ROAD SAFETY IMPROVEMENT OF GOA MEDICAL COLLEGE AREA ON NH-17 IN INDIA – A CASE STUDY

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Safe & speedy movement, single and double "U" turns, Table top area, Vehicular underpass, pedestrian facilities, Channelization, segregation of traffic movements.

1. ROAD SAFETY STATUS OF GOA VIS-A-VIS NATIONAL STATUS:

Road Accidents in India have emerged as one of the major causes of death. Several factors like lack of strict driving competency assessment during driving licensing, lack of strict enforcement of traffic rules, lack of safety centric design & development of roads, unregulated and unauthorized developments along roads, inadequate land use regulation, inadequate emergency care for post crash handling etc., are contributing to the large number of crashes on road network. State of Goa being a tourist based economic region is highly sensitive to Road Safety. Broad status of Road Safety of the state of Goa vis-à-vis National status is as below:

Road Safety Status of the state of Goa vis-à-vis National Status of India

Parameter	Year (Latest)	For the State of Goa	All India
Total No. of Road Accidents	2015	4338	5,01,423
Total No. of persons killed in Road Accidents	2015	311	1,46,133
No. of Road Accidents per 100000 population	2015	**222.10**	40
No. of persons killed in Road Accidents per 100,000 population	2015	15.90	11.70
No. of Road accidents per 10,000 vehicles	2013	45.80	26.80
No. of persons killed in road accidents per 10,000 vehicles	2013	2.80	7.60
No. of road accidents per 10,000 km of road length	2013	**3702**	1123.00
No. of persons killed in road accidents per 10,000 km of road length	2013	229.30	317.60
Severity of road accidents (Road Accident deaths per 100 accidents)	2015	**7.20**	29.10

2. PROJECT STRETCH

Project stretch from km 1.98 to km 5.19 falls on important National Highway-17 (New Number NH-66) running along the coast connecting Maharashtra, Karnataka, Goa and Kerala. This road is very important from tourism perspective to the state of Goa. Heavy traffic of 31,585 Passenger Car Units (PCU) per day is plying with a substantial volume of commercial traffic including busses on this highway. Large volumes of passenger cars move at high speeds on this road. Goa

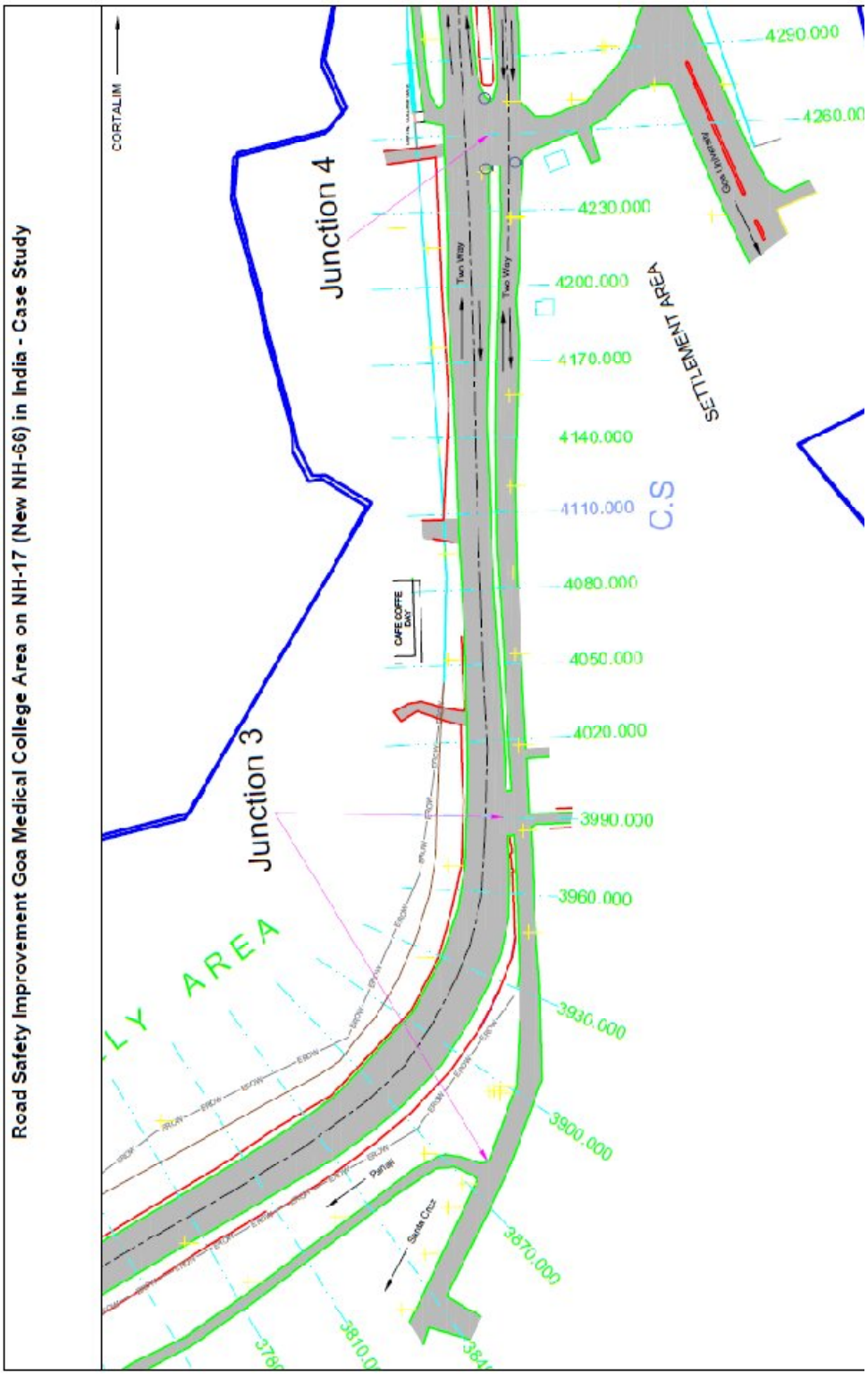
medical college, Dental college complex, Bambolim stadium, GMC pediatric hospital and GMC staff quarters are falling on a short length of project stretch with high volume of pedestrian traffic apart from large volume of vehicular traffic crossing the high speed National Highway due to the location of medical college campuses on both Left hand side and Right hand side of the NH. In the illustrative figures Fig -1 & Fig- 4 depict only existing road /road environment and other figures are superimposition of improvements on the existing road / road environment.

3. EXISTING CONDITIONS OF PROJECT STRETCH AND ITS ROAD ENVIRONMENT

The project stretch is in rolling terrain with upward gradient towards Cortalim. Main carriageway of this NH is varying in width from 10m to 20m without any central divider. There is a road connecting Santa Cruz to Goa Medical College Complex on Right Hand Side (RHS) [with respect to the direction of increasing chainage i.e., from Panaji side to Cortalim side] running parallel to main NH. Santa Cruz Road has 7m undivided carriageway. This road is connected to main NH at two locations with large connecting paved areas without any channelization. This road has two way traffic movement from Junction 3 to Junction 4 (**Fig 1**) with huge traffic turning towards Goa Medical College complex & Goa University on RHS and also towards Dental College complex on Left Hand Side (LHS) cutting across high speed traffic on NH-17 at junction 3 and junction 4. Traffic from Santa Cruz side to Panjim side is taking almost a "U" turn on main NH at junction 3 leading to severe unsafe conditions. Lack of traffic segregation and road signs/ markings are compounding the safety concerns especially at junction 4. As there are no speed reduction measures, higher speeds are further increasing the severity of conflicts.

Unpaved areas acting as central dividing median in different sections of the main NH are not aligned and as such the traffic movements are involving sudden directional changes (at junction 4). Traffic from Goa University road towards Dental College at junction 4 involves movement through un-channelized unregulated junction area cutting across two way streams of the main NH (**Fig 1**). The road leading to Goa Medical College (GMC) entrance is a two way road without any dividing island & channelizing islands (**Fig 4**). Presence of bus parking & temple near GMC in/out gate, enclosed on all 4 sides by main NH and cross connector roads are adding to pedestrian conflicts. Large pedestrian movement is taking place from Goa Medical College on RHS to Dental College complex on LHS cutting across several one way/ two way traffic streams. There are no footpaths along the highway for pedestrians.

Existing NH has open spaces of 5m to 20m acting as median. There are no railings, crash barriers etc. There is a parallel road to NH of about 6m carriageway width connecting pedestrian subway to the cross road leading to Cujira School complex at km 4.77 on LHS (**Fig 6**). This parallel road and other carriageways of main NH are connected through large paved areas / cross connections of varying width without any medians / Channelizers. There is Bambolim stadium on LHS and GMC Quarters/GMC Paediatric Hospital on RHS (**Fig 6**). Vehicles are entering and crossing the NH carriageway at different points through un-regulated & un-channelized junctions. This area has pedestrian activity without any pedestrian facilities thereby forcing pedestrians to use the main carriageway. There are no road signs/markings. Though there is a pedestrian subway at km 4.53, (**Fig 5**) pedestrians are not using it as this is located quite away from the desired pedestrian crossing point at GMC gate.


Road Safety Improvement Goa Medical College Area on NH-17 (New NH-66) in India - Case Study
CORTALIM
Junction 4
Junction 3
SETTLEMENT AREA
C.S
Two Way
Two Way
CAFE COFFE DAY
4290.000
4260.000
4230.000
4200.000
4170.000
4140.000
4110.000
4080.000
4050.000
4020.000
3990.000
3960.000
3930.000
3900.000
3870.000
3810.000
Panjim
Santa Cruz

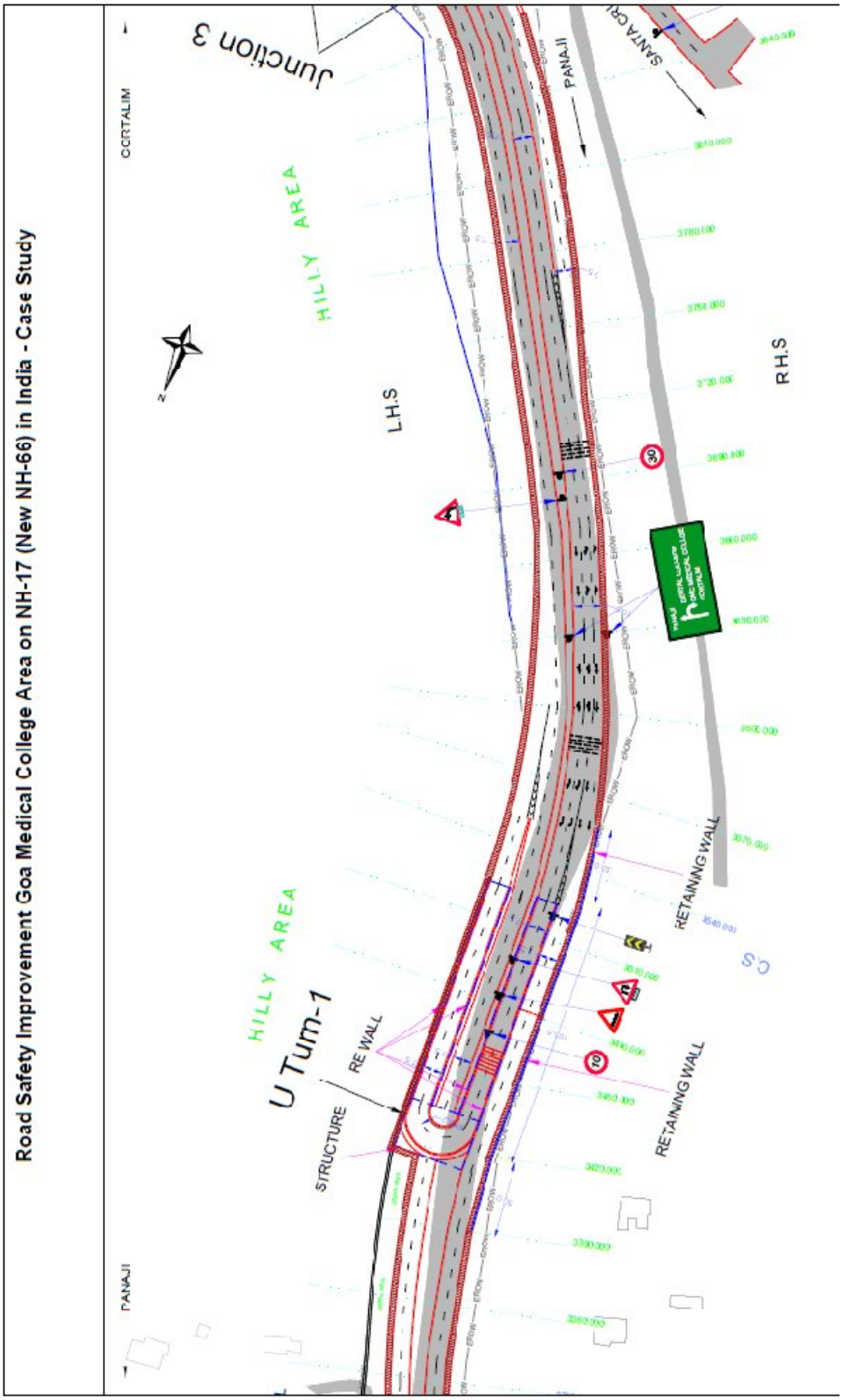
In fact pedestrian subway is being used only by two-wheelers as this has a width of 6m. There is a Bus Stop without any bus shelter on RHS. Though the stretch is having pedestrian activity and large cross traffic movements, there are no speed regulation measures to control the high speeds on NH carriageway.

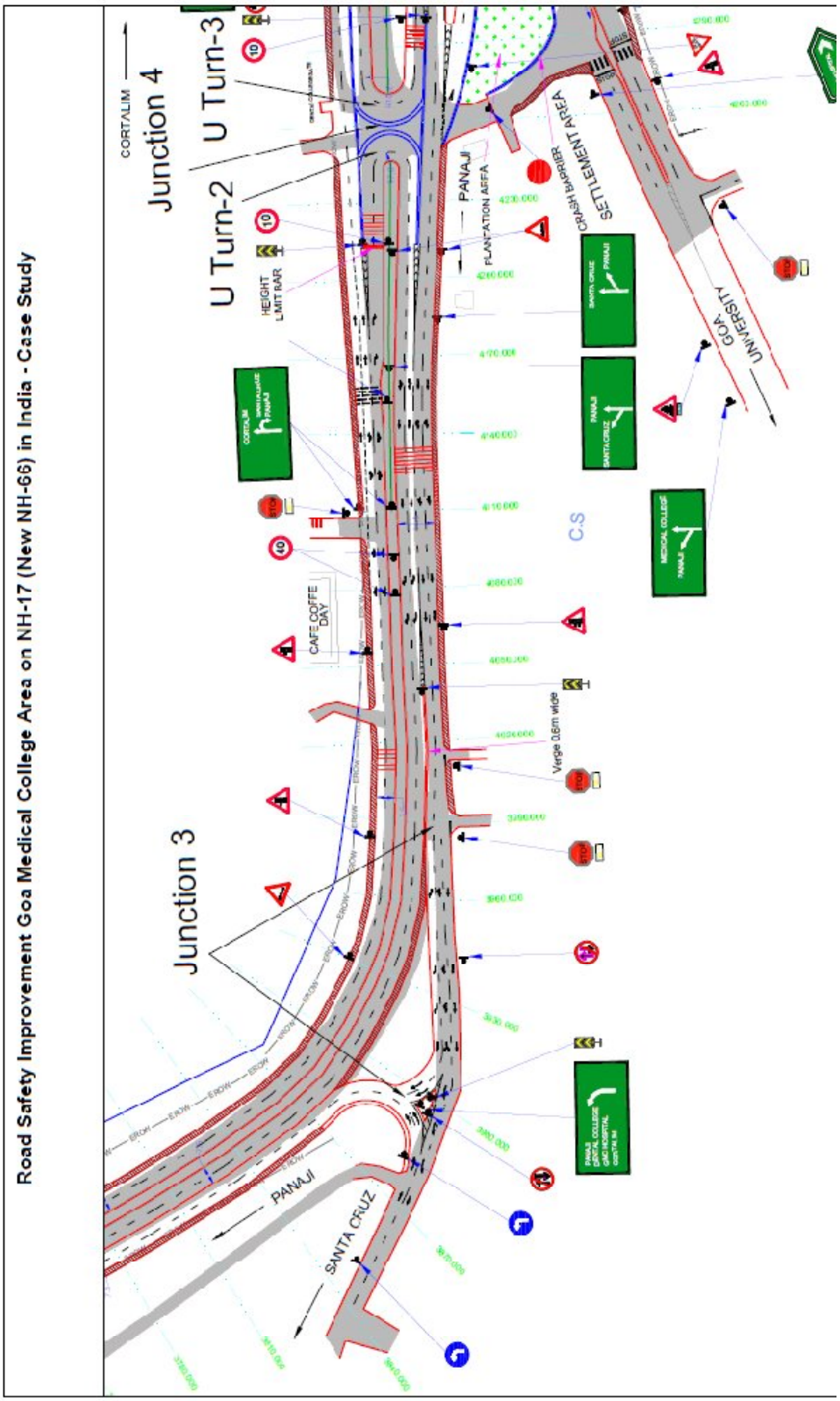
Conflicting crossing movements of vehicles across high speed NH, change of traffic movement from two way to one way and vice versa, pedestrian movements along and across high speed NH carriageway in absence of pedestrian facilities coupled with steep gradient are causing chaotic unsafe conditions leading to large number of accidents.

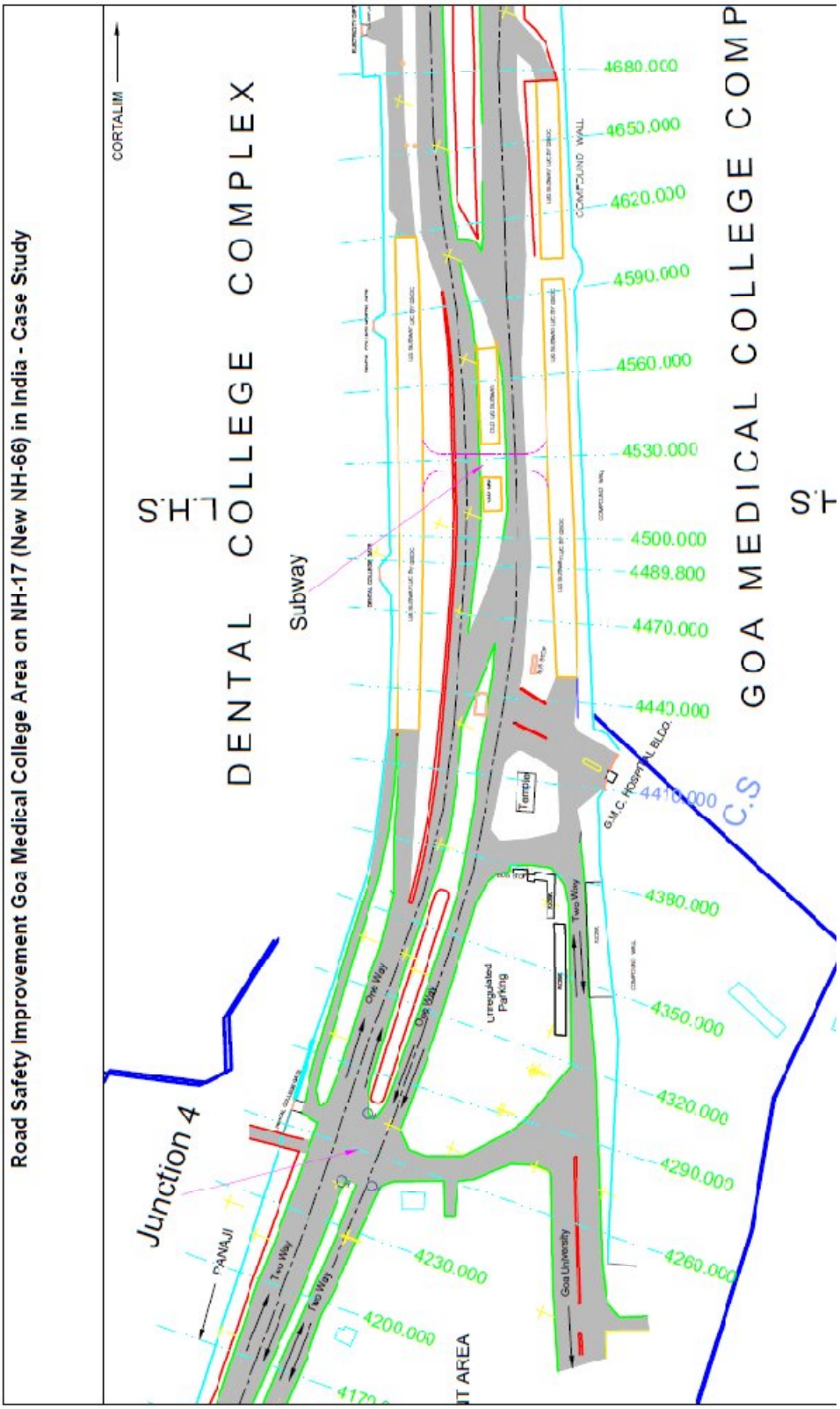
4. PROPOSED IMPROVEMENTS TO REMEDY THE SAFETY CONCERNS

Traffic from Santa Cruz side to Dental College side or to Cortalim side is moving on Santa Cruz road under two way traffic conditions, crossing the traffic streams on both carriageways of main NH making staggered maneuvres as the two way carriageway is converted to one way at Junction-4. This was causing severe conflicts. Therefore, two lane Santa Cruz road from Junction-4 to Junction-3 has now been made one way road with an extra two lane right turning connector road at Junction-3 (**Fig 3**).

All the traffic from Santa Cruz side/Goa University side going to Panjim / Dental College complex/Cortalim is now made to join main NH in one way traffic condition. Out of this traffic, those going to Dental College / Cortalim / Medical College were made to take a "U" turn at 'U turn-1' (**Fig 2**) in one way traffic condition thereby eliminating conflicting movements. 'U turn-1 is provided on an elevated box structure and the LHS carriageway towards Cortalim is taken below the "U" turn structure. Traffic moving towards Panjim has to move towards left two lanes outside the "U" turn structure. This has been guided through turning arrow markings on the pavement coupled with informatory signs. Similarly, at Junction-3 traffic moving towards Santa Cruz from Goa University /Medical College side has to move towards left lanes as the Santa Cruz road is becoming two-way traffic zone beyond Junction-3 towards Santa Cruz direction (**Fig 3**). This is also facilitated through turning arrow markings. NH carriageway between Junction-4 and Junction-3 has been widened to 4-lane on RHS and 4-lane on LHS providing two lanes for straight traffic and two lanes for 'U' turning traffic (**Fig 3**). These are indicated to road users through turning arrows. After Santa Cruz road joins main NH, the carriageway towards Panjim is reduced from 4-lane to 3-lane due to space constraints (**Fig 2**) and has again been widened to 4-lane before 'U turn-1' (form km 3.87 to km 3.5) providing two lanes for straight movement towards Panjim and two lanes for 'U' turning towards Dental College/ Medical College / Cortalim. As there are short weaving lengths before 'U' turning structure, speeds have been reduced using bar code type pavement markings. As there is severe restriction of radius (10 m radius) for 'U' turning on the structure, speeds were reduced to 10kmph using rumble strips and speed limit boards (**Fig 2**). Speed limits of 30 Kmph were provided outside "U" turn to make all the maneuvers safe. Object Hazard markers were provided at Traffic island tips, R.E. wall ends etc, to caution the road users about the possible hazard. As the traffic heading towards Cortalim, Dental College and Medical College from Santa Cruz side have to be instructed to take "U" turn on the structure by moving towards right lanes they were guided at a sufficient advance location through turning arrows and properly designed advance direction sign (**Fig 2**).


Road Safety Improvement Goa Medical College Area on NH-17 (New NH-66) in India - Case Study
CORTALIM
PANAJI
Junction 3
HILLY AREA
HILLY AREA
L.H.S
R.H.S
U Tum-1
RE WALL
STRUCTURE
RETAINING WALL
RETAINING WALL
PANAJI
SANTA CRU
C.S


Road Safety Improvement Goa Medical College Area on NH-17 (New NH-66) in India - Case Study
CORTALIM
Junction 4
U Turn-3
U Turn-2
HEIGHT LIMIT BAR
PANAJI
PLANTATION AREA
CRASH BARRIER
SETTLEMENT AREA
GOA UNIVERSITY
C.S
CAFE COFFE DAY
Verge 0.6m wide
Junction 3
PANAJI
SANTA CRUZ



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traffic destined to P
remaining would take

high speed NH through unregulated paved areas have been eliminated. 1.5m high pedestrian railing has been provided on the central median to prevent Jay pedestrian crossings across the

high speed NH. As weaving maneuvers from right lane to left lane for Santa Cruz bound traffic were involved in a short weaving length, speeds have been reduced to about 40 Kmph using rumble strips. Turning arrow markings have been provided to guide the road users (**Fig 3**).

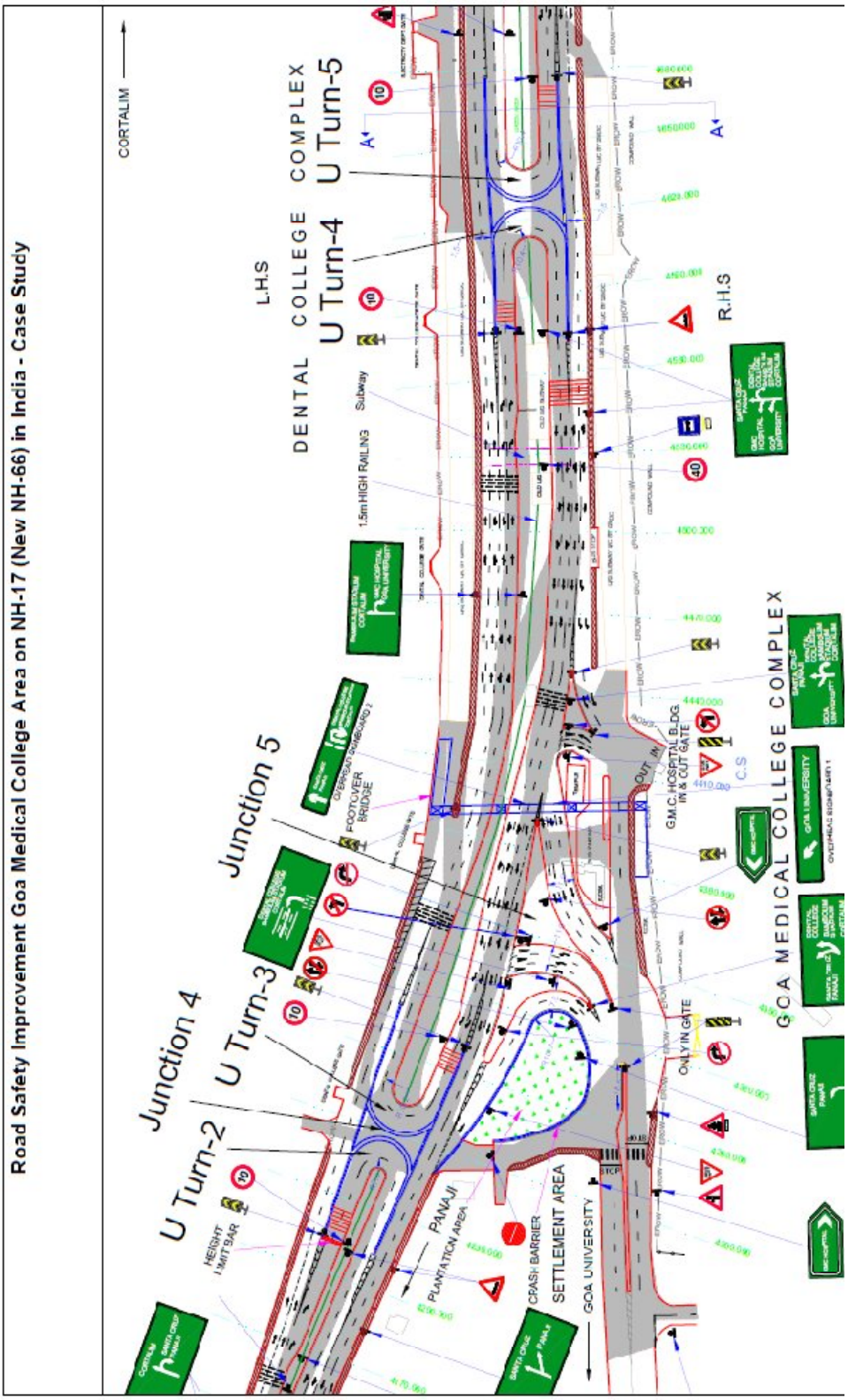
A triangular island Channelizer was provided at Junction-3 facilitating streamlined movement of traffic heading towards Panjim/Dental College from Santa Cruz side. Turning arrow markings are provided to guide the vehicles at Junction-3. Carefully designed advance direction signs aligned with road alignments have been provided to effectively guide the Road users to take their appropriate lane as per their respective destinations. In the existing condition, traffic from Goa University (VIP road) was taking left turn and joining the main NH or was crossing NH to reach Dental College/Cortalim through un-channelized paved areas at junction-4. This was causing severe accidents. Therefore, left turning from Goa University Road has been closed. Entire traffic from Goa University side has been diverted through properly designed turning lanes (km 4.32) at Goa Medical College (**Fig 5**). All the traffic from Santa Cruz side has been made to take left turn through repeated "compulsory left turn" sign (**Fig -3**). Cross roads joining NH on LHS were provided with cautionary "cross road" ahead sign along with rumble strips with a 40 Kmph speed limit (**Fig 3**). Traffic on LHS carriageway destined to Panjim side /Santa Cruz side have to take a "U" turn at 'U turn-2' facility. This has been made clear to road users through properly designed advance direction signs & turning arrow markings. As weaving is involved in changing lanes from left to right for 'U' turning traffic, speeds have been limited to 40 Kmph. Due to space restrictions 'U turn-2' has been provided with 7.0m radius and as such cannot accommodate turning of commercial vehicles. Therefore, height limit sign and height limit cross bar have been provided at km 4.215. At 'U-turn-2', crash barrier has been provided to prevent vehicles / pedestrians crossing the NH avoiding use of "U" turn facility (**Fig 3**).

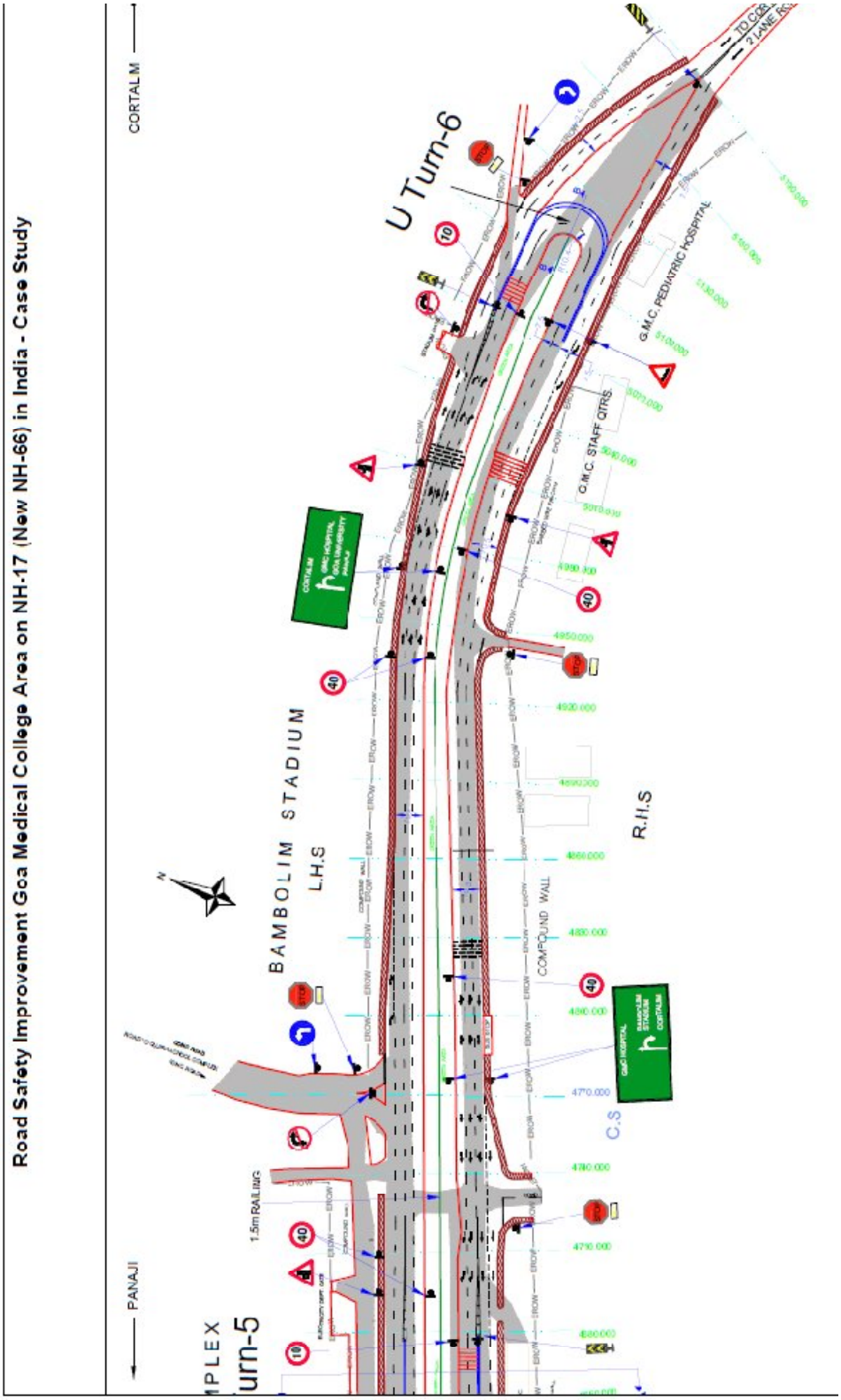
Entire traffic from Goa University side has been made to join main NH through two separate 2-lane and 3 lane left turning connector roads (**Fig 5**), one for the traffic destined to Panjim side /Santa Cruz side moving outside the "U"-turn facility and the other for the traffic entering U-turn facility to reach Dental College complex/Cortalim (**Fig 5**). Traffic joining the NH for destinations of Panjim side/Santa Cruz side should take a compulsory left turn and should not take a right turn at the NH which would cause a head on collision with traffic coming from Cortalim side on RHS carriageway. Therefore, a "No Right Turn" sign has been provided for this traffic. Traffic coming from Goa University side has been guided through two properly designed advance direction signs indicating the road to be taken by Panaji / Santa Cruz bound traffic and Dental College/Bambolim Stadium /Cortalim bound traffic, by aligning the directions on sign boards parallel to the directions of alignment of the road (**Fig 5**). An additional In-gate has been provided for Medical College for smooth entry from the Goa University side. The 3-lane road form main NH towards Goa Medical College has been made one way carrying traffic towards newly proposed In-Gate of Medical College at km 4.32 and also the traffic towards Goa University side. This has been reinforced through arrow markings on the pavement as well as one way sign (**Fig 5**). Traffic coming from Cortalim side has been guided through a over-head sign towards Goa University bound connector road, towards Panaji /Santa Cruz in the straight ahead direction and Dental College/ Bambolim Stadium/ Cortalim side towards "U"-turn bound right lanes. An advance direction sign for Junction-5 has also been provided on the Channelizer island repeating the directions given on the over-head sign (**Fig 5**).

For the traffic from Cortalim side, a properly designed Advance direction sign has been provided giving directions towards all major destinations. As the traffic from Cortalim side is approaching the Complex Junction-5 speeds have been reduced to 40 kmph using rumble strips. Turning arrow markings on each of the lanes are provided reinforcing the directions given in Informatory signs. Bus shelter and Bus Parking areas have been provided carving out space from the excess area between different connector roads and GMC compound. One way and two way Hazard Markers are provided at the tips of traffic islands to caution the road users. A "No Left Turn" sign is provided to avoid traffic from Cortalim side taking a left turn towards Medical College in violation of one way. As there is large pedestrian movement across the NH from Medical College Complex to Dental College complex and vice –versa a foot over bridge with escalator has been provided near out gate of the Goa Medical College (**Fig 5**). Zebra crossings with stop lines have been provided across Goa University road for minor pedestrian movements.

Traffic from Cortalim side destined to Dental College/Bambolim Stadium have to take "U" turn at 'U-turn-3' (**Fig-5**). As the radius of 10.2m could be provided at this "U"-turn commercial vehicles except long trailers can use this "U" turn facility. Rumble strips have been provided in all "U" turns restricting the speeds to 10 kmph. Traffic from Panjim side to Goa University /Goa Medical College side has to take "U" turn at 'U turn-4'. Similarly, commercial vehicles from Panjim side to Santa Cruz side have to take 'U turn-4' facility. On tangent section of RHS carriageway speeds have been reduced through bar code markings and were restricted to 40 kmph due to complex nature of the junction 5. All the advance direction informatory signs have been reinforced through turning arrow markings on pavement. Pedestrian footpath-cum-drains have been continued all along, providing safe walking area and crossing facility with pedestrian railings including FOB with escalator.

Traffic from Cortalim side has to take "U" turn at 'U-Turn-5' facility for Bambolim Stadium and further destinations towards Cortalim (**Fig 5 & Fig 6**). Cross road towards Cujira School complex has been channelized and provided with Stop Sign, Stop Line markings etc. Traffic from Bambolim Stadium/School complex etc., has to take "U" turn at 'U-turn-6' facility to reach Panjim/Goa University/Goa Medical College (**Fig 6**). On footpath, a pedestrian guard rail of 1.2m height and on the central median a railing of 1.5 m height with openings at designated pedestrian crossing facilities has been provided to restrict the pedestrian crossings Pedestrian footpath of 2m width has been provided to facilitate utilities like street light posts. Lighting has been provided all along the stretch to keep the complex junction areas well lit. High mast lights have been provided at 5 locations in the complex junction area for good night visibility.


Road Safety Improvement Goa Medical College Area on NH-17 (New NH-66) in India - Case Study
CORTALIM
Junction 4
U Turn-2
U Turn-3
Junction 5
DENTAL COLLEGE COMPLEX
U Turn-4
U Turn-5
L.H.S
R.H.S
1.5m HIGH RAILING
Subway
FOOTOVER BRIDGE
G.M.C. HOSPITAL BLDG
IN & OUT GATE
ONLY IN GATE
GOA MEDICAL COLLEGE COMPLEX
PANAJI
PLANTATION AREA
CRASH BARRIER
SETTLEMENT AREA
GOA UNIVERSITY
HEIGHT LIMIT BAR



5. IMPORTANCE (

In most of the road im
to the main project.
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traffic properly to the
assume very high importance.

6. Due to space constraints and steep gradient neither a grade separated inter-change could be provided nor the junctions could be made direct. Therefore to achieve safety by reducing conflicts “U” turns have been introduced. This is all the more essential as the stretch is in rolling terrain with gradient. Pedestrian safety has been addressed through pedestrian foot paths cum drains, foot over bridge with escalator coupled with preventive measures like high pedestrian railings etc. With all these measures it is expected that the entire project stretch becomes safer for all categories of road users.

REFERENCES

1. Detailed project proposal submitted to Ministry of Road Transport & Highways for the above case study work.
2. Ministry of Road Transport & Highways guidelines and archived data on Roads and Road Safety.

DISCLAIMER

The views expressed in the paper are the personal views of the author and need not necessarily reflect the views of the organization to which the author belongs. The paper is neither submitted nor published anywhere else than IRF for World Road Meet-2017. The paper generally followed the guidelines specified for this purpose.