

Marine Drive Highway along Central Odisha Coast, India; Feasibility and EIA Inferences

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Author's contribution

The sole author designed, analyzed, interpreted and prepared the manuscript.

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ABSTRACT

The golden sea beaches of Puri district in Odisha state is panoramic and a myriad tourist attractions from India and abroad. The places are famous for their temples of excellence as a part of the Bhartamala project. The high cost involved could not materialize it. Marine drive road has been completed under National Highways of 35.8km between Puri and Chandrabhaga (Konark) which has been successful and have increased the ecotourism of Odisha. Present study is the extension of the coast line highway project of 29.4km between Chandrabhaga and Nuagaon near Devi river mouth. The Comprehensive Transport Study (CTS) has been undertaken to identify coastal transportation network including environmental impact assessment and including design. The methodologies as per Indian Road Congress (IRC) guidelines, and MoRTH specifications, have been adopted to assess the characteristics of the traffic, geometric and pavement design of the proposed Coastal road. The flexible pavement technology having seal coat 25mm thick over 20 mm thick premix carpet (B.U.S.G.) over both 300mm thick subbase and base course has been provided. The slope protection works against erosion along with culverts (mostly box or Hume - pipe) and bridges has been designed for the project. Since the high way to run over mostly unmanned sand dunes and only the Prachi River system the project is cost effective and shall surge the economic status of the fisher group and the villagers of the area.

Keywords: Coastal highways; EIA study; traffic study; culverts and bridges; slope protection.

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ACRONYMS

CTS: Comprehensive Transport Study; IRC: Indian Road Congress; MoRTH: Ministry of Road Transport and Highways; B.U.S.G: Built-up spray Grout; EIA: Environmental Impact assessment; GoO: Government of Odisha; Gol: Government of India; NH: National Highway; SH: State Highway; INR: Indian rupees; ICZMP: Indian coastal zone management programme; BoB: Bay of Bengal; MDR: Major District Road; ODR: Other district road; FY: For the Year; CRP's: Coastal Road Projects; HTL: High tidal line ; LTL: Low tidal line; LU/LC :Land use/ Land cover; MoEF&CC: Ministry of environment and forests and climate change; MoRT: Ministry of Road Transport; EAC: Expert Appraisal Committee; PPP: Public-private Partnership; VUP: vehicular underpasses; OSD: overtaking sight distance; WBM: Water bound macadam: WMML Water mix macadam; CBR: California Bearing Ratio; msa: Maximum axle standard; AASHTO: The American Association of State Highway and Transportation Officials; ASTM: The American Association of State Highway and Transportation Officials; IS: Indian standard code; CRZ: Coastal regulatory zone; JJASO: June to October; MAM: March, April and may months; DBM: Dense grade Bitumen.

1. INTRODUCTION

India houses road network spanning 5.89 million km is ranking the 2nd largest the globe Road connectivity is gradually escalating and is covering goods transports of approximately 64.5% and 90% of entire passenger traffic using to commute (by 2021). The Government of India (Gol), has planned 65Thkm of National Highways (NH) at an estimated cost of about 535MINR is likely to complete by 2022, <https://www.ibef.org/industry/roads-india/showcase>, but could not be possible due to the pandemic in the state.

The Ministry of Road Transport and Highways (MoRTH) have budgeted estimate for 2021-2022 is 118.1billion INR (capital 108.23 and revenue 98.71 GigaINR) for India for connectivity which is an annual surge of 23% above outlay during 2019-2020 [1]. The India's coastal states have NH of length 6968 km. The existing 35.8km long NH-35 (Puri-Konark marine drive road) and proposed extension as 2- Lane roads is shown in (Fig. 1).

Puri district in Odisha (lat.19.8135° N, long 85.8312° E), the well-connected state is the 9th

largest, area of 155707 km², the 11th largest by population in India, and a vibrant tourist hotspot. The six coastal districts of Odisha adjacent Bay of Bengal (BoB) are backing 36% of Odisha's total people and 43% of urban residents (ICZMP project report) lies in the littoral track backed inland by alluvium <http://www.iczmpodisha.org/reports.htm>.

The state has total 30637.9 km of road network including National Highways (NH); (4848.1km), State Highways (SH); (4143.1km), Major District Roads (MDR); (2811.8km), and Other District Roads (ODR); 18835.0km, <https://finance.odisha.gov.in/sites/default/files/2020-05/WORKS-Outcome>.

1.1 Road Transport Odisha

The road development particularly in NH sector is fast in Fig. 2. But the State Highways (SH) development from 2003 till 2018-2019 are under designed land width 30.48m to 45.20m, with formation width of 9.75m.

The state has 269799 km of total lengths of roads of various categories by end of the FY 2019-20 at an annual rate of 0.43% over the FY2018-2019. The state has non-special category status ranking five in terms of pavement density [2]. Only 25km of marine drive road has been constructed connecting Puri to Chandrabhaga (Konark). <https://www.statista.com/statistics/1077826/india-odisha-state-highways-length/>. The development of SH from 2003 to 2018 is shown in Fig. 3.

1.2 Review of Literature

Coastal roads are lifeline for some countries as they not only provide access to marine activities, tourism, and augment coastal to homestead land but also encounter meteorological extremes, inaccessible terrain, productive and social sectors, Charls [3]. According to the activity report of Works Dept. Government of Odisha (GoO), the total length of roads was 30367.9km and their category wise in the Odisha State was NH (4848.058 Km), SH (4143.053 Km), MDR (2811.784 Km) and ODR (18835.008 Km). The 1608km long NH-66 mainly runs adjacent to the Arabian coast passing through the states Tamil Nadu, Kerala, Karnataka, Goa, and Maharashtra, (WIKI). The Coastal Road projects (CRP's) are classic example of transport planning, fiscal resources, the environment and livelihoods, and depletion of air & noise pollution, that slacks the traffic and expand mobility [4],[5].

Puri district has NH (FY 2016-17) 140.37km and SH (FY 2017-2018) 43.56 km [6].

cycle riders with provision of foot over bridges. The methodology adopted in the study is in Fig. 4.

2. METHODOLOGY

Since the highway is along the coastal corridor, the provisions shall be mostly roads on sand dune areas, bridge over drainage channels, Culverts with scope for pedestrian underpasses,

During planning for the roads along the coastal beach stretch it is essential to follow the CRZmaps that show High Tide Line (HTL) and Low Tide Line (LTL) along with LU/LC map of the coastal extent to avoid future complications like ecologically sensitive stretches.

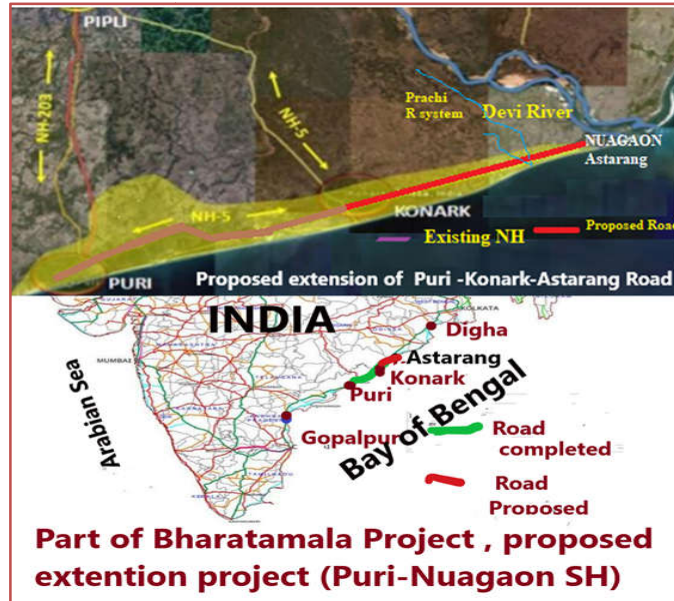


Fig. 1. Proposed Highway from Konark to Astaranga as fraction of Bharatamala project(Proposed Gopalpur to Digha)

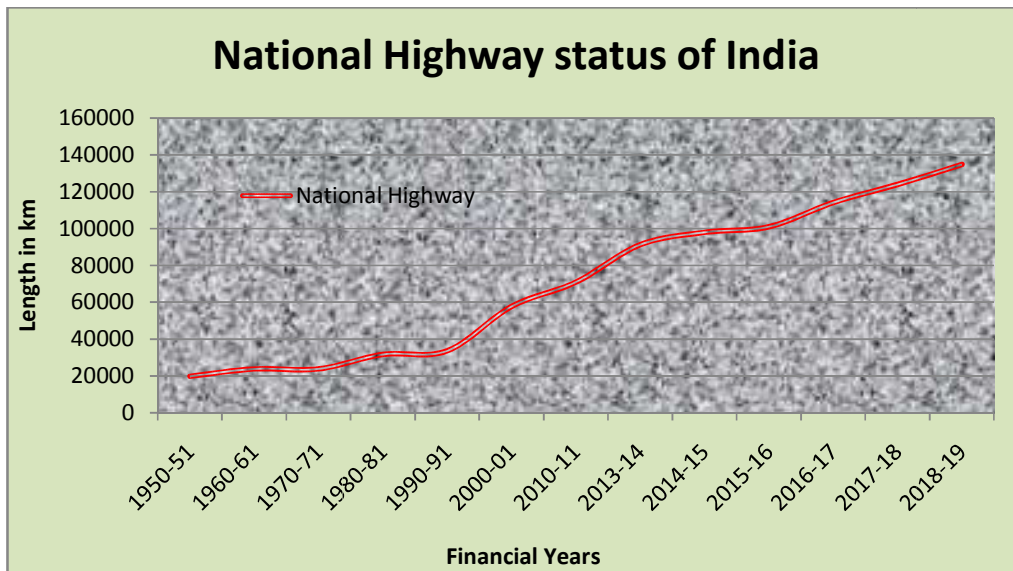


Fig. 2. The status of national Highways in India since Independence

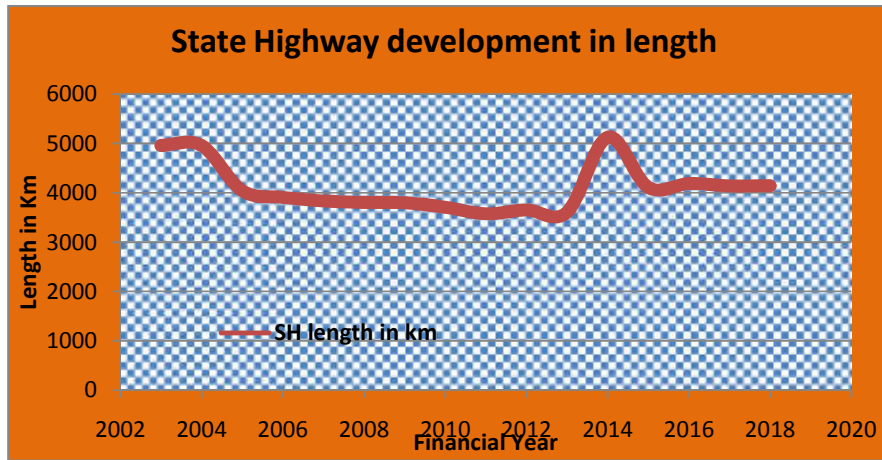


Fig. 3. The State Highway development in Odisha state from 2003 -2018

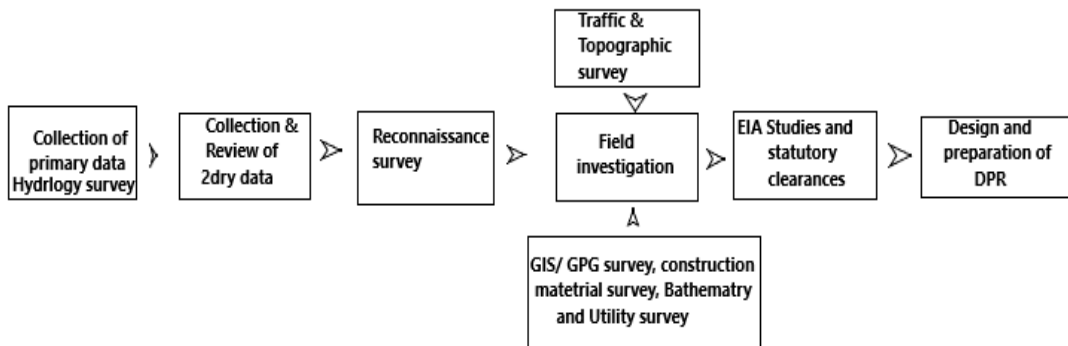


Fig. 4.Methodof Detailed Project Report preparation of the Konark- Astaranga coastal road

2.1 BharatmalaProject

The BharatmalaPariyojana planned as coastal, economic and high ways (connectivity or inter-se-priority) consists of approximately 65000 km construction of highways of various category whereas Odisha’s share is 3110km to be completed in Phase I (FY2017-2018 to FY2021-2022) (Fig. 5),(Loka- Sabha Starred Question No. 65 on 7th Feb,[7].

The objectives of Bhartamala project are for improved commuting amenities, ≈70% time redeem ability, 34% fuel saving, reduction of carbon foot print of 1826 tCO2e/year, reduction of congested city traffic with 2.75m reserve lane and finally coastal erosion protection on construction of sea walls or geo-tubing.

2.2 Necessity of the Road

Odisha has a long coast line of 549.9km [8] potential tourist hotspot, with six major townships

and projected population of about 46.7millions (Census 2011).India has many marine drive roads all along its east and west coast Fig. 5.

The marine drive road from Puri to Konark (35km) has been completed as a part of proposed Bhartamala project between Gopalpur to Digha. But the expert appraisal committee (EAC) comprising of MoEF& CC with MoRT in their 246 EAC meeting has abridged the road length by 80km from original estimated length of 450km. The proposed road has also avoided the bridges on the river Devi and the river Mahanadi. Since the marine road (NH 316A) has been proposed to divert the coastal marine drive road disrupts link between Konark to Dhamara which is considered to be the tourist attraction due to mangrove forests, Bhitarkanika sanctuary, Gahiramatha protected area, Hukitala Bay, Jatadhar beach etc.

Coastal lands are the nature’sbuffer zone and an open area with usual defense arrangement like

sand dunes, coastal levee in beach profile or bluff, mangrove forests, and hard structure. They are proficient to encountering, constructed the roadway.

2.3 Objective of Study

The planning of the marine state highway from Konark (the Kushabhadra river mouth) to Astaranga (Devi R. mouth), Odisha has been studied. The main objectives are:

- a. Extension of highway from Konark to Astaranga which is a direct connectivity from the tourist hot spot Puri to the busiest port of Odisha i.e. Paradip.
- b. To assess the expected benefits after construction as marine drive road.
- c. The study of the drainage system, ground water, soil and the land use and land cover.
- d. Environmental impact assessment (EIA) study
- e. Add to the scenic value as a marine drive road

2.4 Concurrent Transportation Facilities

Over the last decade, as cutting edge, the NH and SH in India has smart initiatives by hosting new transport means, last mile connectivity (E-Rickshaw), safer roads, upskilling, innovative opportunities of employment on Public-private Partnership (PPP) mode by associating with NGOs to ensure road safety along with antilock braking system [9]. To bring

transparency, reduce corruption in transport sector by introducing the Motor Vehicle (Amendment) Bill 2017 has been introduced. Various efficient traffic management systems like E Toll – FAS-Tag, simple license policies, road safety strategies, annual planning, plying of green buses and electric vehicles have been familiarized. Emission standards have been upgraded for vehicles. BS VI norms along with bio fuel B-100, flex-fuel E-85 or E-100, and ethanol ED-95, methanol M-15 or M-100 and methanol MD-95 have been standardized to control pollution for all motorized vehicles.

2.4.1 Geo-morphology of the area

The project lies in tropical savanna climate, with 80% of rainfall from JJASO months by SW monsoon and hot humid summer MAM months. The study area lies in the erosion stretch of the mid-Mahanadi lower coastal plains. The area is regularly visited by disastrous cyclonic storms, a mesho-tidal sandy coast prone to sever erosion. A series of drainage channels like the Kadua, the Prachi, and the Devi. A seismic line passes through the river Devi river mouth and an Amphidromic Point [10]. The topo sheets covering the coastal areas of Odisha for different districts for knowing the topographical features like elevation, communication, water bodies, LU/LC along with some public utilities like power grids, Dak- bungalow's and post offices etc. The updated topo sheet numbers used for the present district wise coastal features ascertaining are in Table 1.



Fig. 5. The present coastal connectivity from Gopalpur to Digha (Part of Bhartamala Project)

Table 1. The district wise open series topo sheets of SOI modified during 2005-06

District	Topo sheet numbers	Major topographic features
Balasore	A45O/15; F45P/2/3,6	Subarnarekha estuary
Bhadrak	F45O/16, F45U/13	Baitarani, Dhamara R., Port
Kendrapada	F45U/14, 11,15, F45V/2,	Mahanadi, Gahiramatha, Bhitarkanika
Jagatsinghpur	F45U/8, 11, 12	Devi estuary, Paradip port,
Puri	E45B/2,6, 9,10,13, E45C/15	Chilika lagoon, Balukhand, Puri/ Konark Beach,
Ganjam	E45A/15,16, E45B/3	Rushikulya and Bahuda R mouth, Tampara lake.

The satellite imagery is downloaded and the shape file is prepared after geo-referencing. The land use land cover of the coastal area including the coastal sands and the rivers/streams and drainage channels are in depicted in the final map. The final GIS imagery of the study area is shown in Fig. 6 and the area of coverage of various topographic features (mostly sands and agricultural fields) is shown in table.

From the LU/LC map it indicated only one major river i.e. the Prachi River system is intervening between the proposed lengths of the road. Since it is a dying river the carriage capacity is less during floods. The drainage channel debouching BoB is the Kadua d/c joining Prachi R. (at Charigaon) which shall intervene and above which the road may ply.

2.5 The Highway Project Rationale

The coastal highway project is a part to the Bhartamala Project (Gopalpur to Digha) along the east coast corridor of length 450km out of which 6.5km in WB and rest in Odisha. The 246EAC has squeezed the length by about 80

km avoiding the present proposed highway due to constraints of constructing bridges over the Devi River and the Mahanadi River near the coast (EAC meeting, MoEF&CC with MoRT H). The present proposed road of 29.4km length is an extension of Puri to Konark marine drive road (35km). The proposed coastal highway shall decongest the traffic of nearby road network and expand mobility for the tourists and the people from the community. The present study is carried out to verify the feasibility of the proposed coastal road, its EIA (Environmental Impact Assessment) and recommendations for detailed design of the project.

Konark: Konark is a Tehsil and Block headquarters in the district Puri. It lies along the coast of the Bay of Bengal (Lat. 19.8921° N and long. 86.0912° E) with population of 16779 in Konark NAC (Notified area council) and Tehsil has projected population of 68199 (FY 2011). The black Pagoda (sun temple) in Konark is one among previously designated seven wonders of India, and the marvelous golden beach is one among the golden triangle of Odisha and a tourist hotspot.

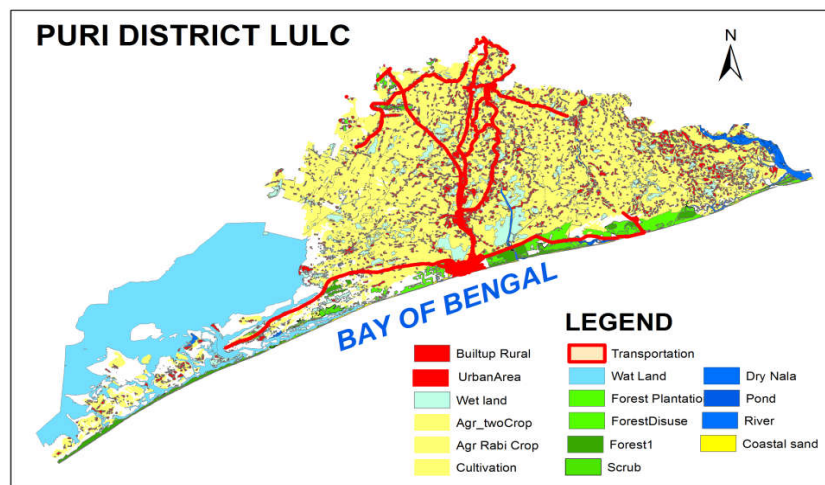


Fig. 6. The land use and land cover map of Puri District using GIS

Astaranga: The fishing area, Astaranga (lat. 19°58'46"N & Long. 86°16'10"E) is a small town in the Puri district. It is an block headquarters in Puri in the mouth of the Devi River which is about 19km from Konark. The Tehsil has growing population of 67,748 (2011 census) and projected population is 84008by 202, <http://www.indiagrowing.com/Odisha/Puri/Astaranga> .

2.5.1 Environmental impact assessment (EIA) studies

Highway development augments mobility and enhances the economic growth of the area. Inapt planning, design, and construction of highways worsens and cause harm to the existing natural landscape, habitat, bio-diversity and shall destroy the socio-economic fronts from cultural, socio-political and environment (air, water, and soil) pollutions. To minimize adverse environmental and socio-economic impacts, the highway infrastructure must be built to a high quality and maintained to a high standard through environ impact analysis. The environmental impact analysis has been done to sensibly assess the pros and cons of the future coastal highway as follows:

1. Identify of possible coastal impacts in natural and socio- economic environment
2. Evaluation and quantification of these impacts.
3. Coastal stretches proposed for protection
4. Improving measures to evade, alleviate and recompense the impacts in antedate.

2.5.2 Environmental consideration

The clearance of EIA has become evident for any major activities like Highway projects, housing schemes, skyscrapers during its inception of project formulation to demolition (life cycle), ill-effect on societal utilities, biodiversity, and environmental burdens

2.5.3 The impacts from EIA aspect

The project aims at improving connectivity, augment logistics performance, reducing traffic congestion instigated due to plying of traffic and shall create the economic corridors add to effectiveness and much more. The potential impacts after construction of the Highways are:

Geotechnical: Soil compaction of alluvium by earth moving tools, erosion and frustum changes of borrow areas, topsoil loss, exploiting agricultural soils, salinity ingress.

Hydrogeology: Water bodies and ground water table modification under changed geohydrology, Sedimentation of flood plain, change flooding or drying pattern and pollution of ground water.

Flora and fauna: loss of mangrove swamps and hence fauna and flora enhance coastal erosion, disproportional appearance of floral and faunal species, and changes in LU/LC pattern. Increasing poaching, criminal activities and loss of natural resources and fishing potentialities, enhance anthropogenic stress by modernized activities along the coast.

2.6 The Pros and the Cons from EIA Studies

However the overall positive effects, provision of all-weather road for coastal inhabitants enhancing employment, surging ecotourism, access to institutions, hospitals, urban markets, and societal and political amenities. The impacts after completion of the project are (Table 2).

2.6.1 EIA of the present project

This is the project of construction of state highway along coast from Konark to Astaranga and is deprived of mangroves and reserved forests. The present project shall stand over either sands of the coast or agricultural fields and there are sporadic settlements. There are no historical monuments, biodiversity hotspot areas or mines and construction of less numbers of culverts and bridges reducing the project cost. The 34km state highway can be easily cleared by the MOEF.

2.7 Public Hearing

The statutory EIA review process and public hearings is the venue for public information and interaction between the proponent and all interested groups. That shall allow people to articulate their visions about the proposed project and put forth inputs that eventually boost the project quality, the environmental sustainability, the harmony among the stake holders and pretentious communities. The EIA processes shall open out the hidden issues during the reviewing process or any malicious intentions of the authority and public hearing shall disclose the lacunae.

2.7.1 Climatic strategies

Odisha, a coastal state adjacent to Bay of Bengal, the state enjoys tropical climate, characterized by high maximum temperature,

humid, normal rainfall of Puri and adjacent Jagatsinghpur district are Puri (1535.7mm), Jagatsinghpur (1513.9mm) respectively and face short and mild winters. As per Koppen's climatic categorizations the coastal states of Odisha fall under the AW (winter dry season) and relishes tropical Savannah type. Normally the onset of south-west (SW) monsoon is from 5th -10th June in the coastal plain, and withdrawal occurs by 15th Oct. along the coast. About 75% to 80% of rainfall is received from June to September. As per "Thorn Thwaite's classification", Odisha ranks under the "Sub humid" category, implying deficient winter rains [11]. The record of pre-monsoon and post-monsoon BoB disturbances hitting the coast line has been less recorded. Floods, droughts and cyclones passing near coast occur almost every year of varying intensity.

2.8 Physiography and Soil Types

The highway stretch in Puri (lat. 20° 10'N and long. 86°25' E falling in SOI topo sheet nos 74 E, 73 H, 74I, 73L. The road shall ply adjacent to the Bay of Bengal along the east coast of India. The state has an area of 155707 km² and variable coastline of about 480.4km [12] and 549.5km [8] long. No major distributaries of the Mahanadi except the Prachi and Kadua drain is the only River/ drain shall cross the highway.

The highway shall pass through the coastal plains, (East & South Eastern Coastal Plain-4), and are of depositional landforms of recent origin and of the Post-Tertiary Period. The 75m contour line delimits the delta from the Middle Eastern ghats Region. The soils are sandy, Coastal Saline, and Alluvial Soil (Halaquepts, Halaquepts). The construction of Highways shall

combat Cyclone & Storm Surges, Flood & Tidal Inundations, Coastal erosion, and Migration of Sand dunes, LU change, Coastal and beach encroachments, Loss of Mangrove associates, and Loss of biodiversity and its habitats.

2.9 Cyclones & Flooding

Odisha is prone to cyclones and gusty winds. The Prachi River emanates from Kantapada lying near Cuttack-Gop road and flows through Kakatpur town and debouches to Bay of Bengal after 11km towards south. The river gets flood from Kadua drainage and Devi system and inundates parts of Kakatpur, and Gop blocks. The major cyclones of the current decade are Phailin, Hudhud, Fani and Amphan. These cyclones have not land fall in the present project area but passed adjacent to the area. The coastal ecosystem and the fisher's communities were affected.

2.10 Coastal Protection

The coastal length of Puri district of Odisha is 136.48km as per inclusive 64.3km coastal track of Chilika Lagoon. The coast is Micro-Tidal (<2m) & have high wave energy. The coast comprises of estuaries of Prachi river, and beaches those are under erosion. About 1.5km length the sea has engulfed the coastal village Nuagaon and its surrounding agricultural lands in the right fringe.

The Astaranga Township is acting as a natural breakwater (natural reefs) of its own due to its geographical topography. The existing sea wall which is weakening due to wave attack requires strengthening and protection [3], (Table 3), (Fig. 7) and (Fig. 8)

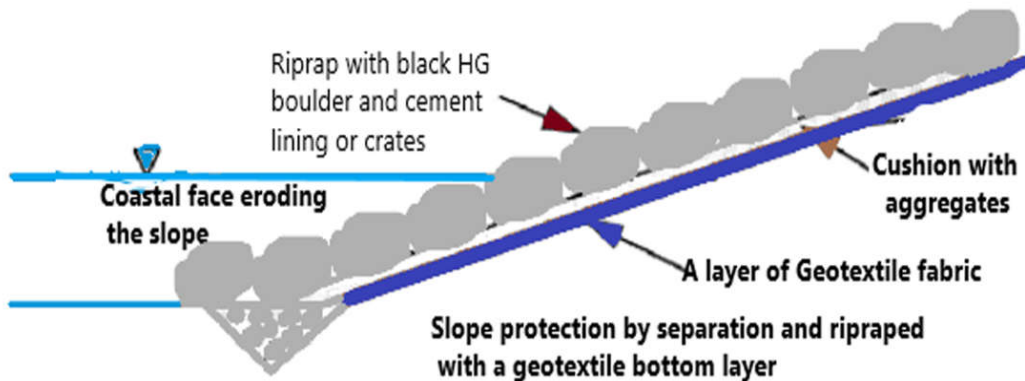


Fig. 7. The proposed slope protection works where sea shall erode the pavement

Table 2. The impact after completion of the Konark-Astaranga highway project (Part of Bharta Mala Project)

#	Bearing statement	Impacts after project completion
The Positive Impacts		
1	Travel time	Though increases but the drive is of less congestion, and overfree road nearby marine pleasing climate.
2	Riding quality/traffic flow	Better driving quality and smooth flow
3	Traffic congestion	Shall reduce as part of traffic shall use this alternate road by the local people.
4	Tourism	The coastal flora, fauna, mind free drive and cool breeze shall attract for a pleasure drive along the marine drive
5	Connectivity	The highway shall connect between Konark & Astaranga and on extension shall connect the port township Paradip
6	Design speed and risk measures	Relaxed driving increases vehicular speed (av. 80-100kmph) with less risk for accidents and fatalities.
7	Branch roads & VUP' (vehicular underpasses)	Shall increase accessibility to local stake holders for carriage of farm yields,
8	Pedestrians & no-motorized traffic	VUP's and service roads shall reduce traffic accidents
10	Local employment	Huge local employment shall be generated
11	Quality of life local people	Shall improve with access to better health care
12	Economy of the area	The new road shall build and strengthen local economy
13	The drainage system	The Prachi and Kadua drainage system shall develop
13	Aesthetics and air quality	Afforestation shall improve the aesthetics and air quality
13	The Prachi Estuary	The mouth of the river Prachi shall develop to a tourist hotspot and fishing icon.
The Negative impacts		
1	Length of road	As increases travel time and fuel consumption.
2	Quality of air	Dusty and saline air bring exhaustion
3	Biodiversity/ecosystem	Constant plying of vehicles shall create a vibrant biome for the ecosystem services, and biodiversity.
4	Effect of growing demography	Gradually the rural environment shall be converted to urban and the sand dunes shall develop settlements
5	Impedance of drainage channels	Runoff is either polluted or contaminated.
6	Disruption of ambient traffic, and noise.	Potential to affect health of local people and disrupt mental peace and tranquility
7	Disturbance of soil stability, forest, and wild life	Deforestation, erosion, soil restoration, wildlife life pattern, tranquility and sustainability.
8	Increases safety of road users	The nuisance in the coastal area and reckless driving, and accidents frequency shall increase in the area

Table 3. Coastal Stretches proposed for coastal protection from Chandrabhaga to Astaranga

Coast protection (km)	Along proposed pavements (km)	Country side (km)	Total (km)
Total coast line	29.430	43.785	73.215
Artificially protected	14.745	11.075	25.820
Naturally protected including beaches	8.300	25.650	33.950
To be protected	6.385	7.060	13.445

2.10.1 Geometric Design (IRC: 73-1980[13];IRC:37-2018[14];)

The design Period is considered for 30 years and design traffic for the 2-lane 2-way road with 25% of total for fatigue design. The different design specifications for the proposed State Highways of flexible Pavements are (Fig. 8).

- | | | |
|--|----|--|
| 1. Terrain classification and cross slope in % | :- | Plain (0 to 10%) |
| 2. Ruling and minimum design speed | :- | 100 and 80kmph |
| 3. Cross slope camber | :- | 1:40 (2.5%) |
| 4. Width of carriageway (Two lane with raised Kerbs) | :- | 7.5m |
| 5. Roadway width (2-lane) | :- | 12m |
| 6. Land width in open areas | :- | 45m |
| 7. Stopping sight distance (SSD) | :- | $SSD = Lag + breakingdistance$
$=> SSD = vt + \frac{v^2}{2g(f \pm 0.1n)}$ |

Where: **v**= Design speed in m/sec; **t** = reaction time of driver (2.5sec as per IRC guideline); **f** = longitudinal design coefficient (0.35-0.40); **n** = Slope of road (+ve for ascending and -ve for descending)

- | | | |
|--|----|---|
| 8. Overtaking Sight Distance (OSD) for 2-lane highways | :- | (a) at speed 40kmph is 165m
(b) At 100kmph is 640m |
| 9. Maximum super elevation limit | :- | 7% |
| 10. Where horizontal curves, the extra width given | :- | 1m to 1.5m |

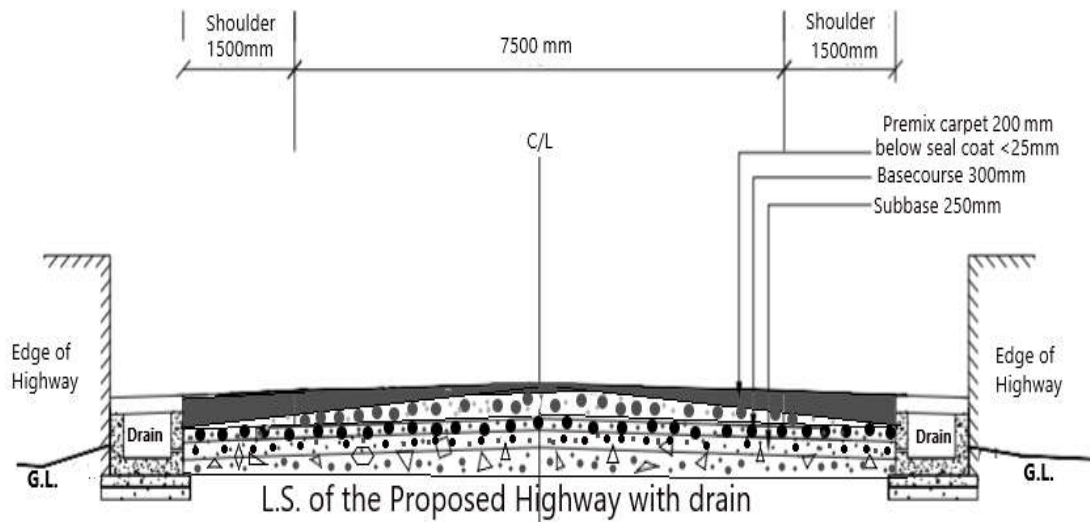


Fig. 8. The proposed highway longitudinal cross section

The failure criteria which shall be considered during the design the pavement, bridges and culverts are sea erosion; possible impact of storms; design traffic; CBR value of subgrade; fatigue cracking (flexural); and rutting criteria (MoRTH R-56).

2.10.2 Socio-economic aspects

The agricultural personnel settle in sporadic settlements in villages which should be nearer to the crop fields but well dependent on major roads for access to the seeds, fertilizers, machineries, and for storing the produces to the nearest market, Mandi or cold storages. The northern part of Puri is famous for buffer yield of crops, fisheries, cashew nuts and coconut. The proposed coastal road shall serve in a better way for the agro-sector. The proposed highway shall cater primarily augment tourism and to the need of the farmers, Patients, students, scheduled and financially backward people. After construction of the road, there shall be women empowerment of the area, poverty alleviation, and Socio-economic development of coastal fisher's community, employment generation, LU/LC pattern, health and Industry infrastructure by increasing the communication and transport.

2.10.3 Design

The Highways is to be constructed close to coastline. Coastal highways are designed after assessing variables including shoreline decline rate, beach profile, dimensions of dune, geology of bluffs, traffic criterion, and costs construction, repair and maintenance. As hard measures the coastal structures are revetments (protecting layers on top of sandy slope), seawalls (walls constructed to combat large waves), bulkheads (retain soil from wave action backing vertical walls), and groins are constructed with tie-backs and wave breakers to save the highways from wave action. As soft measures beach nourishment are the scopes. The failure criterions of riprap in coastal revetments are inadequate armor layer, under layer, flanking, and toe scour, and overtopping splash, US Dept. FHWA-NHI-07-096 [15].

2.11 Various Layers of Pavement

The composition of various layers of the pavement shall be subbase, base course and bitumen work with surface dressing [16].

Subbase: Sub base is provided to have sturdy support against compaction of Water bound macadam (WBM), Wet Mix Macadam (WMM) sub base layer to protect the subgrade from over stress and form a filter layer. The sand, gravel, crushed slag, local brick bats and crushed stones alone or combination of California Bearing Ratio (CBR) value 30% exceeding IRC/ MORTH standards 2 minimum axle standard (msa), and

of minimum depth 250 mm for traffic ≥ 10 msa or 10% extra [17].

Base course [18]: Granular material (unbound) either Water bound macadam (WBM), Wet Mix Macadam (WMM) or locally available alike granular subbase for road construction materials conforming IRC/MORTH specifications of minimum thickness of 300mm for traffic >2 msa.

Bituminous Surface [19,20]: It consists of the binder course and the wearing course. The Wearing course consists of surface dressing, premix carpet (open-graded), seal surfacing by hot mixing. Surface dressing binder course comprises of either bitumen mix (BM), dense graded bitumen (DBM), mix seal surfacing, open-graded premix carpet as wearing surface of ≤ 25 mm thickness and sand blasting [15].

The final provision of different layers above the subbase is seal coat type – a over 20 mm thick premix carpet over 50mm thick B.U.S.G. over 75mm thick Gr - III over 75mm thick Gr – II over 150mm thick sub - base with Grading III material has been provided in the estimate. The proposed testing of materials, and the IS Code and suitable limits are in (Table 4) and Fig. 9.

2.11.1 The design concept

While designing the present coastal highway the factors considered are safety from coastal disasters like cyclones, beach erosion, wave inundations, and coastal flora and fauna. In addition high initial construction, annual maintenance and life cycle cost are considered. The design also include Traffic load, type of subgrade, materials used in construction, drainage (box culverts, Hume pipe culverts, bridges and their flood defensive measures), societal benefits, along with safety and reliability. The project is Local Resource-based using local contractors to optimize balance by deploying local labour, local materials, and light construction machineries to maximize creation of short-term deployment prospects, capacity building with simultaneous upkeep of construction quality like the existing marine drive road, Fig. 10(a) and 10(b).

2.11.2 Construction materials

As flexible pavement; it has been opted for the construction of the highway by using Asphalt as they are environmentally safe and a conventional binding material. It has the advantages of rapid

drainage, less traffic noise, improved skid resistance (summer and rains), less surface glare during night, and fuel efficient due to even surface to ride, and reduced wear and tear. The disadvantage lies are less road strength, aggregate fretting on wheel loading, clogging of

pores causing drainage interruption, reduction in road life, increased construction, and repair & maintenance cost. Local black hard granite stones, metal and chips from av. 70km distance, river sand from the Kuakhai River (av. 50km) are to be used for the pavement construction.

Table 4. Proposed tests to be conducted for materials used for construction and allowable limits

Proposed Layer	Proposed IS code	Types of tests	Suitable limit
Subbase	IS:2386-1963 (P-I)[21]	Flakiness index	40-50%
	IS:2386-1963 (P-III)[22]	Water absorption	≤6%
	IS:2386-1963 (P-I)[21]	Impact value (Aggregate)	50 -60%
Base Course	IS:2386-1963 (P-I)[21]	Flakiness index	30%
	IS:2386-1963 (P-III)[22]	Water absorption	≤3%
	IS:2386-1963 (P-IV)[23]	Impact value (Aggregate)	40-50%
Bitumen Surfacing	IS:2386-1963 (P-IV)[23]	Abrasion value (Los Angel's)	40%
	IS:2386-1963 (P-IV)[23]	Impact value (Aggregate)	30%
	IS:2386-1963 (P-I)[21]	Flakiness & elongation index	≈35%
	IS:6241-1971[24]	Striping Value	15%
	IS:2386-1963 (P-III)[22]	Water absorption	≤02%
	IS:2386-1963 (P-V)[25]	Loss with Na ₂ SO ₄ (5cycles)	12%
	IS:2386-1963 (P-V)	Loss with Mg ₂ SO ₄ (5cycles)	18%

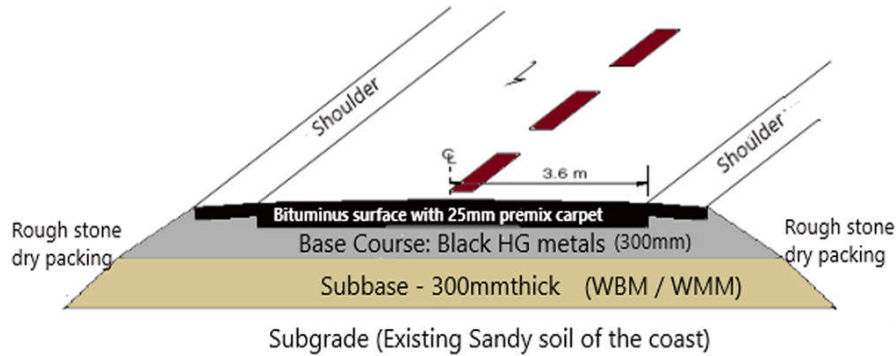


Fig. 9. The cross section of the 2-lane 2-way road of the proposed Highway



Fig. 10 (a) and (b). The existing slope protection work at Konark beach and pleasant coastal road

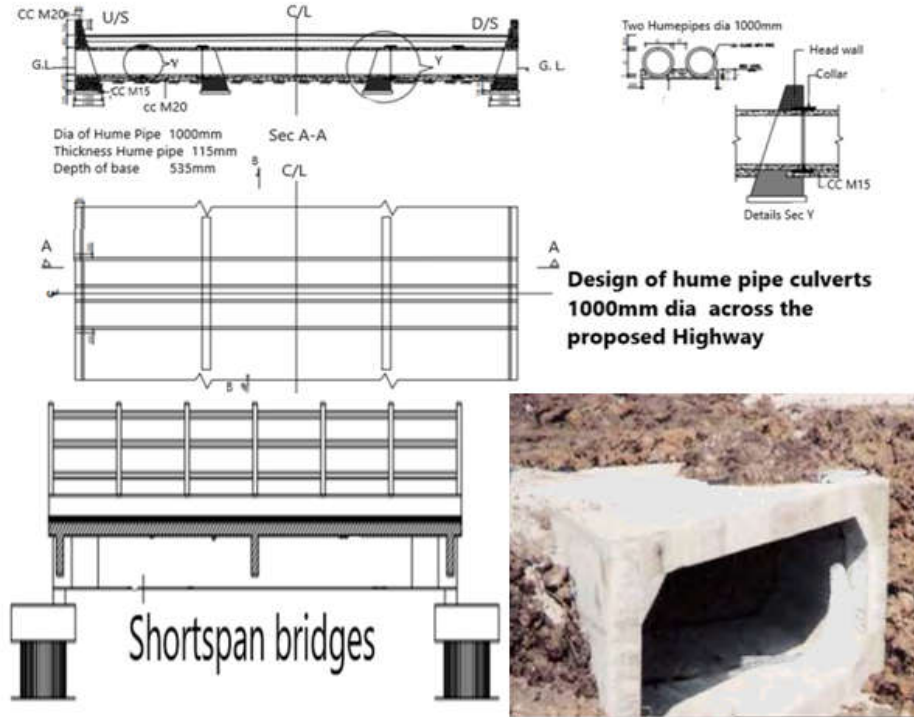


Fig. 11. Cross drainage structures (Hume pipe culverts and small bridges) proposed Highway along the coastal corridor

2.12 Proposed Culverts and Bridges

The proposed roads are to be constructed in the coastal corridors and mostly composed of sand dunes. The soil is sandy and there is less water bodies are encountered except in rainy days. So less numbers of Hume pipe culverts or box culverts (for larger discharge) shall be needed. In the sandy region it has been found that box culverts are better to adopt as sand casting due to wind can be cleared before monsoon as per IRC SP 13[26] and IRC SP 42[27]. A partly constructed box culvert is shown in (Fig. 10& Fig. 11)

3. DISCUSSION

The analysis of traffic data warrants a minimum 2way-2 lane highway is required for the proposed project as the new road shall be new and an extension of Puri Konark marine drive road existing for 35km, a part to Bhartamala Project [28]. To have more tourism the road needs to be extended to Devi river mouth (Nuagaon). The road project shall be passing through the coastal corridor over a series of sand dunes passing through few hamlets and fisher men villages from

Chandrabhaga to Nuagaon. The connecting townships to the road shall be Konark, Kakatpur and Astaranga. As most of the land for the project are coastal regulatory zone (CRZ) and in government possession, there shall be less constraints due to land acquisition, rehabilitation and resettlement problems of normal road projects [29].

The environmental issues shall be encountered by implementation of the highway project shall be loss of mangrove associates, dune vegetation, coastal faunal diversity, Noise level, anthropogenic stresses, Hotels, water parks that shall kill the tranquility of the area. The worst sufferer shall be the fishermen community. There shall be change in the beach profile, Traffic congestion, soil structures and contamination during the construction and operation phase. Societal and political amalgamation after modernization shall augment crimes activities that will disrupt the present peaceful atmosphere.

4. CONCLUSIONS

The key lesson learnt is the public participation in environmental assessment review is essential

which may lead to substantial benefits for both the proponent and affected community. The implementation of the highway shall lead to reduction of conflicts and problems for project implementation, acceptability and sustainability.

The project shall result in mangrove and its associate plantation, increase fishing & Aquaculture, Eco-Tourism, inland plantations, and boost of ecotourism along with the surge in connectivity. The coastal marine drive road which is a temporal extension of the Bhartamala Project shall protect the coast line and the surge in national and international tourism level must augment the socioeconomic status of the son of the soil. The project only covers two drainage system within its 29.4km span shall be the cheapest, and the most beneficial project.

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COMPETING INTERESTS

Author has declared that no competing interests exist.

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