EXECUTIVE SUMMARY

E.1 INTRODUCTION

Khambatki Ghat is located in Pune – Satara section of NH -4 from Km 772.500 to Km 781.000 in Kandala Taluq in Satara District in Maharashtra. This section form part of the Six Laning of Pune-Satara Section of NH-4 from Km 725.000 to Km 865.350 (Length-140.350 km) in the State of Maharashtra being executed under BOT (Toll) on DBFO Pattern under NHDP Phase-V (Package No. NHDP-V / MC-II /14) for which Concession was granted by NHAI to M/s PS Toll Road private Limited.

M/s Aarvee Associates Architects Engineers & Consultants Pvt Ltd., are the Independent Engineer for the project.

In the Kambhati Ghat section, the existing two lane road on LHS is passing through 2 lane tunnel constructed during four laning of Pune - Satara section and the two lane road on the RHS is passing through ghat portion. Drawing showing the alignment is given in Fig E.1. In the concession agreement, the existing two lane tunnel on the LHS was proposed to be retained and the approaches on either side were proposed to be widened to three lanes. The RHS alignment passing through ghat portion was also proposed to be retained with geometric improvements and widening to three lane.

The two lane tunnel is going to become a bottleneck in the long run as the traffic volumes increases and the geometric improvements proposed for the RHS side is also not eliminating all the geometric deficiencies in the alignment. Considering these issues, NHAI desired that a separate DPR be prepared for upgrading the section and M/s Aarvee Associates was entrusted the assignment of DPR preparation vide letter No. NHAI / NHDP – V / MC – II / BOT / 23/ Tunnel / 460 dated 31/07/2014 as a variation to the contract for IE services.

The consultants submitted inception report vide letter dated AA/HW/NHAI/ 1189 / 14 – 15 / 663 dated 29/10/2014 and alignment report vide letter No. AA/HW/PSTRPL / 1189 I 14-15 / 1094 dated 25/02/2015. The alignment options proposed in the alignment report are as under:

- New six lane tunnel options
    - To the west of existing tunnel (Alignment I shown in red colour) with tentative cost of Rs. 647.70 Cr.
    - To the east of existing tunnel and passing through valley (Alignment II shown in blue colour) with tentative cost of Rs 761 Cr.
    - To the east of existing tunnel and passing through ghat section (Alignment III shown in Yellow colour) with tentative cost of Rs. 676 Cr.
- Three lane tunnel option to the east of existing tunnel through valley after improving the geometrics of the existing tunnel at the tunnel exit on Pune side (Shown in blue with tentative cost of Rs. 483.50 crores.

Drawing showing the above alignment options is enclosed at Annex 1 at the end of the report

NHAI recommended the option of six lane tunnel on the west side (Alignment I with tentative cost of Rs. 647.70 cr vide their letter No. NHAI / NHDP – V / MC – II / BOT / 23 / Tunnel / 69723 dated 31/07/2015. Clarifications sought by MoRTH vide letter RW / NH-37011/ 06/ 2008 P&P dated 24/07/2015 were furnished to MoRTH vide NHAI letter No. NHAI / NHDP – V / MC – II / BOT / 23 / Tunnel / 73873 dated 02/11/2015.

The proposals were reviewed in MoRTH under the chairmanship of Secretary, MoRTH on 13.11.2015 and approval to the proposal of NHAI recommending new 6 lane tunnel on west side of the existing alignment was communicated vide letter No. NHAI / PIU /PUNE / New Khambatki Tunnel / 05329 dated 09.12.2015.

E.2 REVISED INCEPTION REPORT

This revised inception report is prepared as per the deliverables envisaged in the RFP for Autram Ghat tunnel based on which revised variation order was submitted to PIU vide letter No. AA/HW/NHAI/1189/16-17/476 dated 12/07/2016

E.3 PROJECT LOCATION

The project section starts near Wele (Km 772.100 on NH 4) and ends near Pargaon Khandala (Km 781.000 on NH 4).

Table-E.1: Project Stretch

S. No	Section	Design Chainage (Km)	Design Chainage (Km)	Length
1	Khambatki ghat	772.500	778.850	6.350

The Index Map is given hereunder:

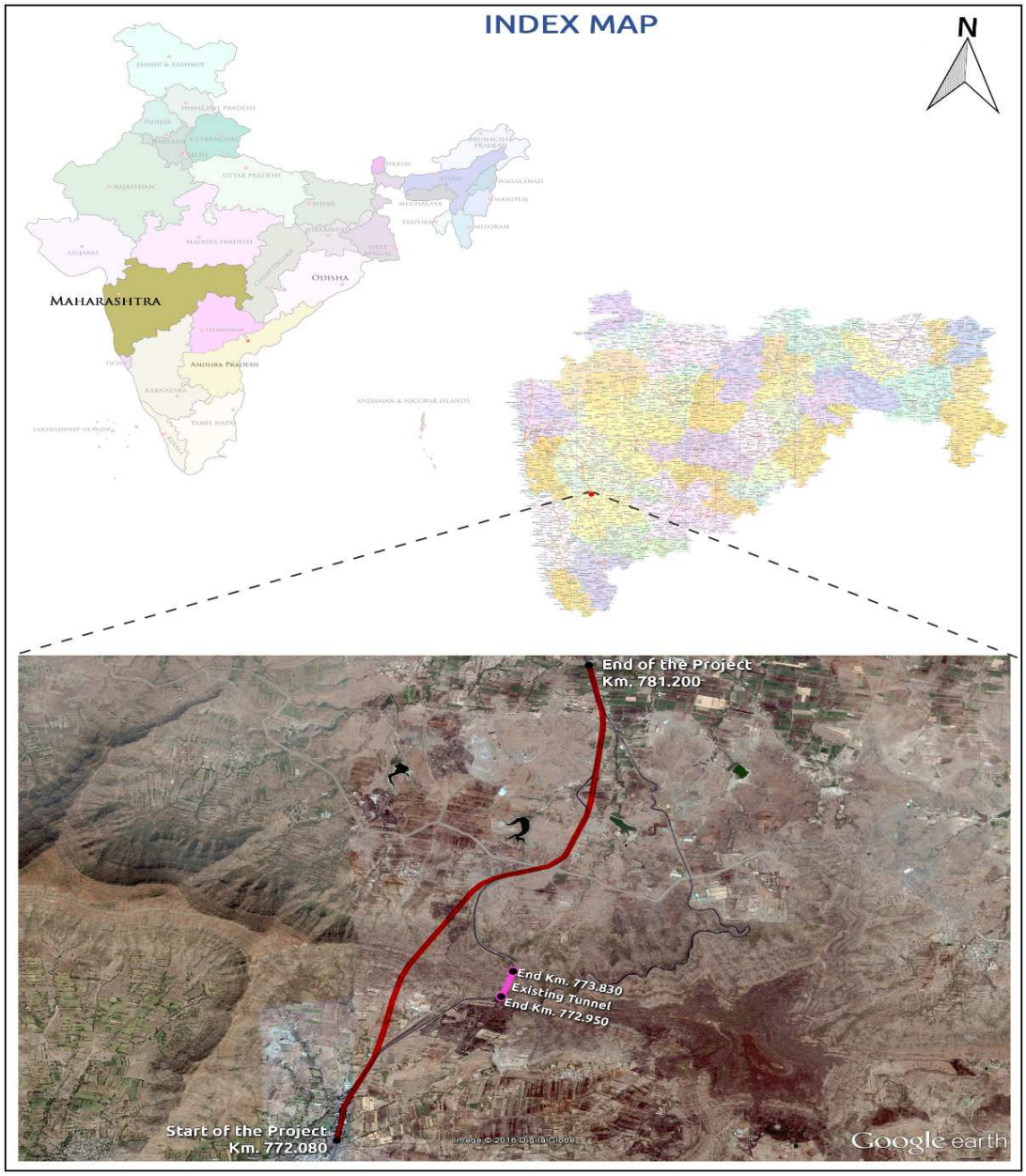

Figure: E-1 Index Map

Three alignment options for tunnel are considered. These were discussed in section E.8

E.4 SURVEYS AND INVESTIGATIONS

The studies and investigations conducted during the feasibility study consisted of the following:

- Detailed Inventory & Condition Surveys for Road
- Detailed Inventory & Condition Survey for Bridges
- Topographic Surveys along the existing alignment
- Traffic surveys viz., Classified Traffic Volume Count, Axle Load, Origin Destination and Commodity Movement etc., including collection of secondary data for traffic projections
- Identification of borrow areas for different types of pavement and bridge construction material, collection of samples and their analysis
- Subsoil investigation for proposed tunnel location and structure locations
- Environmental baseline studies
- Public Consultations

E.5 EXISTING CONDITION OF ROAD & BRIDGES

E.5.1 INVENTORY & CONDITION SURVEYS FOR EXISTING ROAD

The alignment is mostly green field. Existing alignment from Km. 775.900 to Km. 778.300 caters to Pune bound traffic and this was widened from two to three lanes by the Concessionaire.

The pavement is new and is in good condition.

E.5.2 INVENTORY & CONDITION SURVEYS FOR BRIDGES

The detailed inventory and condition survey of structures are discussed in Volume-II Investigation Report. Total numbers of Structures the existing alignment are given hereunder:

a) Total number of Minor bridges - 3
b) Total number of Slab/Box Culverts - 1
c) Pipe culverts - 7

E.6 TRAFFIC STUDIES

Based on reconnaissance studies, the locations for conducting various traffic surveys were finalized. The traffic surveys viz., Classified Traffic Volume Count, Axle Load, Origin Destination and Commodity Movement, Willingness to Pay, etc., including collection of secondary data for traffic projections were carried out in the month of September, 2016. Secondary data was collected for the purpose of determining the Seasonal Variation Factors and Growth Rates at various count stations for different vehicle categories.

E.6.1 AVERAGE ANNUAL DAILY TRAFFIC (AADT)

The Annual Average Daily Traffic (AADT in no. of vehicles) at the survey locations is obtained by multiplying the Average Daily Traffic (ADT) with the seasonal correction factor. The AADT of vehicles for the year 2016 at the survey locations of traffic volume count survey along the Project corridor is presented below.

Table E.2: Average Annual Daily Traffic

Mode	At Km. 781.200
Two Wheelers	4301
Three Wheelers	37
Car / Jeep / Van	11294
Car Yellow board	798
Tata Magic	106
RTC Bus	1002
Private Bus	952
School/College bus	9
Mini Bus	202
2 Axle	3851
3 Axle	1677
M Axle	1502
HEM	13
LCV/LGV	543
Mini LCV	989
Three Wheeler goods	31
Tractor	5
Tractor with trailer	10
Non-Motorized Vehicles	17

Mode		At Km. 781.200
Govt. Exempted Vehicles		28
Tollable Traffic (vehicles)		22,938
Tollable Traffic (PCU's)		43,598
Total Vehicles	Motorized	27,350
	Non-Motorized	17
	Total Traffic	27,367
Total PCUs	Motorized	45,910
	Non-Motorized	42
	Total Traffic	45,952

E.6.2 Vehicle Damage Factors (VDF)

The VDF values calculated for different categories of commercial vehicles are shown below and the detailed analysis is presented in Traffic Report.

Table E.3: Vehicle Damage Factor (VDF) without Mine Traffic

S. No.	Mode	At Km. 781.200		
		To Satara	To Pune	Adopted
1	2 Axle	2.08	2.65	2.65
2	3 Axle	3.18	4.58	4.58
3	M axle	6.12	9.01	9.01
4	LCV	0.23	0.74	0.74

E.6.3 TRAFFIC GROWTH RATES (%)

Traffic growth rates are an important parameter for projecting the traffic for the design life of pavement. The projected traffic, in turn, will form the basis for capacity assessment, pavement design, and financial viability analysis.

Table E.4: Traffic Growth Rates (%)

S. No.	Period	2 Wheeler	3 Wheeler	Cars/ Jeeps	Buses	Trucks			
						2 Axle	3 Axle	M Axle	LCV and Mini LCV
1	Upto 2016	7.0	4.0	7.0	6.0	5.0	7.0	7.0	7.0
2	2017-2021	6.5	3.5	6.5	5.5	4.0	6.5	6.5	6.5
3	2022-2026	6.0	3.0	6.0	5.0	3.0	6.0	6.0	6.0
4	2027-2031	5.5	2.5	5.5	4.5	2.0	5.5	5.5	5.5
5	>2032	5.0	2.0	5.0	4.0	1.0	5.0	5.0	5.0

However, maximum growth rate of 5% is considered for traffic projections as per codal provisions.

Table E-5 : Projected Traffic

Year	Traffic (PCU)
2016	45,946
2020	55,848
2025	71,277
2030	90,970
2035	116,103
2037	128,004
2040	148,180

E.6.4 CAPACITY OF THE HIGHWAY

The Highway Capacity Manual has introduced the concept of "Level of Service" to denote the level of facility one can derive from a road under different operating conditions and traffic volumes. It is defined as a qualitative measure describing the operational conditions with in a traffic stream and their perception by motorists. The level of service for urban and suburban roads can be related to the flow conditions, average overall travel speed, load factor at intersections, peak hour factor and service volume to capacity ratio.

As per expressway manual, the capacity of 6 lane road with access control for LOS B is approximately 1,30,000. Thus, the proposed tunnel will serve at level of service B till 2037.

Table E-6 : Capacity Analysis

S. No.	Homogeneous Section	Chainage		Present Traffic	
		From Km.	To Km.	PCUs	Year
1	Pune to Satara	773.000	781.000	45952	2016

E.7 PAVEMENT DESIGN

E.7.1 INTRODUCTION

The Preliminary Pavement design is done for both flexible and rigid options. The flexible pavement is designed as per IRC: 37-2012. The rigid pavement is designed using IRC and CMA methods. The Sub grade CBR for the new carriage way is considered 10%. Sub grade thickness of 500 mm is considered for both flexible and rigid pavement options.

E.7.2 MILLION STANDARD AXLES (MSA)

Design traffic in terms of Million Standard Axles has been determined at 3 locations based on traffic homogeneous sections, where volume count and axle load surveys were conducted.

Table E.6: Million Standard Axles (MSA)

Direction	10 Years MSA	15 Years MSA	20 Years MSA	25 Years MSA
To Satara	41	72	111	162
To Pune	61	106	177	237

E.7.3 RIGID PAVEMENT

For the design traffic estimated for a life of 30 years and a sub grade CBR of 10%, the pavement composition with granular base & DLC is as follows:

Table E.7: Rigid Pavement Design with Tied Concrete Shoulders

S.No.	Item	Km 773.100 to Km 778.700
1	PQC of M40 grade, mm	280
2	DLC of M10 grade, mm	150
3	GSB, mm	150
4	Dia. of Dowel bar, mm	36
5	Length of Dowel bar, mm	500
6	Spacing of Dowel bar, mm	300
7	Dia. of Tie bar, mm (Plain bars)	12
8	Length of tie bar, mm	580
9	Spacing of tie bar, mm	400

E.7.4 DESIGN OF SHOULDERS

Paved Shoulder: The shoulder would be useable during all seasons of the year and hence as per Clause 5.10 of IRC: SP:87-2013, the crust composition and specification of paved shoulder shall be same as of the main carriageway.

Earthen Shoulder: Earthen shoulder shall be covered with 150 mm thick layer of granular material confirming to the requirements given in Clause 401 of MORTH specifications.

E.7.5 RECOMMENDATION

By considering existing traffic and respective heavy loads and as mentioned in Ministry circular it is recommended to construct Rigid pavement for the proposed project road.

E.8 UPGRADATION PROPOSALS

E.8.1 ALTERNATIVE ALIGNMENTS

Based on topographic data, three alignment alternatives are found feasible from the following considerations:

- Existing Structures on Satara side
- Constructability of the new alignment without obstructing the existing traffic.
- Limiting vertical gradients for tunnel and viaduct

The three alignment alternatives are presented here under and the following are the salient features of all the options.

Table E.8: Salient Features of various Alternatives

S. No	Item	Alternative I	Alternative II	Alternative III
1	Cutting in existing Highway at Vele village near start of project.	Not required	About 20m cutting is required near meeting point at Km 773.050 near existing petrol pump.	Not required
2	Geometry before tunnel	Smooth horizontal curves to merge with existing NH	At meeting of existing NH, the proposed alignment will have S – curve with radius of 400 m.	Horizontal curves better than Alternative I & II

S. No	Item	Alternative I	Alternative II	Alternative III
3	Disturbance to existing Wells/temples	5 nos irrigation/ Drinking wells and one temple is falling in PROW corridor	Nil	One Well, One Hotel (Shiv Kailash) and one Petrol bunk falling in PROW corridor
4	Disturbance to live traffic on existing NH during construction – Before tunnel	Nominal disturbance as the alignment is meeting at existing NH road level	Deep cutting is required for a length of 300m. Adequate traffic safety measures are required during construction for proper diversion of live traffic.	Nominal disturbance as the alignment is meeting at existing NH road level
5	Overpass/ underpass at start of the project	Overpass is required at take off point (Km 772.900) to connect the existing LHS and RHS carriageway	Cut and cover type tunnel is required for a length of 200m near Vele village. This will act as overpass to connect the existing LHS and RHS carriageway	Overpass is required at take off point (Km 772.900) to connect the existing LHS and RHS carriageway

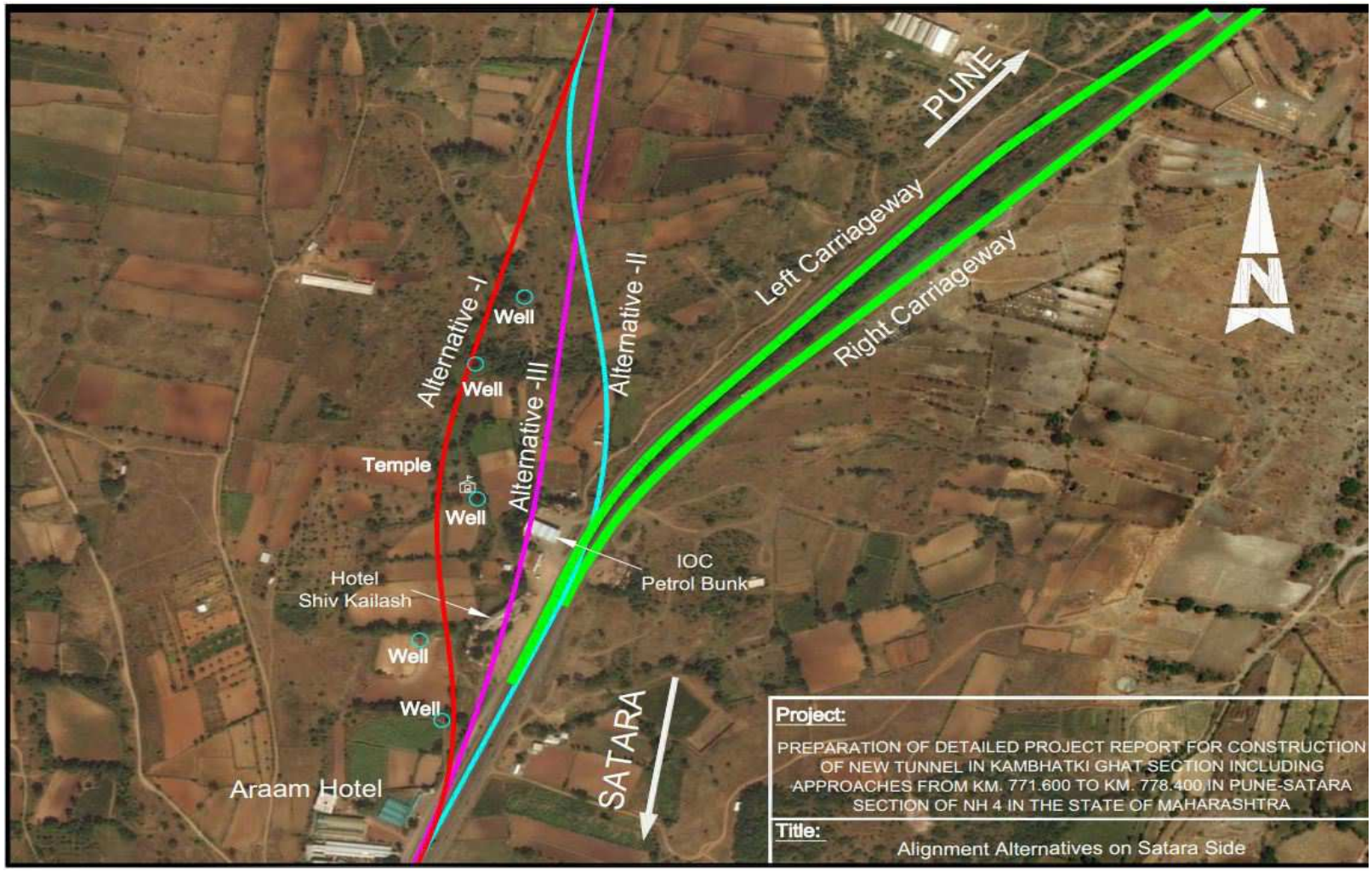

Figure: E – 2 Various Alignment Alternatives on Satara Side

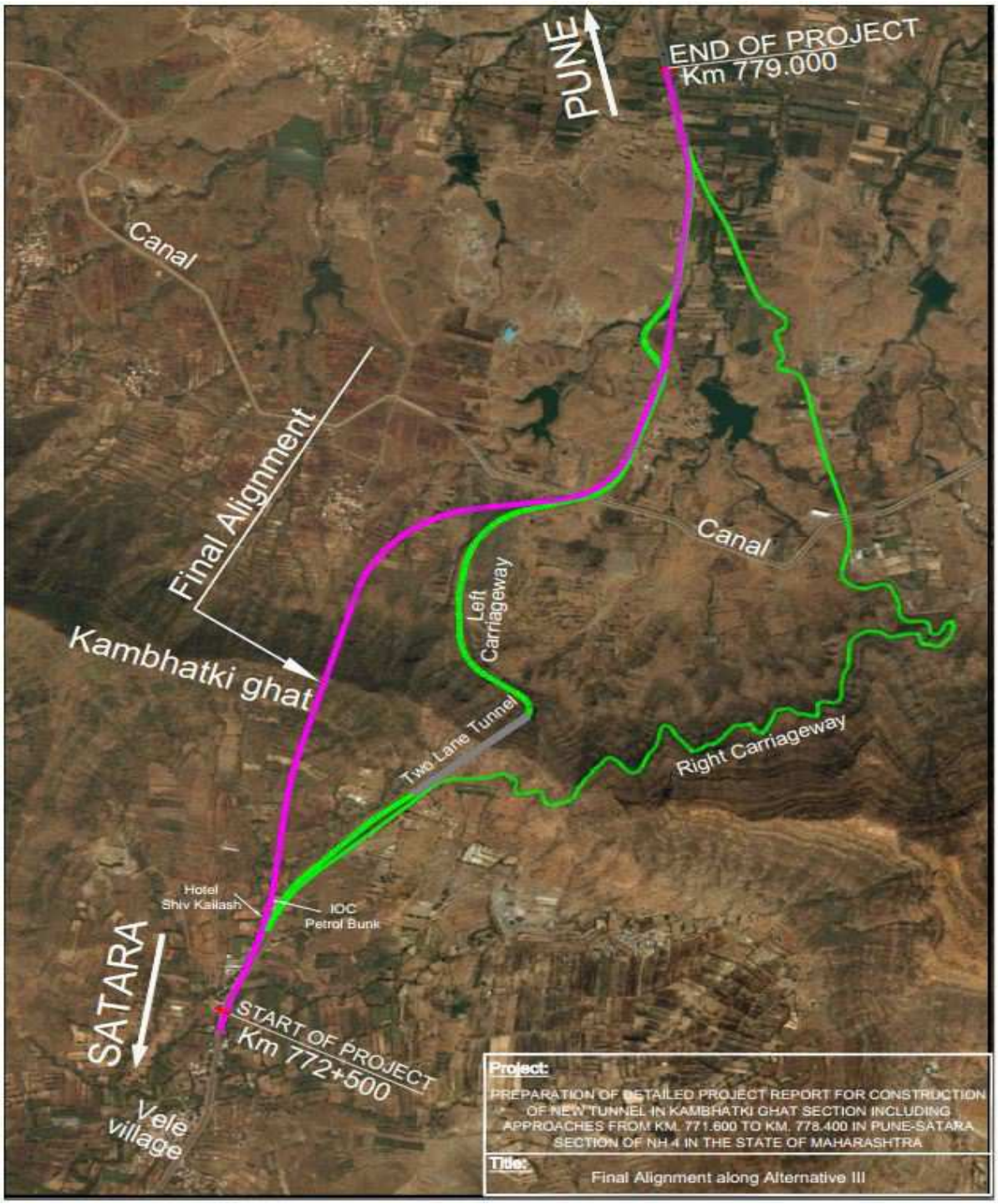

Figure: E – 3 Final Alignment along Alternative III

During the review meeting attended by the RO, Mumbai and PD, PIU ,Pune, the Member (Tech) communicated that, the straight alignment of Alternative III, passing through the hotel and Petrol bunk appears to be feasible.

These three alternatives were presented to the Hon'ble Minister, MoRTH on 10.01.2017, where in the straight alignment was approved. Therefore, alignment **alternative III** is recommended.

The salient features along this alignment are

- Tunnel - LHS from Km 773.500 to Km 774.700 = 1200m (approx.)
- Tunnel - RHS from Km 773.500 to Km 774.700 = 1200m (approx.)

E.8.2 MINOR BRIDGES

Minor bridges are proposed at the following locations:

Table E.9: Minor Bridges

S. No	Design chainage km	Proposed structural Configuration	Proposed structure type	Proposed span arrangement
1	776.100	New six lane bridge (Canal)	PSC I- girder	1 x 25.0(Sk)
2	777.263	New six lane bridge	RCC Box	1 x 6.0

E.8.3 UNDERPASSES

Underpasses are proposed at the following locations:

Table E.10: Underpasses

S. No	Design chainage km	Proposed structural Configuration	Proposed span arrangement
1	772.900	Vehicular Overpass	2 X 21.0 m
2	778.085	Vehicular Underpass	1 x 30 m
3	779.100	Pedestrain Underpass	1 x 10.0 m

E.8.4 VIADUCT

Viaduct is proposed at the following location

Table E.11: Viaduct location

S. No	Design chainage (From Km)	Design chainage (To Km)	Proposed span arrangement
1	774.960	775.915	30 x 31.0

E.8.5 TYPICAL CROSS SECTIONS

Typical Cross Sections (TCS) have been developed duly considering various aspects. The entire alignment passes through hilly and rolling terrain. Different cross sections are proposed for highway, tunnel and high embankment portion, Description of each type of cross section is listed in the Table shown below.

Table E.12: Typical Cross Section (TCS) attached to this report

TCS type	Description
I	6 lane divided highway with 7 m wide service road on both sides
II	6 lane for new alignment in mountainous terrain in cut section with LHS service road (<5.0 m cut)
III	6 lane for new alignment in mountainous terrain in cut section with LHS service road (>5.0 m cut)
IV	6 lane for new alignment in mountainous terrain in cut section with RHS retaining wall
V	6 lane for new alignment in mountainous terrain in cut section
VI	Tunnel cross section
VII	6 lane cross section of viaduct
VIII	6 lane for new alignment in mountainous terrain in cut section on RHS and fill on LHS
IX	6 lane for VUP/PUP with service road on both sides
X	6 lane with eccentric widening with RHS service road
XI	6 lane with new alignment
XII	6 lane with new alignment with RHS service road

E.9 RECOMMENDATIONS

Based on the studies made, Alternative III is recommended with a tunnel length of about 1200m.