendix-A: Post-construction impact of iRAP work: Safe demonstration corridor State Highway 20 Belgaum to Yaragatti, Karnataka, India (Year 2016)

The following images show how iRAP can help reduce the risk of death and serious injury through improved road design and provides the method to quantify improvements in road infrastructure safety. The project is supported by the Global Road Safety Facility (GRSF). The images used below are from the post—construction road survey (Aug.16) and detailed design drawings provided by the Karnataka State Highway Improvement Project (KSHIP).

Location	Design feature	Image	Star Rating - Before	Star Rating - After
SH-20; Belgaum to Nesargi; 28.4km (from Belgaum)	New sidewalk with pedestrian fencing		 <p>Vehicles: 2-star (18.0) Motorcyclist: 1-star (23.5) Pedestrians: 1-star (143.8) Bicyclists: 1-star (93.2)</p>	 <p>Vehicles: 4-star (4.7) Motorcyclist: 3-star (5.6) Pedestrians: 5-star (0.2) Bicyclists: 3-star (21.1)</p>
SH-20; 6.4km	Raised (table-top) pedestrian crossing		 <p>Vehicles: 3-star (9.3) Motorcyclist: 2-star (14.6) Pedestrians: 2-star (65.2) Bicyclists: 2-star (33.7)</p>	 <p>Vehicles: 4-star (2.6) Motorcyclist: 4-star (3.6) Pedestrians: 3-star (34.3) Bicyclists: 3-star (17.6)</p>

<p>SH-20; 15.2km</p>	<p>Traffic calming (road hump)</p>		 <p>Vehicles: 2-star (17.8) Motorcyclist: 1-star (23.4) Pedestrians: 1-star (159.6) Bicyclists: 1-star (111.8)</p>	 <p>Vehicles: 4-star (2.6) Motorcyclist: 4-star (3.2) Pedestrians: 3-star (18.4) Bicyclists: 4-star (7.8)</p>
<p>SH-20; 43.7km</p>	<p>Intersection (turn lane)</p>		 <p>Vehicles: 1-star (197.6) Motorcyclist: 1-star (255.8) Pedestrians: 1-star (573.3) Bicyclists: 1-star (445.8)</p>	 <p>Vehicles: 3-star (9.8) Motorcyclist: 2-star (12.7) Pedestrians: 3-star (32.7) Bicyclists: 3-star (16.7)</p>
<p>SH-20; 26.7km</p>	<p>Roadside barrier</p>		 <p>Vehicles: 2-star (16.9) Motorcyclist: 1-star (39.5) Pedestrians: 1-star (74.4) Bicyclists: 1-star (234.7)</p>	 <p>Vehicles: 3-star (6.5) Motorcyclist: 3-star (12.4) Pedestrians: 1-star (115.6)</p>

<p>SH-20; 14.9km</p>	<p>Speed limit</p>		 <p>Vehicles: 1-star (151.7) Motorcyclist: 1-star (220.8) Pedestrians: 1-star (588.1) Bicyclists: 1-star (527.3)</p>	<p>Bicyclists: 1-star (66.9)</p>  <p>Vehicles: 4-star (2.5) Motorcyclist: 4-star (3.0) Pedestrians: 3-star (22.9) Bicyclists: 4-star (9.2)</p>
<p>SH-20; 22.6km</p>	<p>Bus stop (with road hump and new sidewalk)</p>		 <p>Vehicles: 1-star (23.5) Motorcyclist: 1-star (36.9) Pedestrians: 1-star (74.4) Bicyclists: 1-star (234.7)</p>	 <p>Vehicles: 4-star (2.8) Motorcyclist: 4-star (3.7) Pedestrians: 3-star (31.2) Bicyclists: 3-star (14.9)</p>

Notes

Star Rating – Before results are from the baseline survey conducted in February 2011, with Star Rating Scores shown in brackets.

Star Rating – After calculated using iRAP Star Rating Demonstrator (model version 3.02), with Star Rating Scores shown in brackets.

The SH-20 Safe Corridor Demonstration Project has a target to achieve minimum 3-star and reduce fatalities by 30% from the 2010 baseline.