

**BEFORE THE HON'BLE NATIONAL GREEN TRIBUNAL,  
SOUTHERN ZONE, CHENNAI**

**ORIGINAL APPLICATION NO. 261 OF 2024  
(EARLIER ORIGINAL APPLICATION NO. 1055/2024- PB)**

**IN THE MATTER OF:**

Tribunal on its own motion Suo Moto based on News Item titled "Unscientific work by NHAI led to Shirur landslide Geological Survey of India report" appearing in the Indian Express dated 02.08.2024

VERSUS

National Highways Authority of India & Ors.

...Respondent(s)

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Respondent No.1

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BEFORE THE HON'BLE NATIONAL GREEN TRIBUNAL,  
SOUTHERN ZONE, CHENNAI

ORIGINAL APPLICATION NO. 261/2024  
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**REPLY FILED ON BEHALF OF THE RESPONDENT NO. 1**  
**MOST RESPECTFULLY SHOWETH:**

**PRELIMINARY OBJECTIONS:**

1. That at the outset, it is submitted that the present Original Application vide Original Application No. 261/2024 dated 12.08.2024 [earlier Original *Application No. 1055/2024 (PB)*] (hereinafter referred as 'OA') arises from the news item titled "Unscientific work by NHAI led to Shirur landslide Geological Survey of India report" published in the Indian Express dated 02.08.2024. The said news item has been published without any

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basis, by knowingly making false and incorrect statements in utter disregard of the facts and misleading the Hon'ble Tribunal, therefore the present application is liable to be dismissed in limine on this ground alone itself.

2. That the allegations made in the news item are vague, unsubstantiated, and without any semblance of truth. The news item referenced therein contains false and incorrect statements and it appears to be a possible outcome of misconstruing the facts. The application is misconceived and therefore liable to be dismissed. It is pertinent to note that National Highways Authority of India (hereinafter referred as 'NHAI'), in the execution of any project, adheres strictly to all environmental protection and preservation norms. It may be further noted that NHAI secures all necessary permissions and approvals from the concerned authorities in accordance with the requirement and in compliance of applicable laws.
3. That it is humbly submitted that all the averments made in the OA basis the New Item are without any merit and baseless and therefore Respondent no. 1 denies and disputes each and every statement, contention and/or contained in the present Application which is contrary to and/or inconsistent with what is stated herein below and/or the records of the case, and unless specifically admitted herein, the same shall be deemed to have been denied in seriatim. No part of the Application can be construed as being admitted merely on the ground of non-traverse.

  
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4. That while it is respectfully acknowledged that the tragic incident occurred on 16.07.2024, resulting in the loss of lives and property. However, the alleged term “unscientific work done by NHAI” used in the news item is false and seems to be intentionally misleading the Hon’ble Tribunal in utter disregard of the fact and there is no proof to substantiate the same.
5. That it is humbly submitted that the four-laning of Goa- Karnataka border to Kundapur section of NH-66 from 93.700 km to 283.300 km (hereinafter referred as ‘**Project Highway**’) in the state of Karnataka was executed as BOT Project on DBFOT pattern under NHDP-IV. The said construction in NH-66 was awarded to the M/s IRB Westcoast Tollway Pvt. Ltd. (hereinafter referred as ‘**Concessionaire**’) with an appointed date from 03.03.2014 and with a construction period of 30 months from the appointed date, having a concession period of 28 years.
6. That it may be pertinent to highlight that the Project Highway being a BOT project, the scope of the Concession Agreement included Design, Engineering, Construction, Operation and Maintenance. The construction was carried out in strict adherence and conformity with the Specifications and Standards set forth in the Concession Agreement.
7. That it is significant to note that the Project Highway passes through the Hilly terrain through Karwar, Ankola, Kumta, Honnavar, Bhatkal and Kundapur towns. Some parts pass through the Forests

  
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mainly in Ankola, Kumta, Honnavar and Byndoor. The forest land diversion has been diverted at various places.

8. That it may be noted that at the time of construction of Project Highway, additional 15 meters of forest land was acquired with the required permissions, in order to reduce the slope angle on the hill/forest side, as per the advisory of the experts. The Concessionaire had engaged Prof. T.G. Sitharam, Department of Civil Engineering, Indian Institute of Science, Bengaluru. Prof. T.G. Sitharam in his report dated 17.03.2017 and 30.08.2018 advising on the high hill slopes treatment issues and gave detailed measures to be undertaken to prevent landslides. Basis the expert report and in compliance with clause 1.4.1 of IRC SP 48:2023, the Concessionaire had reduced the slope angle 1.5V:1H which is around 56 degree.
9. That the said tragic incident of landslide occurred around 8:30 am on 16.07.2024 at Km 147.900 was precipitated by an intense episode of torrential rainfall. The region received 503 mm of rainfall in a span of three days causing the landslide and eventually resulting in the loss of lives and property. It is pertinent to highlight that Uttara Kannada's coastal areas and ghats receive a high 3500-4000 mm of rainfall per annum. Out of this, 503 mm of rainfall was received in a short span of three days.
10. Furthermore, at this location, there is a hill/forest on one side and the Gangavali river on the other. The location geographically restricts the widening of the Project Highway on the river side.

  
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11. It is submitted that the origin of the landslide was beyond the Right of Way (hereinafter referred as '**ROW**') of the Project Highway, as the landslide commenced nearly 50 meters farther from the ROW, being primarily caused due to incessant torrential rains received in the region.
12. That it is most humbly submitted that immediate action was taken by the Concessionaire in consultation with NHAI and local authorities, implementing the safety protocols and deploying appropriate machineries for clearing the debris on the affected Project Highway stretch and safeguarding the lives of the commuters.
13. That it is respectfully submitted that team of Geographical Survey of India (hereinafter referred as '**GSI**') led by Dr. R. Sajeev, Director - GSI, Bengaluru inspected the incident site on 17.07.2024 and 18.07.2024 to examine the geogenic causes of the landslide. GSI's report assessed several factors causing the landslide, the summary of the report is mentioned below:
  - a. The site has a very thick weathered rock and in-situ clay-rich lateritic soil (having thickness ranging from 5-15 meters) exposed by slope cutting. The pyroxenite rock in the area is highly weathered, topped by a thick soil cover.
  - b. The fresh pyroxenite rock exposed at the toe tapers, providing minimal natural toe buttress or support for the slid zone. Natural drainage flows have been disturbed due to slope modifications.
  - c. The slide area and the left flank are structurally deformed, presenting friable and gouge-like material.

  
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- d. The adjoining slope on the right of the landslide has a gradient of approximately 40 degrees without benches. Fresh tension cracks present in this area may lead to failure in case of continuous rainfall.
  - e. The debris thickness here is also considerable. Tension cracks of 2 feet depth were observed in the left flank.
  - f. Multi-temporal satellite imagery indicates anthropogenic interference on the slopes from Chainage number 147.400 to 148.200 since 2017, with some landslide scars above the cut slopes.
  - g. The three-day incessant rainfall in the area was 503 mm, causing saturation of the thick debris material and lithomarge, thereby increasing pore water pressure. The steep gradient of the cut slope, presence of highly weathered rock, thick debris, saturation due to rainfall, and lack of toe support are the primary causative factors of the debris flow.
  - h. Intense rainfall acted as the trigger for the landslide. The high relief and overburden material in the hill slope suggest that retrogression of the slide is probable during prolonged rainfall.
14. That it may be noted that furthermore, NHAI immediately constituted a team of eminent experts for assessment of the incident site and finalization of restoration measures. The committee comprises of the following member, which was led by Dr. D.N. Singh:

  
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- a. Dr. D.N. Singh, Professor, Department of Civil Engineering, Geotechnical Engineering Division, IIT-Bombay.
  - b. Dr. Anand Kumar Pandey, Chief Scientist, National Geophysical Research Institute, Hyderabad
  - c. Sh. Ashish D. Gharpure, MD, Genstru Consultants Pvt. Ltd, Pune.
  - d. Dr. R. Sajeev, Director, GSI, Bengaluru.
15. That the findings of the expert's committee are as - under:
- a. The condition of the slope is very critical on both sides of the scar due to incessant rains, which have piled up a huge quantity of soil and boulder matrix on the left carriageway.
  - b. The sliding of this huge amount of mass can be attributed to subsurface failure caused by water channels, which are formed within the body of the hillock.
  - c. Such slides/failures cannot be predicted in advance due to several uncertainties (such as seepage, suffusion-induced cavity formation, etc.).
  - d. Stabilization of such slopes by soil nailing, vegetation etc. will not be effective.
  - e. If possible, channelize water from the hilltop to facilitate proper surface runoff and to prevent its entry into the soil/rock mass of the slopes.

  
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- f. Even after clearing much on the carriageways, the traffic cannot be allowed to ply without taking utmost precautions, as mentioned below:
- i. Restrict vehicle speed to 20 km/hr without honking or acceleration/ deceleration-induced vibrations.
  - ii. Do not allow vehicles to stop in the affected stretch.
  - iii. Report any soil movement or boulder falling to the project manager and stop traffic on both sides.
  - iv. Ensure the entire stretch is monitored by trained security/police official.
  - v. Display cautionary signboards at appropriate locations.
16. That it is humbly submitted that the alleged “unscientific” widening of roads and vertical cutting of hills at this stretch is false and denied. The expert’s report clearly establishes that the incessant torrential rains receiving 503 mm of rainfall in three days is the major factor for triggering the landslide, which was not reported in the news item comprehensibly.
17. That in light of the above, it is crucial to highlight that the news item seems to be making false and incorrect statements and appears to be a possible outcome of misconstruing the facts. The news item has deluded the Hon’ble Tribunal from the issue of

  
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landslide to unscientific construction methods of NHAI, instead of reporting the facts in veracity.

18. That the incessant torrential rains for three days have been the primary cause triggering the landslide at Shirur. Furthermore, the experts are of the view that the landslide is an event of force majeure, as the same was unprecedented and unforeseeable, it could not have been predicted in advance, in order to take preventive measures.
19. That on basis of the news item appearing in The Indian Express dated 02.08.2024, the Hon'ble Tribunal (Principal Bench- Delhi) took Suo moto cognizance vide Original Application no. 261/2024 dated 12.08.2024 [earlier Original Application No. 1055/2024 (PB)], issuing notice to NHAI and others, and transferred the matter to Southern Zone - Chennai. A copy of the Original Application no. 261/2024 dated 12.08.2024 [Earlier – Original Application No. 1055/2024 (PB)] and news item dated 02.08.2024 is annexed as **Annexure R-1 (Colly)**.

#### **SUBMISSIONS:**

20. **ADDITIONAL LAND ACQUIRED TO REDUCE THE SLOPE OF THE HILL TO AVOID INCIDENTS OF LANDSLIDES BASIS THE EXPERT REPORT**

That the decision to widen/built a new road is in the domain of NHAI based on several factors, and involves decision to be taken after considering various factors including inputs from experts

  
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dealing with the subject, employees who expertise on the same etc. Accordingly, the work of construction of 4 lane highway was commenced in the available ROW of 60 meter by cutting down in Hill section in accordance with the provisions of the Concession Agreement.

21. That at the time of construction of the Project Highway in March 2017, the Concessionaire had conducted a detailed analysis for the challenges faced in the construction of the Project Highway. The Concessionaire was facing challenges due to the topography/terrain of the Project Highway and heavy rainfall in the region. The Concessionaire engaged Prof. T.G. Sitharam, Department of Civil Engineering, Indian Institute of Science, Bengaluru, to seek expert opinion in relation to cutting the slope of the hills.
22. Prof. T.G. Sitharam inspected seven sites of the Project Highway namely at chainages 247 km, 245 km, 165 km, 160 km, 148.60 km, 148.0 km and 146.5 km and directed the Concessionaire to conduct soil testing and geotechnical test reports of these sites. Basis, the soil test and geotechnical reports, Prof. T.G. Sitharam conducted second site visit at the chainages 245 km, 160 km and 190 km, wherein he observed excavated slopes treatment and due to heavy rainfall in this region the rain water seeps through the porous lateritic soil, which has a tendency to gush out at the interface of soil layers particularly at the junction of lithomarge clay and laterite layer.

  
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23. It is submitted that lithomarge clay is a cohesionless sandy silt material which is highly erosion prone due to seepage. The issue at hand encountered in dealing with lateritic soil encompass presence of lithomarge clay extending to considerable depth, which is resulting in instability to slopes and landslides, when it gets exposed and comes in contact with huge rain water. These instabilities are attributed to the peculiar type of the soil, which consist of large depth of impervious lithomarge clay strata underlying the porous hard lateritic layers.
24. Prof. T.G. Sitharam in in his report dated 17.03.2017 and 30.08.2018, advised on the high hill slopes treatment issue, by widening the ROW from 15 meter to 50 meter and gave detailed measures to be undertaken to prevent landslides including soil nailing and drainage pipe solutions. Copy of the reports is annexed as **Annexure R-2 (Colly)**.
25. That basis the report of Prof. T.G. Sitharam and due to heavy rainfall in the region, the Concessionaire in his letter dated 22.06.2017 submitted the details of vulnerable sites of the proposed Project Highway and potential threat arising due to hill cutting. The Concessionaire in the said letter also proposed additional land acquisition varying from 15-50 meters required to construct a slope angle of 1.5V:1H. It is to be noted that, as per the provisions of the Concession Agreement, a slope of 12(V):1(H) was to be provided. The copy of the Concessionaire letter dated 22.06.2017 is annexed as **Annexure R-3**.

  
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26. That basis the report of Prof. T.G. Sitharam and Concessionaire's letter dated 22.06.2017, the appointed Road Safety Consultant of the Project Highway namely M/s Lion Engineering Consultants, conducted the safety audit. The Road Safety Consultant examined the vulnerable sites and affirmed with the recommendations of the expert report of Prof. T.G. Sitharam and Concessionaire's letter dated 22.06.2017.
27. The Road Safety Consultant in his June 2017 report, recommended the Project Highway shall be constructed with gentle cut slopes, instead of steep cut slope, for which additional land acquisition would be required along with construction of lined drains at the top of the hill beyond the edge of slope, wherever the same is required so that the water flow from the rainfall can be diverted to flow over directly from the cut slopes to avert situations of landslides. A copy of the report is annexed as **Annexure R-4**.
28. That, basis the above recommendations for acquiring additional land the Project Director (hereinafter referred as 'PD'), Project Implementation Unit (hereinafter referred as 'PIU'), Mangalore informed the Deputy Commissioner, Karwar about the remedial measures to avoid incidences of landslides and requested to provide additional land vide letter dated 03.07.2017.
29. The Concessionaire in his letter dated 18.04.2018 had assessed and identified the additional land which was required to be

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acquired by NHAI. The said identified additional land was primarily forest land to the tune of 27.015 Ha. The additional land acquisition required was further examined by the appointed Independent Engineer (hereinafter referred as 'IE') of the Project Highway, namely M/s AECOM Rodic Consultants.

30. The IE in his letter dated 15.06.2018 also affirmed the requisition of the Concessionaire to acquire additional land for slope protection measures. A copy of the IE letter dated 15.06.2018 is annexed as **Annexure R-5**.
31. That, PD, PIU- Mangalore submitted the proposal for additional land acquisition to the Forest Department, in order to cut hill slope gently and flatten them to avoid incidents of landslides in the Project Highway.
32. That Ministry of Environment, Forest and Climate Change (hereinafter referred as 'MoEFC'), Government of India vide letter dated 17.09.2021, accorded stage 1 in-principal for diversion of 28.218 Ha of forest land in Baad-Binaga-Arga and 20 other villages in Uttara Kannada and Udupi districts comprising of Karwar, Honnavar and Kundapura forest divisions. The said approval from MoEFC included the forest diversion of 0.498 Ha at Ankola taluka from 148.100 Km to 149.00 Km, which is also the said incident site. A copy of the MoEFC letter dated 17.09.2021 is annexed as **Annexure R-6**.

  
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33. It is submitted that Concessionaire post-acquisition of additional land, constructed the Project Highway with slope easing works on the additional ROW at several location along the Project Highway, as recommended/ specified by the experts. The Concessionaire also carried out soil nailing work and other suggestive measures including installation of pipes of rain water drainage. The said work was executed between the period October 2021 to December 2022.
34. The construction of Project Highway was as per the suggestions of the experts and that it is in compliance with clause 1.4.1 of IRC SP 48:2023, the Concessionaire had reduced the slope angle 1.5V:1H which is around 56 degree.
35. It is submitted that from the abovementioned statements it can be construed that NHAI had taken utmost due diligence and had duly considered the suggestive opinions of the experts while constructing the said Project Highway.
36. There is no proof to substantiate the vague allegation made in the OA basis the News Item that the construction of Project Highway was executed in an unscientific manner alleged in Para 4 and 5 of the OA.
37. Furthermore, NHAI has made all reasonable attempts and efforts as an expert in this field to undertake all measures at the time of construction of project highway. Hon'ble Supreme

  
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Court of India in **Union of India v. Kushala Shetty & Ors (2011) 12 SCC 69**, holds as under:

*“28. Here it will be apposite to mention that NHAI is a professionally managed statutory body having expertise in the field of development and maintenance of National Highways. The projects involving construction of new highways and widening and development of the existing highways, which are vital for development of infrastructure in the country, are entrusted to experts in the field of highways. It comprises of persons having vast knowledge and expertise in the field of highway development and maintenance. NHAI prepares and implements projects relating to development and maintenance of National Highways after thorough study by experts in different fields. Detailed project reports are prepared keeping in view the relative factors including intensity of heavy vehicular traffic and larger public interest. The Courts are not at all equipped to decide upon the viability and feasibility of the particular project and whether the particular alignment would subserve the larger public interest. In such matters, the scope of judicial review is very limited.”*

38. That the allegations in Para 4 and 5 of the OA based on News Item are wrong, baseless, and misleading, hence vehemently denied. As already submitted hereinabove that the news item

  
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has misconstrued the facts and mislead the Hon'ble Tribunal in relation to construction of the Project Highway. The construction of the Project Highway is in accordance with the provisions mandated and as per the reports of the experts in this field.

**39. COMPREHENSIVE POST-ANALYSIS OF THE LANDSLIDE INCIDENT AT SHIRUR BY THE APPOINTED EXPERTS COMMITTEE**

That the incident of landslide occurred on 16.07.2024 at Shirur, Ankola Taluka, Uttara Kannada District. NHAI through the Concessionaire had immediately deployed the required workforce and machinery at the incident site, commencing necessary operations to clear the debris under the supervision of the local authorities.

40. That team of GSI led by Dr. R. Sajeev, Director - GSI, Bengaluru inspected the incident site on 17.07.2024 and 18.07.2024 to examine the geogenic causes of the landslide. The GSI's report assessed several factors causing the landslide, the summary of the report is mentioned below:

- a. The site has a very thick weathered rock and in-situ clay-rich lateritic soil (having thickness ranging from 5-15 meters) exposed by slope cutting. The pyroxenite rock in the area is highly weathered, topped by a thick soil cover.

  
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- b. The fresh pyroxenite rock exposed at the toe tapers, providing minimal natural toe buttress or support for the slid zone. Natural drainage flows have been disturbed due to slope modifications.
- c. The slide area and the left flank are structurally deformed, presenting friable and gouge-like material. The landslide movement is extremely rapid and currently active, with the potential for enlargement.
- d. The adjoining slope on the right of the landslide has a gradient of approximately  $40^\circ$  without benches. Fresh tension cracks present in this area may lead to failure in case of continuous rainfall.
- e. The debris thickness here is also considerable. Tension cracks of 2 feet depth were observed in the left flank.
- f. Multi-temporal satellite imagery indicates anthropogenic interference on the slopes from Chainage number 147.400 to 148.200 since 2017, with some landslide scars above the cut slopes.
- g. The three-day incessant rainfall in the area was 503 mm, causing saturation of the thick debris material and lithomarge, thereby increasing pore water pressure. The steep gradient of the cut slope, presence of highly weathered rock, thick debris, saturation due to rainfall, and lack of toe support are the primary causative factors of the debris flow.
- h. Intense rainfall acted as the trigger for the landslide. The high relief and overburden material in the hill slope



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suggest that retrogression of the slide is probable during prolonged rainfall.

A copy of the final report of Geographical Survey of India led by Dr. R. Sajeev, Director - GSI, Bengaluru is annexed as **Annexure R-7**.

41. That, the GSI report also suggested short-term measures to be implemented immediately. The suggested short-term measures are hereunder:
- a. Clear the debris in a phased approach, beginning with the lower sections. Use heavy machinery carefully to avoid disturbing the upslope. Employ spotters to monitor any slope movement. Vehicular traffic at night may be restricted/halted till the landslide site stabilizes.
  - b. Refrain from removing debris material, including large boulders, on the hill ward side below the landslide for the time being.
  - c. Construct temporary channels to divert water away from the debris clearing area to prevent further destabilization.
  - d. No further modifications should be made to the hill ward slope.
  - e. Debris material may be cautiously removed only from the outer lane of the road. Traffic may resume in the outer lane after debris clearance.
  - f. Continuous monitoring of the slope using spotters is crucial, and vehicular movement must be halted if any

  
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slope movement is detected especially during prolonged rainfall.

The abovementioned measures were immediately implemented by NHAI through Concessionaire.

42. Furthermore, acknowledging the gravity of the situation at the incident site, NHAI vide letter dated 22.07.2024, constituted a committee of eminent experts which was led by Dr. D.N. Singh, Professor, Department of Civil Engineering, Geotechnical Engineering Division, IIT-Bombay. The committee was constituted with the objective to examine and ascertain the long-term measures for stability of slope at vulnerable locations alongside the Project Highway. The members of the committee are hereunder:

- a. Dr. D.N. Singh, Professor, Department of Civil Engineering, Geotechnical Engineering Division, IIT-Bombay.
- b. Dr. Anand Kumar Pandey, Chief Scientist, National Geophysical Research Institute, Hyderabad
- c. Sh. Ashish D. Gharpure, MD, Genstru Consultants Pvt. Ltd, Pune.
- d. Dr. R. Sajeev, Director, Geological Survey of India, Bengaluru.

43. That all the expert members of the committee have submitted their individual report, which was summarised in the findings

  
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of Dr. D.N. Singh. The copy of the reports of the expert members of the committee are annexed as **Annexure R-8 (Colly)**.

44. The experts in their findings have observed that primarily, this landslide was triggered due to the presence of water bodies (inside the forest) behind the crown of the scar, causing a dam-burst-like situation that has resulted in the ejection of mud slurry up to distances as high as 200 m (and up to the 2/3rd width of the Gangavali river). The water bodies developed due to the incessant torrential rains for three days in the region has been the triggering factor causing the landslide in Shirur. The experts also observed that such incidents are impossible to be identified in advance, in order to take preventive measures. The relevant extract from Dr. D.N. Singh's report is hereunder:

*"The way forward (in general for such projects):*

.....

*It is not possible to detect/predict slope failures in advance as no prior (visible) symptoms are exhibited, so any proactive actions to alleviate these slopes could be taken. Unfortunately, the failure symptoms start showing up when the slopes become active, which turns out to be too late."*

  
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45. That Dr. D.N. Singh in his report is also of the view that the landslide incident is a force majeure event, which was unprecedented and unforeseeable as the same could not have been anticipated in advance.
46. Furthermore, Dr. D.N. Singh in his report has also suggested long-term measures to be implemented to avoid such incidents in the mere future. The measures suggested are here under:
- a. A detailed drone survey of highly critical hillocks/slopes, including their catchment area, should be conducted to effectively identify and understand the topography, geomorphological features, and water bodies. Various stakeholders/agencies, viz., the state mining, geological remote sensing departments/agencies and the forest department, in particular, should collaborate and leverage their respective expertise and resources.
  - b. Carry out geotechnical investigation, if required.
  - c. Unfortunately, locating the water channels is difficult. Any slope stabilization work, such as soil/rock nailing, shotcreting, vegetation growth, and the creation of toe/retaining walls, will not be effective.
  - d. Instead, the designed slope angle should be based on the geotechnical parameters.
  - e. Design a properly lined drainage system to drain off the surface runoff water. Provision of longitudinal

  
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drains on the top of the slopes/hillocks and their interconnectivity with the longitudinal drains (at suitable intervals) should be attempted.

- f. A series of long weep holes would certainly help stabilize the hillocks/slopes, but their effectiveness, mainly based on the observations from the earlier installations, seems to be a deterrent.
  - g. If the top of the rock face is not significantly deep, say less than three m, the best approach is to trim the soil mass.
47. It is submitted that from the above it can be construed that the landslide incident could not have been anticipated in advance, and the primary factor triggering the landslide is the incessant torrential rains. The expert committee is also of the view that the landslide incident is a force majeure event, and no prediction could have stopped the said incident.
48. That the alleged “unscientific” widening of roads and vertical cutting of hills, stated in Para 4 and 5 of the OA basis the News Item is wrong, baseless, and misleading, hence vehemently denied. As already submitted hereinabove that the news item has misconstrued the facts and mislead the Hon’ble Tribunal on the issue of the construction of the Project Highway. The landslide could not have been predicted, in order to take preventive measures.

  
**DGM (T) & Project Director**  
**NHAI, PIU-Honnavar**

**PRAYER**

In the light of submissions made herein above, it is most respectfully prayed that this Hon'ble Tribunal may graciously be pleased to: -

- i. Dismiss the present Original Application; and
- ii. Pass such further order or orders as this Hon'ble Tribunal deems fit in the facts and circumstances of the present case as well as in the interest of justice.

Place: New Delhi

Date: 23.09.2024

Through:

Filed by:

Respondent

  
**DGM (T & R) Project Director**  
**NHAI, PIU-Honnagar**



Mital & Mital Advocates

347, First Floor, Block-C,

Defence Colony, Delhi- 110024

Email: ankurmittallawyer@gmail.com

aviraj@mitalandmital.com

Mobile: +91 9958500980

**VERIFICATION**

I, M. Shivakumar, s/o B. Madaiah. aged about 54 years, working as the Project Director, PIU- Honnavar, the Respondent no. 1 herein and having office at 2nd Floor, Under Construction Building, Adjacent to HDFC Bank, Masthikatte, Part-1, Vasudeva Business Park, Honnavar do hereby verify and affirm that the contents of this Reply in Paras 1 to 48 are true to best of my knowledge, belief, and information.

Verified at Honnavar on 23 Day of September 2024.

Date: 23.09.2024

Place: New Delhi

*M. Shivakumar*  
23/9/24  
**DGM (T) & Project Director**  
**NHAI, PIU-Honnavar**

**BEFORE THE HON'BLE NATIONAL GREEN TRIBUNAL,  
SOUTHERN ZONE, CHENNAI**

**ORIGINAL APPLICATION NO. 261/2024**

**(EARLIER ORIGINAL APPLICATION NO. 1055/2024-PB)**

**In the matter of:**

Tribunal on its own motion Suo Moto based on News Item titled "Unscientific work by NHAI led to Shirur landslide Geological Survey of India report" appearing in the Indian Express dated 02.08.2024

VERSUS

National Highways Authority of India & Ors.

...Respondent(s)

**AFFIDAVIT**

I, M. Shivakumar, s/o B. Madaiah. aged about 54 years, working as the Project Director, PIU- Honnavar, National Highways Authority of India, having office at 2nd Floor, Under Construction Building, Adjacent to HDFC Bank, Masthikatte, Part-1, Vasudeva Business Park, Honnavar do hereby solemnly affirm and declare as under:

1. That in my official capacity as stated above, I am authorised and competent to swear this affidavit. I am well acquainted with the facts and circumstances of the present case based on my knowledge derived from official record.



NUMBER OF CORRECTIONS...  



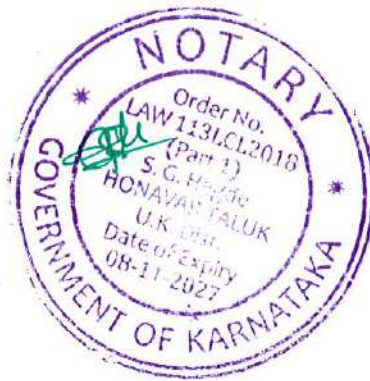
**DGM (T) & Project Director  
NHAI, PIU-Honnavar**

- 2. That the accompanying reply to the application has been drafted by my counsel under my instructions and the contents of the same are true and correct to my knowledge derived from official record.
- 3. That the documents/Annexure appended with the accompanying reply of the application are true/ true photocopies of the respective originals.

*M. S. Hanas* 23/9/24  
 DEPARTMENT & Project Director  
 NHAI, PIU-Honnavar

**VERIFICATION:**

Verified at Honnavar on this 23 day of September 2024 that the contents of the aforesaid affidavit are true to my knowledge based on the record of the case, no part of it is false and nothing material has been concealed there from.



*M. S. Hanas* 23/9/24  
 DEPARTMENT & Project Director  
 NHAI, PIU-Honnavar

SWORN AND SIGNED BEFORE ME

*S.G. Hegde*  
 S. G. Hegde B. Sc., LLB (Spl.)  
 Advocate & Notary  
 HONAVAR Taluk  
 U. K. District, Karnataka State  
 INDIA

*S.G. Hegde*  
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*S.G. Hegde*  
 SL. No. 6545 Page: 2  
 Voll: V Date: 23/9/24

NUMBER OF CORRECTIONS *nil.*

## ANNEXURE R-1(Colly)

Item No. 06

Court No. 1

**BEFORE THE NATIONAL GREEN TRIBUNAL  
PRINCIPAL BENCH, NEW DELHI**

Original Application No. 1055/2024

News Item titled "Unscientific work by NHAI led to Shirur landslide Geological Survey of India report" appearing in the Indian Express dated 02.08.2024

Date of hearing: 12.08.2024

**CORAM: HON'BLE MR. JUSTICE PRAKASH SHRIVASTAVA, CHAIRPERSON  
HON'BLE MR. JUSTICE ARUN KUMAR TYAGI, JUDICIAL MEMBER  
HON'BLE DR. A. SENTHIL VEL, EXPERT MEMBER**

### ORDER

1. This original application is registered *suo-motu* on the basis of the news item titled "Unscientific work by NHAI led to Shirur landslide Geological Survey of India report" appearing in the Indian Express dated 02.08.2024

2. The matter relates to the July 16 landslide in coastal Karnataka's Uttara Kannada district. As per the article, a preliminary report by the Geological Survey of India has listed "unscientific" construction of National Highway (NH) 66 by the National Highway Authority of India (NHAI), combined with heavy rainfall in a short span of time, among factors responsible for the disaster.

3. The news item states that a massive landslide brought down a torrent of mud and debris at Shirur village in Akola, destroying the Karwar-Mangaluru portion of the 1,640-km highway, which connects Maharashtra's Panvel with Kanyakumari in Tamil Nadu. Besides damage to the highway, four houses and two high-tension power transmission towers at Akola were destroyed, and a tea stall and two

trucks got washed away in the landslide. Eight bodies have been recovered so far and search operations have been on for nearly two weeks to look for the remains of three more suspected victims.

4. The news item quotes the GSI report, which states that the natural drainage flows were disturbed when slope modifications were carried out to build the highway. The steep gradient of the cut slope, presence of highly weathered rock, thick debris, saturation due to rainfall and lack of toe support (the distance between the edge of the highway and the beginning of the slope, a key factor while designing stable slopes along highways) are the primary causative factors of the debris flow. Intense rainfall acted as the trigger for the landslide. The high relief and overburden material in the hill slope suggest that retrogression of the slide is probable during prolonged rainfall.

5. The news item further alleges that the authorities have in the past been alerted by scientists and other experts about the “unscientific” widening of roads and vertical cutting of hills at this stretch. Furthermore, it is claimed that the Uttara Kannada’s coastal areas and ghats receive a high 3,500-4,000 mm of rainfall per annum, making it a challenge to execute infrastructure projects. Given these difficulties, it is imperative for government agencies to assess terrain conditions before executing road projects.

6. The above matter indicates violation of the provisions of the Environment Protection Act, 1986.

7. The news item raises substantial issue relating to compliance of the environmental norms and implementation of the provisions of scheduled enactment.

8. Power of the Tribunal to take up the matter *suo-motu* has been recognized by the Hon'ble Supreme Court in the matter of "*Municipal Corporation of Greater Mumbai vs. Ankita Sinha & Ors.*" reported in 2021 SCC Online SC 897.

9. Hence, we implead the following as respondents:

- i. National Highway Authority of India, Through its Secretary  
G 5&6, Sector 10 , Dwarka, New Delhi - 110075
- ii. Geological Survey of India, Through its Director General  
GSI, 27 Jawaharlal Nehru Road, Kolkata 700016
- iii. Ministry of Environment and Forest, Through its Regional Office  
Integrated Regional Office, Kendriya Sadan, 4<sup>th</sup> Floor, E&F  
Wings, 17<sup>th</sup> Main Road, Koramangala II Block, Bangalore –  
560034
- iv. District Magistrate, Uttar Kannada  
Office of the Deputy Commissioner & District Magistrate  
UttaraKannada District Karwar 581 301

10. Issue notice to the respondents for filing their response before the appropriate bench of the Tribunal at least one week before the next date of hearing.

11. Since the matter relates to the Southern Zonal Bench, Chennai, therefore, OA is transferred to the Southern Zonal Bench. Therefore, the original record of this OA be transferred to the Southern Zonal Bench, Chennai for further action.

12. List before Southern Zonal Bench at Chennai on 30.09.2024

Prakash Shrivastava, CP

Arun Kumar Tyagi, JM

Dr. A. Senthil Vel, EM

August 12, 2024  
O.A. No. 1055/2024  
HB

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News / Cities / Bangalore / Unscientific work by NHAI led to Shirur landslide: Geological Survey of India report

# Unscientific work by NHAI led to Shirur landslide: Geological Survey of India report

In its preliminary report submitted to the NHAI and state government, a team from the Geological Survey of India (GSI) has, while assessing the landslide, pointed to the “unscientific” work done by the NHAI on this stretch.

Written by [Kiran Parashar](#) , [Sanath Prasad](#)

Bengaluru | Updated: August 2, 2024 03:15 IST





The landslide site on NH-66 in Ankola. (Express photos by Jithendra M)

A preliminary report by a technical team looking into the causes of the July 16 landslide in coastal Karnataka's Uttara Kannada district has listed "unscientific" construction of National Highway (NH) 66 by the National Highway Authority of India (NHAI), combined with heavy rainfall in a short span of time, among factors responsible for the disaster.

At 8.30 am on July 16, a massive landslide brought down [a torrent of mud and debris at Shirur village](#) in Akola, destroying the Karwar-Mangaluru portion of the 1,640-km highway, which connects [Maharashtra's](#) Panvel with Kanyakumari in [Tamil Nadu](#). Besides damage to the highway, four houses and two high-tension power transmission towers at Akola were destroyed, and a tea stall and two trucks got washed away in the landslide. Eight bodies have been recovered so far and search operations have been on for nearly two weeks to look for the remains of three more suspected victims.

The picturesque two-lane highway has the hills of the Western Ghats on one side and the Gangavali river on the other. According to the NHAI, road building company IRB Infrastructure was in 2013 picked as the concessionaire to build the highway. Construction was completed in 2020 and the same year, NHAI started collecting tolls.

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However, local residents say the problem with the highway is its lack of continuity. In some sections, the NHAI had not yet opened both lanes to the traffic, leading to commuters being diverted to single-lane roads, often through villages, before rejoining the double-lane roads.

In its preliminary report submitted to the NHAI and state government, a team from the Geological Survey of India (GSI) has, while assessing the landslide, pointed to the “unscientific” work done by the NHAI on this stretch.

The report states that natural drainage flows were disturbed when slope modifications were carried out to build the highway. “The steep gradient of the cut slope, presence of highly weathered rock, thick debris, saturation due to rainfall and lack of toe support (the distance between the edge of the highway and the beginning of the slope, a key factor while designing stable slopes along highways) are the primary causative factors of the debris flow. Intense rainfall acted as the trigger for the landslide. The high relief and overburden material in the hill slope suggest that retrogression of the slide is probable during prolonged rainfall,” states the report.

Saying heavy rainfall was also among the factors that led to the landslide, the GSI team pointed out that the area witnessed a “three-day antecedent rainfall” of 503 mm.

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Speaking to [The Indian Express](#), NHAI Regional Officer Vilas Brahmanekar said this stretch of the highway was built under the Build-Operate-Transfer (BOT) and Public Private Partnership (PPP) models. “The NHAI’s role was to get the land delivered to the concessionaire and resolve issues such as railway lines and other things. The incident was unfortunate but I do not agree that the hill was cut vertically (to build the road). NHAI also has constituted a committee of four experts to look into the matter. During the construction, there were minor landslides in the region and the construction company roped in experts from the Indian Institute of Science ([Bangalore](#)) to suggest measures. According to the GSI report, there were multiple factors that led to the landslide, including the massive rainfall in a short duration,” he says.

In the report, the GSI team has suggested both immediate and long-term measures to prevent further damage, including that no further modification should be carried out to the hill slope and a comprehensive geotechnical investigation to determine appropriate slope stabilisation strategies for the Shirur site.

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**EXPLAINED**

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**Development challenge**

Environmentalists say Uttara Kannada’s coastal areas and ghats receive a high 3,500-4,000 mm of rain per annum, making it a challenge to execute infrastructure projects. Given these difficulties, they believe it is imperative

Sources said authorities have in the past been alerted by scientists and other experts about the “unscientific” widening of roads and vertical cutting of hills at this stretch.

Local environmentalists say Uttara Kannada’s coastal areas and ghats receive a high 3,500-4,000 mm of rainfall per annum, making it a challenge to execute infrastructure projects. Given these difficulties, they believe it is imperative for government agencies to assess terrain conditions before executing road projects.

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Local journalist and environmentalist Shivanand Kalave explained, “Ankola region is close to the Gangavali river, which collects between 85 lakh-1 crore litres of rainwater annually. Therefore, one must keep in mind factors like soil integrity, gradient and water-engineering mechanisms before building roads. In the case of NH-66, NHAI clearly missed water-engineering protocols and cut the mountain vertically to construct the road. Imagine 85 lakh litres of rain water flowing vertically. That water will speed up due to the heavy force of all the soil it is carrying along. When that soil loses its integrity, it results in a disaster much like the Shirur landslide.”

Karnataka Chief Minister [Siddaramaiah](#) has in the days since the landslide alleged that though some portions of the road were still to be completed, the NHAI collected tolls from vehicles using the highway.



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Speaking in the Assembly, Revenue Minister Krishna Byre Gowda recently said, "I visited this area last year during heavy rains. The national highways are not constructed scientifically...I had warned NHAI about the possibility of landslides, but they did not heed to my warnings."

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Sanath Prasad

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Sanath Prasad is a senior sub-editor and reporter with the Bengaluru bureau of Indian Express. He covers education, transport, infrastructure and trends and issues in te [... Read More](#)

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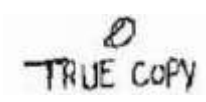
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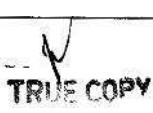
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## ANNEXURE R-2 (Colly)

Four Laning of Goa/Karnataka Border to Kundapura section of NH-66 (formerly NH-17) from Km 93.700 to Km 283.30m –Slope stability issues and requirement of slope protection at KKBOT site

### Site Visit Report

#### CLIENT

M/s Modern Road Makers Pvt. Ltd.  
(A Subsidiary of IRB Infrastructure Developers Ltd.) B/301,  
Universal Business Park, Near Kamani Oil Mills, Chandivali,  
Mumbai 400072.

#### CONSULTANT

Prof. T. G. Sitharam  
Professor in Civil Engineering



DEPARTMENT OF CIVIL ENGINEERING  
INDIAN INSTITUTE OF SCIENCE  
BANGALORE– 560012

August 30th, 2018

Consultant visited the site at four locations (at Km 246+750, Km 199+440, Km 167+700, Km 165+100) and observed excavated slopes treatment to the slopes and failures in these sections. This year due to heavy rains in this area, it was observed that the rain water seeps through the porous lateritic soil, which has a tendency to gush out at the interface of soil layers particularly at the junction of lithomargic clay and laterite layer. Lithomargic clay is a cohesionless sandy silt material which is highly erosion prone due to seepage. The main problems that are presently encountered in dealing with lateritic soil encompass presence of lithomargic clay extending to considerable depth, which is resulting in instability to slopes and landslides, when it gets exposed and comes in contact with huge rain water. These instabilities are attributed to the peculiar type of the soil, which consist of large depth of impervious lithomargic clay strata underlying the porous hard lateritic layers. Slope stability issues and requirement of slope protection at KKBOT sites at chainages have been discussed in the following sections.

#### 1. Location Km. 246.500 -Km. 246.900

As recommended in Consultant's previous report, soil treatment measures such as providing drains, trenches, shotcreting & also turfing with vetivar grass in some portion was completed at selected locations.

Drain at the top of the cut slope of almost 4 to 5m wide and about 3 to 4 m deep was constructed to stop the flow of water directly on the slope faces. This has helped in reducing the rain water flow towards the cut slope. However, it was observed that the drain was unlined. Looking at the quantum of the water which the drain caters & due to the permeability of lateritic soil, the water percolates through the soil & gets out at the cut slopes causing damage to the slope at few locations. It was observed that for such large amount of water inflow the perforated pipes provided for drainage were inadequate & the same needs to be increased by providing the same at closer spacing. Concessionaire has attempted to provide additional pipes where the flow of water was huge & thereby reducing the pore pressure due to which the slope has been able to withstand the excess pressure. It is seen that the water pressure due to heavy flows and erosion of lithomargic clay is the major cause of failure of the slopes.

Considering the prevailing site situation, It is recommended to flatten the slopes in the ratio of 1V:2H in order to have more stable slope. **The top drain shall be lined at the bottom and atleast a minimum of 1.5m vertical height on both sides.** Treating the surface by providing additional weep holes/Drainage Pipes at the closer spacing is recommended. Considering the site situation, a shotcrete layer is recommended as detailed in my previous report.

**2. Location Km.192.200, Km 199+440, Km 167+700, Km 165+100**

Concessionaire has informed the consultant that the proposal for acquisition of land for flattening of slopes is processed & it is expected that land will be made available by authority to carry out the flattening of cut slope work at this chainage.

At all these locations also Lithomargic clay is embedded in between the lateritic soil, when such Lithomargic clay comes in contact with high velocity rainwater as well as water inflow, due to erosion the slope yields causing the failure.

As recommended in my previous report it is reiterated to flatten the slopes to ratio of 1V:2H in order to have more stable slope and treating the surface by providing weep holes/Drainage Pipes and finally the surface shall be shotcreted as per the specifications given earlier.

**3. Location Km. 165+050**

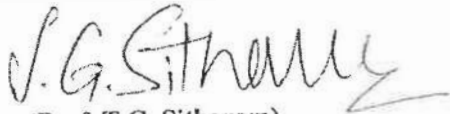
It was seen that for a small portion the cut slope on service road side with the treatment has collapsed and presently concessionaire has put granular material butting against the caved in slope surface. Even at this site, the same lithomargic clay is embedded below the hard lateritic soil & as the clay comes in contact with flowing seepage water, it causes erosion of this cohesionless material and making the slope to collapse. The slope at such locations has caved in & in such situation it would be advisable to construct a breast wall upto @ 2m height & fill granular or lateritic soil behind it, so as to confine the lithomargic material and also provide a toe support.

**Following points are concluded from the site visit:**

1. The flattened slope with safety measures as detailed in my previous report if executed properly at site should be sufficient to ensure the safety of slopes. It is also recommended to drain away any large flow of water from the slope and keep the amount of ingress rain water a minimum. However, looking at the quantum of rain water flow it would be preferable to provide lined drain at the top at Km 246+500 to Km 246+900 (see last para on page 2).
2. The exposed cut surface with flattened slopes shall be treated by providing appropriate drainage with weep holes (perforated drain pipes). The entire surface including berms shall be shotcreted with necessary slopes at the berm.
3. As a preventive measure the pore water pressure on the soil slopes shall be released by providing additional weep holes/drain pipes (in the form of perforated PVC pipes of 50 mm dia of driven @1-1.5m inside the surface). However, spacing of pipes shall be minimized or reduced based on the flow of water observed.
4. At the locations where the cut slopes have caved and no further land is available presently to flatten the slope, PCC/UCR breast wall of @ 2m height shall

be provided beyond drain in order to protect the spilling of soil on road. The gap between the breast wall face & soil shall be filled with granular/lateritic material. A toe drain also needs to be provided.

CONSULTANT

  
(Prof. T.G. Sitharam)

Date: 30<sup>th</sup> August 2018

Place: Bangalore

**Four Laning of Goa/Karnataka Border to Kudampura  
section of NH-66 (formerly NH-17) from Km 93.70 to km km  
283.30m – Slope stability issues and requirement of slope  
protection at KKBOT site**

**Technical Report**

**CLIENT**

**Modern Road Makers Pvt. Ltd.  
(A Subsidiary of IRB Infrastructure Developers Ltd.)  
B/301, Universal Business Park, Near Kamani Oil Mills,  
Chandivali, Mumbai 400072.**

**CONSULTANT**

**Prof. T.G. Sitharam  
Professor in Civil Engineering**



**DEPARTMENT OF CIVIL**

**ENGINEERING**

**INDIAN INSTITUTE OF SCIENCE  
BANGALORE – 560 012**

**March 17<sup>th</sup>, 2017**

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NB: (A) This report consists of 26 pages.

(B) This report should not be published either in part or in full without the permission in writing from the director of the Institute.

## **SLOPE STABILITY ISSUES AND REQUIREMENT OF SLOPE PROTECTION AT KKBOT SITE**

### **1. INTRODUCTION**

Consultant visited the site at seven locations (at Chainages 247 km, 245 km, 165km,160m, 148.60, 148.0km and 146.5 km) and observed excavated slopes and failures in these sections. Due to heavy rain in this area and excavations, water seeps through the porous lateritic soil, which has a tendency to gush out at the interface of soil layers. The main problems that are presently encountered in dealing with lateritic soil encompass presence of lithomargic clay extending to considerable depth which might result in instability to slopes and landslides, when it gets exposed. These instabilities are attributed to the peculiar type of the soil which consisted of large depth of impervious lithomargic clay strata underlying the porous hard lateritic layers. Slope stability issues and requirement of slope protection at KKBOT sites at chainages around 245 km, 160km, and 190 km have been analyzed at great depth. After the initial visit, consultant recommended soil testing at these locations and has provided detailed tests to be carried out. M/s Modern Road Makers Pvt Ltd submitted some of the geotechnical test reports. Consultant reviewed the geotechnical test reports and selected appropriate properties, cross section and soil profiles for the 3 chainages (at Chainages 245 km, 160km, and 190 km). Prof. Sitharam had visited site first time before initializing the project and witnessed all the failures. Detailed slope stability analyses had been carried out with deep seated failures in these slopes and the same was shared with the client (M/s Modern Road Makers Pvt Ltd.). Initially many chainages have been analyzed and looking at the similarity of the issues, only 3 sites were selected after the second site visit.

### **2. Second Visit Report**

Prof. T G Sitharam, consultant from M/s Indian Institute of Science (IISc) visited the site of unstable slopes on 20<sup>th</sup> and 21<sup>st</sup> Feb 2017 at chainages 245.0 km; 190.0 km; 160.0 km; 148 km; and 146.0 km. Mr. Prashant Dongre from head office along with

site engineers for each of the section visited all the above locations. Following are the observations and recommendations:

- i. Generally, at all the locations the instability is related to the presence and expose of lithomargic clay (Shedi soil) layer. Shedi soil (Lithomargic clay), a yellowish-white silty soil underlying lateritic soil (which is densely deposited along Konkan belt of India) is the cause for the slope instability when section is excavated and these shedi soils were exposed for the purpose of road construction. Shedi soil (Lithomargic clay) is the name given to the locally available whitish, pinkish or yellowish silty sand. This is very sensitive to water and loses its strength when it is saturated. Generally, these soils are classified as silty sand or sandy silt with higher percentage of silt content. In particular, when they are exposed and loses its confinement the soil layer settles and causes the slope instability of upper layers. All the test reports at some of these locations as suggested by M/s IISc has already been carried out and submitted to M/s IISc.
- ii. The slope instability was severe at these locations and it has happened as and when the shedi soil gets saturated due to heavy rains and also when exposed to excavations losing the confinement. When soil loses its shear strength, it flows out along with this, it brings down the upper layers. At all the above sections, similar behaviour of instability was observed. Sections adopted for excavations were generally 1H: 8V slopes for the lower layers in lithomargic clay and murrum layers and 1H:12V in the upper hard lateritic layers.
- iii. Sections at chainage 245.0 km; 190.0 km and 160 km were critical and others such as 146.0 and 148 km, there were minor slips with water saturation. M/s Modern road makers Pvt Ltd has asked M/s IISc to look at these critical sections and provide appropriate measures to stabilize the slopes.
- iv. At some stretches (for some length of about 100 to 200m), at these locations corresponding to chainages 245.0 km, 190.0 km and 160 km the land availability was an issue which does not permit any flattening of these slopes. These slopes has to be maintained at 1H:8V and 1H:12V slopes in the final sections of excavated slopes adjacent to the NH carriage way. In particular, at Chainage 245,0 km the road takes a turn and this is in fact critical as heights of about 30m deep cuts have to be stabilized.
- v. Typically, these are stratified soil layers. Typical sections are 10 to 12m hard lateritic layer up to about 10 to 12m from the top followed by 5m of reddish murrum soil and about 8 to 10m of yellowish / whitish soft silty soil which is invariably saturated. Instability has initiated as soon as the bottom soft silty soils are exposed due to excavation. Invariably in all these cross sections the slipped surface started at the upper berms. And has a maximum width of about 2 to 4m from the berm edge (Surface). M/s IISc requested Modern road makers to give us the failed profiles at these locations. Slip surfaces are not circular and they are sort of planar failure forming some sort of wedge failure restricting the failure surface to 2<sup>nd</sup> and 3<sup>rd</sup> layers from the top. M/s IISc informed that analyses will be carried out using planar




failure surfaces at these locations instead deep seated circular failure surfaces. At these three critical sections, due to non-availability of additional land, either for flattening the slopes or for the creation of other mitigation measures such as Gabion walls / RCC retaining walls, M/s IISc suggested for soil nailing in these areas as a remedial measure.

- vi. M/s Modern road makers agreed to send the following details immediately
- vii. Critical cross section at chainage @245 km (with almost 25 m high excavation - which has been completed during the visit) with clearly identifying the layers, type of layer and its description, failed profile superposed on the cross section with dimensions, and shear strength properties (if any additional tests which are being carried out).
- viii. Critical cross section at 190.65 km chainage with the layers, type of layer and its description, failed profile superposed on the cross section with dimensions, and shear strength properties (if any additional tests).
- ix. Critical cross section at 160 km chainage the layers, type of layer and its description, failed profile superposed on the cross section with dimensions, and shear strength properties
- x. It was also informed that chainages near 146 km , 148 and 147 are minor slips and site will handle the same with soil nailing at their end
- xi. M/s IISc has asked the site people to try driving 20mm dia TOR steel rod using Jack hammer and send us their experience in the soft soil layer of silty sand lithomargic clay layer along with some photographs
- xii. M/s IISc asked the company to explore the right of way on the top of the hill if any for fattening of the slope. If there is no extra space available the same may be communicated to M/s IISc
- xiii. Drainage : M/s IISc informed the clients the importance of drainage both at the berm and also within the slope. It was informed that the slope on the berms shall be done towards the slope face during construction to drain out the water naturally without any stagnation and it shall be completely covered with shotcrete after works. Good perforated drain pipes covered geofabric having a batter angle of about 5 to 10 degrees from the horizontal shall be installed as per the final recommendation of M/s IISc, so that no excess pore pressure developed behind the soil nailed walls.

### 3. MATERIAL PROPERTIES

Geotechnical report of each site was provided which was reviewed and site properties were selected after a review of geotechnical report and are presented in Table 1.

Table 1 : Material property adopted for slope stability analysis

| S.No. | Soil Type                                 | Properties           |   |  | color   |
|-------|---|----------------------|---|--|---|
|       |   | Cohesion(c)<br>(kPa) | Unit<br>weight ( $\gamma$ )<br>(kN/m <sup>3</sup> ) | Friction<br>angle( $\phi$ )<br>(degrees) |   |
| 1     | Murum *                                   | 20                   | 17  | 19                                       |  |
| 2     | Lithomargic clay(<br>yellowish /whitish)* | 14                   | 17  | 12                                       |  |
| 3     | Hard Laterite soil**                      | 18                   | 18  | 30                                       |  |

\* (Reference: Laboratory test report on soil core samples ,by Civil Aid Technoclinic Pvt Ltd. & Laboratory test report on soil samples by NITK.

\*\*Reference: Nayak, S., Sunil, B. M., Shrihari, S.. “Shear strength characteristics and chemical characteristics of Leachate contaminated lateritic soils”. A Journal Engineering Geology, Vol. 106, pp 20 - 25, 2009)

#### 4. SOFTWARE USED FOR THE SLOPE STABILITY ANALYSIS

RocScience geotechnical analysis software “Slide” is used for the stability analysis of the proposed slope section remedial measures. This is a 2-D program with a CAD based graphical interface with a wide range of modeling and data interpretation options. Among the various analysis methods available in SLIDE, Bishop Simplified method is adopted for our analysis. The strength type is assumed to be Mohr-Coulomb. In this report, the nonlinear shallow failure surface were assumed similar to the slope failures during the field observations. Initial analyses using deep seated circular failure surfaces were carried out and after detailed deliberations with client at site, these deep seated failures were ruled out after the second visit. Even the analyses indicated too long nails for establishing a safe slope using deep seated circular failure surfaces which were not really practical.

#### 5. SECTIONS ANALYSED

##### 5.1 Section 160 chainage area

**Cross section analyzed:** Chainage 160 – critical section at chainage at 160.020 - 23.240 m height of slope as shown in Fig.1 is selected. All existing slopes are unstable. After remedial measures (with Soil nails –6m length and 32 mm diameter at spacing of 0.9

m) the slopes are found to be safe. An assumption has been made regarding ground water considering Ru Coefficient. Analyses has been carried out considering Ru coefficient =0.3. Seismic coefficient of (horizontal acceleration coefficient =0.04 as per IS 1893:1984) 0.04 was selected for the Kundapura – Karwar area. Cross sections were provided by M/s Modern Road makers Pvt Ltd. Suggested remedial measures are safe. Analyses was carried out with different lengths of soil nails and optimum lengths were arrived at. Summary of results obtained at 160.020 km chainage has been presented in Table.2.

**Table 2 : Summary of results obtained from stability analysis slopes at 160.020**

| S.No | Chainage   | Condition  | Factor of safety | Remark      |
|------|------------|--|------------------|-------------|
| 1    | 160.020 km | Existing slope   | 0.547 (Fig 2)    | Unstable    |
| 2    | 160.020 km | Slope with Soil nail as Remedial measure                               | 1.472 (Fig 4)    | <b>Safe</b> |
| 3    | 160.020 km | Slope with Soil nail as Remedial measure with seismic coefficient 0.04 | 1.435 (Fig 5)    |             |

## 5.2 Section 246.900 chainage area

**Cross section analyzed:** Chainage 246 – critical section at chainage 246.900-29.440 m height of slope as shown in Fig.11) is selected. All existing slopes are unstable. After remedial measures (with Soil nails –6m length and 32 mm diameter at spacing of 0.9 m) the slopes are found to be safe. An assumption has been made regarding ground water considering Ru Coefficient. Analyses has been carried out considering Ru coefficient =0.3. Seismic coefficient of (horizontal acceleration coefficient =0.04 as per IS 1893:1984) 0.04 was selected for the Kundapura – Karwar area. Cross sections were provided by M/s Modern Road makers Pvt Ltd. Geotechnical report of each site was provided which was reviewed and site properties were selected after a review of geotechnical report and are presented in Table1. Suggested remedial measures are

safe. Analyses was carried out with different lengths of soil nails and optimum lengths were arrived at. Summary of results obtained at 246.900 km chainage has been presented in Table.4.

**Table 3 : Summary of results obtained from stability analysis slopes at 246.900 km**

| S.No | Chainage   | Condition  | Factor of safety | Remark   |
|------|------------|--|------------------|----------|
| 1    | 246.900 km | Existing slope   | 0.521 (Fig 7)    | Unstable |
| 2    | 246.900 km | Slope with Soil nail as Remedial measure                               | 1.514 (Fig 9)    | Safe     |
| 3    | 246.900 km | Slope with Soil nail as Remedial measure with seismic coefficient 0.04 | 1.465 (Fig 10)   |          |

### 5.3 Section 246.900 chainage area

**Cross section analyzed:** Chainage 246 – critical section at chainage 246.900-29.440 m height of slope as shown in Fig.11) is selected. All existing slopes are unstable. After remedial measures (with Soil nails –6m length and 32 mm diameter at spacing of 0.9 m) the slopes are found to be safe. An assumption has been made regarding ground water considering Ru Coefficient. Analyses has been carried out considering Ru coefficient =0.3. Seismic coefficient of (horizontal acceleration coefficient =0.04 as per IS 1893:1984) 0.04 was selected for the Kundapura – Karwar area. Cross sections were provided by M/s Modern Road makers Pvt Ltd. Geotechnical report of each site was provided which was reviewed and site properties were selected after a review of geotechnical report and are presented in Table1. Suggested remedial measures are safe. Analyses was carried out with different lengths of soil nails and optimum lengths were arrived at. Summary of results obtained at 246.900 km chainage has been presented in Table.4.

Table 4 : Summary of results obtained from stability analysis slopes at 246.900 km

| S.No | Chainage   | Condition  | Factor of safety | Remark      |
|------|------------|--|------------------|-------------|
| 1    | 246.900 km | Existing slope   | 0.521 (Fig 12)   | Unstable    |
| 2    | 246.900 km | Slope with Soil nail as Remedial measure                               | 1.514 (Fig 14)   | <b>Safe</b> |
| 3    | 246.900 km | Slope with Soil nail as Remedial measure with seismic coefficient 0.04 | 1.465 (Fig 15)   |             |

a. Critical section selected at 160.020 chainage

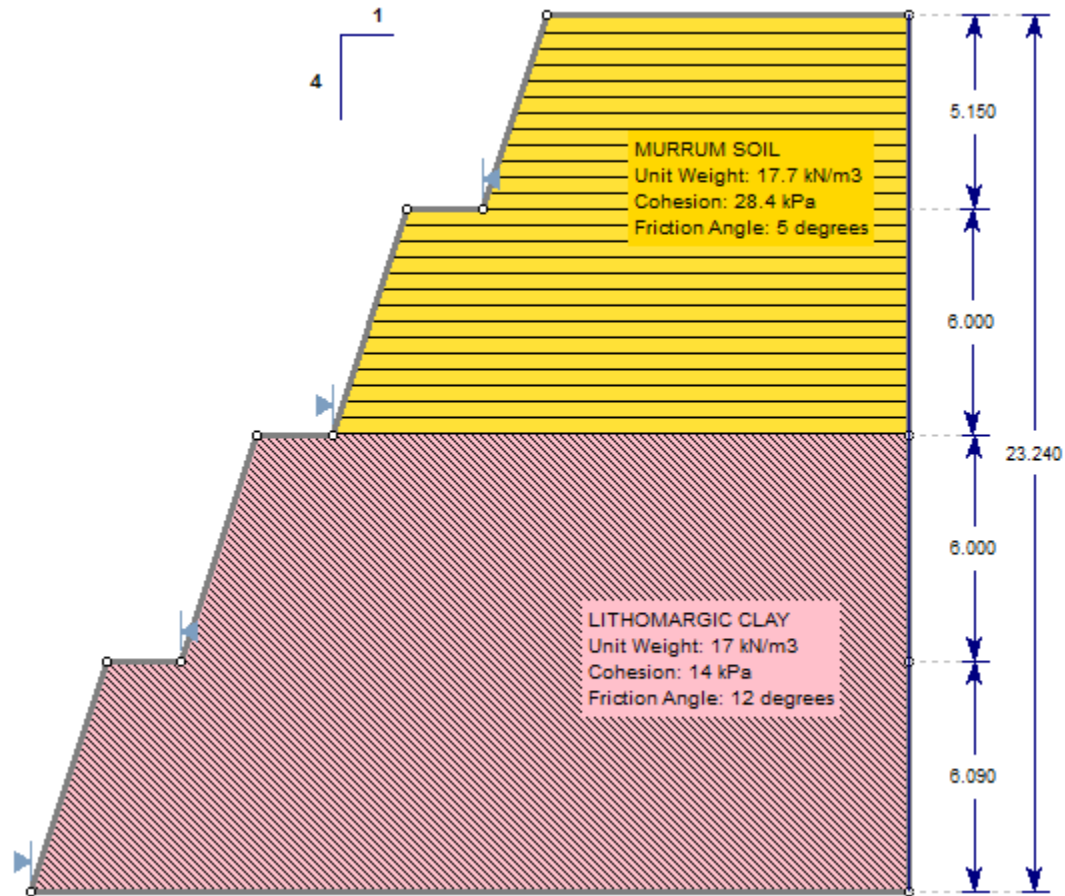


Fig. 1 Critical Section selected at chainage 160.020 km

b. Stability analysis for critical section at 160.020 chainage

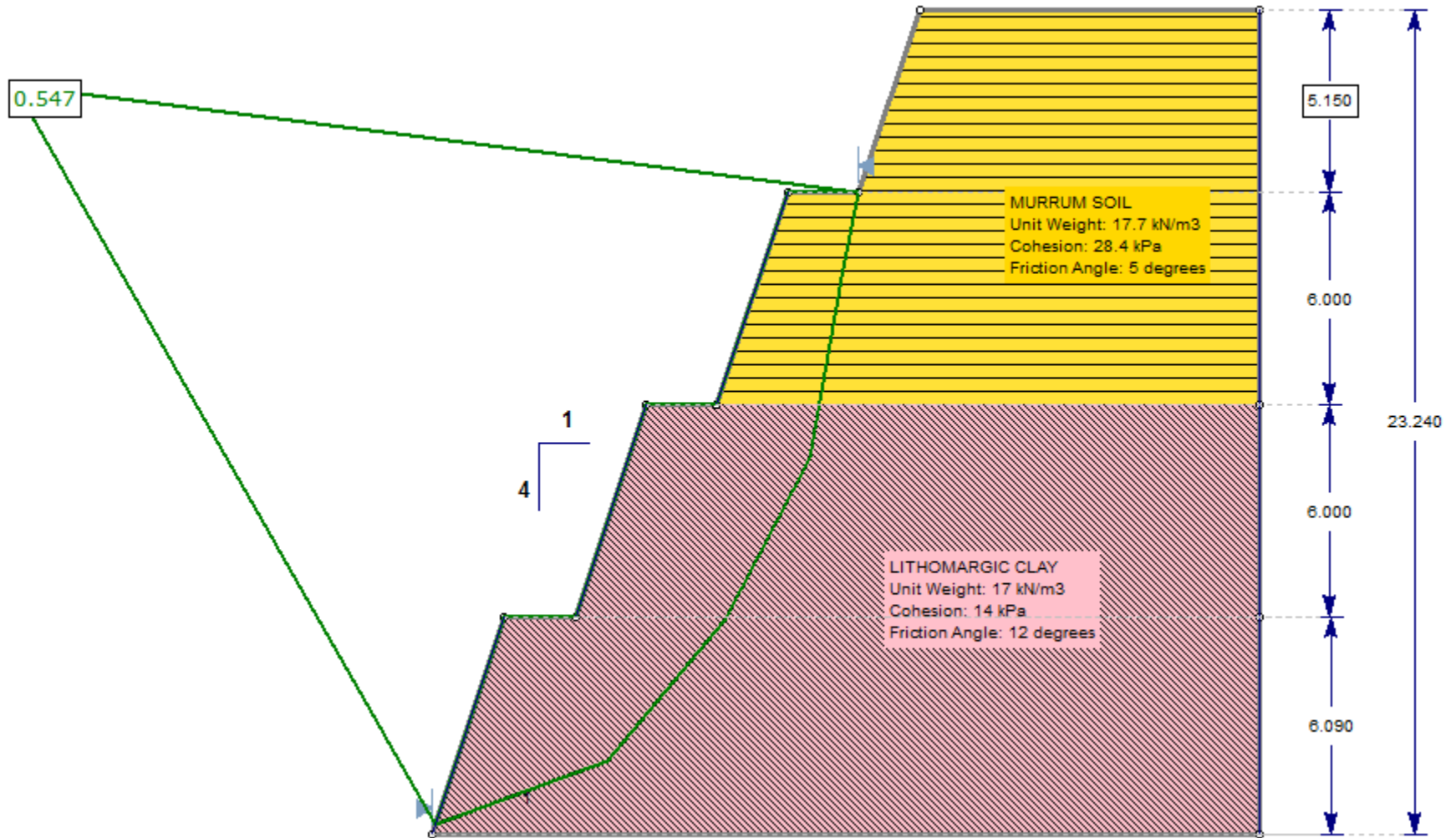


Fig.2 Stability analysis of existing slope at 160.020 km chainage (FS= 0.547, UNSAFE)

c. Proposed remedial measures at 160.020 chainage

*Adopted* : 32 mm diameter soil nail , length = 6 m, spacing =0.9 m

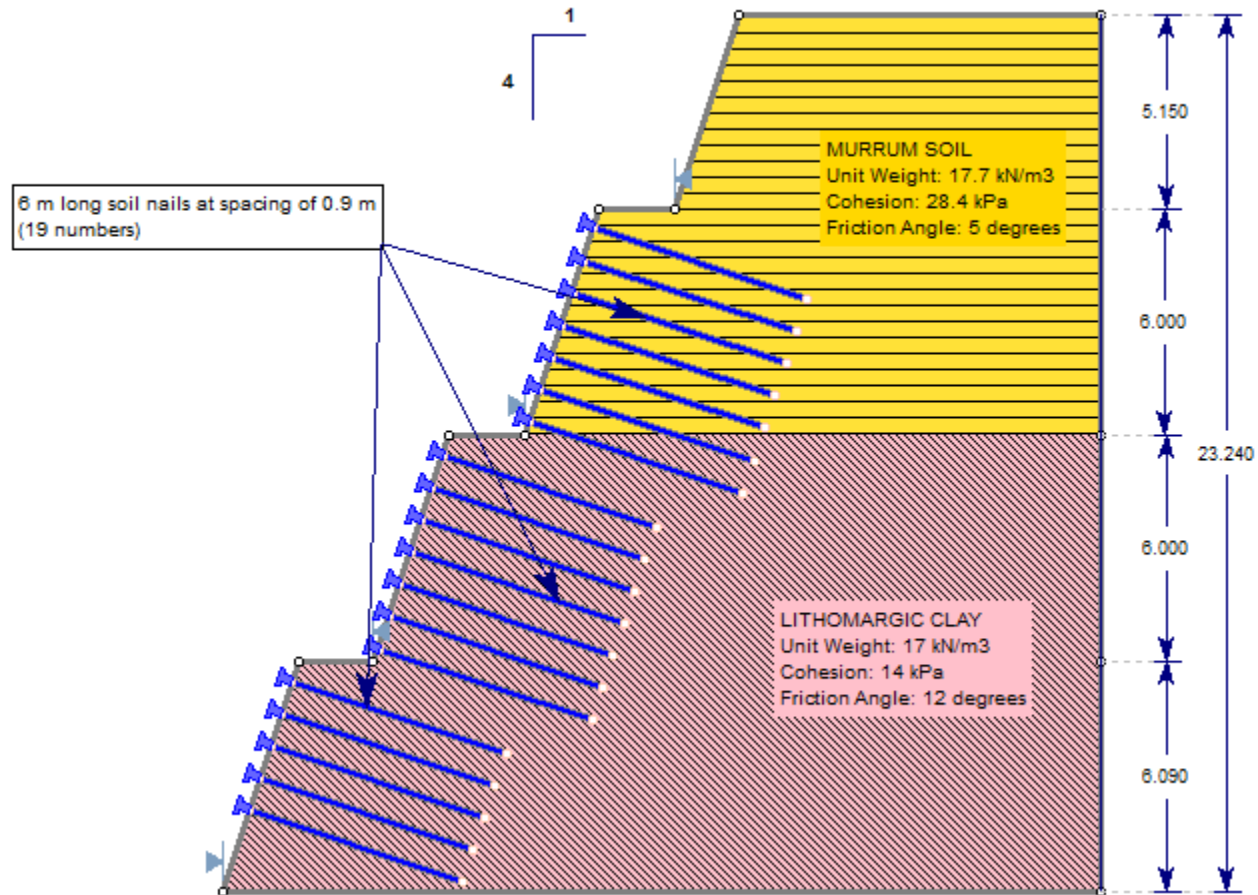


Fig.3 Cross-section of slope at 160.020 with remedial measure, providing 19 numbers of soil nails of 6 m length at spacing of 0.9m

d. Stability analysis with proposed remedial measures at 160.020 chainage

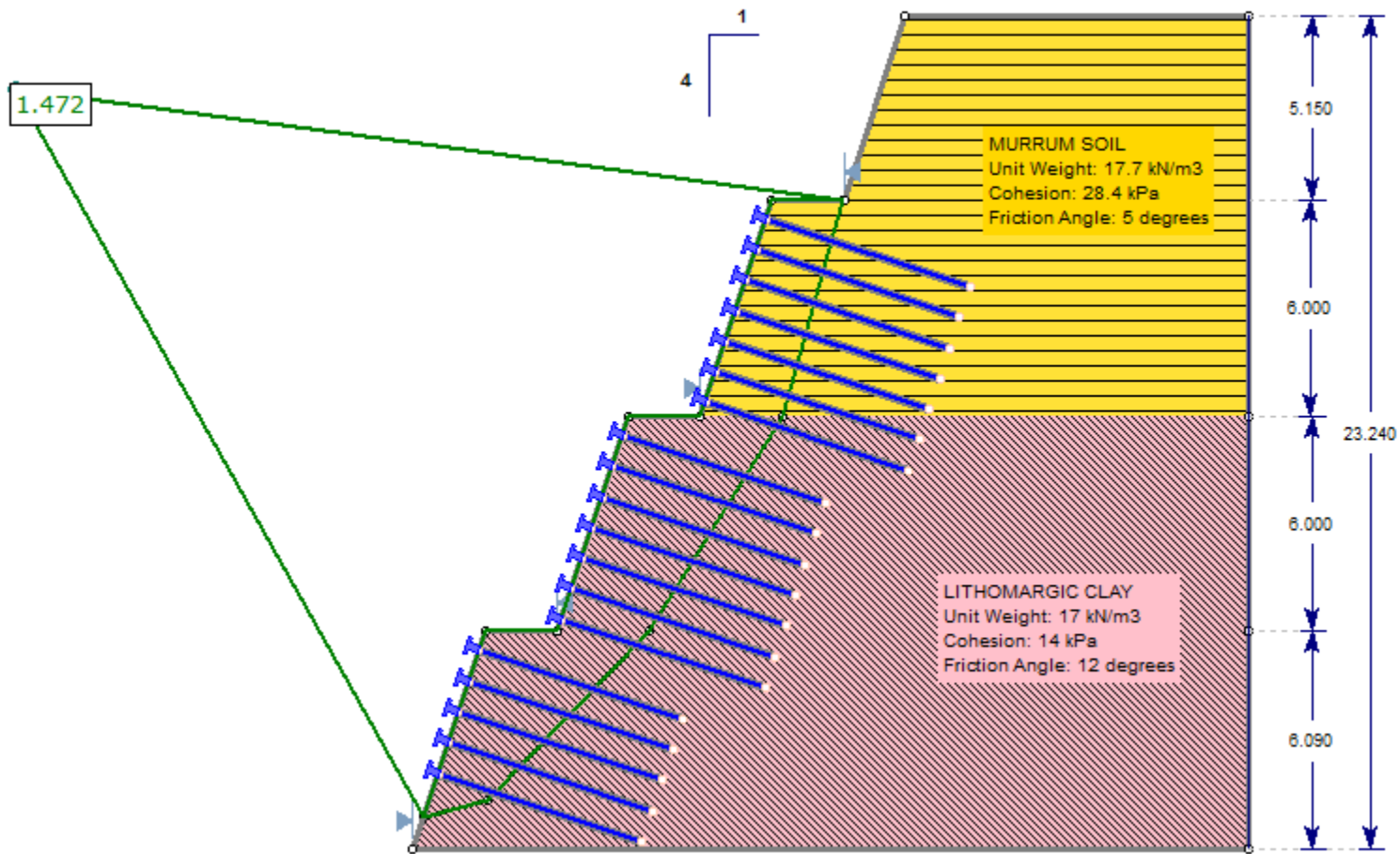


Fig.4 Stability analysis of slope at 160.020 km chainage ,providing 19 numbers of soil nails of 6 m length at spacing of 0.9m (FS= 1.472, SAFE)

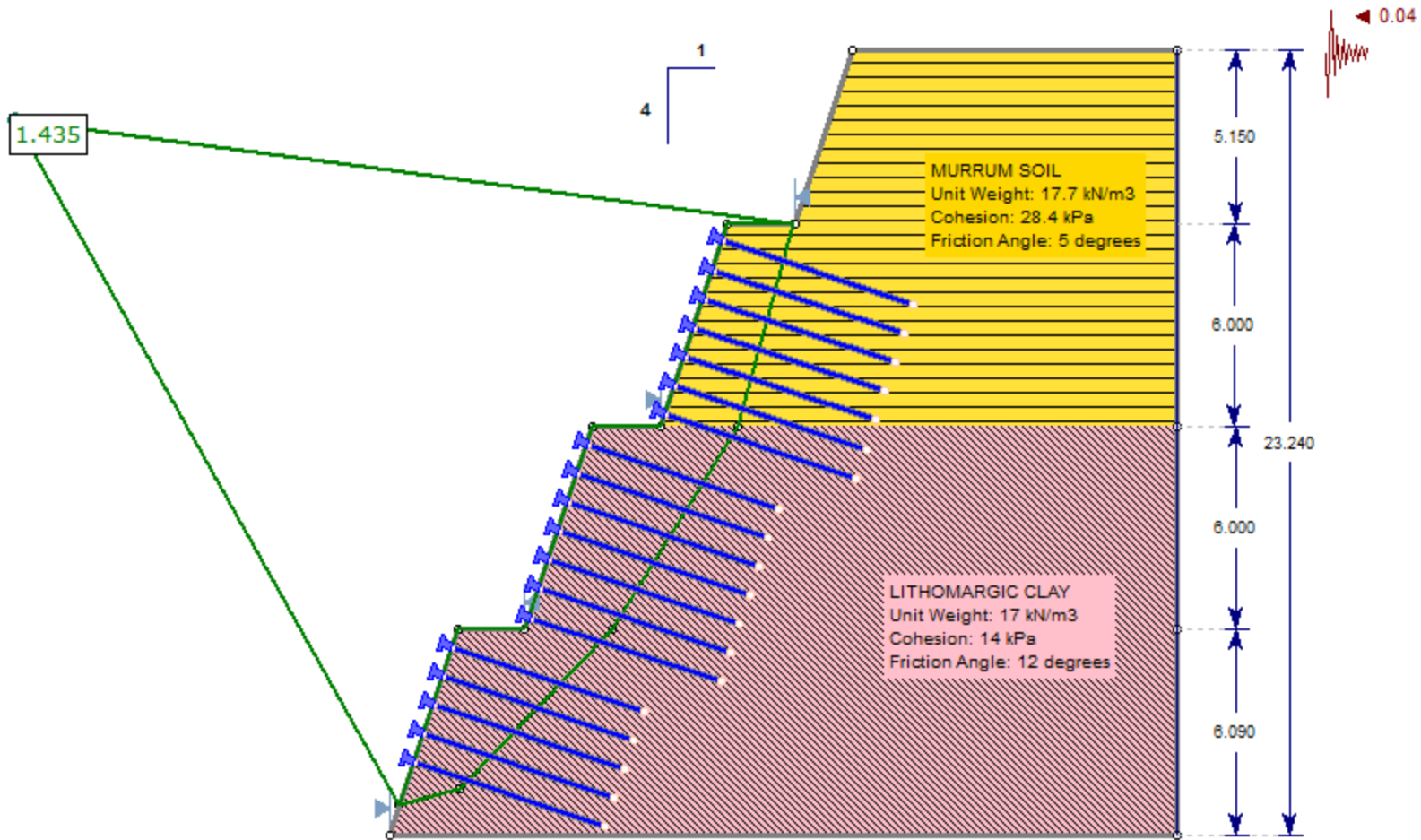


Fig.5 Stability analysis of slope at 160.020 km chainage ,providing 19 numbers of soil nails of 6 m length at spacing of 0.9m seismic coefficient 0.04 (FS= 1.435, SAFE)

e. Critical section selected at 190.640 chainage

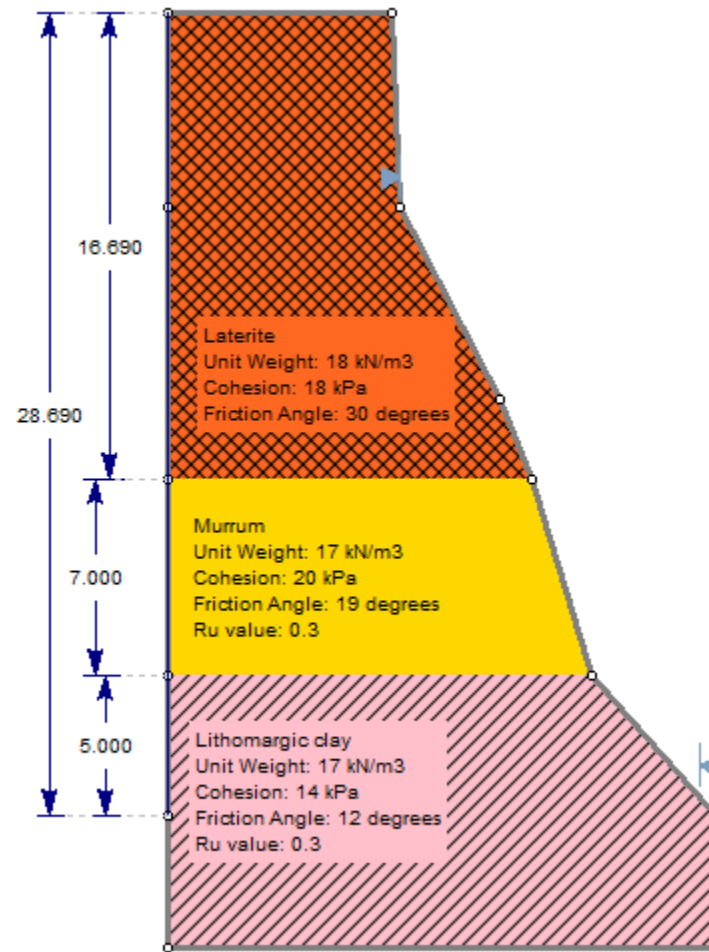


Fig.6 Critical Section selected at chainage 190.640 km

f. Stability analysis for critical section at 190.640 chainage

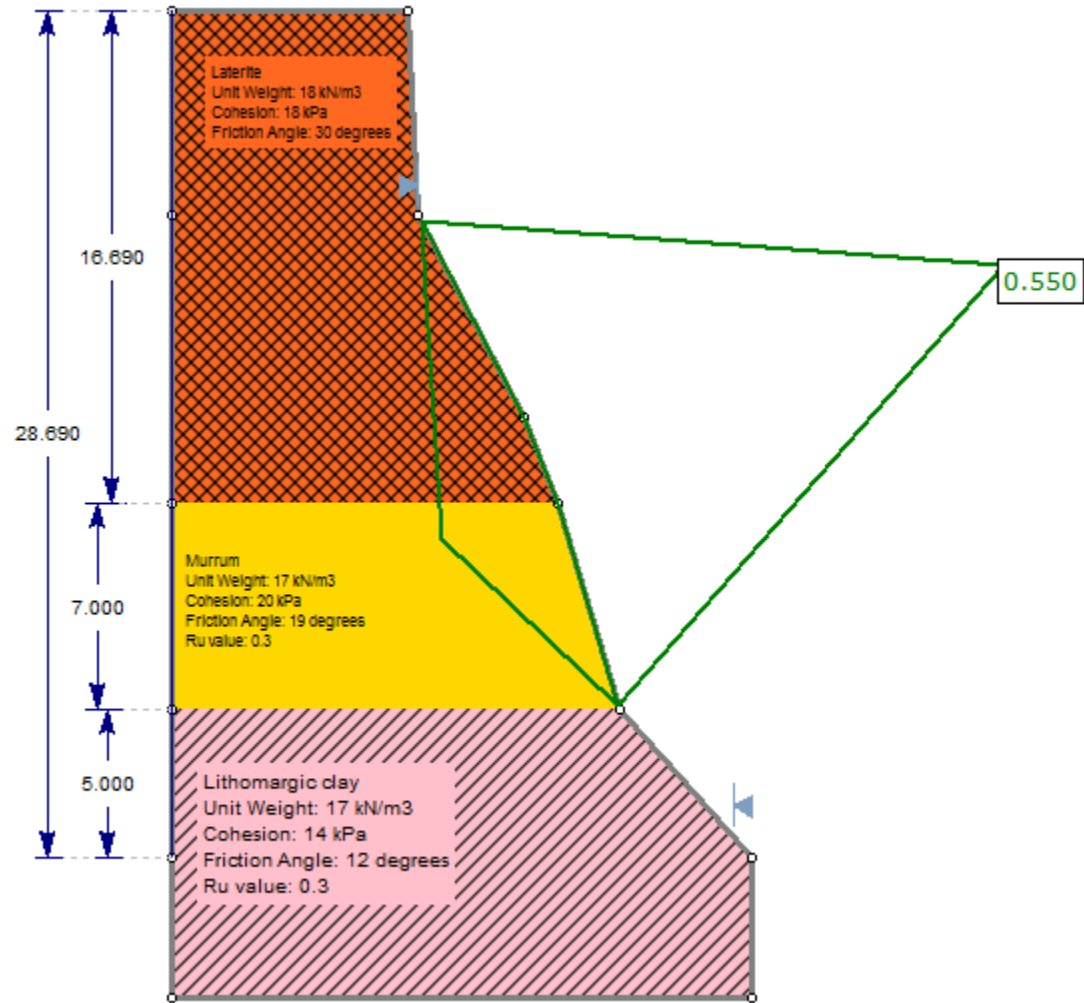
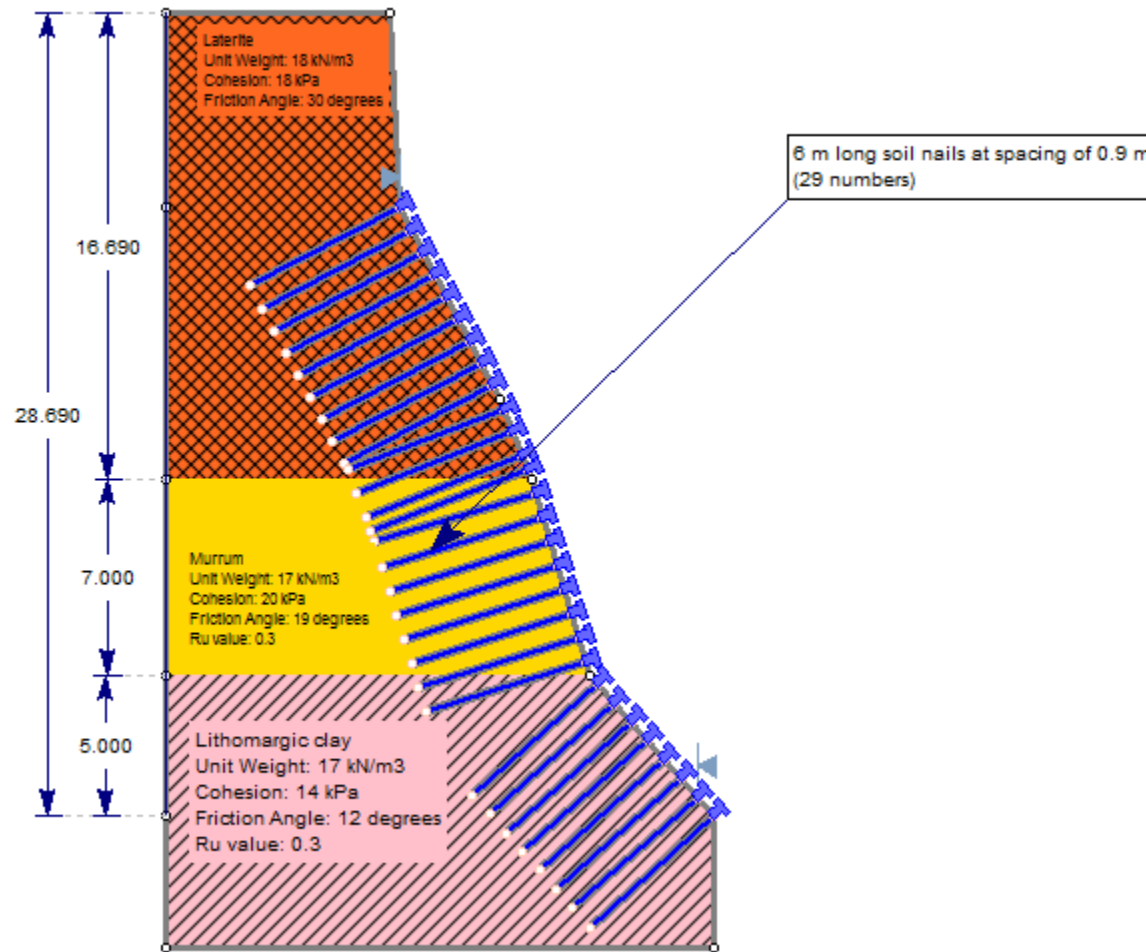


Fig. 7 Stability analysis of existing slope at 190.640 km chainage (FS= 0.550, UNSAFE)

g. Proposed remedial measures at 190.640 chainage

**Adopted** : 32 mm diameter soil nail , length = 6 m , spacing =0.9 m , 29 numbers



**Fig.8** Cross-section of slope at 190.640 with remedial measure, providing 29 numbers of soil nails of 6 m length at spacing of 0.9m

h. Stability analysis with proposed remedial measures at 190.640 chainage

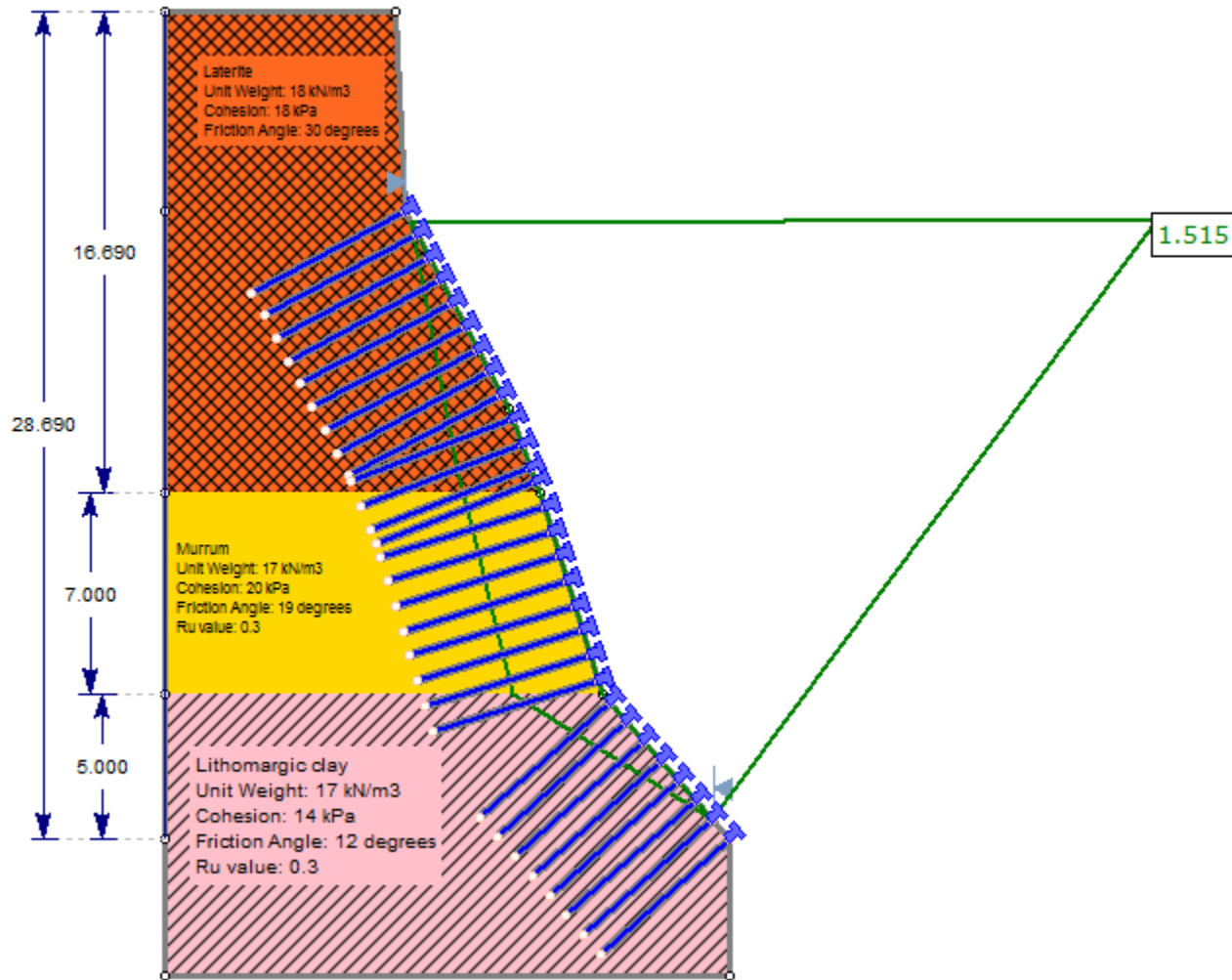


Fig.9 Stability analysis of slope at 190.640 km chainage ,providing 29 numbers of soil nails of 6 m length at spacing of 0.9m  
**(FS= 1.515, SAFE)**

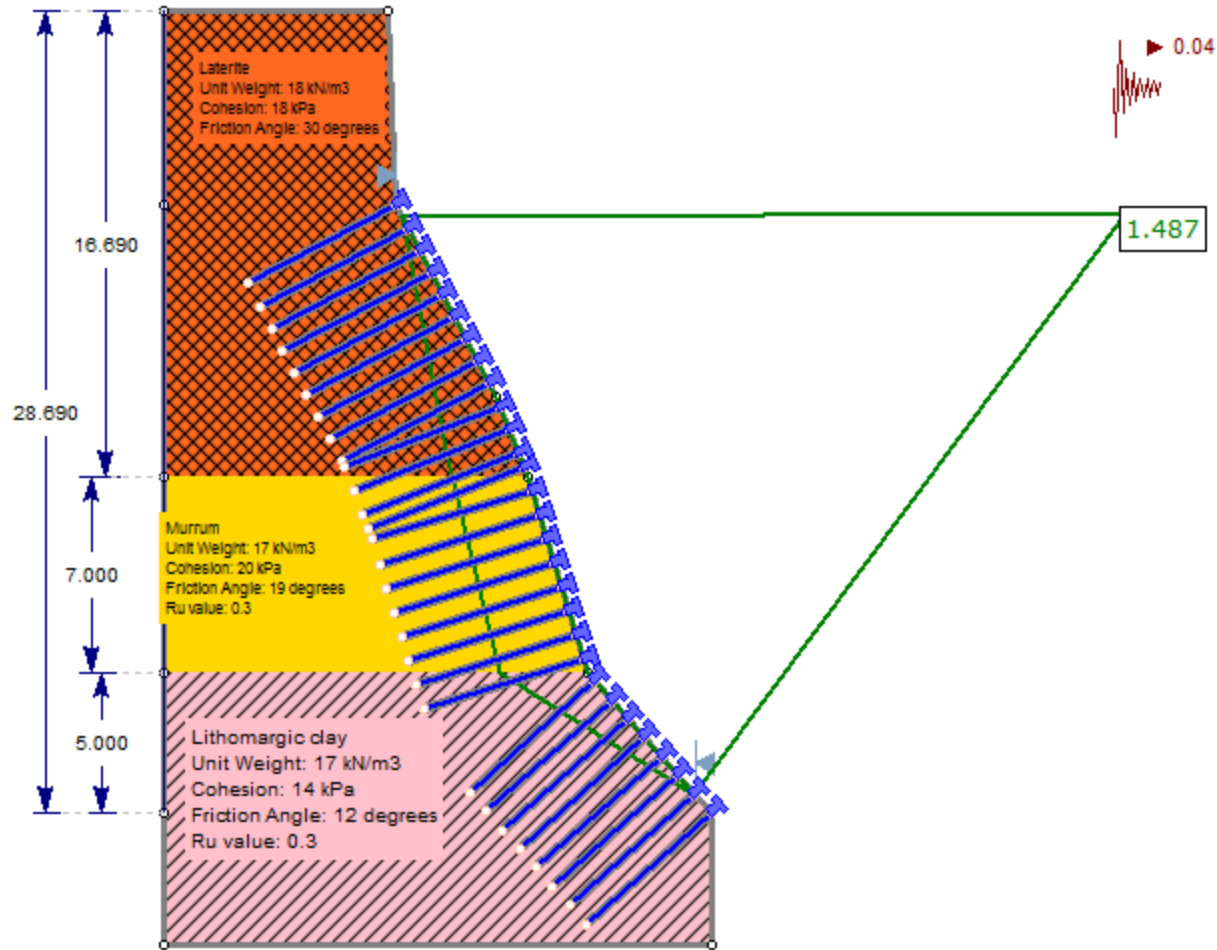


Fig.10 Stability analysis of slope at 190.640 km chainage ,providing 29 numbers of soil nails of 6 m length at spacing of 0.9m with seismic coefficient 0.04 (FS= 1.487, SAFE)

i. Critical section selected at 246.900 chainage

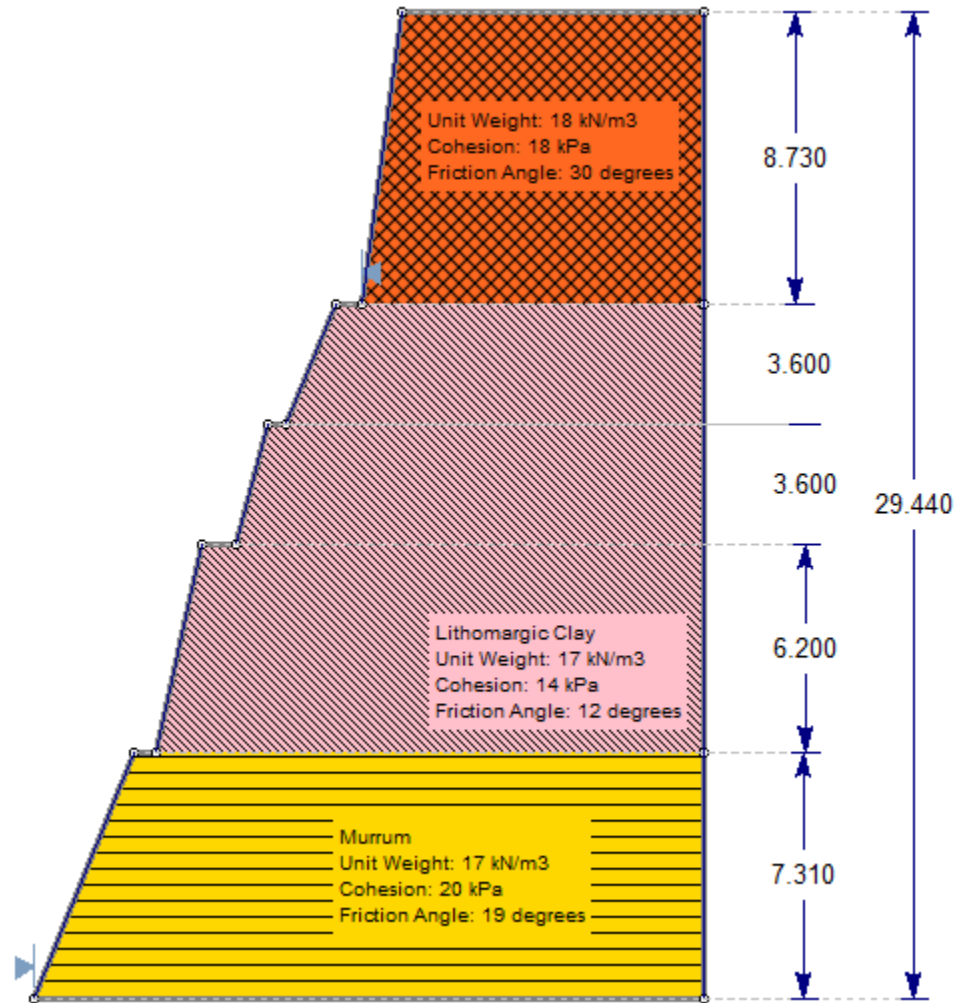


Fig. 11 Critical Section selected at chainage 246.900 km

j. Stability analysis for critical section at 246.900 chainage

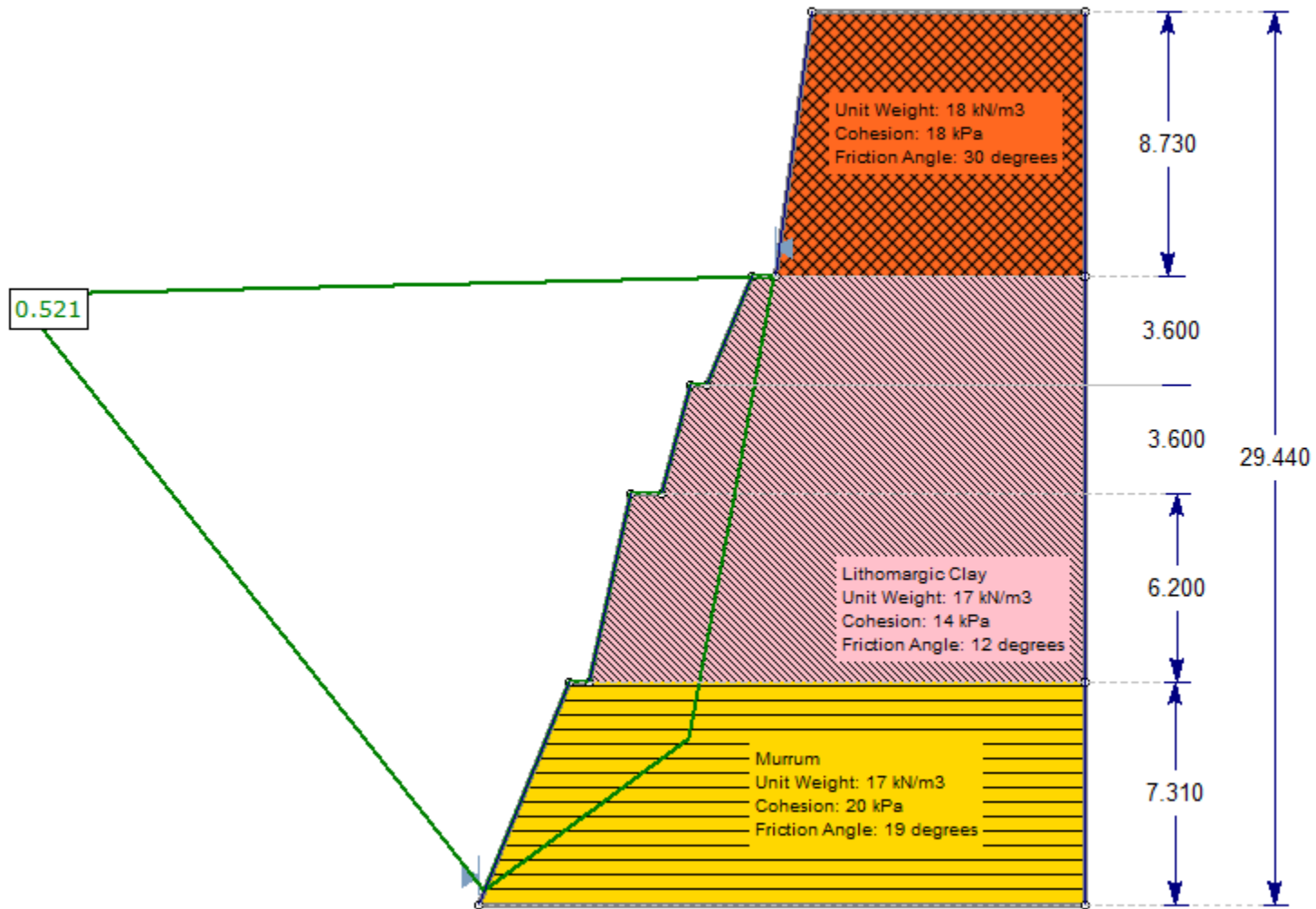


Fig.12 Stability analysis of existing slope at 246.900 km chainage (FS= 0.521, UNSAFE)

k. Proposed remedial measures at 246.900 chainage

Adopted : 32 mm diameter soil nail , length = 6 m , spacing =0.9 m , 22 numbers

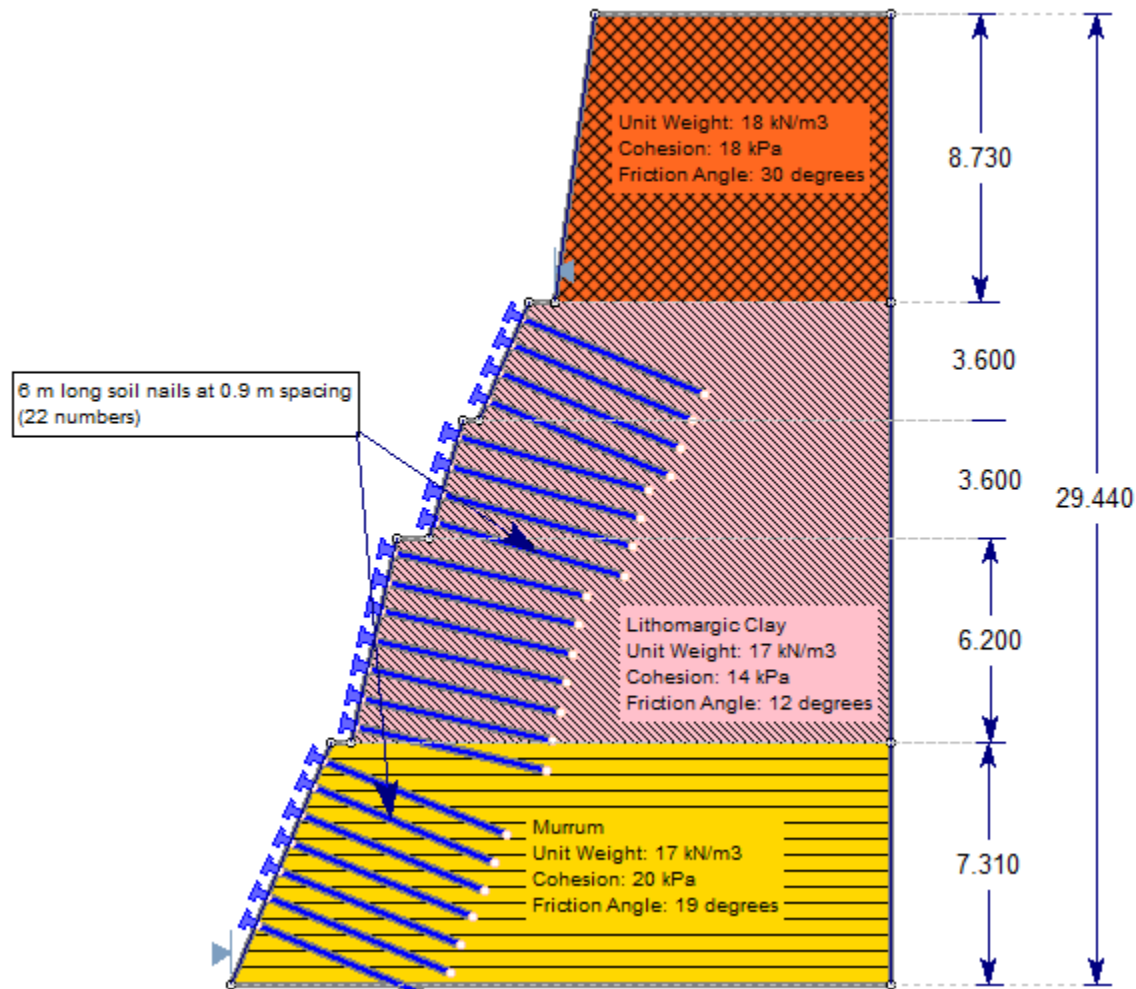


Fig.13 Cross-section of slope at 246.900 with remedial measure, providing 22 numbers of soil nails of 6 m length at spacing of 0.9m

I. Stability analysis with proposed remedial measures at 246.900 chainage

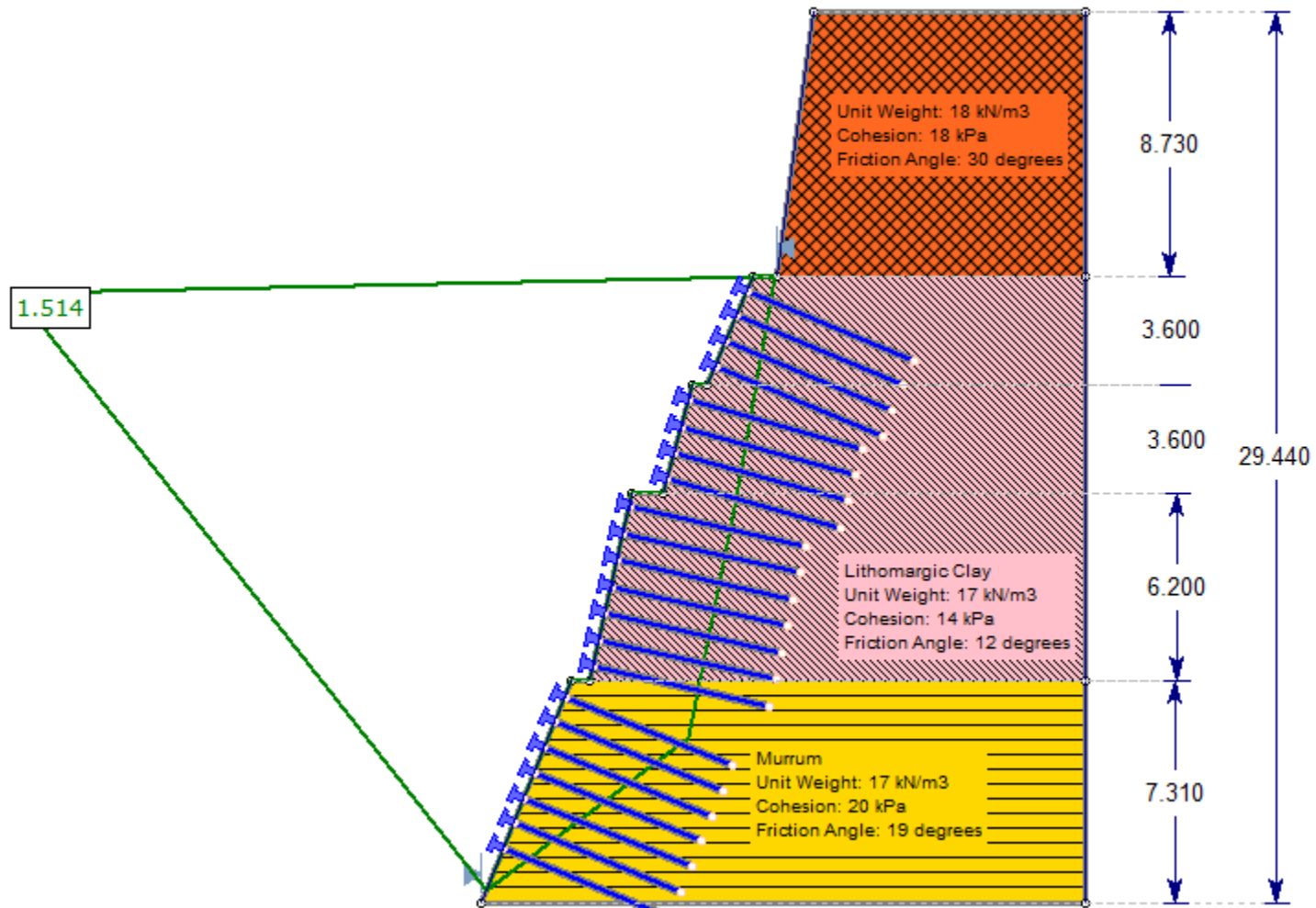


Fig.14 Stability analysis of slope at 246.900 km chainage ,providing 22 numbers of soil nails of 6 m length at spacing of 0.9m  
 (FS= 1.514, SAFE)

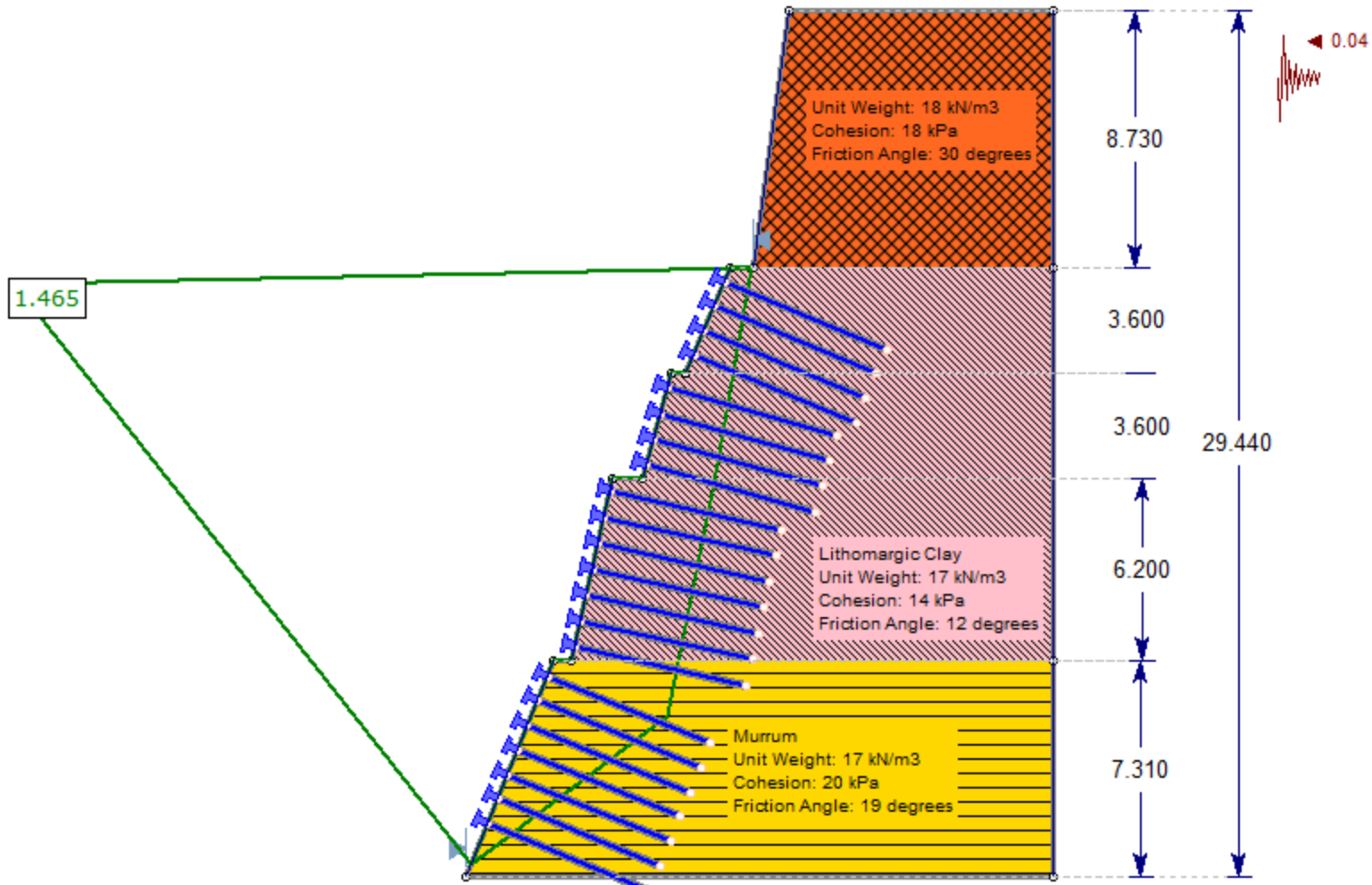


Fig.15 Stability analysis of slope at 246.900 km chainage ,providing 22 numbers of soil nails of 6 m length at spacing of 0.9m seismic coefficient 0.04 (FS= 1.465, SAFE)

## 6. RECOMMENDATIONS

- For the soil profiles (for the 3 chainages i.e at 160 km, 190 km and 245 km), analyses was carried out for provided sections considering the critical sections(at around chainages 160.020 , 190.640 and 246.900km).
- With the observed shallow seated failures in Lithomargic clay and murrum soil layers, excavated slopes are found to be unsafe, thus as a remedial measure with soil nails have been provided ( 32 mm diameter, 6 m length at each). Use Grade Fe 415;  $f_y = 415$  MPa Tor Steel rods as soil nails.
- All critical slopes found to be stable by providing the 6 m long soil nails (32 mm diameter) at spacing of 0.9 m both ways (as against minimum required factor of safety 1.3)
- The recommended procedure is to provide driven nail system for soil nailed wall. Soil-nail reinforcement is directly driven into the ground by the ballistic method using a compressed air launcher/ by the percussive method using jack hammering equipment, or by the vibratory method using a vibrator. During the driving process, the ground around the reinforcement will be displaced and compressed. The installation process is rapid and it causes minimal ground disruption.
- If the soil-nail reinforcement is damaged by the presence of a boulder or corestones, the equivalent length which did not penetrate may be provided in the adjacent area by reducing the spacing.
- As the soil-nail reinforcement is in direct contact with the ground, it is susceptible to corrosion, thus Tor steel rod is recommended with sacrificial additional thickness.
- It is recommended to drive the nail perpendicular to the exposed surface
- Apply shotcrete of 75mm thick in two stages.
- Apply the 1<sup>st</sup> phase of shotcrete with welded wire mesh (with a square grid) tied to the driven Tor Steel rods. Welded wire mesh (temporary facing): WMM 102 x 102–MW19 x MW19 is recommended.
- Square Bearing plate of Grade 250 ( $f_y = 250$  MPa); Shape: Square; Length: LBP = 225 mm; Thickness:  $t_p = 25$  mm is recommended at the end of the torsteel rod.

- A shotcrete of Grade M20 with characteristic compressive strength:  $f_{ck} = 20$  MPa is recommended.
- After the bearing plate is placed in position over the 1<sup>st</sup> Phase of shotcrete, second phase of shotcrete shall be applied.
- Total thickness of shotcrete recommended is 75mm (apply equally in both phases)
- 2inch (50mm dia) perforated PVC pipes wrapped around using 200 GSM geofabric filter, which are of length 2m with an upward gradient of 5 to 10 degrees is recommended for weep holes in between the nails (one weep hole for 4 soil nails). Weep holes are critical element of the soil nailed walls to arrest any excess pore pressure development behind the shotcreted wall.
- It is also recommended to do atleast two field pullout tests in each of the chainages area to capture variation in the soil properties and asses the pullout resistance of the bars.

#### **7. DESIGN BASIS and PROCEDURE OF CONSTRUCTION OF SOIL NAILED WALL**

A soil-nailed system is considered as a soil-nailed retaining wall if the facing of the system is sub-vertical, and it is designed to perform as a structural member that provides retention action to the ground by virtue of its self-weight, bending strength or stiffness. The soil nailing technique improves the stability of slopes, retaining walls and excavations principally through the mobilization of tension in the soil nails. The tensile forces are developed in the soil nails primarily through the frictional interaction between the soil nails and the ground as well as the reactions provided by soil-nail heads/facing. Soil-nail heads and the facing also provide a confinement effect by limiting the ground deformation close to normal to the slope surface. Weepholes / drain pipe releases any excess pore pressure due to water behind the soil nailed walls. A soil-nailed system has been designed to fulfil fundamental requirements of stability, serviceability and durability during construction and later on as well. A pull out capacity of nail with a factor of safety 2.5 has been taken as 25 KN/m.

Procedure for installation of soil nailed walled is described as below:

1. As the slopes are already excavated it is recommended to provide soil nails from bottom to top. The staggered spacing of nails in each row shall be followed.
2. Install 6m long 32mm dia Tor Steel rods / nails by using Jack hammer with a spacing of 0.9 m x 0.9m almost perpendicular to the surface.
3. IN each area, once installation of nails are completed, tie the wire mesh to the rod, carryout the 1<sup>st</sup> phase of shotcrete
4. Place the square bearing plate on each of nails abutting to the shotcreted surface, complete the second phase of the shotcrete layer.
5. Repeat steps until the entire excavated soil surfaces in the excavation levels are soil nailed.
6. Drainage / weep holes are provided before installing the shotcrete and covered during the shotcreting face.
7. Install the toe drain (PCC section) at the toe of the slope adjacent to the carriage way, one side of the toe drain is abutted to the toe of the slope. PCC section shall be a minimum of 1m depth towards the slope, which will also act as tow wall.

**CONSULTANT**

  
(Prof. T.G. Sitharam)

Place: Bangalore

Date: 17.03.2017

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**Mumbai Office:**

B-301, Universal Business Park, Kamani Oil Mill Road, Chandivli Estate, Andheri (E),  
Mumbai-400 072 • Tel: 91-22-6733 5900 • Fax: 91-22-6733 5905 • www.irb.co.in  
CIN : U45490MH2012PTC234786

**IRBWTP/CTO/KKBOT/2473/2017  
22/06/2017**

**To**

**The Team Leader,**

**M/s. AECOM Asia Company Ltd. in association with Rodic Consultants Pvt. Ltd.**

**C/o Nagashree Building,**

**Rajithagiri, KHB Colony,**

**Honnavara – 581334 Uttara Kannada, Karnataka**

**Project: - Four Laning of Goa / Karnataka Border to Kundapur section of NH-17 from Km. 93.700 to Km. 283.300 in the state of Karnataka under NHDP Phase IV on Design, Build, Operate, Transfer (DBFOT) toll basis.**

**Subject: - Potential land slide location during Monsoon Season**

**Reference: - Your office letter no. AECOM/HWH/2017-18/GOA/2434, dated 16.06.2017**

**Dear Sir,**

This is in reference to your office letter cited above, vide which your office has enclosed list of the locations alongwith photographs, stating further that these locations are Vulnerable and Potential danger due to hill cutting for the formation and requested us to take all the preventive safety measures to avoid inconvenience to the road users, traffic and the public next three months of Monsoon period.

In regards to your said statement, we would like invite your attention towards the Clause 4.4 (a) of Appendix BIV of revised Schedule B of the Concession Agreement and the Cross Section type 17, which is to be followed for the cutting section. The Cross type 17 given at page 285 under Appendix -II of Schedule B of the Concession Agreement is for hill cutting sections. According to which, the side slope of 12 (Vertical): 1 (Horizontal) is to be provided upto 6m height then Berm of 2m width and thereafter again slope of 12 (Vertical): 1(Horizontal) is to be provided upto height of 15m of hill.

You are well aware that the width of ROW handover by NHAI is maximum 60m, mostly pertains to Forest Department. You are aware that the process of land acquisition as well as diversion of Forest land was initiated by NHAI with State Government and MoEF in the year 2012-13 on the basis of detailed Project Report prepared by DPR Consultant appointed by NHAI prior to bidding.

You are also aware that the working permission from MoEF was received in August 2014 subjected to fulfillment of certain conditions stipulated therein, which was to be fulfilled by NHAI. However, the work in the Forest land could be commenced in October'2015 after fulfilling the conditions by NHAI and Tree Felling by the Forest Department being their Policy.

The developed Cross sections in conformity to the Scope of Work defined under Schedule B & C of the Concession Agreement were submitted to your office, which had been reviewed & consented by your office.

Registered Office : IRB Complex, Chandivli Farm, Chandivli Village, Andheri (E), Mumbai - 400 072.

Tel: 91 - 22 - 6640 4220 • Fax: 91 - 22 - 6675 1024 • e-mail: info@irb.co.in • www.irb.co.in

The work has been executed at site in accordance to the Cross Sections submitted and cross section given under Schedule B, which is a scope of work as per the Concession Agreement. Whereas we have made more flatter slopes and provided more berms within available ROW against the 12 (Vertical): 1(Horizontal) mentioned in the Concession Agreement. Further, the Forest Officials did not allowed to work in their land.

You are also aware that there is no provision made under the type 17 cross section given under Schedule B of the Concession Agreement for protection. However, we had engaged the Consultant Dr. Uday Kulkarni of M/s. Nobel Geo-Structs, who had studied the hill sections & suggested the slope protection measures in cut sections, but during the site office of Manager (T), NHAI in 1<sup>st</sup> week of October'2016, it was instructed to engage the IISC, Bangalore for studying the cutting section and suggest their recommendations. In accordance to said instructions, we had engaged to Professor Sitharam of IISC, Bangalore for the said purpose, who had visited the entire site twice in presence of Independent Engineer & our representative and submitted the report with his recommendations for soil nailing at 3 locations. The said report was submitted to Authority / Independent Engineer vide this office letter no. IRBWTPL/CTO/KKBOT/2290/2017, dated 31/03/2017. Kindly refer this office letter no. IRBWTPL/CTO/KKBOT/2297/2017, dated 03/04/2017, wherein it is requested to convey in principle approval under Change of Scope as the said protection work is beyond the scope of work defined in the Cross Section given under Schedule B of the Concession Agreement. The In-principal approval of the same under Change of Scope is still awaited from the Independent Engineer / Authority. However, keeping pending approval of Change of Scope, the work of soil nailing was commenced at Km. 246+700 in LHS by inserting 32mm dia. rods and partial work had been completed, further work could not be continued due to restriction of working space required for machinery movement for drilling & inserting the 6m long rod in cut section at height of 6m & above height.

In the meantime, unprecedented heavy & continues rains started in the said region and the land slide in certain sections took place, which was a purely "Natural Calamity" arising out due to incessant torrential rain, which was beyond our control.

It is also noticed due to continuous heavy rains, the small pockets of the cut sections collapses, for which one of the reason is seepage from the backside of hill i.e. from outside the ROW, which percolates through the hill.

Considering the above, we are hereby propose to have the slope of 1.5 (Vertical): 1(Horizontal) minimum to have more stable scope to avoid sliding, for which additional land varying from 15m to 50m width according the height of cutting at the locations mentioned in your letter, is required. The details enclosed under Annexure - 1.

You are hereby kindly requested to take up the matter with Authority to provide additional land by end of September 2017 by taking up the matter with State Government & Forest Department on TOP PRIORITY, so that the slopes are cut and protective measure are taken up immediately once the rainy season is over and completed prior to next rainy season.

You are also requested to convey the In-principle approval for additional works to be carried out by us for cutting of extra slopes and providing protective measures i.e. Soil Nailing, as the said works are additional works and beyond the Scope of Work defined in the Cross Section provided under Schedule B of the Concession Agreement.

Please note that the Concessionaire shall not be held responsible for untoward incidence / accident, if any take place, due to sliding of cut sections due to non-availability of adequate land as required.

An early action is solicited in this regard.

Thanking you,  
Yours Faithfully,

  
J. P. Nandi  
(Deputy Head Project Construction)

Encl.: As above.

C.C.: - 1) GM (T) & Ro, Bangalore - For kind information and necessary action please.

2) The Project Director, National Highway Authority of India, (Ministry of Road Transport and Highways), Project Implementation Unit- Mangalore - For kind information and necessary action please.

|                       |   |
|-----------------------|---|
| <b>AECOM RODIC JV</b> |   |
| Received On:          | 24/06/17  |
| Time:                 |   |
| By Name:              | Dina  |
| Signature:            |  |

## MODERN ROAD MAKERS PVT LTD

Four Laning of Goa/ Karnataka Border to Kundapur Section of NH-17 from Km 93.700 to Km 283.300 in the State of Karnataka under NHDP phase IV on design, build, operate, transfer (DBFOT) toll basis

## Statement for Additional Land required for provision of stable slopes from Km.140+00 to Km.195+00

| Sr.No  | Location           | Village Name                | From    | To      | Side | Length (Km) | Additional width required beyond PROW (M) | Total Area in Sqm |
|--|--------------------|-----------------------------|---------|---------|------|-------------|---|-------------------|
| 1  | 192+175            | Near colnel Hill, Honnavar  | 191.950 | 192.175 | LHS  | 225.000     | 32.000                                    | 7,200.00          |
| 2  | 190+700            | Karki Naka                  | 190.600 | 190.800 | LHS  | 200.000     | 48.000                                    | 9,600.00          |
| 3  | 168+600            | Devgi                       | 168.600 | 168.800 | LHS  | 200.000     | 35.000                                    | 7,000.00          |
| 4  | 167+800            | Tandrakuli , Devgi          | 167.700 | 167.800 | LHS  | 100.000     | 50.000                                    | 5,000.00          |
| 5  | 165+100            | Kathgal Sirsi Junction      | 165.050 | 165.200 | LHS  | 150.000     | 42.000                                    | 6,300.00          |
| 6  | 160+000            | Near Bargi                  | 159.900 | 160.100 | RHS  | 200.000     | 24.000                                    | 4,800.00          |
| 7  | 151+600 to 151+900 | Balale Cross                | 151.600 | 151.900 | LHS  | 300.000     | 17.000                                    | 5,100.00          |
| 8  | 164+450            | Mirjan ( Opp Tourist Hotel) | 164.400 | 164.550 | LHS  | 150.000     | 15.000                                    | 2,250.00          |
| 9  | 165+600            | Mirjan , Khaire             | 165.550 | 165.650 | LHS  | 100.000     | 15.000                                    | 1,500.00          |
| 10   | 181+700            | Dhareshwar                  | 181.550 | 181.700 | RHS  | 150.000     | 22.000                                    | 3,300.00          |
| <b>Total Additional area required for flatter Slope (1.5 : 1) beyond PROW in Sqm</b> |                    |                             |         |         |      |             |   | <b>52,050.00</b>  |

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PA / v. yadav / 30/6/17



# NATIONAL HIGHWAY AUTHORITY OF INDIA

Safety Consultant for 4-laning from km 93+700 to km 283+300 of Goa-Karnataka Border to Kundapur Section of NH-17 in the state of Karnataka to be executed as BOT (Toll Basis) on DBFOT basis

## ROAD SAFETY AUDIT REPORT

(June-2017)



Submitted By:  
M/s Lion Engineering Consultants





### 1.1 General

The Government of India had entrusted to the National Highway Authority of India for the development, maintenance and management of National Highway No. 17 including the section from km 93.700 to km 283.300 (approx. 187.28 km).

The NHAI had resolved to augment the existing road from km. 93.700 to km 283.300 (approximately 187.28 km) on the Goa/ Karnataka Border to Kundapur Section of National Highway No. 17 in the State of Karnataka by four- Laning on design, build, finance, operate and transfer ("**DBFOT**") basis in accordance with the terms and conditions to be set forth in a concession agreement to be entered into.

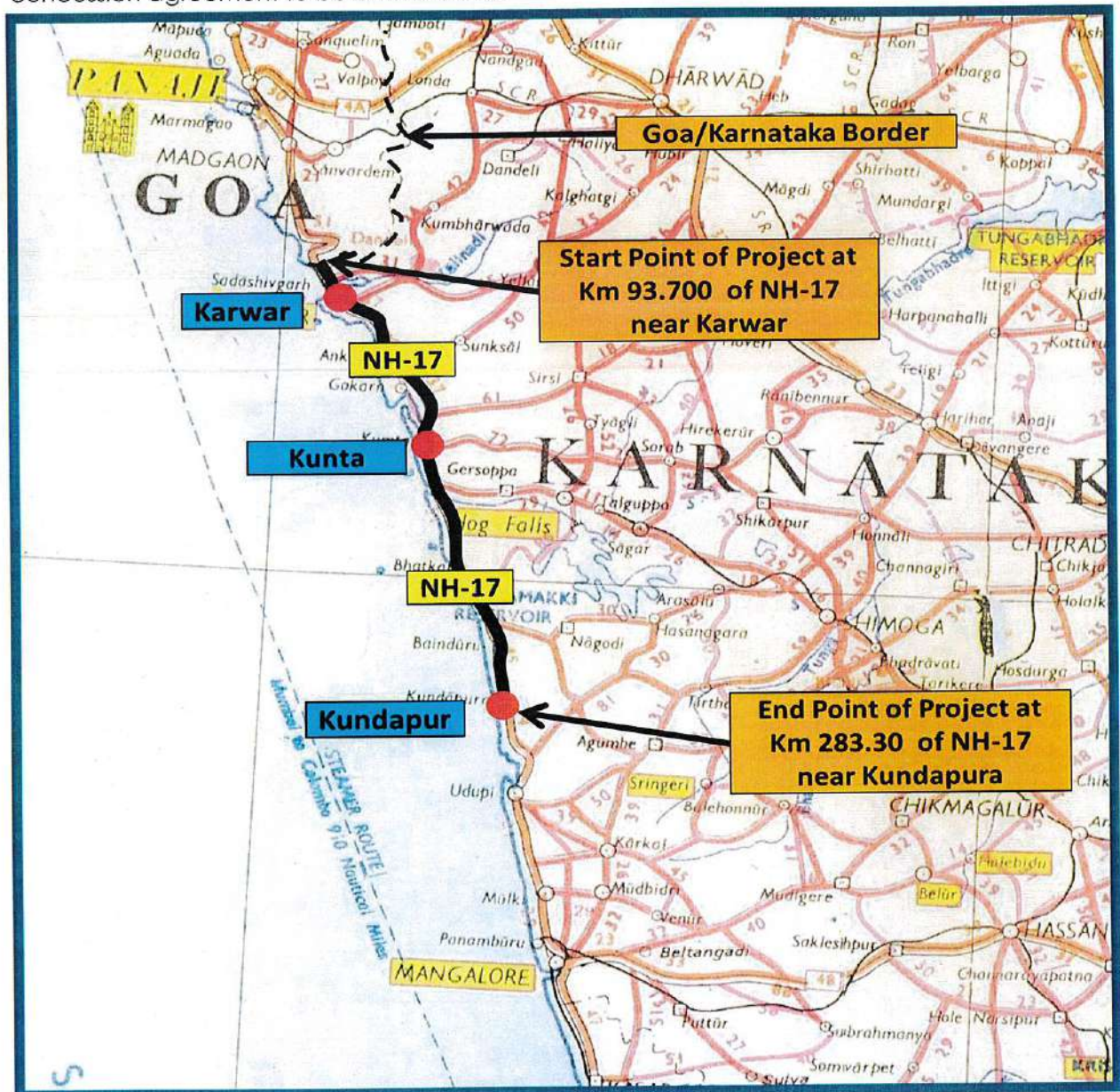


Photo- 1- Project Map



## 1.2 Project Background

The project highway alignment is located between Arabian Sea coast and Western Ghats in Karnataka. At few stretches the highway is close to the Arabian Sea. NH: 63 from Gooty joins the project road near Ankola at km 135.450 and NH: 206 from Tumkur join at Honnavar at Km 195.450.

Land use along the highway is predominantly for agriculture. Majority of the land is being used for wet crop viz, Paddy, Cashew plantation. There are number of settlements all along the road. The settlements are for Residential, Commercial, Schools, Hospitals, Petrol stations, Religious structures etc. Major settlements are close to the existing highway at number of locations, i.e. Karwar port from Km 108.300 to Km 108.800 (500m), Seabird compound wall from Km 109.000 to Km 115.800 (7.800 km length) and Navy Fence on either side of project road approx. from Km 132.050 to Km 135.000 (2.950 km length)

| S.No. | Item   | Unit | Qty                  |
|-------|--|------|----------------------|
| 1     | Total Project Length                             | km   | Approx. 187.28 km    |
| 2     | Total Length of Realignment (Design Chainage)    | Km   | 21.93 (20 Stretches) |
| 3     | Total Length of Realignment (Existing Chainage)  | Km   | 23.49 (20 Stretches) |
| 4     | Total Length of Service Road                     | Km   | 61.262               |
| 5     | Major Junction                                   | Nos. | 17                   |
| 6     | Minor Junction                                   | Nos. | 06                   |
| 7     | Cross Roads other than Major and Minor Junctions | Nos. | 83                   |
| 8     | Truck Lay-Byes                                   | Nos. | 04                   |
| 9     | Bus-Bays and Bus Shelters                        | Nos. | 53                   |
| 10    | Toll Plaza                                       | Nos. | 03                   |
| 11    | Rest Areas                                       | Nos. | 03                   |
| 12    | Overhead Traffic Signs (Cantilever gantry)       | Nos. | 16                   |
| 13    | Major Bridge (New Construction)                  | Nos. | 14                   |
| 14    | Major Bridge (Rehabilitation/ Repair/ Widening)  | Nos. | 14                   |
| 15    | Minor Bridges (New Construction)                 | Nos. | 39                   |
| 16    | Minor Bridge (Rehabilitation/ Repair/ Widening)  | Nos. | 20                   |
| 17    | Pipe Culvert (Reconstruction)                    | Nos. | 304                  |
| 18    | Pipe Culvert (Widening)                          | Nos. | 81                   |
| 19    | RCC Box Culvert (New Construction)               | Nos. | 66                   |
| 20    | Slab Culvert (Widening)                          | Nos. | 96                   |
| 21    | Slab Culvert (Reconstruction)                    | Nos. | 25                   |
| 22    | Cut Stone Slab Culvert (Reconstruction)          | Nos. | 01                   |



4-laning of Goa/ Karnataka Border to Kundapur Section from Km. 93.700 to Km. 283.300 of NH-17 in the state of Karnataka to be executed as BOT (Toll) on DBFO Pattern.

| S.No. | Item  | Unit | Qty |
|-------|---|------|-----|
| 23    | Flyover (Proposed)                          | Nos. | 04  |
| 24    | Vehicular Underpass (Proposed)              | Nos. | 03  |
| 25    | Pedestrian/Cattle Crossing (Proposed)       | Nos. | 19  |
| 26    | ROB (Proposed)                              | Nos. | 02  |
| 27    | RUB (Proposed)                              | Nos. | 01  |
| 28    | Tunnels                                     | Nos. | 02  |
| 29    | Entry and Exit Ramps to Service Road on LHS | Nos. | 40  |
| 30    | Entry and Exit Ramps to Service Road on RHS | Nos. | 37  |

### 1.3 Objective of Report

In compliance of meeting held in the Hon'ble DC's Office on 14<sup>th</sup> June-2017 regarding Safety works to be taken along NH-66, the Project Director, PIU-NHAI, Mangalore has directed to Safety Consultant, vide their letter dtd: 20.06.2017, to carry out safety audit on project highway and identify dangerous spot and suggest necessary measures to be taken.

In this context, Safety Consultant has visited the project highway during 26.06.2017 to 28.06.2017 (as informed our office letter dtd: 23.06.2017) to carryout safety audit.

During the Safety Audit, the Safety Consultant examined all such potential hazards locations and identified locations along with suggestions for necessary measures to be taken to ensure safety on project highway. Such potential hazards locations and their remedial measures are presented in **Annexure-3 of this report**.

However, brief on such observations and recommendations of the Safety Consultant are presented in table as under:

| Brief on Observation and Recommendations of Safety Consultant |  |   |
|---|--|---|
| S.No.   | Particular/Observation   | Recommendations of Safety Consultant  |
| 1   | Steep hill cutting along the project highway leading land slide. | It is recommended that the Concessionaire shall construct <b>gentle cut slope instead of steep cut to avoid land slide</b> . (As reported by the Concessionaire, land is not available to carryout gentle slope at steep hill cut locations mostly being Forest lands. It is observed during safety audit at site that Concessionaire has tried their best to flatten the cut slope in the land made available to them. In this regard, the requirements of necessary additional land at priority locations have been requested by Concessionaire to IE/NHAI. Please refer <b>Annexure-1</b> enclosed here for such locations. As reported by the Concessionaire, identification of additional land requirement at other such locations is under process and to be submitted to |



**Brief on Observation and Recommendations of Safety Consultant**

| S.No. | Particular/Observation  | Recommendations of Safety Consultant  |
|-------|---|---|
|       |   | IE/NHAJ shortly. (Please refer <b>Annexure-2</b> enclosed here for such locations). It is recommended that the additional land is essential to be made available by NHAJ/State Government, so that Concessionaire could able to flatten the cut slopes to have more stable slope to avoid sliding in future.<br>Also it is recommended that the concessionaire shall construct <b>lined drain (wherever required as per prevailing site situation)</b> at the top of Hill, beyond the cut edge of slope, so that hill water can be diverted and flow of rain water can be avoided to flow over cut slope as much as possible to avoid land slide in future. |
| 2     | It is observed that safety measures are provided at all diversion locations but some sign boards (like Take Diversion/Diversion), barricading are missing at some diversions.   | It is recommended that the Concessionaire shall provide necessary sign boards and barricading ( <b>refer Fig no. 10.1, 10.2, 10.3, 10.4, 10.5, 10.10 of IRC:SP-55-2014</b> ) at such locations as indicated in <b>Annexure-3</b> enclosed here.   |
| 3     | It is observed that some of road signage having poor visibility due to deposition of dust/mud due to rains.   | It is recommended that the Concessionaire shall carryout regular maintenance and cleaning of sign boards wherever required.   |
| 4     | Barricading is missing at some high embankment approaches, deep excavation near to Main carriageway (MCW). However, it is observed that barricades are provided at such locations, but close barricading is required at such locations. | The Concessionaire shall provide necessary barricading ( <b>refer Fig no. 10.1, 10.2, 10.3, 10.4, 10.5, 10.10 of IRC:SP-55-2014</b> ) at locations as indicated in <b>Annexure-3</b> enclosed here.   |
| 5     | It is observed that railing/parapet wall are damaged and having poor visibility at Existing Major & Minor bridges along project highway.  | The Concessionaire shall repair of railing (wherever required), provide reflective tape on railing at all locations as indicated in <b>Annexure-3</b> enclosed here.  |
| 6     | It is observed that minor roads are meeting at/near diversion locations. Minor Road traffic is entering in very high speed at such diversion locations, which may hazards for safe movement of traffic.                                 | It is recommended that the Concessionaire shall provide speed breaker at approach of minor junctions ( <b>refer fig 9.3 of IRC: SP-84-2014</b> ) and provide speed limit sign board at Main Carriageway (such locations are indicated in <b>Annexure-3 enclosed here</b> ).   |
| 7     | It is observed that the minor roads meeting project highway with steep ascending/descending gradient.   | It is recommended that the Concessionaire shall provide speed breaker at approach of minor junctions ( <b>refer fig 9.3 of IRC: SP-84-2014</b> ) and provide speed limit sign board at MCW (Such locations are indicated in <b>Annexure-3 enclosed here</b> ).  |



| Brief on Observation and Recommendations of Safety Consultant |   |                                      |
|---|---|--------------------------------------|
| S.No.   | Particular/Observation  | Recommendations of Safety Consultant |
| 8   | It is noticed during the safety Audit that most of the accidents occur due to over speeding, overtaking, drunken driving, careless driving and not following the traffic Rules & Regulations etc. Hence, it is recommended that the Concessionaire shall provide Cautionary sign boards showing message like Speed Limit, Driving with Caution, Go slow, Construction Work Zone, Men at Work etc. at all the locations of constructions zones and at/before habitat area. |                                      |

For & On Behalf of M/s Lion Engineering Consultants,



(Sushil Nimbark)

General Manager (Tech./BD) cum Project Coordinator

**Enclosures of this report:**

1. Annexure: 1- Requirement of addition land at land slide prone stretches (Submitted to NHAI/IE)
2. Annexure: 2- Requirement of addition land at other land slide prone stretches (To be submitted to NHAI/IE)
3. Annexure: 3- Detailed work zone safety audit

# ROAD SAFETY AUDIT REPORT

77

Start Point of Project at  
Km 93.700 of NH-17  
near Karwar

## *Annexure-1:* Requirement of Addition Land at Land Slide Prone Stretches (Submitted to NHAI/IE)

End Point of Proj  
Km 283.30 of N  
near Kundapu

# IRB Westcoast Tollway Pvt. Ltd.

A subsidiary of

# IRB

INFRASTRUCTURE DEVELOPERS LTD

**Mumbai Office:**

B-301, Universal Business Park, Kamani Oil Mill Road, Chandivli Estate, Andheri (E),  
Mumbai-400 072 • Tel: 91-22-6733 5900 • Fax: 91-22-6733 5905 • www.irb.co.in  
CIN : U45400MH2012PTC234786

**IRBWTP/CTO/KKBOT/2473/2017**  
**22/06/2017**

To  
The Team Leader,  
M/s. AECOM Asia Company Ltd. in association with Rodic Consultants Pvt. Ltd.  
C/o Nagashree Building,  
Rajithagiri, KHB Colony,  
Honnavaara – 581334 Uttara Kannada, Karnataka

**Project:-** Four Laning of Goa / Karnataka Border to Kundapur section of NH-17 from Km. 93.700 to Km. 283.300 in the state of Karnataka under NHDP Phase IV on Design, Build, Operate, Transfer (DBFOT) toll basis.

**Subject:-** Potential land slide location during Monsoon Season

**Reference:-** Your office letter no. AECOM/HWH/2017-18/GOA/2434, dated 16.06.2017

Dear Sir,

This is in reference to your office letter cited above, vide which your office has enclosed list of the locations alongwith photographs, stating further that these locations are Vulnerable and Potential danger due to hill cutting for the formation and requested us to take all the preventive safety measures to avoid inconvenience to the road users, traffic and the public next three months of Monsoon period.

In regards to your said statement, we would like invite your attention towards the Clause 4.4 (a) of Appendix BIV of revised Schedule B of the Concession Agreement and the Cross Section type 17, which is to be followed for the cutting section. The Cross type 17 given at page 285 under Appendix -II of Schedule B of the Concession Agreement is for hill cutting sections. According to which, the side slope of 12 (Vertical): 1 (Horizontal) is to be provided upto 6m height then Berm of 2m width and thereafter again slope of 12 (Vertical): 1(Horizontal) is to be provided upto height of 15m of hill.

You are well aware that the width of ROW handover by NHAI is maximum 60m, mostly pertains to Forest Department. You are aware that the process of land acquisition as well as diversion of Forest land was Initiated by NHAI with State Government and MoEF in the year 2012-13 on the basis of detailed Project Report prepared by DPR Consultant appointed by NHAI prior to bidding.

You are also aware that the working permission from MoEF was received in August 2014 subjected to fulfillment of certain conditions stipulated therein, which was to be fulfilled by NHAI. However, the work in the Forest land could be commenced in October 2015 after fulfilling the conditions by NHAI and Tree Felling by the Forest Department being their Policy.

The developed Cross sections in conformity to the Scope of Work defined under Schedule B & C of the Concession Agreement were submitted to your office, which had been reviewed & consented by your office.

Registered Office : IRB Complex, Chandivli Farm, Chandivli Village, Andheri (E), Mumbai - 400 072.  
Tel: 91 - 22 - 6640 4220 • Fax: 91 - 22 - 6675 1024 • e-mail: info@irb.co.in • www.irb.co.in

IRB Westcoast Tollway Pvt. Ltd.



The work has been executed at site in accordance to the Cross Sections submitted and cross section given under Schedule B, which is a scope of work as per the Concession Agreement. Whereas we have made more flatter slopes and provided more berms within available ROW against the 12 (Vertical): 1(Horizontal) mentioned in the Concession Agreement. Further, the Forest Officials did not allowed to work in their land.

You are also aware that there is no provision made under the type 17 cross section given under Schedule B of the Concession Agreement for protection. However, we had engaged the Consultant Dr. Uday Kulkarni of M/s. Nobel Geo-Structs, who had studied the hill sections & suggested the slope protection measures in cut sections, but during the site office of Manager (T), NHAI in 1<sup>st</sup> week of October 2016, it was instructed to engage the IISC, Bangalore for studying the cutting section and suggest their recommendations. In accordance to said instructions, we had engaged to Professor Sitharam of IISC, Bangalore for the said purpose, who had visited the entire site twice in presence of Independent Engineer & our representative and submitted the report with his recommendations for soil nailing at 3 locations. The said report was submitted to Authority / Independent Engineer vide this office letter no. IRBWTPL/CTO/KKBOT/2290/2017, dated 31/03/2017. Kindly refer this office letter no. IRBWTPL/CTO/KKBOT/2297/2017, dated 03/04/2017, wherein it is requested to convey in principle approval under Change of Scope as the said protection work is beyond the scope of work defined in the Cross Section given under Schedule B of the Concession Agreement. The In-principal approval of the same under Change of Scope is still awaited from the Independent Engineer / Authority. However, keeping pending approval of Change of Scope, the work of soil nailing was commenced at Km. 246+700 in LHS by inserting 32mm dia. rods and partial work had been completed, further work could not be continued due to restriction of working space required for machinery movement for drilling & inserting the 6m long rod in cut section at height of 6m & above height.

In the meantime, unprecedented heavy & continues rains started in the said region and the land slide in certain sections took place, which was a purely "Natural Calamity" arising out due to incessant torrential rain, which was beyond our control.

It is also noticed due to continuous heavy rains, the small pockets of the cut sections collapses, for which one of the reason is seepage from the backside of hill i.e. from outside the ROW, which percolates through the hill.

Considering the above, we are hereby propose to have the slope of 1.5 (Vertical): 1(Horizontal) minimum to have more stable slope to avoid sliding, for which additional land varying from 15m to 50m width according the height of cutting at the locations mentioned in your letter, is required. The details enclosed under Annexure - 1.

You are hereby kindly requested to take up the matter with Authority to provide additional land by end of September 2017 by taking up the matter with State Government & Forest Department on TOP PRIORITY, so that the slopes are cut and protective measure are taken up immediately once the rainy season is over and completed prior to next rainy season.

You are also requested to convey the In-principle approval for additional works to be carried out by us for cutting of extra slopes and providing protective measures i.e. Soil Nailing, as the said works are additional works and beyond the Scope of Work defined in the Cross Section provided under Schedule B of the Concession Agreement.

Please note that the Concessionaire shall not be held responsible for untoward incidence / accident, if any take place, due to sliding of cut sections due to non-availability of adequate land as required.

An early action is solicited in this regard.

Thanking you,  
Yours Faithfully,

  
**J. P. Nandi**  
(Deputy Head Project Construction)

Encl.: As above.

- C.C.: - 1) GM (T) & Ro, Bangalore - For kind information and necessary action please.
- 2) The Project Director, National Highway Authority of India, (Ministry of Road Transport and Highways), Project Implementation Unit- Mangalore - For kind information and necessary action please.

|                       |          |
|-----------------------|----------|
| <b>AECOM RODIC JV</b> |          |
| Received              | 24/06/17 |
| Time:                 |          |
| By No.                | Dina     |
| Signature:            | Dina     |

**MODERN ROAD MAKERS PVT LTD**

Four Laning of Goa/ Karnataka Border to Kundapur Section of NH-17 from Km 93.700 to Km 283.300 in the State of Karnataka under NHDP phase IV on design, build, operate, transfer (DBFOT) toll basis

**Statement for Additional Land required for provision of stable slopes from Km.140+00 to Km.195+00**

| Sr.No  | Location           | Village Name                | From    | To      | Side | Length (Km) | Additional width required beyond PROW (M) | Total Area in Sqm |
|--|--------------------|-----------------------------|---------|---------|------|-------------|---|-------------------|
| 1  | 192+175            | Near colonel Hill, Honnavar | 191.950 | 192.175 | LHS  | 225.000     | 32.000                                    | 7,200.00          |
| 2  | 190+700            | Karki Naka                  | 190.600 | 190.800 | LHS  | 200.000     | 48.000                                    | 9,600.00          |
| 3  | 168+600            | Devgi                       | 168.600 | 168.800 | LHS  | 200.000     | 35.000                                    | 7,000.00          |
| 4  | 167+800            | Tandrakull, Devgi           | 167.700 | 167.800 | LHS  | 100.000     | 50.000                                    | 5,000.00          |
| 5  | 165+100            | Kachgal Sirsi Junction      | 165.050 | 165.200 | LHS  | 150.000     | 42.000                                    | 6,300.00          |
| 6  | 180+000            | Near Bargi                  | 159.900 | 160.100 | RHS  | 200.000     | 34.000                                    | 4,800.00          |
| 7  | 151+600 to 151+900 | Bafale Cross                | 151.600 | 151.900 | LHS  | 300.000     | 17.000                                    | 5,100.00          |
| 8  | 164+450            | Mirjan ( Opp Tourist Hotel) | 164.400 | 164.550 | LHS  | 150.000     | 15.000                                    | 2,250.00          |
| 9  | 165+600            | Mirjan, Khairi              | 165.550 | 165.650 | LHS  | 100.000     | 15.000                                    | 1,500.00          |
| 10   | 181+700            | Dhadeshwar                  | 181.550 | 181.700 | RHS  | 150.000     | 22.000                                    | 3,300.00          |
| <b>Total Additional area required for flatter Slope (1.5 : 1) beyond PROW in Sqm</b> |                    |                             |         |         |      |             |   | <b>52,050.00</b>  |

Mumbai Office:  
9-201, Universal Business Park, Kamani Oil Mill Road, Chondvli Estate, Andheri (E),  
Mumbai-400 072 ■ Tel: 91-22-6733 5900 ■ Fax: 91-22-6733 5905 ■ www.irb.co.in

CIN : U45400MH2012PTC234786  
IRBWTPL/CTO/KKBOT/2495/2017  
29/06/2017

To  
The Team Leader,  
M/s. AECOM Asia Company Ltd.,  
in association with Rodic Consultants Pvt. Ltd.,  
C/o Nagashree Building,  
Rajithagiri, KHB Colony,  
Honnagara – 581334 Uttara Kannada, Karnataka

**Project: -** Four Laning of Goa / Karnataka Border to Kundapur section of NH-17 from Km. 93.700 to Km. 283.300 in the state of Karnataka under NHDP Phase IV on Design, Build, Operate, Transfer (DBFOT) toll basis.

**Subject: -** Potential land slide during monsoon season - Additional Land required for provision of stable slopes from Km. 199+350 to Km. 208+500.

**Ref: -** 1] Your office letter no. AECOM/HWH/2017-18/GOA/2434, dated: 16.06.2017  
2] Our office letter no. IRBWTPL/CTO/KKBOT/2473/2017, dated: 22.06.2017.

Dear Sir,

This is in continuation of our office letter referred at Sr no. (2) cited above, we require additional land for provision of stable slopes from Km. 199+350 to Km. 208+500. So we hereby propose to have the slope of 1.5 (Vertical): 1(Horizontal) minimum to have more stable slope to avoid sliding, for which additional land varying from 15m to 50m width according the height of cutting at the locations mentioned in your letter, is required. The details enclosed under Annexure-I.

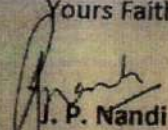
You are hereby kindly requested to take up the matter with Authority to provide additional land by end of September-2017 by taking up the matter with State Government & Forest Department on TOP PRIORITY, so that the slopes are cut and protective measure are taken up immediately once the rainy season is over and completed prior to next rainy season.

You are also requested to convey the In-principle approval for additional works to be carried out by us for cutting of extra slopes and providing protective measures i.e. Soil Nailing, as the said works are additional works and beyond the Scope of Work defined in the Cross Section provided under Schedule B of the Concession Agreement.

Please note that the Concessionaire shall not be held responsible for untoward incidence / accident, if any take place, due to sliding of cut sections due to non-availability of adequate land as required.

An early action is solicited in this regard.

Thanking you,  
Yours Faithfully,



J. P. Nandi  
(Deputy Head Project Construction)

Encl.: As above.

- CC.: - 1) GM (T) & Ro, Bangalore - For kind information and necessary action please.
- 2) The Project Director, National Highway Authority of India, (Ministry of Road Transport and Highways), Project Implementation Unit- Mangalore - For kind information and necessary action please.

|                       |   |
|-----------------------|---|
| <b>AECOM RODIC JV</b> |   |
| Received On:          | 29/06/17  |
| Time:                 |   |
| By Name:              | Dinpa   |
| Signature:            |  |

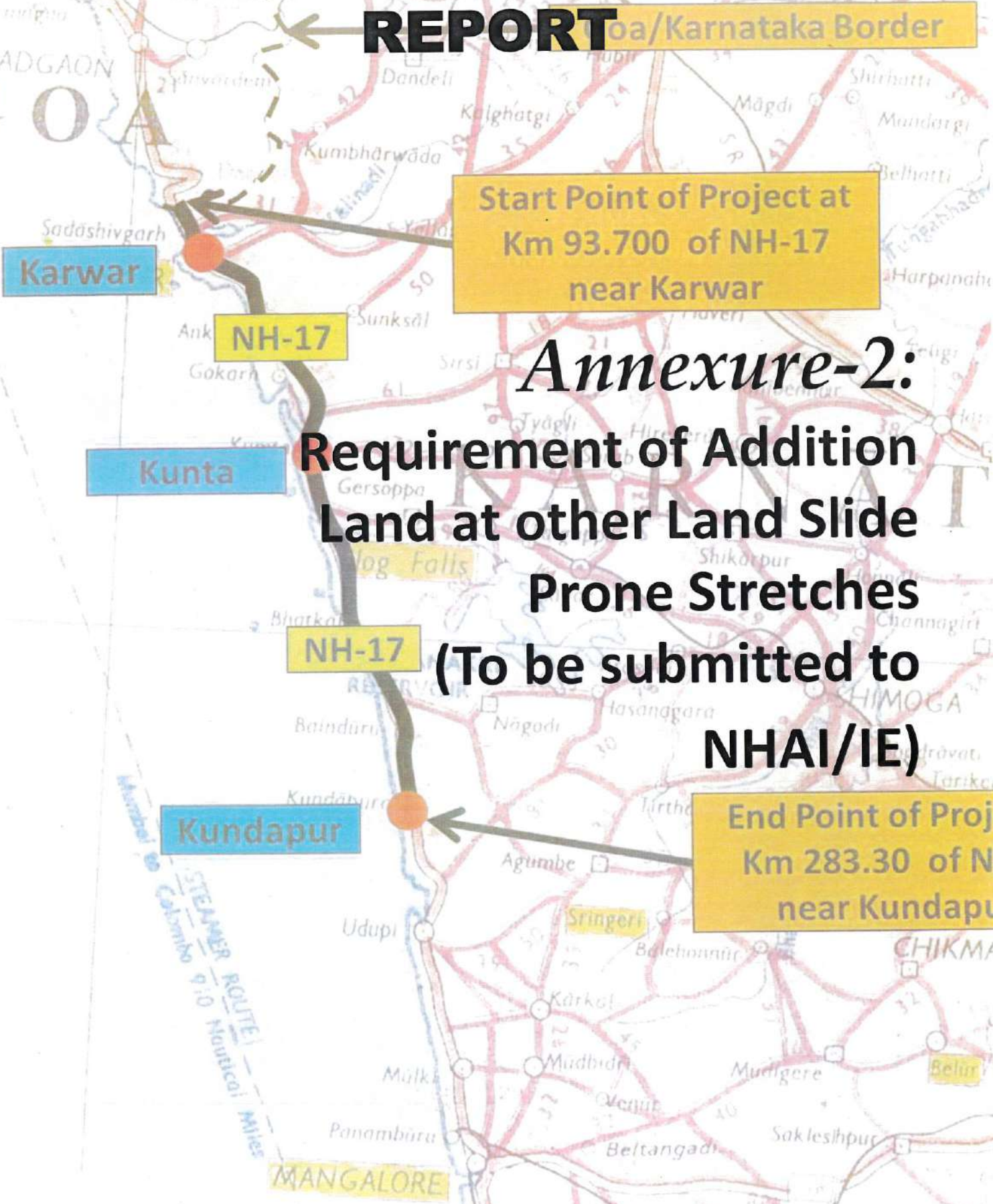
## MODERN ROAD MAKERS PVT LTD

Four Laning of Goa/ Karnataka Border to Kundapur Section of NH-17 from Km 99.700 to Km 289.300 in the State of Karnataka under NHDP phase IV on design, build, operate, transfer (DBFOT) toll basis

## Statement for Additional Land required for provision of stable slopes from Km.199+350 to Km.208+500

| Sr.No   | Location | Village Name            | From    | To      | Side | Length (Km) | Additional width required beyond PROW (M) | Total Area in Sqm |
|---|----------|-------------------------|---------|---------|------|-------------|---|-------------------|
| 1   | 199.440  | Kelaginoor              | 199.350 | 199.520 | RHS  | 170.000     | 35.500                                    | 6,035.00          |
| 2   | 199.740  | Kelaginoor(nagar cross) | 199.600 | 199.830 | RHS  | 230.000     | 25.500                                    | 5,865.00          |
| 3   | 199.940  | Kelaginoor              | 199.830 | 200.150 | RHS  | 320.000     | 48.500                                    | 15,520.00         |
| 4   | 202.400  | Gunavante               | 202.380 | 202.550 | RHS  | 170.000     | 11.500                                    | 1,955.00          |
| 5   | 208.460  | Manki                   | 208.370 | 208.500 | LHS  | 130.000     | 22.500                                    | 2,825.00          |
| Total Additional area required for flatter Slope (1.5 : 1) beyond PROW in Sqm |          |                         |         |         |      |             |   | 32,300.00         |

# ROAD SAFETY AUDIT REPORT

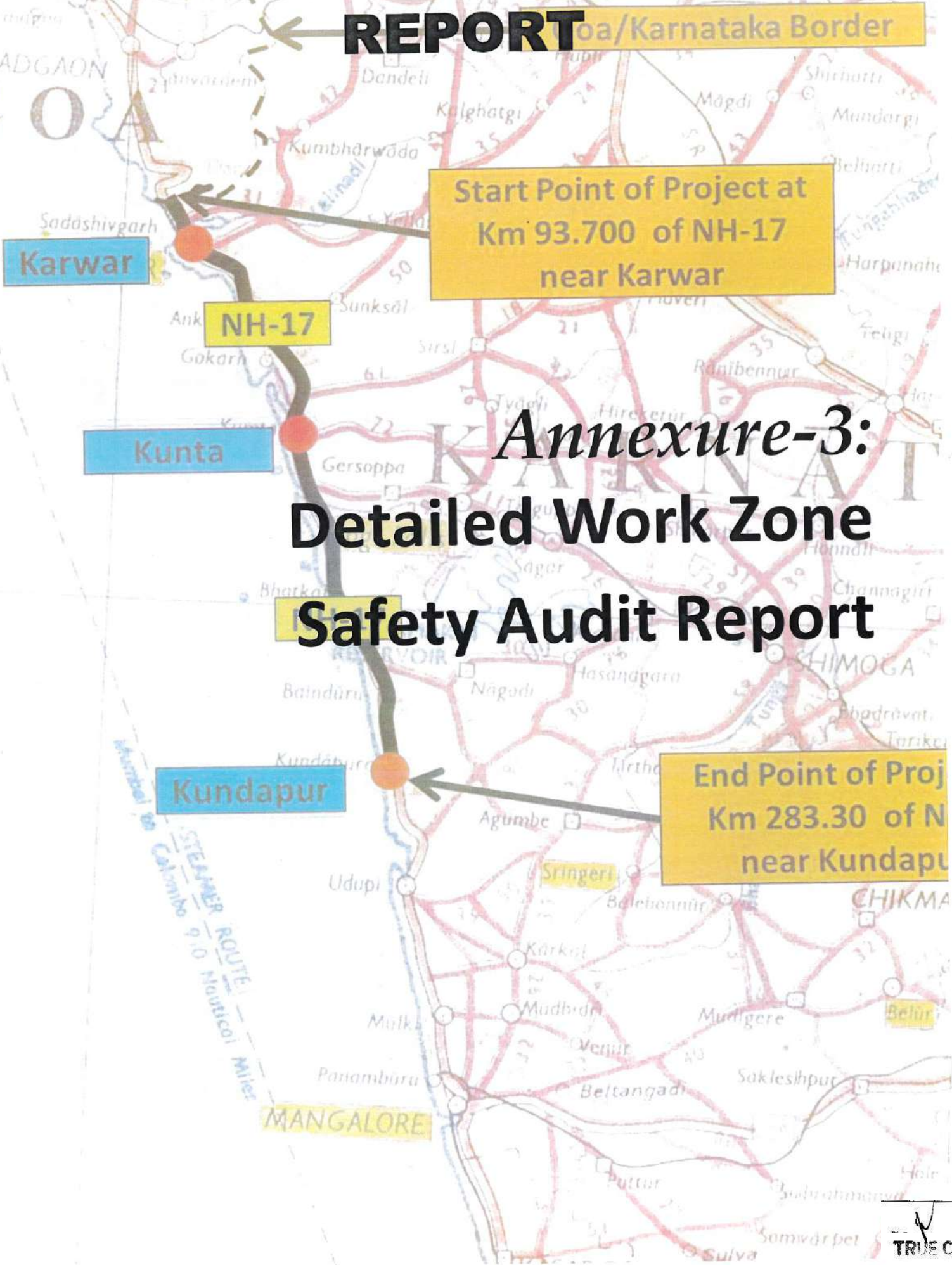


*Annexure-2:*  
**Requirement of Addition  
Land at other Land Slide  
Prone Stretches  
(To be submitted to  
NHAI/IE)**

| Annexure-2   |          |         |      |        |
|--|----------|---------|------|--------|
| Locations of extra land required beyond PROW to flattern cut slope |          |         |      |        |
| Sl. No.  | Chainage |         | Side | Length |
|  | From     | To      |      |        |
| 1  | 107+220  | 107+470 | LHS  | 250    |
| 2  | 107+400  | 107+470 | RHS  | 70     |
| 3  | 107+820  | 107+900 | BHS  | 80     |
| 4  | 110+000  | 110+300 | LHS  | 300    |
| 5  | 111+000  | 111+450 | LHS  | 450    |
| 6  | 111+750  | 111+900 | LHS  | 150    |
| 7  | 112+600  | 112+790 | LHS  | 190    |
| 8  | 123+450  | 124+700 | LHS  | 1250   |
| 9  | 123+950  | 124+100 | RHS  | 150    |
| 10   | 124+500  | 124+700 | RHS  | 200    |
| 11   | 127+400  | 127+500 | RHS  | 100    |
| 12   | 144+800  | 145+850 | BHS  | 1050   |
| 13   | 146+200  | 146+850 | BHS  | 650    |
| 14   | 146+900  | 147+100 | LHS  | 200    |
| 15   | 147+300  | 147+550 | BHS  | 250    |
| 16   | 147+600  | 148+000 | LHS  | 400    |
| 17   | 148+100  | 148+400 | LHS  | 300    |
| 18   | 148+800  | 149+000 | BHS  | 200    |
| 19   | 159+200  | 159+500 | BHS  | 300    |
| 20   | 168+050  | 168+250 | LHS  | 200    |
| 21   | 170+100  | 170+500 | LHS  | 400    |
| 22   | 208+020  | 208+140 | RHS  | 120    |
| 23   | 209+120  | 209+320 | LHS  | 200    |
| 24   | 230+780  | 230+900 | LHS  | 120    |
| 25   | 234+400  | 234+560 | RHS  | 160    |
| 26   | 245+100  | 245+550 | LHS  | 450    |







# ROAD SAFETY AUDIT REPORT









Appointment of Safety Consultant for 4-laning of Goa/ Karnataka Border to Kundapur Section from Km. 93.700 to Km. 283.300 of NH-17 in the state of Karnataka to be executed as BOT (Toll) on DBFO Pattern.

| Annexure-3: Detailed Work zone Safety Audit |          |   |  |  |
|---|----------|---|--|--|
| Sr. No.                                     | Chainage | Photographs   | Observations of Safety Consultant  | Recommendations of Safety Consultant   |
| 1   | 94+500   |    | Deep cut is observed at RHS side near diversion. Vehicle entering into work zone   | Provide barricading to keep away traffic from deep excavation. Close the work zone with barricade with retro reflective for night visibility |
| 2   | 95+610   |   | un authorized Median opening observed and minor road merging here  | Immediate closure of median opening is required to control the access at minor road providing speed breaker.                                 |
| 3   | 96+030   |  | Median opening formed unauthorized T-junction  | Immediate closure of median opening is required.   |
| 4   | 98+450   |  | Wrong sign board placed "Diversion Ahead" at Diversion. A minor road is meeting just after diversion at LHS side. Minor Road traffic is entering in very high speed at MCW and situation becomes hazard due to diversion location. | Replace sign board indicating "Take Diversion"<br>Provide speed breaker on minor road, so vehicle enters in slow speed at MCW.               |







Appointment of Safety Consultant for 4-laning of Goa/ Karnataka Border to Kundapur Section from Km. 93.700 to Km. 283.300 of NH-17 in the state of Karnataka to be executed as BOT (Toll) on DBFO Pattern.

| Annexure-3: Detailed Work zone Safety Audit |                    |   |   |   |
|---|--------------------|---|---|---|
| Sr. No.                                     | Chainage           | Photographs   | Observations of Safety Consultant   | Recommendations of Safety Consultant  |
| 5   | 101+700            |    | Other CW is not properly closed at diversion. It may hazards due to traffic is getting confuse just before diversion. | Other CW need to properly closed with adequate barricading and provide effective diversion sign board.      |
| 6   | 102+000 to 102+100 |   | Existing road is passing through high hillock. Pavement surface is found damaged                                      | Provide road delineators at both side of CW for better night visibility. Maintain existing pavement surface |
| 7   | 103+200            |  | Minor road meeting at MCW at very steep ascending grade.  | It should be closed or maintain properly. Provide speed breaker on minor road.                              |
| 8   | 112+000            |  | LHS side high hillock is observed with very big stone which may come in to MCW during heavy rain.                     | Provide cautionary sign board so that traffic can plying with caution.                                      |





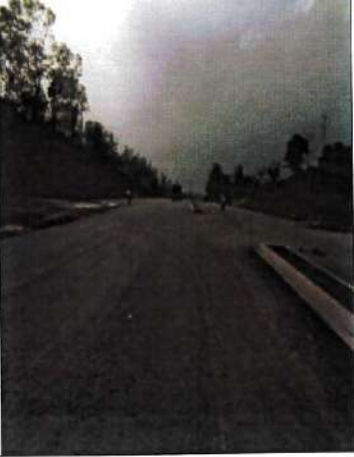

Appointment of Safety Consultant for 4-laning of Goa/ Karnataka Border to Kundapur Section from Km. 93.700 to Km. 283.300 of NH-17 in the state of Karnataka to be executed as BOT (Toll) on DBFO Pattern.

| Annexure-3: Detailed Work zone Safety Audit |          |   |  |  |
|---|----------|---|--|--|
| Sr. No.                                     | Chainage | Photographs   | Observations of Safety Consultant  | Recommendations of Safety Consultant   |
| 9   | 124+700  |    | Very sharp curve with high embankment at outer side.   | Provide delineators at outer edge of sharp curve.                            |
| 10  | 126+600  |   | Some signs are missing at diversion.   | Provide take diversion sign, barricading and advance warning sign.           |
| 11  | 130+100  |   | railing of existing bridge damaged and not effective during night  | Safety Measures with reflective tape to be provided.                         |
| 12  | 132+000  |   | High embankment is observed  | Provide delineators to keep away traffic from high embankment edge.          |
| 13  | 134+900  |   | Existing road condition is very poor. barricading is missing at diversion  | Maintain existing pavement surface. Provide barricading at diversion         |
| 14  | 138+000  |  | A minor road is meeting just after diversion. Minor Road traffic is entering in very high speed at MCW and situation becomes hazard due to diversion location. | Provide speed breaker on minor road, so vehicle enters in slow speed at MCW. |
| 15  | 138+200  |   | RHS side 2 minor road meeting (in very steep ascending grade) with MCW at short interval   | Provide speed Breaker on minor roads.  |








Appointment of Safety Consultant for 4-laning of Goa/ Karnataka Border to Kundapur Section from Km. 93.700 to Km. 283.300 of NH-17 in the state of Karnataka to be executed as BOT (Toll) on DBFO Pattern.

| Annexure-3: Detailed Work zone Safety Audit |                    |   |   |   |
|---|--------------------|---|---|---|
| Sr. No.                                     | Chainage           | Photographs   | Observations of Safety Consultant   | Recommendations of Safety Consultant  |
| 16  | 141+000 to 141+250 |   | Level difference between new and existing CW.   | Provide reflective tape/delineators at kerb of upper side CW.                     |
| 17  | 142+200            |   | Both side cross road meeting with MCW with very steep descending grade. Also there is median opening is provided which creates dangerous. | Provide speed breaker on minor road, so that vehicles enters in slow speed at MCW |
| 18  | 142+400            |   | Minor road merging with steep downward slope. Shoulder on curve is not compacted.   | Shoulder on curve is need to be compacted(LHS)                                    |
| 19  | 146+000            |  | Existing pavement condition is found very poor  | Maintain existing pavement surface.   |







Appointment of Safety Consultant for 4-laning of Goa/ Karnataka Border to Kundapur Section from Km. 93.700 to Km. 283.300 of NH-17 in the state of Karnataka to be executed as BOT (Toll) on DBFO Pattern.

| Annexure-3: Detailed Work zone Safety Audit |          |   |   |   |
|---|----------|---|---|---|
| Sr. No.                                     | Chainage | Photographs   | Observations of Safety Consultant   | Recommendations of Safety Consultant  |
| 20  | 147+350  |    | Minor road (almost parallel to MCW alignment) is meeting with MCW                             | Provide speed Breaker on minor roads  |
| 21  | 149+240  |   | A minor road (having very steep ascending grade) is meeting with MCW having very sharp curve. | Provide speed Breaker on minor roads  |
| 22  | 149+350  |   | railing of existing bridge damaged and not effective during night                             | Provide safety measures and reflective tape for better night visibility.  |
| 23  | 151+200  |   | High embankment along the road  | delineators needs to be provided along the road (LHS)   |
| 24  | 151+580  |  | Steep vertical cutting at LHS side.   | It is recommended that the Concessionaire shall construct <b>gentle cut slope instead of steep cut to avoid land slide</b> . As reported by the Concessionaire, land is not available to carryout gentle slope at steep hill cut locations mostly being Forest lands. It is |





Appointment of Safety Consultant for 4-laning of Goa/ Karnataka Border to Kundapur Section from Km. 93.700 to Km. 283.300 of NH-17 in the state of Karnataka to be executed as BOT (Toll) on DBFO Pattern.

| Annexure-3: Detailed Work zone Safety Audit |          |   |   |  |
|---|----------|---|---|--|
| Sr. No.                                     | Chainage | Photographs   | Observations of Safety Consultant   | Recommendations of Safety Consultant   |
|   |          |   |   | observed during safety audit at site that Concessionaire has tried their best to flatten the cut slope in the land made available to them.   |
| 25  | 156+800  |   | Both side traffic is playing on LHS side newly constructed CW which having vertical curve with poor sight distance. | Provide no overtaking sign board.  |
| 26  | 158+900  |   | RHS side deep cut is observed between MCW and shoulder  | Provide shoulder filling with required compaction  |
| 27  | 160+000  |  | Steep vertical cutting at RHS side.   | It is recommended that the Concessionaire shall construct <b>gentle cut slope instead of steep cut to avoid land slide</b> . As reported by the Concessionaire, land is not available to carryout gentle slope at steep hill cut locations mostly being Forest lands. It is observed during safety audit at site that Concessionaire has tried their best to flatten the cut slope in the land made available to them. |






Appointment of Safety Consultant for 4-laning of Goa/ Karnataka Border to Kundapur Section from Km. 93.700 to Km. 283.300 of NH-17 in the state of Karnataka to be executed as BOT (Toll) on DBFO Pattern.

| Annexure-3: Detailed Work zone Safety Audit |          |             |   |   |
|---|----------|-------------|---|---|
| Sr. No.                                     | Chainage | Photographs | Observations of Safety Consultant   | Recommendations of Safety Consultant  |
| 28  | 160+500  |             | A minor road is meeting (having steep descending grade) just after diversion. Minor Road traffic is entering in very high speed at MCW and situation becomes hazard due to diversion location. Few sign boards are missing at diversion. Median Opening is proposed at this location. | Provide speed breaker on minor road, so that vehicle can enter in slow speed at MCW. Missing diversion sign, barricading shall be provided.   |
| 29  | 161+000  |             | Very high embankment is observed at approach of existing bridge   | Provide delineators to keep away traffic from high embankment   |
| 30  | 163+850  |             | barricading is missing at diversion   | Provide missing barricading boards at diversion   |
| 31  | 164+600  |             | Steep vertical cutting at LHS side.   | It is recommended that the Concessionaire shall construct <b>gentle cut slope instead of steep cut to avoid land slide</b> . As reported by the Concessionaire, land is not available to carryout gentle slope at steep hill cut locations mostly being Forest lands. It is observed during safety audit at site that Concessionaire has tried their best to flatten the cut slope in |






Appointment of Safety Consultant for 4-laning of Goa/ Karnataka Border to Kundapur Section from Km. 93.700 to Km. 283.300 of NH-17 in the state of Karnataka to be executed as BOT (Toll) on DBFO Pattern.

| Annexure-3: Detailed Work zone Safety Audit |          |   |                                     |  |
|---|----------|---|-------------------------------------|--|
| Sr. No.                                     | Chainage | Photographs   | Observations of Safety Consultant   | Recommendations of Safety Consultant   |
|   |          |   |                                     | the land made available to them.   |
| 32  | 165+000  |  | Steep vertical cutting at LHS side. | It is recommended that the Concessionaire shall construct <b>gentle cut slope instead of steep cut to avoid land slide</b> . As reported by the Concessionaire, land is not available to carryout gentle slope at steep hill cut locations mostly being Forest lands. It is observed during safety audit at site that Concessionaire has tried their best to flatten the cut slope in the land made available to them. |
| 33  | 166+100  |   | Steep vertical cutting at LHS side. | It is recommended that the Concessionaire shall construct <b>gentle cut slope instead of steep cut to avoid land slide</b> . As reported by the Concessionaire, land is not available to carryout gentle slope at steep hill cut locations mostly being Forest lands. It is observed during safety audit at site that Concessionaire has tried their best to flatten the cut slope in the land made available to them. |








Appointment of Safety Consultant for 4-laning of Goa/ Karnataka Border to Kundapur Section from Km. 93.700 to Km. 283.300 of NH-17 in the state of Karnataka to be executed as BOT (Toll) on DBFO Pattern.

| Annexure-3: Detailed Work zone Safety Audit |          |   |   |  |
|---|----------|---|---|--|
| Sr. No.                                     | Chainage | Photographs   | Observations of Safety Consultant                             | Recommendations of Safety Consultant   |
| 34  | 166+700  |   | Steep vertical cutting at LHS side.                           | It is recommended that the Concessionaire shall construct <b>gentle cut slope instead of steep cut to avoid land slide</b> . As reported by the Concessionaire, land is not available to carryout gentle slope at steep hill cut locations mostly being Forest lands. It is observed during safety audit at site that Concessionaire has tried their best to flatten the cut slope in the land made available to them. |
| 35  | 167+700  |  | Steep vertical cutting at LHS side. Accident Prone location.  | It is recommended that the Concessionaire shall construct <b>gentle cut slope instead of steep cut to avoid land slide</b> . As reported by the Concessionaire, land is not available to carryout gentle slope at steep hill cut locations mostly being Forest lands. It is observed during safety audit at site that Concessionaire has tried their best to flatten the cut slope in the land made available to them. |
| 36  | 167+800  |   | High embankment is observed at inner side of horizontal curve | Provide delineators to keep away traffic from high embankment  |






Appointment of Safety Consultant for 4-laning of Goa/ Karnataka Border to Kundapur Section from Km. 93.700 to Km. 283.300 of NH-17 in the state of Karnataka to be executed as BOT (Toll) on DBFO Pattern.

| Annexure-3: Detailed Work zone Safety Audit |          |   |  |  |
|---|----------|---|--|--|
| Sr. No.                                     | Chainage | Photographs   | Observations of Safety Consultant  | Recommendations of Safety Consultant   |
| 37  | 167+850  |    | Steep vertical cutting at LHS side.  | It is recommended that the Concessionaire shall construct <b>gentle cut slope instead of steep cut to avoid land slide</b> . As reported by the Concessionaire, land is not available to carryout gentle slope at steep hill cut locations mostly being Forest lands. It is observed during safety audit at site that Concessionaire has tried their best to flatten the cut slope in the land made available to them. |
| 38  | 169+000  |  | A minor road is meeting at LHS side just near to diversion. Minor Road traffic is entering in very high speed at MCW and situation becomes hazard due to diversion location. | Provide speed breaker on minor road, so that vehicle can enter in slow speed at MCW.   |
| 39  | 170+250  |  | Steep vertical cutting at LHS side.  | It is recommended that the Concessionaire shall construct <b>gentle cut slope instead of steep cut to avoid land slide</b> . As reported by the Concessionaire, land is not available to carryout gentle slope at steep hill cut locations mostly being Forest lands. It is observed during safety audit at site   |







Appointment of Safety Consultant for 4-laning of Goa/ Karnataka Border to Kundapur Section from Km. 93.700 to Km. 283.300 of NH-17 in the state of Karnataka to be executed as BOT (Toll) on DBFO Pattern.

| Annexure-3: Detailed Work zone Safety Audit |          |   |   |  |
|---|----------|---|---|--|
| Sr. No.                                     | Chainage | Photographs   | Observations of Safety Consultant                                   | Recommendations of Safety Consultant   |
|   |          |   |   | that Concessionaire has tried their best to flatten the cut slope in the land made available to them.  |
| 40  | 180+700  |   | Steep vertical cutting.   | It is recommended that the Concessionaire shall construct <b>gentle cut slope instead of steep cut to avoid land slide</b> . As reported by the Concessionaire, land is not available to carryout gentle slope at steep hill cut locations mostly being Forest lands. It is observed during safety audit at site that Concessionaire has tried their best to flatten the cut slope in the land made available to them. |
| 41  | 183+465  |   | railing of existing bridge damaged and not effective during night   | Provide Safety measures & reflective tape for better night visibility.   |
| 42  | 186+900  |  | Shoulder is not compacted adequately , A truck is stuck on shoulder | Shoulder is need to be compacted adequately  |
| 43  | 187+400  |   | Temple is located at median side of newly constructed CW.           | Provide reflective tap at wall of temple for better night visibility.  |








Appointment of Safety Consultant for 4-laning of Goa/ Karnataka Border to Kundapur Section from Km. 93.700 to Km. 283.300 of NH-17 in the state of Karnataka to be executed as BOT (Toll) on DBFO Pattern.

| Sr. No. | Chainage | Photographs   | Observation/Summary   | Recommendations/Requirements   |
|---------|----------|---|---|--|
| 44      | 190+700  |    | Steep vertical cutting at LHS side.                               | It is recommended that the Concessionaire shall construct <b>gentle cut slope instead of steep cut to avoid land slide</b> . As reported by the Concessionaire, land is not available to carryout gentle slope at steep hill cut locations mostly being Forest lands. It is observed during safety audit at site that Concessionaire has tried their best to flatten the cut slope in the land made available to them. |
| 45      | 192+000  |  | A minor road is meeting (having steep descending grade) with MCW. | Provide speed breaker so that traffic from minor road can enter in slow speed at MCW.  |
| 46      | 196+000  |   | High embankment is observed at MCW                                | Provide delineators to keep away traffic from high embankment  |
| 47      | 197+000  |   | Cattles are observed along the MCW                                | Make suitable arrangement  |








Appointment of Safety Consultant for 4-laning of Goa/ Karnataka Border to Kundapur Section from Km. 93.700 to Km. 283.300 of NH-17 in the state of Karnataka to be executed as BOT (Toll) on DBFO Pattern.

| Sr. No. | Chainage | Photographs   | Observation/Summary                            | Recommendations/Requirements   |
|---------|----------|---|--|--|
| 48      | 197+400  |    | Land slide prone area is observed              | It is recommended that the Concessionaire shall construct <b>gentle cut slope instead of steep cut to avoid land slide</b> . As reported by the Concessionaire, land is not available to carryout gentle slope at steep hill cut locations mostly being Forest lands. It is observed during safety audit at site that Concessionaire has tried their best to flatten the cut slope in the land made available to them. |
| 49      | 198+100  |  | Unauthorized median opening is observed        | It is recommended that close the median immediately.   |
| 50      | 199+800  |  | High embankment is observed at RHS side of MCW | Provide close delineators to keep away traffic from high embankment edge.  |
| 51      | 203+300  |   | High embankment is observed at RHS side of MCW | Provide delineators to keep away traffic from high embankment  |









Appointment of Safety Consultant for 4-laning of Goa/ Karnataka Border to Kundapur Section from Km. 93.700 to Km. 283.300 of NH-17 in the state of Karnataka to be executed as BOT (Toll) on DBFO Pattern.

| Sr. No. | Chainage | Photographs   | Observation/Summary   | Recommendations/Requirements  |
|---------|----------|---|---|---|
| 52      | 205+200  |    | Minor road meeting with MCW and sight distance obstructing by existing buildings. | Provide speed breaker on minor road.  |
| 53      | 206+100  |   | Deep cuts are observed at near Culvert.   | Provide barricading to keep away traffic from deep cut.   |
| 54      | 208+000  |  | Land slide prone area is observed   | It is recommended that the Concessionaire shall construct <b>gentle cut slope instead of steep cut to avoid land slide</b> . As reported by the Concessionaire, land is not available to carry out gentle slope at steep hill cut locations mostly being Forest lands. It is observed during safety audit at site that Concessionaire has tried their best to flatten the cut slope in the land made available to them. |








Appointment of Safety Consultant for 4-laning of Goa/ Karnataka Border to Kundapur Section from Km. 93.700 to Km. 283.300 of NH-17 in the state of Karnataka to be executed as BOT (Toll) on DBFO Pattern.

| Sr. No. | Chainage | Photographs   | Observation/Summary  | Recommendations/Requirements   |
|---------|----------|---|--|--|
| 55      | 209+00   |    | Deep excavation near MCW   | Concessionaire is filling up the deep cut by GSB material at this location.            |
| 56      | 210+600  |   | A fatal accident is reported due to overtaking.                            | Provide no overtaking sign, speed limit board of 40km/h                                |
| 57      | 211+500  |  | A board of village name very near to carriageway without retro reflection. | Remove and replace at suitable location.   |
| 58      | 215+500  |   | Deep cuts are observed at RHS of MCW                                       | Provide barricading/delineators to keep away traffic from deep cut.                    |
| 59      | 221+400  |  | It is observed that barricading are not provide properly to close the CW.  | Provide adequate barricading so that traffic movement safely pass from work zone area. |
| 60      | 222+800  |   | Deep excavation is observed at RHS of MCW                                  | Provide barricading/delineators to keep away traffic from deep cut.                    |
| 61      | 226+900  |   | deep excavation near   | Provide barricading  |








Appointment of Safety Consultant for 4-laning of Goa/ Karnataka Border to Kundapur Section from Km. 93.700 to Km. 283.300 of NH-17 in the state of Karnataka to be executed as BOT (Toll) on DBFO Pattern.

| Sr. No. | Chainage | Photographs   | Observation/Summary                             | Recommendations/Requirements   |
|---------|----------|---|---|--|
|         |          |   | Culvert   | /delineators to keep away traffic from deep cut.   |
| 62      | 232+800  |    | High embankment and sharp curve is observed     | Provide barricading / delineators to keep away traffic from high embankment  |
| 63      | 234+400  |   | High embankment is observed                     | Provide delineators to keep away traffic from high embankment  |
| 64      | 240+000  |   | High embankment is observed at LHS side of MCW  | Provide delineators to keep away traffic from high embankment.   |
| 65      | 245+000  |  | High embankment is observed at RHS side of MCW. | Provide delineators to keep away traffic from high embankment.   |
| 66      | 246+000  |  | Land slide prone area is observed.              | It is recommended that the Concessionaire shall construct <b>gentle cut slope instead of steep cut to avoid land slide</b> . As reported by the Concessionaire, land is not available to carryout gentle slope at steep hill cut locations mostly being Forest lands. It is observed during safety audit at site that Concessionaire |








Appointment of Safety Consultant for 4-laning of Goa/ Karnataka Border to Kundapur Section from Km. 93.700 to Km. 283.300 of NH-17 in the state of Karnataka to be executed as BOT (Toll) on DBFO Pattern.

| Sr. No. | Chainage | Photographs   | Observation/Summary   | Recommendations/Requirements  |
|---------|----------|---|---|---|
|         |          |    |   | has tried their best to flatten the cut slope in the land made available to them. |
| 67      | 247+000  |   | RHS rain cut are observed at shoulder at high embankment          | Provide barricading/delineators to keep away traffic from high embankment         |
| 68      | 250+625  |   | Railing is absent on existing bridge.                             | It is recommended to provide railing on the bridge.                               |
| 69      | 253+550  |   | Some sign board are missing at diversion.                         | It is recommended to provide proper diversion.                                    |
| 70      | 256+600  |  | High embankment is observed at RHS side of MCW                    | Provide delineators to keep away traffic from high embankment.                    |
| 71      | 256+700  |   | railing of existing bridge damaged and not effective during night | Provide safety measures & reflective tape for better night visibility.            |









Appointment of Safety Consultant for 4-laning of Goa/ Karnataka Border to Kundapur Section from Km. 93.700 to Km. 283.300 of NH-17 in the state of Karnataka to be executed as BOT (Toll) on DBFO Pattern.

| Sr. No. | Chainage | Photographs   | Observation/Summary                                    | Recommendations/Requirements                                       |
|---------|----------|---|--|--|
| 72      | 259+350  |    | Few sign board are missing at diversion.               | Provide take diversion sign, barricading and advance warning sign. |
| 73      | 260+350  |   | Few sign board are not provided at diversion.          | Provide take diversion sign, barricading and advance warning sign. |
| 74      | 259+400  |   | RHS side deep cut is observed between MCW and shoulder | Provide barricading to keep away traffic from deep cut.            |
| 75      | 261+320  |  | Unauthorised median cuts are observed.                 | The unauthorised median cut must be closed immediately.            |
| 76      | 262+700  |   | Some sign board are missing at diversion.              | Provide take diversion sign, barricading and advance warning sign. |








Appointment of Safety Consultant for 4-laning of Goa/ Karnataka Border to Kundapur Section from Km. 93.700 to Km. 283.300 of NH-17 in the state of Karnataka to be executed as BOT (Toll) on DBFO Pattern.

| Sr. No. | Chainage          | Photographs   | Observation/Summary  | Recommendations/Requirements  |
|---------|-------------------|---|--|---|
| 77      | 267+00 to 267+650 |    | Road is passing very near to beach at appx 300-400m length. Large number of trucks and tourist vehicle are stopped and parked at/very near to MCW. | Provide speed limit sign board before this location.  |
| 78      | 269+750/269+850   |   | Few sign board are missing at diversion.   | Provide missing signs, like barricading and advance warning sign.   |
| 79      | 271+950           |   | Few sign board are missing at diversion toward Kundapur side.  | Provide take diversion sign, barricading and advance warning sign.  |
| 80      | 271+200           |  | Deep excavation is observed at RHS side of MCW   | Provide barricading to keep away traffic from deep excavation.  |
| 81      | 272+850           |  | railing of existing bridge damaged and not effective during night<br>Very high embankment is observed at approach of existing bridge               | Provide safety measures & reflective tape for better night visibility.<br>Provide delineators to keep away traffic from high embankment |





Appointment of Safety Consultant for 4-laning of Goa/ Karnataka Border to Kundapur Section from Km. 93.700 to Km. 283.300 of NH-17 in the state of Karnataka to be executed as BOT (Toll) on DBFO Pattern.

| Sr. No. | Chainage | Photographs   | Observation/Summary  | Recommendations/Requirements  |
|---------|----------|---|--|---|
| 82      | 276+750  |   | railing of existing bridge damaged and not effective during night<br>Very high embankment is observed at approach of existing bridge | Provide Safety measures and reflective tape for better night visibility.<br>Provide delineators to keep away traffic from high embankment             |
| 83      | 277+500  |   | A minor road is meeting (having steep descending grade) with MCW.  | Provide speed breaker so that traffic from minor road can enter in slow speed at MCW.   |
| 84      | 278+530  |  | railing of existing bridge damaged and not effective during night<br>Very high embankment is observed at approach of existing bridge | Provide safety measures and reflective tape for better night visibility.<br>Provide barricading/delineators to keep away traffic from high embankment |
| 85      | 279+540  |  | railing of existing bridge damaged and not effective during night<br>Very high embankment is observed at approach of existing bridge | Provide Safety measures and reflective tape for better night visibility.<br>Provide barricading/delineators to keep away traffic from high embankment |



# ANNEXURE R-5

108

**AECOM**



In association with

Ref: AECOM/HWH/2018-19/GOA/3167

O/o Construction Supervision Consultants  
Nagashree Building, Rajithagiri,  
KHB Colony, Honnavara-581334  
Uttara Kannada(Dist), Karnataka  
[www.aecom.com](http://www.aecom.com) and [www.rodiconsultants.com](http://www.rodiconsultants.com)

Date: 15/06/2018

To,  
The Project Director  
National Highways Authority of India  
Project Implementation Unit  
Door No.3-29, Bethel,  
Tharethota, Near Pumpwell (NH-66)  
Mangalore - 57505

*Handwritten signature and date: 15/06/18*

**Subject:** Four Laning of Goa/Karnataka border – Kundapur Section of NH-17 (Now NH 66) from Km.93.700 to km.283.300 in the state of Karnataka under NHDP phase IV on design build Operate Transfer (DBFOT) toll basis- Additional land required for making the slope stable as suggested by prof. Sh. T.G. Sitaram -reg.

Ref: IRB letter No. IRBWTPL/CTO/KKBOT/3021/2018 dated 16/04/2018 received 18.04.2018

Dear Sir,

We are in receipt of concessionaire letter no IRB letter No. IRBWTPL/CTO/KKBOT/3021/2018 dated 16/04/2018 received on 18.04.2018 we have gone through content of letter where in the concessionaire has assessed the additional forest land required is 27.015 Ha.

The enclosed list along with this letter is found in order.

This is for your kind information and necessary action.

Thanking you

Yours faithfully,  
For AECOM Asia Company Ltd. In Association with  
Rodie Consultants Pvt Ltd

*(Handwritten signature of Kiran S. Vishwaroop)*  
(Kiran S. Vishwaroop)  
Team Leader

Encl: As stated above.

Cc: 1 The Project Manager, IRB weastcost Pvt.Ltd, Kumta.  
2. AECOM Asia Company Ltd, Gurgaon.  
3. Rodie Consultants Pvt. Ltd. Gurgaon.

-For your kind information.

TRUE COPY

# RB Westcoast Tollway Pvt. Ltd.

Corporate Office:

3rd Floor, IRB Complex, Chandivali Farm, Chandivali Village, Andheri (E), Mumbai - 400 072.  
Tel: 91 - 22 - 6640 4220 • Fax: 91 - 22 - 6675 1024 • e-mail: info@irb.co.in • www.irb.co.in  
CIN : U45400MH2012PTC234786

A subsidiary of

**IRB**  
INFRASTRUCTURE DEVELOPERS LTD

IRBWTPL/CTO/KKBOT/3201/2018

16/04/2018

To,

The Project Director,  
National Highways Authority of India,  
(Ministry of Road Transport and Highways),  
Project Implementation Unit - Mangalore,  
Door No. 3-29, Bethel, Tharehota, Near Pumpwell (NH-66),  
Mangalore-575005

**Project** : Four Laning of Goa/Karnataka Border to Kundapur Section of NH-17 from Km. 93.700 to Km. 283.300 in the State of Karnataka under NHDP Phase-IV on Design, Build, Operate, and Transfer (DBFOT) Toll Basis.

**Subject** : Additional land required for making the slope stable as suggested by Prof. Sh. T.G. Sitaram.

**Ref** :1] IE letter no. AECOM/HWH/2017-18/GOA/2424, dated: 13.06.2017.  
2] IE letter no. AECOM/HWH/2017-18/GOA/2480, dated: 10.07.2017.  
3] Our office letter no. IRBWTPL/CTO/KKBOT/2536/2017, dated: 12.07.2017.  
4] IE letter no. AECOM/HWH/2017-18/GOA/2689, dated: 06.11.2017.  
5] Our office letter no. IRBWTPL/CTO/KKBOT/2816/2017, dated: 08.11.2017.  
6] IE letter no. AECOM/HWH/2017-18/GOA/2659, dated: 10.10.2017.  
7] IE letter no. AECOM/HWH/2017-18/GOA/2740, dated: 28.11.2017.  
8] IE letter no. AECOM/HWH/2017-18/GOA/2805, dated: 26.12.2017.  
9] Our office letter no. IRBWTPL/CTO/KKBOT/3132/2018, dated: 17.03.2018.

Dear Sir,

This is with reference to the subject & letters cited above. Referring to the contents of the letter of the Independent Engineer referred at Sr no. (8) above it is noticed that the total additional area required for stable slope proposed by the Independent Engineer is 29.156 Ha.

Further we have assessed the requirement of additional land as per the requirement of site in correlation with the letter of the Independent Engineer which works out to 27.015 Ha (Statement enclosed for reference).

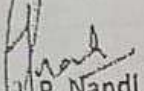
Please note that the assessment is done division wise as we need to acquire the land from the forest department. It is hereby requested to your good self to kindly take up the matter with the offices of the concerned DCF and write letter from your end to concerned DCF's so that the

Registered Office: Wing - A, 2<sup>nd</sup> Floor, Office No. 201, Universal Business Park,  
Chandivali Farm Road, Off Saki Vihar Road, Andheri (E), Mumbai 400 072  
Tel: 91-22-6733 6400 • Fax: 91-22-6733 6440 • e-mail: info@irb.co.in • www.irb.co.in

process of handing over of the forest land can be commenced from the forest department as the procedure itself is time consuming and a lengthy process.


This is for your information & further necessary action.

Thanking you,  
Yours faithfully,

  
P. Nandi  
(Deputy Head Project Construction)

Encl.: As stated above.

CC: The Team Leader, AECOM Asla Company Ltd.: For kind information.

|                       |   |
|-----------------------|---|
| <b>AECOM RODIC JV</b> |   |
| Received              | 18/04/18  |
| Time:                 |   |
| By Name:              | Pradeep   |
| Signature:            |  |

IRB Westcoast Tollway Pvt. Ltd  
 Inning of Goa Karnataka Border to Kundapur Section of NH 17 from 93.70 to km 283.100 in the state of Karnataka under NHDP phase IV on design build, operate, transfer (DBFOT) toll basis.

Statement showing details of additional land required for Provision of Stable slopes (1.5 H : 1 V)  
 Proposed by AECOM (Independent Engineer)

| No  | District | Taluk  | Village  | Forest Survey Numbers | From    | To      | Side | Length (m) | Additional width required beyond PROW (m) | Total Area In Sqm |
|---|----------|--------|----------|-----------------------|---------|---------|------|------------|---|-------------------|
| <b>Karwar Forest Division</b>               |          |        |          |                       |         |         |      |            |   |                   |
|   |          |        |          |                       |         |         |      |            | 15  | 375               |
| 1   | U.K      | Karwar | Baad     | 1445A                 | 107.220 | 107.245 | LHS  | 25         | 15  | 3150              |
| 2   | U.K      | Karwar | Baad     | 1336                  | 107.245 | 107.455 | LHS  | 210        | 15  | 225               |
| 3   | U.K      | Karwar | Baad     | 1376                  | 107.455 | 107.470 | LHS  | 15         | 15  | 825               |
| 4   | U.K      | Karwar | Baad     | 1336                  | 107.400 | 107.455 | RHS  | 55         | 15  | 225               |
| 5   | U.K      | Karwar | Baad     | 1376                  | 107.455 | 107.470 | RHS  | 15         | 15  | 4800              |
|   |          |        |          |                       | TOTAL   |         |      |            |   |                   |
| 6   | U.K      | Karwar | Binaga   | 16A1A                 | 107.820 | 107.900 | LHS  | 80         | 15  | 1200              |
| 7   | U.K      | Karwar | Binaga   | 16A1A                 | 107.820 | 107.900 | RHS  | 80         | 15  | 1650              |
| 8   | U.K      | Karwar | Binaga   | 9A1                   | 109.850 | 109.960 | LHS  | 110        | 15  | 4050              |
|   |          |        |          |                       | TOTAL   |         |      |            |   |                   |
| 9   | U.K      | Karwar | Arga     | 52A1A                 | 109.960 | 110.000 | LHS  | 40         | 15  | 600               |
| 10  | U.K      | Karwar | Arga     | 52A1A                 | 110.000 | 110.160 | LHS  | 160        | 15  | 2400              |
| 11  | U.K      | Karwar | Arga     | 52A1A                 | 110.160 | 110.790 | LHS  | 630        | 15  | 9450              |
| 12  | U.K      | Karwar | Arga     | 52A1A                 | 111.100 | 111.450 | LHS  | 350        | 15  | 5250              |
| 13  | U.K      | Karwar | Arga     | 52A1A                 | 111.750 | 111.900 | BHS  | 300        | 15  | 4500              |
| 14  | U.K      | Karwar | Arga     | 66A1A                 | 112.600 | 112.790 | LHS  | 190        | 15  | 2850              |
|   |          |        |          |                       | TOTAL   |         |      |            |   | 25050             |
| 15  | U.K      | Karwar | Amdalli  | 489A1                 | 123.450 | 124.700 | LHS  | 1250       | 15  | 18750             |
| 16  | U.K      | Karwar | Amdalli  | 489A1                 | 123.950 | 124.100 | RHS  | 150        | 15  | 2250              |
| 17  | U.K      | Karwar | Amdalli  | 489A1                 | 124.460 | 124.500 | RHS  | 40         | 15  | 600               |
| 18  | U.K      | Karwar | Amdalli  | 489A1                 | 124.620 | 124.700 | RHS  | 80         | 15  | 1200              |
|   |          |        |          |                       | TOTAL   |         |      |            |   | 22800             |
| 19  | U.K      | Ankola | Harwada  | 169                   | 127.400 | 127.490 | RHS  | 90         | 15  | 1350              |
|   |          |        |          |                       | TOTAL   |         |      |            |   | 1350              |
| 20  | U.K      | Ankola | Aversa   | 300A                  | 127.490 | 127.500 | RHS  | 10         | 15  | 150               |
|   |          |        |          |                       | TOTAL   |         |      |            |   | 150               |
| 21  | U.K      | Ankola | Shedgeri | 108A                  | 136.520 | 136.640 | LHS  | 120        | 15  | 1800              |
| 22  | U.K      | Ankola | Shedgeri | 108A                  | 136.520 | 136.640 | RHS  | 120        | 15  | 1800              |
| 23  | U.K      | Ankola | Shedgeri | 319A1A1A1A            | 144.800 | 145.650 | RHS  | 850        | 15  | 12750             |
|   |          |        |          |                       | TOTAL   |         |      |            |   | 16350             |
| 24  | U.K      | Ankola | Belse    | 319A1A1A1A            | 144.800 | 145.650 | RHS  | 850        | 10  | 8500              |
| 25  | U.K      | Ankola | Belse    | 319A1A1A1A            | 145.650 | 145.700 | LHS  | 50         | 10  | 500               |
|   |          |        |          |                       | TOTAL   |         |      |            |   | 9000              |
| 26  | U.K      | Ankola | Shirur   | 164A1A1               | 145.700 | 145.850 | LHS  | 150        | 10  | 1500              |
| 27  | U.K      | Ankola | Shirur   | 164A1B1               | 146.200 | 146.520 | RHS  | 320        | 10  | 3200              |
| 28  | U.K      | Ankola | Shirur   | 169A1A1               | 146.520 | 148.850 | RHS  | 330        | 10  | 3300              |
| 29  | U.K      | Ankola | Shirur   | 169A1A1               | 146.900 | 147.100 | RHS  | 200        | 10  | 2000              |
| 30  | U.K      | Ankola | Shirur   | 169A1A1               | 147.300 | 147.550 | RHS  | 250        | 51  | 12750             |
| 31  | U.K      | Ankola | Shirur   | 169A1A1               | 147.600 | 148.000 | RHS  | 400        | 37  | 14800             |
|   |          |        |          |                       | TOTAL   |         |      |            |   | 37550             |
| 32  | U.K      | Ankola | Kodsani  | 28                    | 148.100 | 148.400 | BHS  | 300        | 15  | 4500              |
| 33  | U.K      | Ankola | Kodsani  | 19A1                  | 148.800 | 149.000 | LHS  | 200        | 68  | 13600             |
|   |          |        |          |                       | TOTAL   |         |      |            |   | 18100             |
| Karwar Forest Division Total area in Sqmtrs |          |        |          |                       |         |         |      |            |   | 139200            |

For IRB West Coast Tollway Pvt. Ltd

Honnavar Forest Division

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| District  | Taluk  | Village         | Forest Survey Numbers | From    | To      | Side    | Length (m) | Additional width required beyond PROW (m) | Total Area in Sqm |       |
|---|--------|-----------------|-----------------------|---------|---------|---------|------------|---|-------------------|-------|
| U.K   | Ankola | Balale          | 17                    | 151 600 | 151 900 | BHS     | 300        | 12  | 3600              |       |
|   |        |                 |                       | TOTAL   |         |         |            |   | 3600              |       |
| U.K   | Kumta  | Bargi-Kurigadde | 32                    | 159 200 | 159 500 | RHS     | 300        | 60  | 18000             |       |
|   |        |                 |                       | TOTAL   |         |         |            |   | 18000             |       |
| 36  | U.K    | Kumta           | Yettinball            | 23      | 159 900 | 160 100 | LHS        | 200                                       | 4800              |       |
|   |        |                 |                       | TOTAL   |         |         |            |   | 4800              |       |
| 37  | U.K    | Kumta           | Mirjan                | 127     | 164 400 | 164 550 | LHS        | 150                                       | 4500              |       |
| 38  | U.K    | Kumta           | Mirjan                | 145     | 165 050 | 165 200 | LHS        | 150                                       | 6300              |       |
|   |        |                 |                       | TOTAL   |         |         |            |   | 10800             |       |
| 39  | U.K    | Kumta           | Antarvalli            | 330     | 165 550 | 165 650 | RHS        | 100                                       | 1500              |       |
|   |        |                 |                       | TOTAL   |         |         |            |   | 1500              |       |
| 40  | U.K    | Kumta           | Divgi                 | 96A1    | 167 700 | 167 800 | LHS        | 100                                       | 5000              |       |
| 41  | U.K    | Kumta           | Divgi                 | 96A1    | 168 050 | 168 250 | LHS        | 200                                       | 4000              |       |
| 42  | U.K    | Kumta           | Divgi                 | 96A1    | 168 600 | 168 800 | LHS        | 200                                       | 7000              |       |
|   |        |                 |                       | TOTAL   |         |         |            |   | 16000             |       |
| 43  | U.K    | Kumta           | Manaki                | 108B3   | 170 100 | 170 330 | LHS        | 230                                       | 2300              |       |
| 44  | U.K    | Kumta           | Manaki                | 108B2   | 170 330 | 170 500 | LHS        | 170                                       | 1700              |       |
|   |        |                 |                       | TOTAL   |         |         |            |   | 4000              |       |
| 45  | U.K    | Honnavar        | Honnavar              | 483A1   | 190 600 | 190 800 | LHS        | 200                                       | 6000              |       |
|   |        |                 |                       | TOTAL   |         |         |            |   | 6000              |       |
| 46  | U.K    | Honnavar        | Kelaginoor            | 400A1   | 199 600 | 199 830 | RHS        | 230                                       | 13800             |       |
| 47  | U.K    | Honnavar        | Kelaginoor            | 400A1   | 199 830 | 200 150 | RHS        | 320                                       | 10240             |       |
|   |        |                 |                       | TOTAL   |         |         |            |   | 24040             |       |
| 48  | U.K    | Honnavar        | Gunavante             | 275     | 201 450 | 201 600 | RHS        | 150                                       | 4500              |       |
|   |        |                 |                       | TOTAL   |         |         |            |   | 4500              |       |
| 49  | U.K    | Honnavar        | Manki                 | 238     | 208 370 | 208 500 | LHS        | 130                                       | 1170              |       |
|   |        |                 |                       | TOTAL   |         |         |            |   | 1170              |       |
| 50  | U.K    | Honnavar        | Sulebeelu             | 11      | 213 020 | 213 160 | RHS        | 140                                       | 1540              |       |
|   |        |                 |                       | TOTAL   |         |         |            |   | 1540              |       |
| Honnavar Forest Division Total area in Sqmtrs   |        |                 |                       |         |         |         |            |   | 95050             |       |
| <b>Kundapur Forest Division</b>   |        |                 |                       |         |         |         |            |   |                   |       |
| 51  | Udupi  | Byndoor         | Shirur                | 217     | 245 100 | 245 300 | LHS        | 200                                       | 20                | 4000  |
| 52  | Udupi  | Byndoor         | Shirur                | 217     | 245 350 | 245 550 | LHS        | 200                                       | 35                | 7000  |
|   |        |                 |                       | TOTAL   |         |         |            |   |                   | 11000 |
| 53  | Udupi  | Byndoor         | Paduvari              | 241     | 248 550 | 248 950 | LHS        | 400                                       | 60                | 24000 |
|   |        |                 |                       | TOTAL   |         |         |            |   |                   | 24000 |
| Kundapur Forest Division Total area in Sqmtrs   |        |                 |                       |         |         |         |            |   | 35000             |       |
| Karwar Forest Division area in Hec  |        |                 |                       |         |         |         |            | 13.920                                    |                   |       |
| Honnavar Forest Division area in Hec  |        |                 |                       |         |         |         |            | 9.595                                     |                   |       |
| Kundapur Forest Division area in Hec  |        |                 |                       |         |         |         |            | 3.500                                     |                   |       |
| Total additional land required for Provision of Stable slopes (1.5 H : 1 V ) beyond PROW in Hec |        |                 |                       |         |         |         |            | 27.015                                    |                   |       |

For IRB West Coast Tollway Pvt. Ltd.

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# ANNEXURE R-6



सत्यमेव जयते

भारत सरकार  
GOVERNMENT OF INDIA  
पर्यावरण, वन एवं जलवायु परिवर्तन मंत्रालय  
MINISTRY OF ENVIRONMENT, FOREST & CLIMATE CHANGE  
समन्वित क्षेत्रीय कार्यालय  
INTEGRATED REGIONAL OFFICE  
Kendriya Sadan, IVth Floor, E& F Wings, 17<sup>th</sup> Main Road,  
Ind Block, Koramangala, Bangalore - 560 034.  
Tel.No.080-25635908, E.Mail: ros.z.bng-mef@nic.in



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**BY SPEED POST**

F.No.4-KRC1250/2020-BAN/ 631

Dated the 17<sup>th</sup> September, 2021

To

The Additional Chief Secretary to Government of Karnataka,  
Forest, Ecology & Environment Department,  
M.S. Building, Dr. Ambedkar Veedhi,  
Bangalore – 560 001.

Subject: Diversion of 28.218 ha of forest land in Baad, Binaga-Arga and 20 other villages in Uttara Kannada and Udupi Districts (Karwar, Honnavar and Kundapura Forest Divisions) for slope protection of Four laning of Goa-Karnataka Border to Kundapur Section of NH-66 (formerly NH-17) from KM 93.700 to KM 283.300 in favour of National Highways Authority of India (PIU), Mangalore -reg.

Sir,

I am directed to refer to the State Government's letter No. FEE 27 FLL 2020 dated 19/06/2020 and No. FEE 27 FLL 2020 (e) dated 17/03/2021 seeking prior approval of the Central Government under Section'2' of the Forest (Conservation) Act, 1980 for the above project.

The proposal was examined by the Regional Empowered Committee constituted under sub-rule (1) of rule 4A of the Forest (Conservation) Rules, 2003 in its meeting held on 31/08/2021.

After careful examination of the proposal of the State Government and on the basis of the approval of the Regional Empowered Committee, **in-principle approval /Stage-I clearance** of the Central Government is hereby granted for diversion of 28.218 ha of forest land in Baad, Binaga-Arga and 20 other villages in Uttara Kannada and Udupi Districts (Karwar, Honnavar and Kundapura Forest Divisions) for slope protection of Four laning of Goa-Karnataka Border to Kundapur Section of NH-66 (formerly NH-17) from KM 93.700 to KM 283.300 in favour of National Highways Authority of India (PIU), Mangalore, subject to the following conditions:-

**A: Conditions which need to be complied prior to handing over of forest land by the State Forest Department.**

1. The User Agency shall transfer online, the Net Present Value (NPV) of the forest land being diverted under this proposal, as per the orders of the Hon'ble Supreme Court of India, dated 28.03.2008, 24.04.2008 and 09.05.2008 in Writ Petition (Civil) No.202/1995 and the guidelines issued by this Ministry vide its letter No. 5-3/2007-FC dated 05.02. 2009. The requisite funds shall be transferred through online portal into CAMPA account of the State Concerned.

2. The User Agency shall transfer the cost of raising and maintaining the Compensatory Afforestation over double the extent of degraded forest land in Sy.No. 178, Honnebail RF, Ankola Taluk, Karwar Division, Uttara Kannada District at the current wage rate, in consultation with State Forest Department in the account of CAMPA of the concerned State through online portal. The scheme shall include demarcation of CA area using appropriate fencing and tall plants for better survival, provision for watering and SMC works to be included and appropriate provision to be provided for anticipated cost escalation for the works scheduled for subsequent years.
3. The User Agency shall restrict the felling of trees to minimum number in the diverted forest land and the trees shall be felled under the strict supervision of the State Forest Department and the cost of felling of trees shall be deposited by the User Agency with the State Forest Department.
4. All the funds received from the user agency under the project shall be transferred/deposited in CAMPA account only through e-portal (<https://parivesh.nic.in/>). Amount deposited through other mode will not be accepted as compliance of the Stage-I clearance.
5. The user agency should take up measure to rectify the alignment and slope of trench excavated as an emergency measure in Byndoor, so as to drain out the excess water to a common drainage point without creating water stagnation or water logging in forest area or private areas. The user agency should also ensure establishment of suitable safety measures like 6 ft high chain-link fence all along the trench to prevent accident fall of humans and animals. The side slope of the trench should be made gentle in few locations to facilitate safe passage of animals, in case, if any animal falls in to the trench.
6. The old road in the forest area that will be left abandoned after re-alignment should be resumed by the forest department.
7. The user agency should restore the forest area where the excavated soil has been dumped.
8. The tree planting along the side of NHAI road should be completed on priority.
9. The KML file of the area diverted and CA area shall be uploaded on the e-green watch portal with all requisite details and same shall be submitted along with compliance report.
10. The compliance report shall be uploaded on e-portal (<https://parivesh.nic.in/>).
11. The State Government shall complete settlement of rights, in term of the Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act 2006, if any, on the forest land to be diverted and submit the documentary evidence as prescribed by this Ministry in it's letter No. 11-9/1998-FC dated 3<sup>rd</sup> August 2009 read with 05.07.2013 with necessary enclosures, in support thereof.
12. The boundary of the diverted forest land shall be demarcated on ground at the project cost, by erecting four feet high reinforced cement concrete pillars, each inscribed with its serial number, distance from pillar to pillar and GPS co-ordinates.

13. Violation of any of these conditions will amount to violation of Forest (Conservation) Act, 1980 and action would be taken as prescribed in para 1.21 of Chapter 1 of the Handbook of comprehensive guidelines of Forest (Conservation) Act, 1980 as issued by this Ministry's letter No. 5-2/2017-FC dated 28.03.2019.

**B: Conditions which need to be strictly complied on field after handing over of forest land to the user agency by the State Forest Department but the compliance in form of undertaking shall be submitted prior to Stage-II approval:**

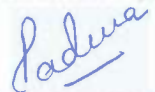
1. Legal status of the diverted forest land shall remain unchanged.
2. Compensatory Afforestation shall be raised over double the extent of degraded forest land within three years from the date of Stage –II Clearance and maintained thereafter by the State Forest Department at the cost of the User Agency and at least 1000 plants per hectare shall be planted over identified degraded forest land within three years of grant of final approval. If it is not possible to plant so many saplings in the area identified for CA, the balance saplings will be planted in any other forests as per prescriptions of approved working plan with provision for ten years on subsequent maintenance.
3. At the time of payment of the Net Present Value (NPV) at the then prevailing rate, the User Agency shall furnish an undertaking to pay the additional amount of NPV, if so determined, as per the final decision of the Hon'ble Supreme Court of India.
4. Tree felling shall be restricted to the barest minimum possible and under confirmation from the local forest officials.
5. Suitable signages for speed regulation and animal safety will be erected along the road through forest areas.
6. The User Agency / concessionaire at their cost shall take up strip plantation on both sides and central verge of the road as per the IRC norms, wherever possible in consultation with State Forest Department as per the guidelines issued by Ministry vide letter No.FC-11/39/2020-FC dated 08/09/2021.
7. The period of diversion under this approval shall be co-terminus with the period of lease to be granted in favour of the user agency or the project life, whichever is less.
8. No labour camp shall be established on the forest land.
9. No additional or new path will be constructed inside the forest area for transportation of construction materials for execution of the project work.
10. Sufficient firewood, preferably the alternate fuel, shall be provided by the User Agency to the labourer after purchasing the same from the State Forest Department or the Forest Development Corporation or any other legal source of alternate fuel.
11. The forest land shall not be used for any purpose other than that specified in the project proposal.

12. The forest land proposed to be diverted shall under no circumstances be transferred to any other agency, department or person without prior approval of the Central Government.
13. No damage to the flora and fauna of the adjoining area shall be caused.
14. User Agency shall obtain the Environmental Clearance as per the provisions of the Environment (Protection) Act, 1986, if applicable.
15. The layout plan of the proposal shall not be changed without the prior approval of the Central Government.
16. The User Agency shall submit the annual self-compliance report in respect of the above stated conditions to the State Government and Integrated Regional Office, Bangalore by the end of March every year.
17. The user agency shall comply with all the provisions of the all Acts, Rules, Regulations, Guidelines, Hon'ble Court Order (s) and NGT Order (s) pertaining to this project, if any, for the time being in force, as applicable to the project.

After receipt of compliance report on fulfilment of the conditions mentioned above, the proposal shall be considered for final approval under Section-2 of the Forest (Conservation) Act, 1980. The User Agency shall take up the work as per the Guidelines in force and after ensuring that all necessary clearances for the entire stretch are in place. Working permission, if any issued, shall be intimated to IRO, Bengaluru. Transfer of forest land shall not be effected till final approval is granted by the Central Government in this regard.

Further, it may also be noted that this in-principle approval shall be valid for a period of 5 years from the date of issue of this letter. In the event of non-compliance of the above conditions, this in-principle approval shall be revoked after 5 years.

Yours sincerely,

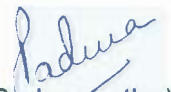


(R. Padmawathe)

Deputy Inspector General of Forests (Central)

Copy to:-

1. The Principal Chief Conservator of Forests (HoFF), Forests Department, Govt. of Karnataka, Aranya Bhavan, 18<sup>th</sup> Cross, Malleswaram, Bangalore – 560 003.
2. The Principal Chief Conservator of Forests (FC) /Nodal Officer (FCA), Office of the Principal Chief Conservator of Forests, Forests Department, Govt. of Karnataka, Aranya Bhavan, 18<sup>th</sup> Cross, Malleswaram, Bangalore – 560 003.
3. The Project Director, Project Implementation Unit, National Highway Authority of India, Door No. 3-29, Bethel, Tharethota, Near Pumpwell, NH-66, Mangalore -575 005.
4. Guard file.



(R. Padmawathe)

Deputy Inspector General of Forests (Central)



# ANNEXURE R-7

भारत सरकार  
Government of India  
भारतीय भूवैज्ञानिक सर्वेक्षण  
Geological Survey of India

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REPORT ON  
SHIRUR LANDSLIDE, ANKOLA TALUK, UTTARA KANNADA DISTRICT,  
KARNATAKA  
&  
LANDSLIDE SUSCEPTIBILITY ALONG NH-66 (KARWAR TO NORTH OF BAINBUR)

एम4एलएस/ एनसी/एसआर/एसयू- केजी/2024/50072

M4LS/NC/SR/SU-KG/2024/50072

कार्य सत्र 2024-25  
Field Season 2024-25

डॉ आर सजीव, निदेशक  
राहुल वडाक्केडथ, वरिष्ठ भूवैज्ञानिक  
अचन कोन्याक, वरिष्ठ भूवैज्ञानिक

Dr. R Sajeew, Director  
Rahul Vadakkedath, Senior Geologist  
Achan Konyak, Senior Geologist

मिशन - IV  
MISSION-IV

Engg. Geology & Landslide Division  
State Unit: Karnataka & Goa  
Southern Region

जुलाई, 2024  
July 2024

महानिदेशक, भारतीय भूवैज्ञानिक सर्वेक्षण, कोलकाता की पूर्वानुमति के बिना आंशिक या पूर्ण किसी भी रूप में उद्धरित ना किया जाये  
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**REPORT ON  
SHIRUR LANDSLIDE, ANKOLA TALUK, UTTARA KANNADA DISTRICT,  
KARNATAKA &  
LANDSLIDE SUSCEPTIBILITY ALONG NH-66 (KARWAR TO NORTH OF BAINBUR)**

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# 1. SHIRUR LANDSLIDE, ANKOLA TALUK, UTTARA KANNADA DISTRICT, KARNATAKA

## 1.1 Introduction

This report presents the findings from a slope stability investigation conducted at Shirur landslide, by the Geological Survey of India (GSI). A team led by Dr. R Sajeew, Director, Shri. Rahul Vadakkedath and Shri. Achan Konyak Senior Geologists carried out the investigation. On July 16, 2024, at 8:30 AM, a large debris flow occurred on the left-hand side of Chainage number 148.000 (14.603554°N / 74.371219°E) of NH-66, in Shirur village, Ankola Taluk, Uttara Kannada District, Karnataka. This event caused severe disruptions, including the loss of 10 lives, and substantial damage to infrastructure and property (Fig. 1.1, Fig. 1.2). This report provides an overview of the landslide, its causes, and recommended remedial measures.

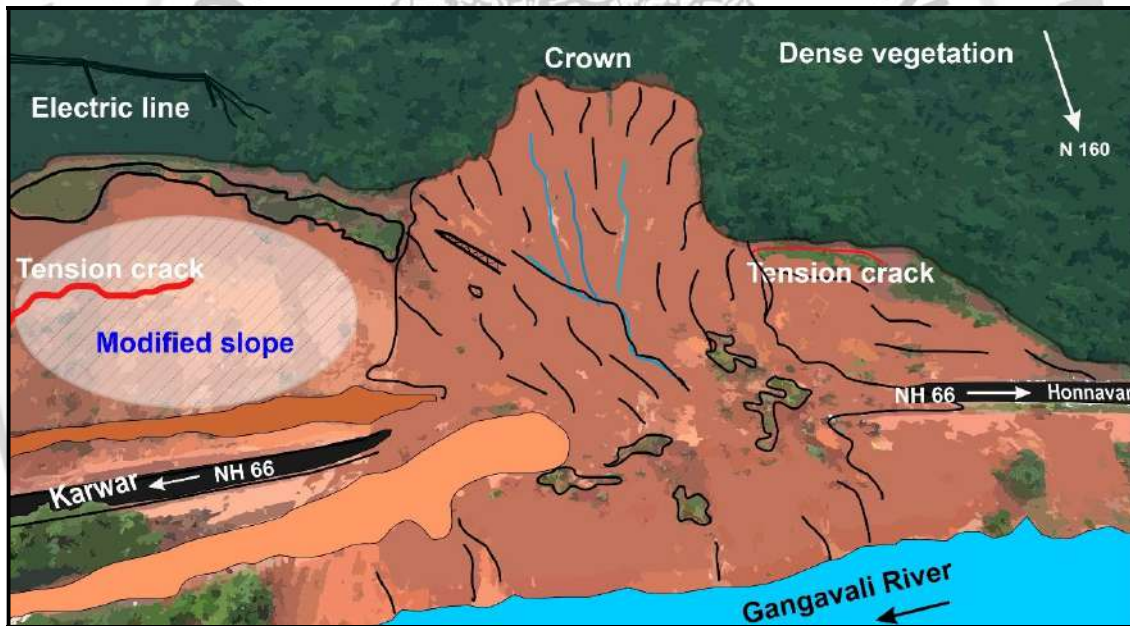


Fig. 1.1: Schematic sketch of Shirur landslide (Not to scale)

The preliminary assessment of the Shirur landslide was conducted by GSI on the 17th and 18th of July 2024. The primary objectives were to understand the geogenic causes of the landslide, assess the potential for reactivation, and develop temporary remedial measures to restore communication that the district administration can implement. The initial findings were submitted to the district administration on the 19th of July. A subsequent site visit was conducted from the 24th to the 26th of July, 2024, to observe the activity and distribution of the landslide, and to assess the condition of the adjoining slopes, including the crown and flanks for signs of potential enlargement.



Fig. 1.2: Aerial view of Shirur landslide blocking the communication corridor NH-66 (courtesy IRB)

## 1.2 Casualties and Damage

The landslide resulted in ten fatalities and washed away two gas tankers and one truck. Additionally, a semi-permanent hotel structure was destroyed. The debris from the landslide travelled over 200 meters, eventually depositing into the Ganagavali River, creating an impact wave that demolished four houses on the opposite bank. The scar left by the landslide measured approximately 150 meters in length, 120 meters in width, and 60 meters in height, with the total volume of debris exceeding 100,000 cubic meters (Fig. 1.2).

## 1.3 Lithology

The site is mainly comprised of Pyroxenite of the Motimakki Ultramafites (Fig. 1.3). The base of the landslide exposes medium to coarse-grained, dark green to black pyroxenite with high specific gravity, dominated by pyroxenes that exhibit a characteristic luster on the cleavage surfaces. Intermittent pegmatite intrusions, 5-10 meters wide, are present on both flanks of the slide. These pegmatites are highly weathered, forming whitish clay (Fig. 1.4). The depleted zone of the landslide has greenish-tinted, medium to coarse-grained boulders, rich in olivine, and showing serpentinization. Vanadiferous titanomagnetite bodies are observed at higher elevations above the landslide, composed mainly of magnetite with subordinate plagioclase, exhibiting banding and high specific gravity. The flanks and crown area also expose large laterite boulders.



Fig. 1.3: Pyroxenite exposed at the base of cut slope section near Shirur landslide



Fig. 1.4: Weathered pegmatite forming whitish clay Kaolinite

#### 1.4 Structure

The toe area of the right flank exposes hard, compact pyroxenite, with rock mass quality assessed as fair according to  $RMR_{basic}$  (Bieniawski, 1989). The area features at least four prominent joint sets, i.e. two sub-vertical (NW-SE, NE-SW) and two moderately dipping (NE-SW, NW-SE) along with numerous fractures allowing free water flow. Open folding is observed, with the left limb oriented  $155^{\circ}/30^{\circ}$  (Strike/Dip) and the right limb  $335^{\circ}/10^{\circ}$  and affected by radial fractures along the hinges. Localized faults trending NW-SE are present on both the left and right flanks of the landslide (Fig. 1.5).



Fig. 1.5: Minor Fault observed at the base of the cut slope on the right flank of the slide

#### 1.5 Susceptibility Status as per NLSM

The slope sector from Chainage 147.400 to 148.200 shows moderate to high susceptibility according to the National Landslide Susceptibility Map (NLSM) of GSI (Fig. 1.6). Multi-temporal satellite imagery indicates anthropogenic interference on the slopes from

Chainage 147.400 to 148.200 since 2017, exacerbating some landslide scars above the cut slopes (Fig.1.7). 124

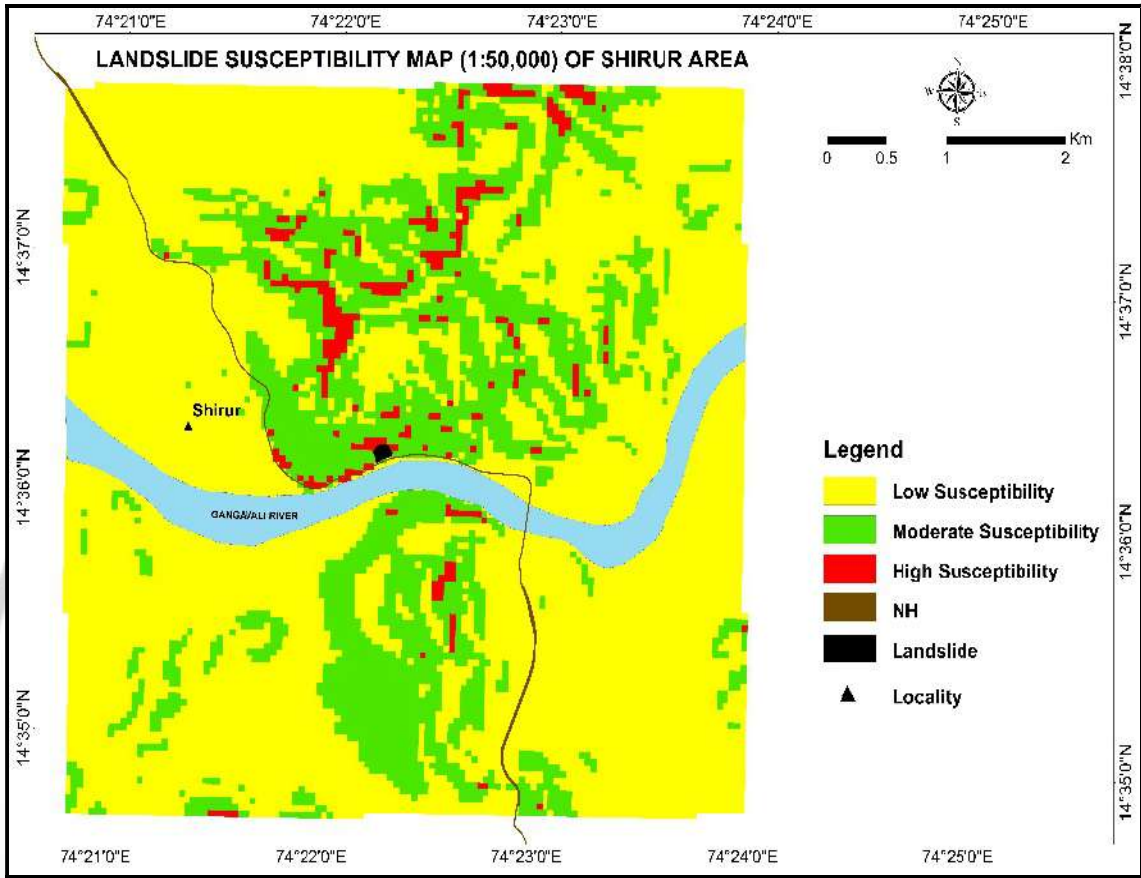


Fig. 1.6: Landslide Susceptibility Map of Shirur area, (NLSM GSI)



Fig. 1.7: Multi-temporal satellite imageries of Shirur

## 1.6 Observations

- a. **Chainage 148.000:** Prior signs of slope instability include at least two minor slumps observed in Google Street View (Fig. 1.8 & 1.9).



Fig. 1.8: Slump as seen through Google Street View of the Shirur landslide site



Fig. 1.9: Slump as seen through Google Street View of the Shirur landslide site

- b. **Right Flank:** Fresh pyroxenite at the base tapers towards the toe of the rupture, providing minimal natural buttress due to rock unit warping and thick soil development. Extensive rill erosion was observed pre-landslide.
- c. **Slope Material:** The site investigation of the slopes shows that the slope-forming material has a striking variation both along the depth and the lateral extension of the cut slope section. The upper part is hard ferruginous laterite while the lower sections expose mottled clay-rich horizons where hydrostatic pressure has built up. The hard rock is inconsistently present only at the toe area.
- d. **Tension Cracks:** The left flank has two transverse cracks at different elevations – a crack at a higher elevation (Fig. 1.10) trending N120° (20m long, 1.5m deep) and also

at a lower elevation (Fig. 1.11) trending N80° (30m long, 2 ft deep), with no visible expansion by 25<sup>th</sup> July 2024. The Crack in the right flank (Fig. 1.12) trends N15° (15m long, 2m behind the scarp). Here, in the right flank there is relatively thicker soil with 6-7 m while the left flank exposes at least 3-4m of soil. No visible cracks were noticed on the crown area. The main scarp exposes soil of about 3-4 m (Fig. 1.13).



Fig. 1.10: Tension cracks behind the side scar of the slide trending N120°



Fig. 1.11: Tension cracks at lower elevation of the left flank of the slide



Fig. 1.12: Transverse cracks at the right flank of the landslide trending N15°



Fig. 1.13: Thickness of overburden at the main scarp

- e. **Rupture Surface:** The rupture surface also exposes moderately weathered rock which is highly jointed and favours displacement of slope material along the overburden-rock interface. The right flank exposes a vulnerable joint plane of 70:75 (Dip: Direction).
- f. **Water seepages:** The water seepages are pronounced along the soil-rock interface on the main scarp area of the landslide and also observed along the interface of ferruginous and clay-rich laterite horizons
- g. **Slope Morphometry:** A non-perennial stream is observed on the upslope above the crown. The immediate upslope has a concave morphometry which facilitates water infiltration thereby increasing the probability of slope failure.

### 1.7 Factors Contributing to the Landslide

It is imperative to understand the multifaceted factors contributing to the Shirur landslide. Key elements include anthropogenic activities, geological characteristics, and meteorological conditions, all of which played critical roles in the event.

### 1.7.1 Anthropogenic Activities

Multi-temporal satellite imagery has shown significant anthropogenic interference with the slopes since 2017. Continuous slope modifications and the presence of landslide scars above the cut slopes have exacerbated the slope's vulnerability. The lack of proper retaining structures further destabilized the area, increasing the risk of slope failure.

### 1.7.2 Meteorological Conditions

Intense and prolonged rainfall acted as the immediate trigger for the landslide. Specifically, a three-day antecedent rainfall totalling 503 mm led to the saturation of debris material, increasing pore water pressure and reducing shear strength (Fig.1.14). This intense rainfall significantly weakened the slope's stability, and acted as a trigger.

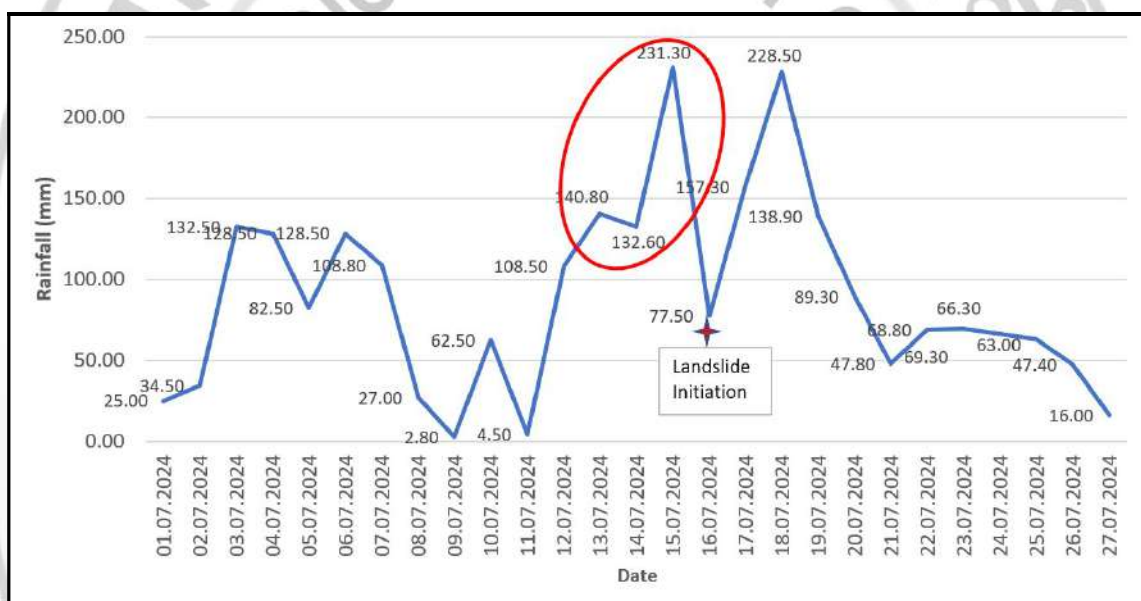


Fig. 1.14: Rainfall distribution near Shirur during July 2024 (source:IRB)

### 1.7.3 Geological Characteristics

The site features a complex lithology with a combination of hard ferruginous laterite and clay-rich horizons, creating variations in slope material along both depth and lateral extensions. The steep gradient of the cut slope combined with thick, highly porous slope material was a major contributing factor. The fresh pyroxenite rock exposed at the base of the right flank of the Shirur landslide is observed to taper towards the toe of rupture of the slide thereby providing minimal natural toe buttress. This tapering of the rock is attributed partly due to the warping of the rock unit over which thick soil has developed. There is also a considerable subsurface water flow which could have played a major role in saturating the soil column.

#### 1.7.4 Slope Morphometry

The concave slope morphometry at the crown area and thick overburden material at the site facilitated the convergence of surface and subsurface water flow. This morphometric characteristic increased the probability of slope failure, suggesting a potential for further widening or retrogression during prolonged rainfall events.

#### 1.8 Recommendations for the Shirur Landslide and Adjoining Slopes

1. **Road alignment, Slope Gradient and Benching:** At the Shirur area, since the road is under construction, an alignment shift towards RHS from chainage 147.300 to 147.800 is proposed if the land is available. This would reduce the height of the slope cut of the currently undisturbed or unmodified slope from 147.300 to 147.500 to a minimum and shift the carriageway from the toe of the disturbed horizon from 147.500 to 148.100. For any slope modification at the site, a detailed investigation is necessary. Ensure compliance with BIS codes for slope modification with appropriate benching, based on geotechnical properties of the soil. Bench width should be adequate to enable slope segments to act independently (IS code 14680:1999).
2. **Drainage:** Trenches (Fig. 1.15) above Ch. 147.500 should be lined. It is observed that the surface water is draining freely (Fig. 1.16) along the boundary wall towards the slope which should be diverted or provided with stepped chute drains on the slope face.
3. **Erosion Control:** Install adequate surface drainage channels along with slope reinforcement and erosion control measures.
4. **Culvert Installation:** The convergence of natural drainage is anticipated at the landslide face with time. A culvert with sufficient diameter pre-cast pipes should be provided to accommodate water and debris discharge at the toe of the landslide at Ch. No. 148. 000. Else the water may be diverted by lined toe drainage.
5. **Monitoring and Surveying:** It is recommended to monitor and survey for signs of instabilities even above the Right of Way especially for slope sections with higher relative relief on the right and left flanks of Shirur landslide. Shirur landslide is a classic case where the rupture surface extended beyond the ROW due to higher relief above the cut slope. Deploy flaggers for traffic control and restrict access to high-risk areas.



Fig. 1.15: Trenches observed above the Ch. no. 147.500



Fig. 1.16: Unguided surface water flowing along the slope above the Ch. no. 147.500

6. **Subsurface Water Drainage:** Include perforated horizontal pipes of appropriate diameter and sufficient length in engineered slopes to manage subsurface water flow.
7. **Geotechnical Investigation:** Conduct comprehensive investigations to determine suitable stabilization strategies for the Shirur landslide, considering potential landslide enlargement due to the considerable thickness of soil in the crown and hydrological conditions.

## 1.9 Conclusion

The Shirur landslide was the result of a combination of anthropogenic activities, geological characteristics, and meteorological conditions. Understanding these factors is crucial for implementing effective monitoring, stabilization, and remedial measures to mitigate future risks and ensure slope stability. Anthropogenic activities, including slope modifications and the absence of proper retaining structures, have significantly destabilized the area while the key geological factors include the variability in soil strata, sub-surface hydrological conditions, and a weathered, deformed rock mass. Meteorological factors, particularly intense and prolonged rainfall, contributed to the saturation and weakening of the soil. The concave slope morphometry, with higher relative relief, facilitated the convergence of surface and subsurface water flow, increasing the probability of slope failure. Despite the challenges in predicting the magnitude and timing of such deep-seated landslides, it is crucial to implement comprehensive monitoring and stabilization measures.

Recommendations include strict adherence to slope gradient and benching guidelines, improved drainage systems, regular monitoring for signs of instability, and comprehensive geotechnical investigations. Public safety measures should continue, with restricted access to high-risk areas and the deployment of traffic control measures. Long-term monitoring using advanced technologies and periodic inspections of remedial measures are essential to mitigate future risks and ensure the stability of the affected slopes.

## 2. LANDSLIDE SUSCEPTIBILITY ALONG NH-66 (KARWAR NORTH OF BAINDUR)

### 2.1 Introduction

A slope stability investigation was conducted from July 27 to July 29, 2024 along NH-66 covering chainages 109.9 to 245.6 from Karwar to the north of Baidur, focusing on the Shirur sector and other landslide-vulnerable sections of NH-66. The primary objectives were to identify landslide-prone areas, evaluate the contributing factors, and develop strategic mitigation measures to enhance the stability and safety of the highway corridor. The team was accompanied by National Highway Authority of India (NHAI) officials and engineers from IRB Infrastructure Developers Ltd.

The highway passes through the western margin of Western Ghat mountain ranges and has a few sections where the hill slopes had to be cut to make way for the road corridor. The major geological unit exposed in the corridor is the Peninsular Gneissic Complex (PGC), a suite of rocks with mainly granitic composition. The corridor also cut through various mafic and ultramafic rock units at different locations (Fig. 2.10).

The landslide susceptibility map, produced after the National Landslide Susceptibility Mapping (NLSM) of GSI in 1:50,000 scale, is available for the road corridor up to 220.000 chainages (Fig. 2.11). Most of the landslide incidences in the corridor have occurred in moderate to high landslide susceptibility areas. The road corridor was divided into four sectors, each with unique slope instability scenarios and contributing factors.

### 2.2 Sector-1 (Chainage 109.500 to 129.000)

#### 2.2.1 Geological Characteristics:

The corridor passes through Granitoids and Granite Gneisses of the PGC and some basic intrusive rocks. The typical road section in this corridor consists of hard granitic rocks at the bottom, overlain by weathered lithomarge and soil cover of varying thickness.

#### 2.2.2 Slope Instability Factors

- The debris thickness is high and is cut at a steeper angle where minor failures are observed along the exposed debris face (Fig. 2.1).
- Drainage from the upslope saturates the debris thereby reducing its strength and resulting in a rotational failure (Fig. 2.2)
- The groundwater is seeping between the rock-debris interface and debris is sliding down the interface due to a reduction in friction between the layers.



Fig. 2.1: Typical cut section in the sector showing rock-debris interface



Fig. 2.2: Deep rotational failure with possible piping at chainage 160.080

### 2.2.3 Recommendations

- Reducing the debris thickness exposed by maintaining a shallower cut slope angle along with benching and proper drainage.

- Arrest surface water erosion by channelling the streams to proper drainage systems. Geo jutes installation with suitable grass (Vetiver) varieties can also be implemented.
- Reducing debris saturation by providing effective horizontal drainage systems. The existing horizontal drainage systems installed in the corridor are observed to be ineffective in discharging water.

It is to be noted that the soil thickness and composition vary considerably across the slope and to suggest a uniform solution for the entire corridor is not possible. The vulnerable sectors should be identified and site-specific engineering solutions should be provided depending on the site conditions.

At chainages 111.300 to 111.400 where the relative relief is very high and the road cut is steep, the rocks are highly jointed with some having near vertical dips. The rocks also exhibit exfoliation joints which are formed due to repeated heating and thawing of the rocks. The intersection of these two planes produces blocks, which fall along the slope (Fig. 2.3). The stretch requires a detailed study to figure out engineering solutions such as rock bolting intervals, shotcreting, etc. However, if the land is available, a slight deviation (20m) in the road alignment towards the south western side away from the vertical slope cut can be considered after detailed studies to minimize the risk factor associated with rock falls (Fig. 2.4).



Fig. 2.3: Rockfall incidence at chainage 111.400

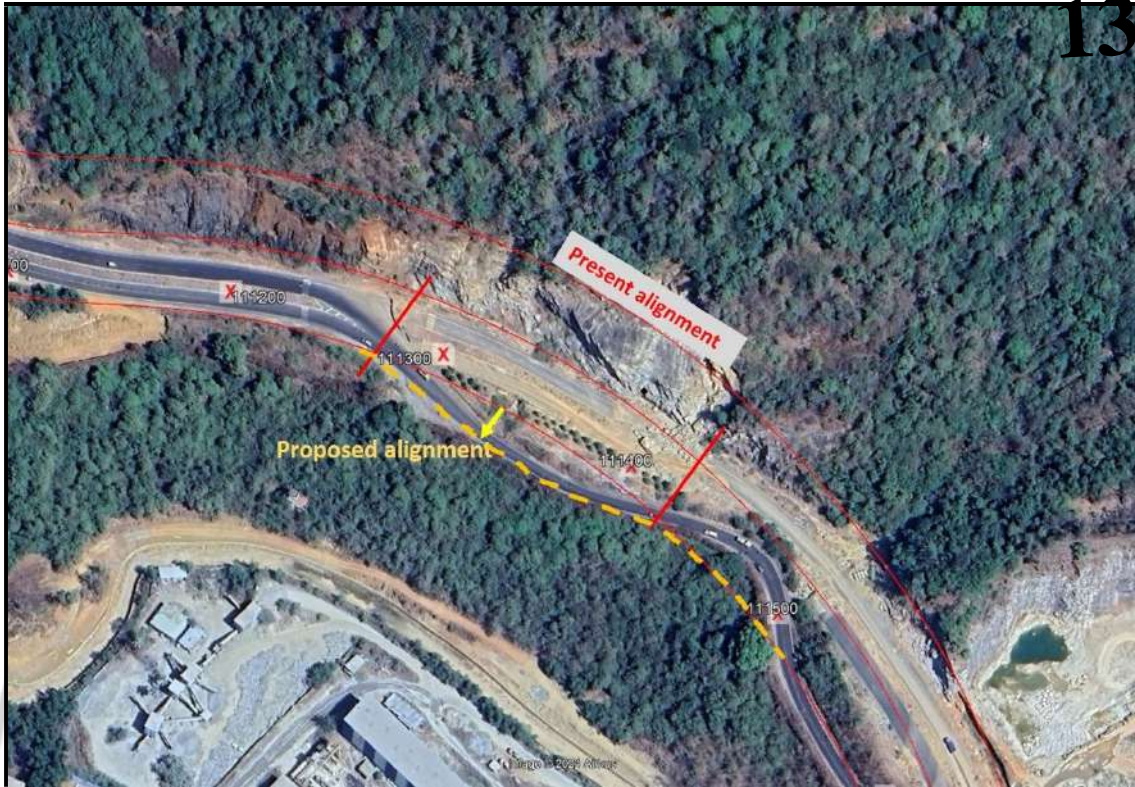


Fig. 2.4: Proposed alignment to mitigate the direct risk of rockfalls

## 2.3 Sector-2 (Chainage 141.600 to 153.600)

### 2.3.1 Geological Characteristics

This sector exposes Gneisses of PGC, Pyroxenites of Layered Ultramafic Complex and Hornblende Actinolite Chlorite schist of Dharwar Supergroups. The areas where the road corridor intersects rocks of the Layered Ultramafic Complex were observed to cause complex slope instability problems.

### 2.3.2 Slope Instability Factors

The ultramafic rocks are susceptible to a high degree of weathering. The thickness of debris and lithomarge would be higher as compared to areas occupied by granitic rocks. There is also a considerable variability in the litho units exposed from bottom to top as is typical in such layered complexes. The weathered rock horizon and soil also show vertical variability where the top of the hill is characterized by ferruginous laterite and the middle part shows lateritic clay-rich horizons. The clay layers have lesser permeability, leading to water accumulation in the column. Slope cuts in this region should be kept to a minimal height as possible so that the exposed cut slopes can be stabilized by providing good drainage and retaining structures. Benching of slopes alone is not an effective slope stabilization method as observed in the Shirur site. Shotcreting in such thick debris cover also would be ineffective. The landslide management strategy in such cases should be to minimize the slope cut height

by shifting the alignment wherever land is available and providing efficient surface and subsurface drainage solutions.



Fig. 2.5: Variability in lithounits near the right flank of the Shirur landslide

### 2.3.3 Recommendations

At the Shirur area, since the road is still under construction, an alignment shift from chainage 147.300 to 147.800 can be considered after detailed studies, and if the land is available (Fig.2.6). This would also reduce the height of the planned slope cut for the current undisturbed slope from 147.300 to 147.500 to a minimum and shift the carriageway from the toe of the disturbed horizon along 147.500 to 148.100 chainages.

Geomorphologically, the planned slope cut from chainages 147.300 to 147.500 will be cutting across a “spur” which could cause slope instability issues post-modification. If the alignment shift is not feasible, it is recommended to provide the newly cut slope with adequate drainage management and support measures immediately. However, it is advised to avoid or minimize slope cuts in the location as far as possible.



Fig. 2.6: Proposed alignment shift to prevent further slope failures at the Shirur site.

## 2.4 Sector-3 Chainage 163.000 to 170.000

### 2.4.1 Geological Characteristics

This sector exposes Gneisses of PGC, Gabbro of Layered Ultramafic Complex and Hornblende Actinolite Chlorite schist of Dharwar Supergroups.

### 2.4.2 Slope Instability Factors

There are three major vulnerable zones in this sector at **166.250, 168.200 and 168.700** chainages respectively.

The landslide at 166.250 is a 90m in length and 120m in width debris slump that has occurred in the cut slope made for the road (Fig.2.7). The cut slope exposes a thick lithomarge and laterite cover developed over Gabbroic rocks. The laterite layer is not strong enough to withstand the existing overburden slope profile which resulted in a slump. A drone survey was conducted at the site by IRB which revealed a large crack at the top of the cut slope. Widening of the slide parallel to the slope is possible due to the similar lithology and slope cut on the southern side. A detailed study in the zone is recommended to analyse possible slope stabilization measures or road alignment changes.

Another potentially vulnerable zone was observed at 168.200 where the slope has been cut almost vertically for a length of approximately 60m (Fig. 2.8). During the field visit, minor tension cracks were observed on the slope. The road passes right beneath the slope and

there are settlements opposite to the slope cut. It is recommended to monitor the slope for any crack development and take immediate action if any movement is noticed. It is also recommended to sensitize the local population regarding the potential hazard and the families living just opposite the slope may be shifted in case of any crack development. Detailed studies for proper slope grading, drainage provisions and to arrest gully erosion are recommended.



Fig. 2.7: Drone footage showing the recent landslide scar at 166.250



Fig. 2.8: Slope cut at chainage 168.200 exposing lithomarge and debris

Another similar slope cut was observed at chainage 168.700 where a 50 m horizon of lithomarge and debris is exposed in the slope cut (Fig. 2.9). There are approximately 12 buildings opposite to the slope cut. It is recommended to conduct a detailed site-specific study to provide mitigation measures for the slope.



Fig. 2.9: Slope cut at chainage 168.700 showing the debris and minor scars

The zones at 168.200 and 168.700 have settlements in the down-slope area which significantly increases the risk involved in case of any slope failures. The residents may be made aware of early slope failure signatures and instructed to inform local authorities in case of any observed movement. They may also be instructed to shift to safer locations in case of any observed movement in the slope.

## 2.5 Sector 4 (Chainages 198.100 to 205.400)

This sector is characterized by flat-topped laterite-covered hills and the slope instabilities are smaller in dimensions mainly involving the soil layer. The hill slopes from this sector to chainage 245.600 have minor instabilities that do not pose a major risk to the traffic and local population.

The landslide incidences recorded all along the NH-66 route in Uttara Kannada have been elaborated in Annexure-1.

## 2.6 General Recommendations

- Proper drainage management is of paramount importance in any such project. Water flow from the slopes should be diverted using lined drainage and culverts. Subsurface water management is also a crucial part of slope stability.
- The horizontal drainages at most of the slopes are observed to be clogged. Alternative designs for the drainage pipes have to be adopted for efficient drainage of subsurface water.
- It should be noted that planning in the DPR stage and construction stage would significantly reduce the cost and risk during the operational phase. Sufficient time and budgetary allocation should be made for the DPR stage of any project.
- Landslide susceptibility map is a free database from GSI that can be consulted during the planning of any large-scale project in mountainous terrains to avoid potentially vulnerable zones and minimize the associated risks.
- The best mitigation strategy for landslides is to avoid it. Extensive slope cuts should be minimized as far as possible by shifting the alignment during the planning stage.

## 2.7 Acknowledgment

The GSI team extends its gratitude to the District Administration of Karwar for their essential logistical support during the two spells of landslide studies. We also acknowledge the valuable coordination provided by the NHAI and IRB officials during our visits to the Shirur landslide site and other critical sectors of NH-66. Our thanks go to the state government's Forest officials for accommodating us at the Guest House during the field visits. Finally, we gratefully acknowledge the support of Dr. S. Ravi, DDG, SU: KG, Shri. K V Maruthi, DDG & RMH-IV, GSI, SR, and Shri. S.D. Patbhaje, ADG & HoD, SR, whose contributions were indispensable to our efforts.

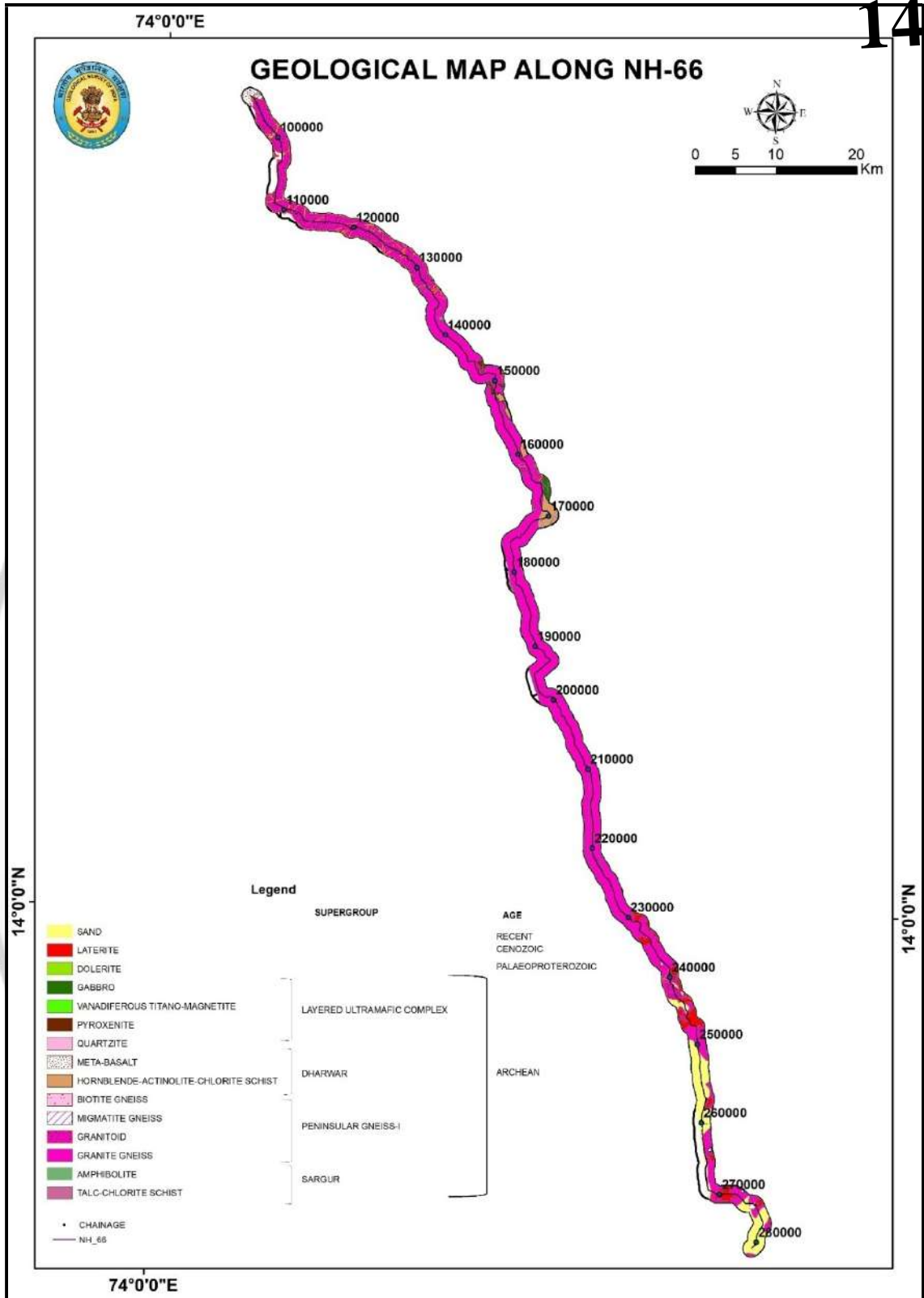


Fig. 2.10: Geological map of the road corridor

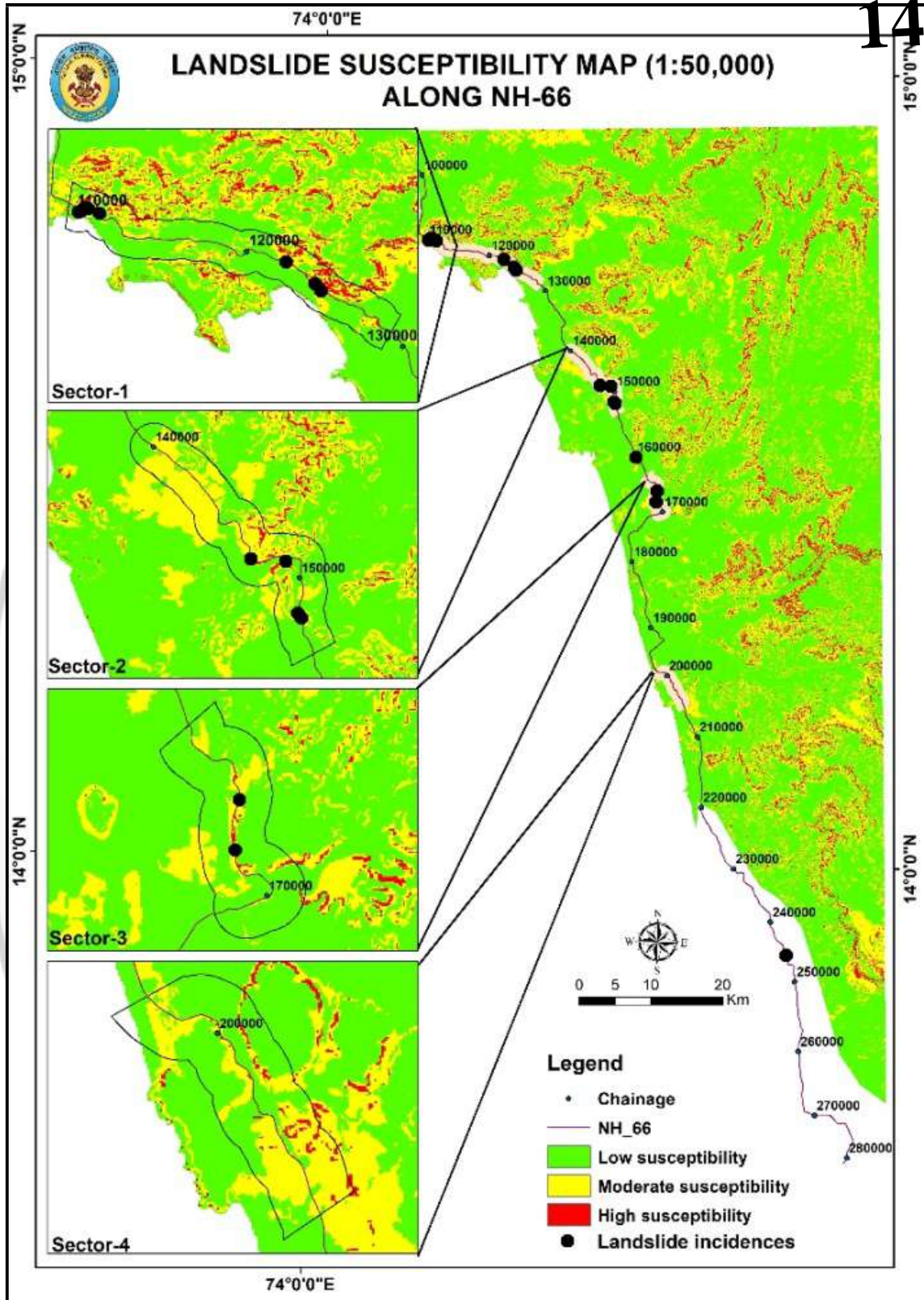




Fig. 2.11: Landslide susceptibility map of the road corridor


| No | Field                     | Description   |
|----|---------------------------|---|
| 1  | Slide No (LS .No.)        | KA/UK/48J01/2024/01   |
| 2  | State                     | Karnataka   |
| 3  | District                  | Uttara Kannada  |
| 4  | Toposheet                 | 48J/01  |
| 5  | Name of the slide         | --  |
| 6  | NH/SH/Locality            | NH-66 (Chainage – 110.200)                                      |
| 7  | Latitude                  | 14.781677° N  |
| 8  | Longitude                 | 74.136913° E  |
| 9  | Length                    | ~ 40m   |
| 10 | Width                     | ~ 60m   |
| 11 | Height                    | ~ 35m   |
| 12 | Area                      | ~ 2400m <sup>2</sup>  |
| 13 | Depth                     | ~2-5m   |
| 14 | Volume                    | --  |
| 15 | Run out distance          | NA  |
| 16 | Type of Material          | Debris  |
| 17 | Type of movement          | Slide   |
| 18 | Rate of movement          | Very rapid  |
| 19 | Activity                  | Suspended   |
| 20 | Distribution              | Retrogressive   |
| 21 | Style                     | Single  |
| 22 | Failure mechanism         | Shallow rotational failure                                      |
| 23 | History                   | Old landslide   |
| 24 | Geomorphology             | Low dissected hills   |
| 25 | Geology                   | Granitoids of Peninsular Gneissic Complex                       |
| 26 | Structure                 | Foliation - 55°→30° ; J1- 78° →135 ; J2- 80° →85° ; J3- 6° →25° |
| 27 | Land use/ Land cover      | Forest  |
| 28 | Hydrological condition    | Flowing   |
| 29 | Triggering Factor         | Rainfall  |
| 30 | Death of persons          | Nil   |
| 31 | People affected           | Nil   |
| 32 | Live-stock loss           | Nil   |
| 33 | Communication             | Road  |
| 34 | Infrastructure            | Nil   |
| 35 | Agriculture/forest/Barren | Forest  |

|    |   |  |
|----|---|--|
| 36 | Geo-scientific Causes                         | Slope cut has been done in a high-relief area exposing the rock-debris interface. The landslide has occurred in the debris due to saturation of the material.      |
| 37 | Remedial measures                             | Monitor the slide area regularly for any movement. Any further slope modification might contribute to further instability  |
| 38 | Remarks, if any                               | The debris has been depleted from the slide area. Debris exposed on the crown and the flanks of the slide may lead to minor slides during intense rainfall events. |
| 39 | Photos. Sketch of Plan & section of the slide |   |
| 40 | Summary/Abstract                              | --   |
| 41 | Pdf   | --   |
| 42 | Landslide category                            | II   |


| No | Field                      | Description                        |
|----|----------------------------|------------------------------------|
| 1  | Slide No (LS .No.)         | KA/UK/48J01/2024/02                |
| 2  | State                      | Karnataka                          |
| 3  | District                   | Uttara Kannada                     |
| 4  | Toposheet                  | 48J/01                             |
| 5  | Name of the slide          | --                                 |
| 6  | NH/SH/Locality             | NH-66 (Chainage 110.340)           |
| 7  | Latitude                   | 14.782055° N                       |
| 8  | Longitude                  | 74.138237° E                       |
| 9  | Length                     | ~ 6m                               |
| 10 | Width                      | ~ 10m                              |
| 11 | Height                     | ~ 5m                               |
| 12 | Area                       | ~60m <sup>2</sup>                  |
| 13 | Depth                      | ~ 1-2m                             |
| 14 | Volume                     | --                                 |
| 15 | Run out distance           | ~ 25m                              |
| 16 | Type of Material           | Debris                             |
| 17 | Type of movement           | Slide                              |
| 18 | Rate of movement           | Extremely rapid                    |
| 19 | Activity                   | Active                             |
| 20 | Distribution               | Retrogressive                      |
| 21 | Style                      | Single                             |
| 22 | Failure mechanism          | Shallow rotational failure         |
| 23 | History                    | Initiated in 07/2024               |
| 24 | Geomorphology              | Low dissected hills                |
| 25 | Geology                    | Peninsular Gneissic Complex        |
| 26 | Structure                  | J1-75:240, J2 – 18:10, J3 - 78:145 |
| 27 | Land use/ Land cover       | Forest                             |
| 28 | Hydrological condition     | Dripping                           |
| 29 | Triggering Factor          | Rainfall                           |
| 30 | Death of persons           | Nil                                |
| 31 | People affected            | Nil                                |
| 32 | Live-stock loss            | Nil                                |
| 33 | Communication              | Road blocked                       |
| 34 | Infrastructure             | Nil                                |
| 35 | Agriculture/forest/Barr en | Forest                             |

|    |   |   |
|----|---|---|
| 36 | Geo-scientific Causes                         | The road cut is along a 25m thick rock layer overlain by lithomarge and soil. The steep cut in the soil layer has caused the slide. |
| 37 | Remedial measures                             | Easing of the soil layer and providing adequate drainage measures.  |
| 38 | Remarks, if any                               | --  |
| 39 | Photos. Sketch of Plan & section of the slide |    |
| 40 | Summary/Abstract                              | --  |
| 41 | Pdf   | --  |
| 42 | Landslide category                            | II  |


| No | Field                     | Description   |
|----|---------------------------|---|
| 1  | Slide No (LS .No.)        | KA/UK/48J01/2024/03   |
| 2  | State                     | Karnataka   |
| 3  | District                  | Uttara Kannada  |
| 4  | Toposheet                 | 48J/01  |
| 5  | Name of the slide         | --  |
| 6  | NH/SH/Locality            | NH-66 (Chainage 110.430)  |
| 7  | Latitude                  | 14.782712° N  |
| 8  | Longitude                 | 74.138830° E  |
| 9  | Length                    | ~ 8m  |
| 10 | Width                     | ~ 12m   |
| 11 | Height                    | ~ 7m  |
| 12 | Area                      | ~ 96m <sup>2</sup>  |
| 13 | Depth                     | ~ 2-4m  |
| 14 | Volume                    | --  |
| 15 | Run out distance          | ~ 20m   |
| 16 | Type of Material          | Debris  |
| 17 | Type of movement          | Slide   |
| 18 | Rate of movement          | Very rapid  |
| 19 | Activity                  | Active  |
| 20 | Distribution              | Retrogressive   |
| 21 | Style                     | Single  |
| 22 | Failure mechanism         | Shallow rotational failure  |
| 23 | History                   | Initiated on 07/2024  |
| 24 | Geomorphology             | Low dissected hills   |
| 25 | Geology                   | Peninsular Gneissic Complex   |
| 26 | Structure                 | --  |
| 27 | Land use/ Land cover      | Forest  |
| 28 | Hydrological condition    | Flowing   |
| 29 | Triggering Factor         | Rainfall  |
| 30 | Death of persons          | Nil   |
| 31 | People affected           | Nil   |
| 32 | Live-stock loss           | Nil   |
| 33 | Communication             | Road blocked  |
| 34 | Infrastructure            | --  |
| 35 | Agriculture/forest/Barren | Forest  |
| 36 | Geo-scientific Causes     | Reduction of strength of soil layer due to saturation and steep slope gradient. |

|    |   |  |
|----|---|--|
| 37 | Remedial measures                             | Slide movement should be monitored. Detailed studies should be carried out before any future slope modification. |
| 38 | Remarks, if any                               | --   |
| 39 | Photos. Sketch of Plan & section of the slide |                               |
| 40 | Summary/Abstract                              | --   |
| 41 | Pdf   | --   |
| 42 | Landslide category                            | II   |


| No | Field                     | Description                 |
|----|---------------------------|-----------------------------|
| 1  | Slide No (LS .No.)        | KA/UK/48J01/2024/04         |
| 2  | State                     | Karnataka                   |
| 3  | District                  | Uttara Kannada              |
| 4  | Toposheet                 | 48J/01                      |
| 5  | Name of the slide         | --                          |
| 6  | NH/SH/Locality            | NH-66 (Chainage- 110.530)   |
| 7  | Latitude                  | 14.783218° N                |
| 8  | Longitude                 | 74.139477° E                |
| 9  | Length                    | ~ 15m                       |
| 10 | Width                     | ~ 20m                       |
| 11 | Height                    | ~ 12m                       |
| 12 | Area                      | ~ 300m <sup>2</sup>         |
| 13 | Depth                     | >5m                         |
| 14 | Volume                    | --                          |
| 15 | Run out distance          | ~ 25-30m                    |
| 16 | Type of Material          | Debris                      |
| 17 | Type of movement          | Slide                       |
| 18 | Rate of movement          | Rapid                       |
| 19 | Activity                  | Active                      |
| 20 | Distribution              | Enlarging                   |
| 21 | Style                     | Single                      |
| 22 | Failure mechanism         | Deep rotational failure     |
| 23 | History                   | Initiated prior to 2024     |
| 24 | Geomorphology             | Low dissected hills         |
| 25 | Geology                   | Peninsular Gneissic Complex |
| 26 | Structure                 |                             |
| 27 | Land use/ Land cover      | Forest                      |
| 28 | Hydrological condition    | Flowing                     |
| 29 | Triggering Factor         | Rainfall                    |
| 30 | Death of persons          | Nil                         |
| 31 | People affected           | Nil                         |
| 32 | Live-stock loss           | Nil                         |
| 33 | Communication             | --                          |
| 34 | Infrastructure            | --                          |
| 35 | Agriculture/forest/Barren | Forest                      |

|    |   |  |
|----|---|--|
| 36 | Geo-scientific Causes                         | Reduction of strength by saturation of debris in the slope which has been cut steeply.                           |
| 37 | Remedial measures                             | Slide movement should be monitored. Detailed studies should be carried out before any future slope modification. |
| 38 | Remarks, if any                               | --   |
| 39 | Photos. Sketch of Plan & section of the slide |                               |
| 40 | Summary/Abstract                              | --   |
| 41 | Pdf   | --   |
| 42 | Landslide category                            | II   |


| No | Field                     | Description                        |
|----|---------------------------|------------------------------------|
| 1  | Slide No (LS .No.)        | KA/UK/48J01/2024/05                |
| 2  | State                     | Karnataka                          |
| 3  | District                  | Uttara Kannada                     |
| 4  | Toposheet                 | 48J/01                             |
| 5  | Name of the slide         | --                                 |
| 6  | NH/SH/Locality            | NH-66 (Chainage- 110.620)          |
| 7  | Latitude                  | 14.783530° N                       |
| 8  | Longitude                 | 74.140167° E                       |
| 9  | Length                    | ~ 15m                              |
| 10 | Width                     | ~ 40-45m                           |
| 11 | Height                    | ~ 10-12m                           |
| 12 | Area                      | --                                 |
| 13 | Depth                     | >5m                                |
| 14 | Volume                    | --                                 |
| 15 | Run out distance          | ~ 25-30m                           |
| 16 | Type of Material          | Debris                             |
| 17 | Type of movement          | Slide                              |
| 18 | Rate of movement          | Extremely rapid                    |
| 19 | Activity                  | Active                             |
| 20 | Distribution              | Enlarging                          |
| 21 | Style                     | Single                             |
| 22 | Failure mechanism         | Deep rotational failure            |
| 23 | History                   | Initiated during 2022              |
| 24 | Geomorphology             | Low dissected hills                |
| 25 | Geology                   | Peninsular Gneissic Complex        |
| 26 | Structure                 | J1-68:40, J2 – 89:110, J3 - 20:180 |
| 27 | Land use/ Land cover      | Forest                             |
| 28 | Hydrological condition    | Flowing                            |
| 29 | Triggering Factor         | Rainfall                           |
| 30 | Death of persons          | Nil                                |
| 31 | People affected           | Nil                                |
| 32 | Live-stock loss           | Nil                                |
| 33 | Communication             | Road blocked                       |
| 34 | Infrastructure            | --                                 |
| 35 | Agriculture/forest/Barren | Forest                             |

|    |   |  |
|----|---|--|
| 36 | Geo-scientific Causes                         | Saturation of debris in a steeply cut slope.   |
| 37 | Remedial measures                             | Slide movement should be monitored. Detailed studies should be carried out before any future slope modification. |
| 38 | Remarks, if any                               | --   |
| 39 | Photos. Sketch of Plan & section of the slide |                               |
| 40 | Summary/Abstract                              | --   |
| 41 | Pdf   | --   |
| 42 | Landslide category                            | II   |


| No | Field                     | Description                       |
|----|---------------------------|-----------------------------------|
| 1  | Slide No (LS .No.)        | KA/UK/48J01/2024/06               |
| 2  | State                     | Karnataka                         |
| 3  | District                  | Uttara Kannada                    |
| 4  | Toposheet                 | 48J/01                            |
| 5  | Name of the slide         | --                                |
| 6  | NH/SH/Locality            | NH-66 (Chainage- 110.690)         |
| 7  | Latitude                  | 14.783522° N                      |
| 8  | Longitude                 | 74.140903° E                      |
| 9  | Length                    | ~ 10-15m                          |
| 10 | Width                     | ~ 20m                             |
| 11 | Height                    | ~ 12m                             |
| 12 | Area                      | ~ 200m <sup>2</sup>               |
| 13 | Depth                     | <5m                               |
| 14 | Volume                    | --                                |
| 15 | Run out distance          | ~ 25-30m                          |
| 16 | Type of Material          | Debris                            |
| 17 | Type of movement          | Slide                             |
| 18 | Rate of movement          | Very rapid                        |
| 19 | Activity                  | Active                            |
| 20 | Distribution              | Retrogressive                     |
| 21 | Style                     | Single                            |
| 22 | Failure mechanism         | Shallow rotational failure        |
| 23 | History                   | 3 <sup>rd</sup> week of July 2024 |
| 24 | Geomorphology             | Low dissected hills               |
| 25 | Geology                   | Peninsular Gneissic Complex       |
| 26 | Structure                 | J1-78:18, J2 – 70:70, J3 - 15:150 |
| 27 | Land use/ Land cover      | Forest                            |
| 28 | Hydrological condition    | Flowing                           |
| 29 | Triggering Factor         | Rainfall                          |
| 30 | Death of persons          | Nil                               |
| 31 | People affected           | Nil                               |
| 32 | Live-stock loss           | Nil                               |
| 33 | Communication             | Road blocked                      |
| 34 | Infrastructure            | --                                |
| 35 | Agriculture/forest/Barren | Forest                            |

|    |   |   |
|----|---|---|
| 36 | Geo-scientific Causes                         | Saturation of debris in a steeply cut slope.  |
| 37 | Remedial measures                             | Detailed analysis of the slope is required for long term remedial measures.         |
| 38 | Remarks, if any                               | --  |
| 39 | Photos. Sketch of Plan & section of the slide |  |
| 40 | Summary/Abstract                              | --  |
| 41 | Pdf   | --  |
| 42 | Landslide category                            | II  |


| No | Field                     | Description                        |
|----|---------------------------|------------------------------------|
| 1  | Slide No (LS .No.)        | KA/UK/48J01/2024/07                |
| 2  | State                     | Karnataka                          |
| 3  | District                  | Uttara Kannada                     |
| 4  | Toposheet                 | 48J/01                             |
| 5  | Name of the slide         | --                                 |
| 6  | NH/SH/Locality            | NH-66 (Chainage- 110.750)          |
| 7  | Latitude                  | 14.783217                          |
| 8  | Longitude                 | 74.141485                          |
| 9  | Length                    | ~ 15m                              |
| 10 | Width                     | ~ 25m                              |
| 11 | Height                    | ~ 10m                              |
| 12 | Area                      | --                                 |
| 13 | Depth                     | <5m                                |
| 14 | Volume                    | --                                 |
| 15 | Run out distance          | ~ 40-50m                           |
| 16 | Type of Material          | Debris                             |
| 17 | Type of movement          | Slide                              |
| 18 | Rate of movement          | Extremely rapid                    |
| 19 | Activity                  | Active                             |
| 20 | Distribution              | Enlarging                          |
| 21 | Style                     | Single                             |
| 22 | Failure mechanism         | Shallow rotational failure         |
| 23 | History                   | July 2024                          |
| 24 | Geomorphology             | Low dissected hills                |
| 25 | Geology                   | Basic intrusives                   |
| 26 | Structure                 | J1-85:10, J2 – 78:145, J3 - 80:255 |
| 27 | Land use/ Land cover      | Forest                             |
| 28 | Hydrological condition    | Dripping                           |
| 29 | Triggering Factor         | Rainfall                           |
| 30 | Death of persons          | Nil                                |
| 31 | People affected           | Nil                                |
| 32 | Live-stock loss           | Nil                                |
| 33 | Communication             | Road blocked                       |
| 34 | Infrastructure            | --                                 |
| 35 | Agriculture/forest/Barren | Forest                             |

|    |   |  |
|----|---|--|
| 36 | Geo-scientific Causes                         | Saturation of debris in a steeply cut slope. Failure is along the rock-debris interface  |
| 37 | Remedial measures                             | Adequate drainage measures like horizontal perforated pipes for discharging the water from the debris. Detailed geotechnical study is required for long term stabilization measures. |
| 38 | Remarks, if any                               | --   |
| 39 | Photos. Sketch of Plan & section of the slide |   |
| 40 | Summary/Abstract                              | --   |
| 41 | Pdf   | --   |
| 42 | Landslide category                            | II   |


| No | Field                     | Description  |
|----|---------------------------|--|
| 1  | Slide No (LS .No.)        | KA/UK/48J01/2024/08  |
| 2  | State                     | Karnataka  |
| 3  | District                  | Uttara Kannada   |
| 4  | Toposheet                 | 48J/01   |
| 5  | Name of the slide         | --   |
| 6  | NH/SH/Locality            | NH-66 (Chainage 111.380)   |
| 7  | Latitude                  | 14.781229° N   |
| 8  | Longitude                 | 74.146864° E   |
| 9  | Length                    | ~ 40m  |
| 10 | Width                     | ~ 81 m   |
| 11 | Height                    | ~ 40m  |
| 12 | Area                      | ~  |
| 13 | Depth                     | ~ >5m  |
| 14 | Volume                    | ~  |
| 15 | Run out distance          | ~ 40m  |
| 16 | Type of Material          | Rock   |
| 17 | Type of movement          | Fall   |
| 18 | Rate of movement          | Extremely rapid  |
| 19 | Activity                  | Active   |
| 20 | Distribution              | Widening   |
| 21 | Style                     | Multiple   |
| 22 | Failure mechanism         | Deep translational   |
| 23 | History                   |  |
| 24 | Geomorphology             | Low dissected hills  |
| 25 | Geology                   | Peninsular Gneissic Complex  |
| 26 | Structure                 | Slope direction → N200° ; Exfoliation joints parallel to the slope |
| 27 | Land use/ Land cover      | Forest   |
| 28 | Hydrological condition    | Dripping   |
| 29 | Triggering Factor         | --   |
| 30 | Death of persons          | Nil  |
| 31 | People affected           | Nil  |
| 32 | Live-stock loss           | Nil  |
| 33 | Communication             | Road blocked and damaged   |
| 34 | Infrastructure            | --   |
| 35 | Agriculture/forest/Barren | forest   |

|    |   |   |
|----|---|---|
| 36 | Geo-scientific Causes                         | The slope has a road cut of approximately 30m in height. The cut has exposed highly jointed rock mass. The thick exfoliation joints in the rock surface dip sub parallel to the slope. This along with the vertical joints in the rock creates blocks of rocks without support. The rock falls occur along the exfoliation joint plane. |
| 37 | Remedial measures                             | Detailed studies are required along the Chainage 111.300 to 111.450. Precarious blocks may be removed and adequate support measures like proper netting should be provided for the slope.   |
| 38 | Remarks, if any                               | The area is highly susceptible to rock falls. Traffic may continue in the old parallel alignment and only be resumed after geotechnical interventions are made in the slope   |
| 39 | Photos. Sketch of Plan & section of the slide |    |
| 40 | Summary/Abstract                              | --  |
| 41 | Pdf   | --  |
| 42 | Landslide category                            | I   |


| No | Field                     | Description                        |
|----|---------------------------|------------------------------------|
| 1  | Slide No (LS .No.)        | KA/UK/48J01/2024/09                |
| 2  | State                     | Karnataka                          |
| 3  | District                  | Uttara Kannada                     |
| 4  | Toposheet                 | 48J/01                             |
| 5  | Name of the slide         | --                                 |
| 6  | NH/SH/Locality            | NH-66 (Chainage 122.220)           |
| 7  | Latitude                  | 14.759265° N                       |
| 8  | Longitude                 | 74.234887° E                       |
| 9  | Length                    | ~ 10-12m                           |
| 10 | Width                     | ~ 15m                              |
| 11 | Height                    | ~ 10m                              |
| 12 | Area                      | --                                 |
| 13 | Depth                     | <5m                                |
| 14 | Volume                    | --                                 |
| 15 | Run out distance          | --                                 |
| 16 | Type of Material          | Debris                             |
| 17 | Type of movement          | Slide                              |
| 18 | Rate of movement          | Rapid                              |
| 19 | Activity                  | Active                             |
| 20 | Distribution              | Widening                           |
| 21 | Style                     | Single                             |
| 22 | Failure mechanism         | Shallow rotational                 |
| 23 | History                   | --                                 |
| 24 | Geomorphology             | Low dissected hills                |
| 25 | Geology                   | Peninsular Gneissic Complex        |
| 26 | Structure                 | J1-80:130, J2 – 50:230, J3 - 20:20 |
| 27 | Land use/ Land cover      | Forest                             |
| 28 | Hydrological condition    | Flowing                            |
| 29 | Triggering Factor         | Rainfall                           |
| 30 | Death of persons          | Nil                                |
| 31 | People affected           | Nil                                |
| 32 | Live-stock loss           | Nil                                |
| 33 | Communication             | Road blocked                       |
| 34 | Infrastructure            | --                                 |
| 35 | Agriculture/forest/Barren | Forest                             |

|    |   |   |
|----|---|---|
| 36 | Geo-scientific Causes                         | Saturation and lack of support for the debris material exposed after steep slope cut. |
| 37 | Remedial measures                             | Remove the precarious boulders mechanically. Easing of the slope.                     |
| 38 | Remarks, if any                               | --  |
| 39 | Photos. Sketch of Plan & section of the slide |    |
| 40 | Summary/Abstract                              | --  |
| 41 | Pdf   | --  |
| 42 | Landslide category                            | II  |

| No | Field                     | Description                         |
|----|---------------------------|-------------------------------------|
| 1  | Slide No (LS .No.)        | KA/UK/48J01/2024/10                 |
| 2  | State                     | Karnataka                           |
| 3  | District                  | Uttara Kannada                      |
| 4  | Toposheet                 | 48J/02                              |
| 5  | Name of the slide         | --                                  |
| 6  | NH/SH/Locality            | NH-66 (Chainage-124.090)            |
| 7  | Latitude                  | 14.749197° N                        |
| 8  | Longitude                 | 74.248513° E                        |
| 9  | Length                    | ~ 20m                               |
| 10 | Width                     | ~ 40m                               |
| 11 | Height                    | ~ 15m                               |
| 12 | Area                      | --                                  |
| 13 | Depth                     | >5m                                 |
| 14 | Volume                    | --                                  |
| 15 | Run out distance          | --                                  |
| 16 | Type of Material          | Debris                              |
| 17 | Type of movement          | Slide                               |
| 18 | Rate of movement          | Very rapid                          |
| 19 | Activity                  | Active                              |
| 20 | Distribution              | Enlarging                           |
| 21 | Style                     | Single                              |
| 22 | Failure mechanism         | Deep rotational failure             |
| 23 | History                   | Initiated during 2024               |
| 24 | Geomorphology             | Low dissected hills                 |
| 25 | Geology                   | Peninsular Gneissic Complex         |
| 26 | Structure                 | J1-20:195, J2 – 89:110, J3 - 70:340 |
| 27 | Land use/ Land cover      | Forest                              |
| 28 | Hydrological condition    | Dripping                            |
| 29 | Triggering Factor         | Rainfall                            |
| 30 | Death of persons          | Nil                                 |
| 31 | People affected           | Nil                                 |
| 32 | Live-stock loss           | Nil                                 |
| 33 | Communication             | Road blocked                        |
| 34 | Infrastructure            | --                                  |
| 35 | Agriculture/forest/Barren | Forest                              |

|    |   |   |
|----|---|---|
| 36 | Geo-scientific Causes                         | Saturation and lack of support for the debris material exposed after steep slope cut.   |
| 37 | Remedial measures                             | Easing of the slope of the debris layer. Providing erosion control mats like geo jute with suitable grass variety plantation can be an effective solution for such slopes |
| 38 | Remarks, if any                               | The location has chances for further landslides   |
| 39 | Photos. Sketch of Plan & section of the slide |    |
| 40 | Summary/Abstract                              | --  |
| 41 | Pdf   | --  |
| 42 | Landslide category                            | II  |


| No | Field                     | Description                       |
|----|---------------------------|-----------------------------------|
| 1  | Slide No (LS .No.)        | KA/UK/48J01/2024/11               |
| 2  | State                     | Karnataka                         |
| 3  | District                  | Uttara Kannada                    |
| 4  | Toposheet                 | 48J/06                            |
| 5  | Name of the slide         | --                                |
| 6  | NH/SH/Locality            | NH-66 (Chainage-124.620)          |
| 7  | Latitude                  | 14.745973° N                      |
| 8  | Longitude                 | 74.251330° E                      |
| 9  | Length                    | ~ 25m                             |
| 10 | Width                     | ~ 20m                             |
| 11 | Height                    | ~ 22m                             |
| 12 | Area                      | --                                |
| 13 | Depth                     | >5m                               |
| 14 | Volume                    | --                                |
| 15 | Run out distance          | ~ 30-40m                          |
| 16 | Type of Material          | Rock and debris                   |
| 17 | Type of movement          | Slide                             |
| 18 | Rate of movement          | Extremely rapid                   |
| 19 | Activity                  | Active                            |
| 20 | Distribution              | Confined                          |
| 21 | Style                     | Single                            |
| 22 | Failure mechanism         | Shallow planar failure            |
| 23 | History                   | --                                |
| 24 | Geomorphology             | Low dissected hills               |
| 25 | Geology                   | Peninsular Gneissic Complex       |
| 26 | Structure                 | J1-40:40, J2 – 60:220, J3 - 75:95 |
| 27 | Land use/ Land cover      | Forest                            |
| 28 | Hydrological condition    | Dripping                          |
| 29 | Triggering Factor         | Rainfall                          |
| 30 | Death of persons          | Nil                               |
| 31 | People affected           | Nil                               |
| 32 | Live-stock loss           | Nil                               |
| 33 | Communication             | Road blocked                      |
| 34 | Infrastructure            | --                                |
| 35 | Agriculture/forest/Barren | Forest                            |

|    |   |   |
|----|---|---|
| 36 | Geo-scientific Causes                         | Lithomarge and soil layer exposed in a vertical slope                               |
| 37 | Remedial measures                             | Easing of the slope   |
| 38 | Remarks, if any                               | --  |
| 39 | Photos. Sketch of Plan & section of the slide |  |
| 40 | Summary/Abstract                              | --  |
| 41 | Pdf   | --  |
| 42 | Landslide category                            | II  |


| No | Field                     | Description              |
|----|---------------------------|--------------------------|
| 1  | Slide No (LS .No.)        | KA/UK/48J01/2024/12      |
| 2  | State                     | Karnataka                |
| 3  | District                  | Uttara Kannada           |
| 4  | Toposheet                 | 48J/06                   |
| 5  | Name of the slide         | --                       |
| 6  | NH/SH/Locality            | NH-66 (Chainage 147.030) |
| 7  | Latitude                  | 14.602864° N             |
| 8  | Longitude                 | 74.362828° E             |
| 9  | Length                    | ~ 80m                    |
| 10 | Width                     | ~ 100m                   |
| 11 | Height                    | ~ 60m                    |
| 12 | Area                      | --                       |
| 13 | Depth                     | >5m                      |
| 14 | Volume                    | --                       |
| 15 | Run out distance          | ~ 40m                    |
| 16 | Type of Material          | Debris                   |
| 17 | Type of movement          | Slide                    |
| 18 | Rate of movement          | Rapid                    |
| 19 | Activity                  | Active                   |
| 20 | Distribution              | Enlarging                |
| 21 | Style                     | Single                   |
| 22 | Failure mechanism         | Deep rotational failure  |
| 23 | History                   | August 2023              |
| 24 | Geomorphology             | Low dissected hills      |
| 25 | Geology                   | Ultramafic rocks         |
| 26 | Structure                 | --                       |
| 27 | Land use/ Land cover      | Forest                   |
| 28 | Hydrological condition    | Dripping                 |
| 29 | Triggering Factor         | Rainfall                 |
| 30 | Death of persons          | Nil                      |
| 31 | People affected           | Nil                      |
| 32 | Live-stock loss           | Nil                      |
| 33 | Communication             | Road blocked             |
| 34 | Infrastructure            | --                       |
| 35 | Agriculture/forest/Barren | Forest                   |

|    |   |   |
|----|---|---|
| 36 | Geo-scientific Causes                         | The thick lithomarge and soil layer which is clay rich was exposed after slope modification. Saturation of the material resulted in reduction of strength. The benches provided in the slope have also been failed. |
| 37 | Remedial measures                             | Detailed assessment is required for stabilization of the slope  |
| 38 | Remarks, if any                               | --  |
| 39 | Photos. Sketch of Plan & section of the slide |    |
| 40 | Summary/Abstract                              | --  |
| 41 | Pdf   | --  |
| 42 | Landslide category                            | II  |


| No | Field                         | Description                                  |
|----|-------------------------------|--|
| 1  | Slide No (LS .No.)            | KA/UK/48J01/2024/13                          |
| 2  | State                         | Karnataka                                    |
| 3  | District                      | Uttara Kannada                               |
| 4  | Toposheet                     | 48J/06                                       |
| 5  | Name of the slide             | --   |
| 6  | NH/SH/Locality                | NH-66 (Chainage 151.580)                     |
| 7  | Latitude                      | 14.582058° N                                 |
| 8  | Longitude                     | 74.381403° E                                 |
| 9  | Length                        | ~ 6m   |
| 10 | Width                         | ~ 40m  |
| 11 | Height                        | ~ 5m   |
| 12 | Area                          | --   |
| 13 | Depth                         | ~ 3-4m                                       |
| 14 | Volume                        | --   |
| 15 | Run out distance              | ~ 5m   |
| 16 | Type of Material              | Debris                                       |
| 17 | Type of movement              | Slide  |
| 18 | Rate of movement              | Rapid  |
| 19 | Activity                      | Active                                       |
| 20 | Distribution                  | Widening                                     |
| 21 | Style                         | Multiple                                     |
| 22 | Failure mechanism             | Shallow rotational failure                   |
| 23 | History                       | NA   |
| 24 | Geomorphology                 | Low dissected hills                          |
| 25 | Geology                       | Peninsular Gneissic Complex                  |
| 26 | Structure                     | Initiated prior to 2024. Reactivated on 2024 |
| 27 | Land use/ Land cover          | Forest                                       |
| 28 | Hydrological condition        | Wet  |
| 29 | Triggering Factor             | Rainfall                                     |
| 30 | Death of persons              | Nil  |
| 31 | People affected               | Nil  |
| 32 | Live-stock loss               | Nil  |
| 33 | Communication                 | Road (Has been cleared)                      |
| 34 | Infrastructure                | Nil  |
| 35 | Agriculture/forest/Barr<br>en | Forest                                       |

|    |   |   |
|----|---|---|
| 36 | Geo-scientific Causes                         | Landslide occurred due to saturation of debris exposed in steep cut.                |
| 37 | Remedial measures                             | Easing of slope   |
| 38 | Remarks, if any                               | --  |
| 39 | Photos. Sketch of Plan & section of the slide |  |
| 40 | Summary/Abstract                              | --  |
| 41 | Pdf   | --  |
| 42 | Landslide category                            | III   |


| No | Field                     | Description                                  |
|----|---------------------------|--|
| 1  | Slide No (LS .No.)        | KA/UK/48J01/2024/14                          |
| 2  | State                     | Karnataka                                    |
| 3  | District                  | Uttara Kannada                               |
| 4  | Toposheet                 | 48J/06                                       |
| 5  | Name of the slide         | --   |
| 6  | NH/SH/Locality            | NH-66 (Chainage 151.800)                     |
| 7  | Latitude                  | 14.580318° N                                 |
| 8  | Longitude                 | 74.382860° E                                 |
| 9  | Length                    | ~ 10-12 m                                    |
| 10 | Width                     | ~15-20 m                                     |
| 11 | Height                    | ~ 10m  |
| 12 | Area                      | --   |
| 13 | Depth                     | ~ 1-2 m                                      |
| 14 | Volume                    | --   |
| 15 | Run out distance          | --   |
| 16 | Type of Material          | Earth  |
| 17 | Type of movement          | Slide  |
| 18 | Rate of movement          | Very rapid                                   |
| 19 | Activity                  | Active                                       |
| 20 | Distribution              | Enlarging                                    |
| 21 | Style                     | Single                                       |
| 22 | Failure mechanism         | Shallow rotational failure                   |
| 23 | History                   | Initiated prior to 2024, Reactivated on 2024 |
| 24 | Geomorphology             | Low dissected hills                          |
| 25 | Geology                   | Peninsular Gneissic Complex                  |
| 26 | Structure                 | J1-75:315, J2 – 88:235, J3 - 8:260           |
| 27 | Land use/ Land cover      | Forest                                       |
| 28 | Hydrological condition    | Flowing                                      |
| 29 | Triggering Factor         | Rainfall                                     |
| 30 | Death of persons          | Nil  |
| 31 | People affected           | Nil  |
| 32 | Live-stock loss           | Nil  |
| 33 | Communication             | Road (cleared)                               |
| 34 | Infrastructure            | --   |
| 35 | Agriculture/forest/Barren | Forest                                       |

|    |   |  |
|----|---|--|
| 36 | Geo-scientific Causes                         | The road cut is along an approximately 15 m height section which exposed granite gneiss at the bottom and clay rich laterite at the top. The failure is due to the saturation of the laterite layer due to rainfall. |
| 37 | Remedial measures                             | The slope may not be disturbed by any excavation as it may further destabilize the slope.  |
| 38 | Remarks, if any                               | The area is susceptible to minor slope failures from the laterite layer.   |
| 39 | Photos. Sketch of Plan & section of the slide |   |
| 40 | Summary/Abstract                              | --   |
| 41 | Pdf   | --   |
| 42 | Landslide category                            | II   |


| No | Field                     | Description                 |
|----|---------------------------|-----------------------------|
| 1  | Slide No (LS .No.)        | KA/UK/48J01/2024/15         |
| 2  | State                     | Karnataka                   |
| 3  | District                  | Uttara Kannada              |
| 4  | Toposheet                 | 48J/06                      |
| 5  | Name of the slide         | --                          |
| 6  | NH/SH/Locality            | NH-66                       |
| 7  | Latitude                  | 14.521306° N                |
| 8  | Longitude                 | 75.409556° E                |
| 9  | Length                    | ~ 7m                        |
| 10 | Width                     | ~20m                        |
| 11 | Height                    | ~ 6m                        |
| 12 | Area                      | --                          |
| 13 | Depth                     | ~1-2m                       |
| 14 | Volume                    | --                          |
| 15 | Run out distance          | --                          |
| 16 | Type of Material          | Earth                       |
| 17 | Type of movement          | Slide                       |
| 18 | Rate of movement          | Rapid                       |
| 19 | Activity                  | Active                      |
| 20 | Distribution              | Enlarging                   |
| 21 | Style                     | Single                      |
| 22 | Failure mechanism         | Shallow rotational failure  |
| 23 | History                   | Reactivated on 2024         |
| 24 | Geomorphology             | Low dissected hills         |
| 25 | Geology                   | Peninsular Gneissic Complex |
| 26 | Structure                 | --                          |
| 27 | Land use/ Land cover      | Forest                      |
| 28 | Hydrological condition    | Dripping                    |
| 29 | Triggering Factor         | Rainfall                    |
| 30 | Death of persons          | Nil                         |
| 31 | People affected           | Nil                         |
| 32 | Live-stock loss           | Nil                         |
| 33 | Communication             | Road (cleared)              |
| 34 | Infrastructure            | Nil                         |
| 35 | Agriculture/forest/Barren | Forest                      |

|    |   |   |
|----|---|---|
| 36 | Geo-scientific Causes                         | The section exposes a 6-7 m thick lithomarge and clay-rich lateritic soil over the granite gneiss. The section is vertically cut, thereby facilitating minor slides in the unsupported soil horizon |
| 37 | Remedial measures                             | The slope may not be disturbed by any excavation as it may further destabilize the slope.   |
| 38 | Remarks, if any                               | The area is susceptible to minor slope failures from the laterite layer.  |
| 39 | Photos. Sketch of Plan & section of the slide |    |
| 40 | Summary/Abstract                              | --  |
| 41 | Pdf   | --  |
| 42 | Landslide category                            | II  |


| No | Field                     | Description                       |
|----|---------------------------|-----------------------------------|
| 1  | Slide No (LS .No.)        | KA/UK/48J01/2024/16               |
| 2  | State                     | Karnataka                         |
| 3  | District                  | Uttara Kannada                    |
| 4  | Toposheet                 | 48J/06                            |
| 5  | Name of the slide         | --                                |
| 6  | NH/SH/Locality            | NH-66 (Chainage 160.080)          |
| 7  | Latitude                  | 14.513155° N                      |
| 8  | Longitude                 | 74.411225° E                      |
| 9  | Length                    | ~ 20m                             |
| 10 | Width                     | ~ 10m                             |
| 11 | Height                    | ~10m                              |
| 12 | Area                      | ~                                 |
| 13 | Depth                     | >5m                               |
| 14 | Volume                    | ~                                 |
| 15 | Run out distance          | ~ 40m                             |
| 16 | Type of Material          | Debris                            |
| 17 | Type of movement          | Flow                              |
| 18 | Rate of movement          | Rapid                             |
| 19 | Activity                  | Active                            |
| 20 | Distribution              | Retrogressive                     |
| 21 | Style                     | Single                            |
| 22 | Failure mechanism         | Deep rotational                   |
| 23 | History                   | Reactivation on 18/07/2024        |
| 24 | Geomorphology             | Low dissected hills               |
| 25 | Geology                   | Peninsular Gneissic Complex       |
| 26 | Structure                 | J1-80:30, J2 – 60:50, J3 - 80:260 |
| 27 | Land use/ Land cover      | Forest                            |
| 28 | Hydrological condition    | Flowing                           |
| 29 | Triggering Factor         | Rainfall                          |
| 30 | Death of persons          | Nil                               |
| 31 | People affected           | Nil                               |
| 32 | Live-stock loss           | Nil                               |
| 33 | Communication             | Road blocked                      |
| 34 | Infrastructure            | Nil                               |
| 35 | Agriculture/forest/Barren | Forest                            |

|    |   |  |
|----|---|--|
| 36 | Geo-scientific Causes                         | The debris flow is caused by oversaturation and resultant piping in the soil layer                                   |
| 37 | Remedial measures                             | Remove the debris from the run-out zone. Any further slope modification without detailed studies is not recommended. |
| 38 | Remarks, if any                               | The area is susceptible to similar failures in the future.   |
| 39 | Photos. Sketch of Plan & section of the slide |                                   |
| 40 | Summary/Abstract                              | --   |
| 41 | Pdf   | --   |
| 42 | Landslide category                            | II   |


| No | Field                      | Description                          |
|----|----------------------------|--------------------------------------|
| 1  | Slide No (LS .No.)         | KA/UK/48J01/2024/17                  |
| 2  | State                      | Karnataka                            |
| 3  | District                   | Uttara Kannada                       |
| 4  | Toposheet                  | 48J/07                               |
| 5  | Name of the slide          | --                                   |
| 6  | NH/SH/Locality             | NH-66 (Chainage 166.250)             |
| 7  | Latitude                   | 14.470933° N                         |
| 8  | Longitude                  | 74.439445° E                         |
| 9  | Length                     | ~ 80-90m                             |
| 10 | Width                      | ~ 120m                               |
| 11 | Height                     | ~ 30-40m                             |
| 12 | Area                       | --                                   |
| 13 | Depth                      | >5m                                  |
| 14 | Volume                     | --                                   |
| 15 | Run out distance           | --                                   |
| 16 | Type of Material           | Debris                               |
| 17 | Type of movement           | Slide                                |
| 18 | Rate of movement           | Moderate                             |
| 19 | Activity                   | Active                               |
| 20 | Distribution               | Enlarging                            |
| 21 | Style                      | Multiple                             |
| 22 | Failure mechanism          | Deep rotational failure              |
| 23 | History                    | Reactivated on 2024                  |
| 24 | Geomorphology              | Low dissected hills                  |
| 25 | Geology                    | Vanadiferous Titano-Magnetite Gabbro |
| 26 | Structure                  | --                                   |
| 27 | Land use/ Land cover       | Forest                               |
| 28 | Hydrological condition     | Damp                                 |
| 29 | Triggering Factor          | Rainfall                             |
| 30 | Death of persons           | Nil                                  |
| 31 | People affected            | Nil                                  |
| 32 | Live-stock loss            | Nil                                  |
| 33 | Communication              | Road blocked                         |
| 34 | Infrastructure             | --                                   |
| 35 | Agriculture/forest/Barr en | Forest                               |

|    |   |   |
|----|---|---|
| 36 | Geo-scientific Causes                         | The road cut is through a thick lithomarge and laterite cover developed over Gabbroic rocks. The laterite layer is not strong enough to withstand the existing slope profile resulting in a slump.  |
| 37 | Remedial measures                             | A detailed study on the slope section is recommended with emphasis on drainage management, slope geometry modification and structural support measures. Since the slide scar has almost reached the hilltop, major retrogression may not occur, but widening of the slide is likely |
| 38 | Remarks, if any                               | The latest drone footage has revealed a major scar developed.   |
| 39 | Photos. Sketch of Plan & section of the slide |    |
| 40 | Summary/Abstract                              | --  |
| 41 | Pdf   | --  |
| 42 | Landslide category                            | II  |

| No | Field                     | Description                           |
|----|---------------------------|---------------------------------------|
| 1  | Slide No (LS .No.)        | KA/UK/48J01/2024/18                   |
| 2  | State                     | Karnataka                             |
| 3  | District                  | Uttara Kannada                        |
| 4  | Toposheet                 | 48J/06 (Chainage 167.800)             |
| 5  | Name of the slide         | --                                    |
| 6  | NH/SH/Locality            | NH-66                                 |
| 7  | Latitude                  | 14.457233° N                          |
| 8  | Longitude                 | 74.438342° E                          |
| 9  | Length                    | ~ 35m                                 |
| 10 | Width                     | ~ 40m                                 |
| 11 | Height                    | ~ 30m                                 |
| 12 | Area                      | --                                    |
| 13 | Depth                     | ~ 1-2m                                |
| 14 | Volume                    | --                                    |
| 15 | Run out distance          | --                                    |
| 16 | Type of Material          | Debris                                |
| 17 | Type of movement          | Slide                                 |
| 18 | Rate of movement          | Rapid                                 |
| 19 | Activity                  | Active                                |
| 20 | Distribution              | Enlarging                             |
| 21 | Style                     | Single                                |
| 22 | Failure mechanism         | Shallow translational failure         |
| 23 | History                   | --                                    |
| 24 | Geomorphology             | Low dissected hills                   |
| 25 | Geology                   | Hornblende-Chlorite-Actinolite Schist |
| 26 | Structure                 | --                                    |
| 27 | Land use/ Land cover      | Forest                                |
| 28 | Hydrological condition    | Wet                                   |
| 29 | Triggering Factor         | Rainfall                              |
| 30 | Death of persons          | Nil                                   |
| 31 | People affected           | Nil                                   |
| 32 | Live-stock loss           | Nil                                   |
| 33 | Communication             | Road                                  |
| 34 | Infrastructure            | --                                    |
| 35 | Agriculture/forest/Barren | Forest                                |

|    |   |  |
|----|---|--|
| 36 | Geo-scientific Causes                         | Steep cut in lateritic horizon. The shotcrete provided in the slope is observed to be falling off due to the development of pore water pressure in the laterite. |
| 37 | Remedial measures                             | Adequate horizontal drainage measures may be provided for the slope.   |
| 38 | Remarks, if any                               | --   |
| 39 | Photos. Sketch of Plan & section of the slide |   |
| 40 | Summary/Abstract                              | --   |
| 41 | Pdf   | --   |
| 42 | Landslide category                            | II   |

| No | Field                      | Description             |
|----|----------------------------|-------------------------|
| 1  | Slide No (LS .No.)         | KA/UK/48J01/2024/19     |
| 2  | State                      | Karnataka               |
| 3  | District                   | Uttara Kannada          |
| 4  | Toposheet                  | 48K/09                  |
| 5  | Name of the slide          | --                      |
| 6  | NH/SH/Locality             | NH-66 (Chainage245.500) |
| 7  | Latitude                   | 13.888483° N            |
| 8  | Longitude                  | 74.617990° E            |
| 9  | Length                     | ~ 30m                   |
| 10 | Width                      | ~ 100m                  |
| 11 | Height                     | ~ 25m                   |
| 12 | Area                       | ~                       |
| 13 | Depth                      | >5m                     |
| 14 | Volume                     | --                      |
| 15 | Run out distance           | ~ 15m                   |
| 16 | Type of Material           | Earth                   |
| 17 | Type of movement           | Slide                   |
| 18 | Rate of movement           | Rapid                   |
| 19 | Activity                   | Suspended               |
| 20 | Distribution               | Enlarging               |
| 21 | Style                      | Multiple                |
| 22 | Failure mechanism          | --                      |
| 23 | History                    | Reactivated on 2024     |
| 24 | Geomorphology              | Low dissected hill      |
| 25 | Geology                    |                         |
| 26 | Structure                  |                         |
| 27 | Land use/ Land cover       | Vegetation              |
| 28 | Hydrological condition     | Dripping                |
| 29 | Triggering Factor          | Rainfall                |
| 30 | Death of persons           | Nil                     |
| 31 | People affected            | Nil                     |
| 32 | Live-stock loss            | Nil                     |
| 33 | Communication              | Nil                     |
| 34 | Infrastructure             | Nil                     |
| 35 | Agriculture/forest/Barr en |                         |

|    |   |  |
|----|---|--|
| 36 | Geo-scientific Causes                         | The hard and ferruginous blocks of laterite in the upslope have fractures within them. The blocks of laterite are sliding down after being detached from the surface.  |
| 37 | Remedial measures                             | The existing retaining wall may be continued till the slide location to arrest the movement of the blocks till the road. Else steel piles may also be erected instead of the RCC wall. Enough provisions should be provided for the unhindered flow of the subsurface water. |
| 38 | Remarks, if any                               | The slope is not susceptible to deep rotational failure  |
| 39 | Photos. Sketch of Plan & section of the slide |   |
| 40 | Summary/Abstract                              | --   |
| 41 | Pdf   | --   |
| 42 | Landslide category                            | II   |

| No | Field                  | Description   |
|----|------------------------|---|
| 1  | Slide No (LS .No.)     | KA/UK/48J06/2024/01   |
| 2  | State                  | Karnataka   |
| 3  | District               | Uttara Kannada  |
| 4  | Toposheet              | 48J06   |
| 5  | Name of the slide      | Shirur Slide  |
| 6  | NH/SH/Locality         | NH-66   |
| 7  | Latitude               | 14.603554° N  |
| 8  | Longitude              | 74.371219° E  |
| 9  | Length                 | ~150m   |
| 10 | Width                  | ~120m   |
| 11 | Height                 | ~60m  |
| 12 | Area                   | ~18000m <sup>2</sup>  |
| 13 | Depth                  | ~10m  |
| 14 | Volume                 | >1,00,000 m <sup>3</sup>  |
| 15 | Run out distance       | ~200 m  |
| 16 | Type of Material       | Debris  |
| 17 | Type of movement       | Flow  |
| 18 | Rate of movement       | Extremely Rapid   |
| 19 | Activity               | Active  |
| 20 | Distribution           | Enlarging   |
| 21 | Style                  | Single  |
| 22 | Failure mechanism      | Deep rotational   |
| 23 | History                | Initiation-16-07-2024, 08:30 am                                 |
| 24 | Geomorphology          | Low dissected hill  |
| 25 | Geology                | Pyroxenite  |
| 26 | Structure              | Foliation - 210°/45°; J1- 35°:30°; J2 – 80°:295°; J3 - 80°:230° |
| 27 | Land use/ Land cover   | Dense vegetation  |
| 28 | Hydrological condition | Flowing   |

|    |                           |   |
|----|---------------------------|---|
| 29 | Triggering Factor         | Rainfall  |
| 30 | Death of persons          | 10 at the time of investigation   |
| 31 | People affected           | 4 people critically injured on the opposite bank  |
| 32 | Live-stock loss           | NA  |
| 33 | Communication             | Road blockage   |
| 34 | Infrastructure            | Road damaged, 4 houses destroyed, one tea stall washed away, two high tension power transmission towers destroyed, 3 trucks washed away   |
| 35 | Agriculture/forest/Barren | Forest  |
| 36 | Geo-scientific Causes     | <ol style="list-style-type: none"> <li>1. The site has a very thick weathered rock and in-situ clay-rich lateritic soil exposed by slope cutting.</li> <li>2. The pyroxenite rock in the area is highly weathered, topped by a thick soil cover. The fresh pyroxenite rock exposed at the toe tapers, providing minimal natural toe buttress.</li> <li>3. Natural drainage flows have been disturbed due to slope modifications.</li> <li>4. The slide area and the left flank are structurally deformed, presenting friable and gouge-like material.</li> <li>5. <b><i>The steep gradient of the cut slope, presence of highly weathered rock, thick debris, saturation due to rainfall, and lack of toe support are the primary causative factors of the debris flow</i></b></li> </ol> |
| 37 | Remedial measures         | <p><b>1. Road alignment, Slope Gradient and Benching:</b> At the Shirur area, since the road is under construction, an alignment shift from chainage 147300 till 147800 is proposed if the land is available. This would reduce the height of slope cut of the currently undisturbed slope from 147300 to 147500 to a minimum and shift the carriageway from the toe of the disturbed horizon from 147500 to 148100 For any slope modification at the site, ensure compliance with BIS codes for slope gradient with appropriate benching, based on geotechnical properties of the soil. Bench width should be adequate to enable slope segments to act</p>   |

|    |                 |  |
|----|-----------------|--|
|    |                 | <p>independently (IS code 14680:1999).</p> <p>2. <b>Drainage Improvements:</b> Contour drains (Fig. 13) above Ch. 147.500 should be lined and provide stepped chute drains on slope faces depending on hydrological conditions.</p> <p>3. <b>Erosion Control:</b> Install lined ditches or drainage on benches, along with slope reinforcement measures.</p> <p>4. <b>Culvert Installation:</b> The convergence of natural drainage is anticipated at the landslide face with time. A culvert with sufficient diameter pre-cast pipes should be provided to accommodate water and debris discharge at the toe of the landslide at Ch. No. 148.000.</p> <p>5. <b>Monitoring and Surveying:</b> It is recommended to monitor and survey for signs of instabilities even above Right of Way especially for slope sections with higher relative relief on the right and left flanks of Shirur landslide. Shirur landslide is a classic case where the rupture surface extended beyond the ROW due to higher relief above the cut slope. Deploy flaggers for traffic control and restrict access to high-risk areas.</p> <p>6. <b>Subsurface Water Drainage:</b> Include perforated horizontal pipes of appropriate diameter and sufficient length in engineered slopes to manage subsurface water flow.</p> <p>7. <b>Geotechnical Investigation:</b> Conduct comprehensive investigations to determine suitable stabilization strategies for Shirur landslide, considering potential landslide enlargement due to considerable thickness of soil in the crown and hydrological conditions.</p> |
| 38 | Remarks, if any | Detailed geotechnical studies should be carried out before implementation of recommended remedial measures.  |

|           |  |  |
|-----------|--|--|
| <p>39</p> | <p>Photos. Sketch of Plan &amp; section of the slide</p> |  |
| <p>40</p> | <p>Summary/Abstract</p>                                  | <p><i>The landslide incident at Shirur village, Ankola Taluk, in Uttara Kannada district occurred on 16th July 2024 at approximately 08:30 Hrs. The steep gradient of the cut slope, presence of highly weathered rock, thick debris, saturation due to rainfall, and lack of natural toe support are the primary causative factors of the debris flow. A comprehensive geotechnical investigation is recommended to determine appropriate slope stabilization strategies for the Shirur site.</i></p> |
| <p>41</p> | <p>Pdf</p>   | <p>Attached</p>  |
| <p>42</p> | <p>Landslide category</p>                                | <p>I</p>   |

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## ANNEXURE R-8 (Colly)

04.08.2024

**The Regional Officer**  
**National Highways Authority of India**  
Bangalore-560 073

**Project:** Four-laning of Goa/Karnataka Border to Kundapur section of NH-17 from Km. 93.700 to Km. 283.300 in the state of Karnataka under NHDP Phase IV on a Design, Build, Operate, Transfer (DBFOT) toll basis.

**Subject:** Geotechnical experts' review and recommendations for restoration of slopes on the landslide incident on 16.07.2024, at National Highway NH-66 (@Km. 148.100, Shiroor Village of Ankola Taluk).

Dear Sir,

The following experts,

- Dr. Anand Kumar Pandey, Chief Scientist, Geology, National Geophysical Research Institute, Hyderabad.
- Sh. Ashish D. Gharpure, MD, Genstru Consultants Pvt. Ltd., Pune
- Dr. R. Sajeev, Director, Geological Survey of India, Bangalore.

assessed the cause(s) and the conditions prevailing at the site for restoration of the damaged hillock. As head of the committee constituted by you, I have visited the site, interacted with the other NHAI officials, and gone through the reports submitted by the colleagues mentioned above, I wish to point out/recommend as follows:

### A. Report submitted by Dr. Anand Kumar Pandey:

- The devastating Mud (debris) flow primarily occurred due to over-saturation of the Lithomarge (lateritic) soil during heavy rains and concentration of seepage along the soil-rock interface, facilitating a gravity flow of the lateritic soil.  
*I agree with this observation. Primarily, this landslide was triggered due to the presence of water bodies (inside the forest) behind the crown of the scar, causing a dam burst-like situation that has resulted in the ejection of mud slurry up to distances as high as 200 m (and up to the 2/3<sup>rd</sup> width of the Gangavali river).*
- The mud flow occurred even though the steepness of the slope was reduced by repeated removal of the soil column before the present event.  
*I agree with this fact, which was brought to my notice by the NHAI officials and concessionaire.*
- Since the mud (debris) flow has removed a large part of the soil column and the bare rocky slope is still experiencing subsurface seepage from the upstream soil column, it makes the upstream section with a very high slope gradient vulnerable to future slope failure.  
*I agree with this observation and recommend that a proper strategy should be evolved to stabilize the remaining slope.*
- Further, the adjoining slopes with seepages are also vulnerable to slope failure and, at places, show signs of the development of slope failure scars.  
*I agree with this observation and recommend that a proper strategy should be evolved to stabilize these slopes.*

- e) The mud flow has a large (>150m wide) toe region with variable mass movement. It is difficult to consider the sections as one unit, and therefore, the preventive measures have to be designed.  
*I agree with this observation and recommend that a proper strategy should be evolved to stabilize the remaining slope.*

**The mitigation measures recommended by Dr. Pandey are:**

- f) As the vulnerable slopes are constituted of Lithomarge soil, which lacks cohesion and have a high potential for mass movement when over-saturated, these slopes should be dewatered by implementing perforated pipe insertion at regular intervals and blocking upstream seepages wherever possible.  
*Though conceptually, I agree with this observation and recommendation, in real life, installation of such a drainage system is not feasible due to the fact that during my site visits to different locations, I observed that the installed pipes are mostly defunct as the water does not drain out.*
- h) The disjointed retaining walls with adequate provisions for dewatering should be built and anchored on the hard rocks exposed at the toe of the hill slope.  
*Though conceptually I agree with this recommendation, in real life, installation of such retention systems will not be techno-commercially viable.*
- i) Since the landslide is large and the mass flow is variable, the disjointed retaining walls with alternate openings should be built with extra protection (two lines) towards the middle of the landslide zone. This will also reduce the force of any mass movement arising out of future slope failure from the upslope region.  
*Though conceptually I agree with this recommendation, in real life, installation of such retention systems will not be techno-commercially viable. How such spots will be identified and that too by adopting which scientific methodology, how foundations for such systems would be placed, etc. remain major questions.*
- j) The back of the retaining wall in the landslide zone should not be filled with Mud or debris, as it provides a vacancy for accommodating material arising from further mass movements from the upslope region.  
*No comments.*
- k) The dewatering from the adjoining slopes should be prioritized, which will delay lateral expansion of the landslide zone and reduce the chances of slope instability and mass movement.  
*No comments.*
- l) The steep slopes should be made gentler as per the standard guidelines.  
*Though I agree with this recommendation, in real life, the acquisition of land seems to be a significant deterrent for such projects. This is where the intervention of NHAI in facilitating approvals from the state administration and the Forest Dept. becomes inevitable.*

**B. Report submitted by Shri. Ashish D Gharpure:**

The root cause appears to be a combination of

- a) Hill getting charged (saturated) by continuous rainfall.
- b) Steep slopes of cut, which could survive in dry conditions or limited moisture, not sustaining saturated water pressure.
- c) Lithomargic Clay blocks the sub-surface flow of water and thus increasing water pressure.
- d) Piping conditions in the matrix reduce shear strength due to internal erosion.
- e) Interface between rock strata and overburden soil sloughing due to reduced interface friction.  
*I agree with the above-mentioned facts.*

**The mitigation measures suggested by Mr. Gharpure are:**

- a) Flattening the top overburden portion to 2H:1V slope and greening it  
*I agree with this recommendation.*
- b) Providing a small toe structure at the junction of overburden and rock strata with drainage arrangement  
*Though I agree with this recommendation conceptually, in real life, installing such structures will not be techno-commercially viable.*
- c) Making berm at intermediate level with berm drain for collecting surface and sub-surface water and bringing it down with a cascade to merge with road side drain.  
*I agree with this observation and recommend that a proper strategy should be evolved to implement this recommendation.*
- d) Once the rock strata cut is cleared, explore the possibility of making an anchored wall extending above the rock strata so that in case of future sloughing from the top, the failed mass can be contained behind the extended portion of the wall.  
*Though I agree with this recommendation conceptually, in real life, installing such retention systems will not be techno-commercially viable.*
- e) A schematic section for mitigation measure is enclosed. Detailed design and further detailing on drainage and sizing etc. will be required for implementation.  
*No comments.*

**C. Report submitted by Dr. R. Sajeev:**

- a) The Shirur landslide of July 16, 2024, was a devastating event resulting from the interplay of anthropogenic activities, geological characteristics, and meteorological conditions.  
*I beg to disagree with this observation. This (landslide) incident was very unfortunate. The sliding/collapse of the rock/soil mass from the hillock was unprecedented, unforeseeable, and catastrophic (primarily due to the flow of over-saturated lithomarge clay).*
- b) The detailed investigation revealed that continuous slope modifications, coupled with intense rainfall and unfavorable geological conditions, led to the saturation and weakening of debris material.  
*I disagree with this observation. Primarily, this landslide was triggered by the presence of water bodies (inside the forest) behind the crown of the scar, causing a dam burst. This situation has resulted in the ejection of mud slurry up to distances as high as 200 m (and up to the 2/3<sup>rd</sup> width of the Gangavali river).*
- a) The absence of proper retaining structures and the presence of highly porous and permeable slope material further exacerbated the situation, resulting in a large-scale debris flow. Addressing both immediate and long-term needs with a multi-faceted approach is essential to enhance the resilience of the NH-66 corridor and protect the local community from similar events in the future. Implementing the recommended measures will significantly reduce the area's vulnerability to landslides, ensuring the safety and stability of this critical infrastructure.  
*I disagree with this observation. Even if any toe wall/retaining wall existed, it would have been washed away completely, due to the huge velocity/impact of the ejected mud slurry.*

**D. My Observations/Analysis:**

At the outset, I wish to convey that this incident is a very unfortunate sliding/collapse of the rock/soil mass from the hillock, unprecedented, unforeseeable, and catastrophic in nature (in short, a **force majeure** event). Such slides/failures cannot be predicted/detected by any instrumentation, a priori, due to several uncertainties (viz., formation of several weak planes in the rock/soil mass which get created due to seepage/suffusion-induced cavity formation, etc.). As the whole process mentioned above is invisible and unpredictable, site engineers/executing agencies remain clueless, if not helpless.

Please note the following site visit observations and probable cause(s) of failure:

- a) The condition of the slope is very critical on both sides of the **scar** due to incessant rains, which have piled up a huge quantity of soil and boulder matrix on the left carriageway.
- b) It is observed that topsoil cover (overburden soil) has slid against the underlying rock.
- c) As the slope is more than 25-30 m in height and the soil mass has experienced extremely high seepage/pore pressures, the resultant mudflow could attain so much velocity within a very short duration. Such a situation has resulted in washing away of any obstacle (viz., vehicles, temporary structures, people sitting at the hotel, trees, etc.) that came in its way.
- d) The water has not seeped through the soil mass to saturate it but through several channels visible on the surface of the failed slope/hillock.
- e) Under extreme seepage, this soil mass, which lacks inherent cohesion, was eroded due to the suffusion-induced formation of large cavities. Primarily, this phenomenon has caused instability/collapse of the hillock along the interface of the overburden soil and the underlying bedrock.
- f) In my opinion, stabilizing such slopes by soil nailing, vegetation, shotcrete, etc., will not be effective.

**Immediate Actions to be Taken at the Site (Temporary Preventive Measures):**

1. If possible, channel water from the hilltop to facilitate proper surface runoff and prevent its ingress into the soil/rock mass.
2. Traffic can be allowed on fulfilment of the short-term measures suggested earlier along the Riverside main carriageway.
3. Restrict the vehicle's speed to about 20 km/hr without honking or acceleration/deceleration-induced vibrations.
4. Do not allow vehicles to stop in the affected stretch.
5. If any movement of the soil mass sliding/falling/falling of the boulders is observed, the project manager should be notified, and traffic on both sides should be stopped.
6. The entire stretch has to be under the vigilance of the trained security/police officials.
7. Display cautionary sign boards at appropriate locations.

**Detailed Engineering**

- i. After the rains cease, the affected stretch needs to be technically audited from an overall stability and surface/subsurface drainage point of view.
- ii. Carry out a high-resolution drone/manual survey of this stretch, including the catchment area on top of the hillock.
- iii. Plot topographical plan, contour maps and sections at the critical locations.
- iv. A detailed analysis for stabilization of the hillock/slope will be conducted by considering the site topography, slope height, availability of the land, availability of equipment/material, time and cost.

**The way forward (in general for such projects):**

The roads in the cutting areas are not designed keeping in view the local/global stability, mainly due to the want of adequate *right-of-way*. The hindrances in obtaining the required *right of way* are; property owner's unrealistic/unreasonable demands, approval from the forest department, the lengthy land acquiring procedures, etc. In such a scenario, it is difficult to complete the projects on time, as stabilization of the cut slopes becomes a 'separate project', which might not be viable financially.

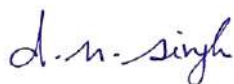
It is not possible to detect/predict slope failures in advance as no prior (visible) symptoms are exhibited, so any proactive actions to alleviate these slopes could be taken. Unfortunately, the failure symptoms start showing up when the slopes become active, which turns out to be too late.

Under these circumstances, the following line of action appears to be the most appropriate *way forward*:

- a) A detailed drone survey of highly critical hillocks/slopes, including their catchment area, should be conducted to effectively identify and understand the topography, geomorphological features, and water bodies. Various stakeholders/agencies, viz., the state mining/geological/remote sensing departments/agencies and the forest department, in particular, should collaborate and leverage their respective expertise and resources.
- b) Carry out geotechnical investigation, if required.
- c) Unfortunately, locating the water channels is difficult. Any slope stabilization work, such as soil/rock nailing, shotcreting, vegetation growth, and the creation of toe/retaining walls, will not be effective.
- d) Instead, the designed slope angle should be based on the geotechnical parameters.
- e) Design a properly lined drainage system to drain off the surface runoff water. Provision of longitudinal drains on the top of the slopes/hillocks and their interconnectivity with the longitudinal drains (at suitable intervals) should be attempted.
- f) A series of long weep holes would certainly help stabilize the hillocks/slopes, but their effectiveness, mainly based on the observations from the earlier installations, seems to be a deterrent.
- g) If the top of the rock face is not significantly deep, say less than 3 m, the best approach is to trim the soil mass.

If you have further queries, please feel free to contact me.

Best wishes!



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**Report Title: Visit Report, Preliminary Assessment of Root Cause, and Conceptual Mitigation Measure for Landslide at Chainage 148 of NH-66**

**Submitted to:**

**National Highway Authority of India (NHAI)**



**Submitted By:**

**Ashish D Gharpure**



**August 2 - 2024**

## 1 Preamble

4 laning of Goa-Karnataka Border to Kundapur (Km 93.70 – Km 283.30) section of NH-66 on BOT (Toll); Hasan-Maranhally section of NH-48; and 4 laning of Addahole (Near Gundy) to Bantwal section (Pkg-1 & 2) are facing landslide issues due to incessant rains and a particular section on NH-66 near Shirur in Ankola Taluk faced a severe landslide on 16-07-2024. National Highway Authority of India constituted Expert Committee of Dr Anand Kumar Pandey (Chief Scientist, Geology, NGRI Hyderabad), Dr R. Sajeev (Director, GSI, Bengaluru), Ashish D Gharpure (MD, Genstru Consultants) under the head of the committee Dr D N. Singh (Professor, IIT Bombay) on 22-07-2024.

While the committee has a wider role for the scope mentioned above, its immediate task was to visit the critical landslide at chainage 148 of NH-66 mentioned above to assess the damage and propose restoration measure. This particular report is limited to the mentioned task only. Other slides and vulnerable areas shall be taken up in the next phase of work.

## 2 Site Visit and Observations

A site visit was conducted on July 25 / 26, 2024 along with PD Mr. Harikrishna, and IRB officials. The officials gave a brief on previous incidents, experts help taken in the past and how the slope surface was treated with flattened cuts. However, due to ROW restrictions the slope was cut at steep angle and had survived 2 monsoon seasons previously before the catastrophic landslide on 16<sup>th</sup> July 2024.

The site observations, preliminary understanding on root cause, type of failure and interim mitigation measures are noted and discussed with committee on July 31, 2024. The same forms part of this report as Annexure-I

## 3 Broad Inferences based on limited observations

The root cause appears to be a combination of

- 1) Hill getting charged (saturated) by continuous rainfall.
- 2) Steep slopes of cut, which could survive in dry condition or limited moisture, not sustaining saturated water pressure.
- 3) Lithomargic Clay blocking the sub-surface flow of water and thus increasing water pressure.
- 4) Piping condition in the matrix reducing shear strength due to internal erosion.
- 5) Interface between rock strata and overburden soil sloughing due to reduced interface friction.

While the debris avalanche is not predictable certain minimum measures should always be adopted at high cut slopes and must be designed / checked for slope stability with investigated and assessed parameters including water condition, seismic influence etc.

**Annexure – I**

**Observations, Root Cause,  
and  
Interim Mitigation Suggestions**

**Observations, Root Cause, & Interim Mitigation Suggestions**

Picture Showing the crown, main scarp, and left flank of the landslide

Important to notice the sub-surface water flow daylighting at the junction of more intact rock and the overburden of fractured rockmass and topsoil.

Any subsequent slip is expected above this junction.

**Observations, Root Cause, & Interim Mitigation Suggestions**

Tension cracks and subsidence is visible on the left flank of the slide.

These could have been prior existing or appeared post slide due to steep retained slopes.



**Observations, Root Cause, & Interim Mitigation Suggestions**

The adjacent cut shows the rock strata at toe of the slope with varying height. The failed slope was probably having lower height rock cut toe. Due to the debris deposit it was not clearly visible.

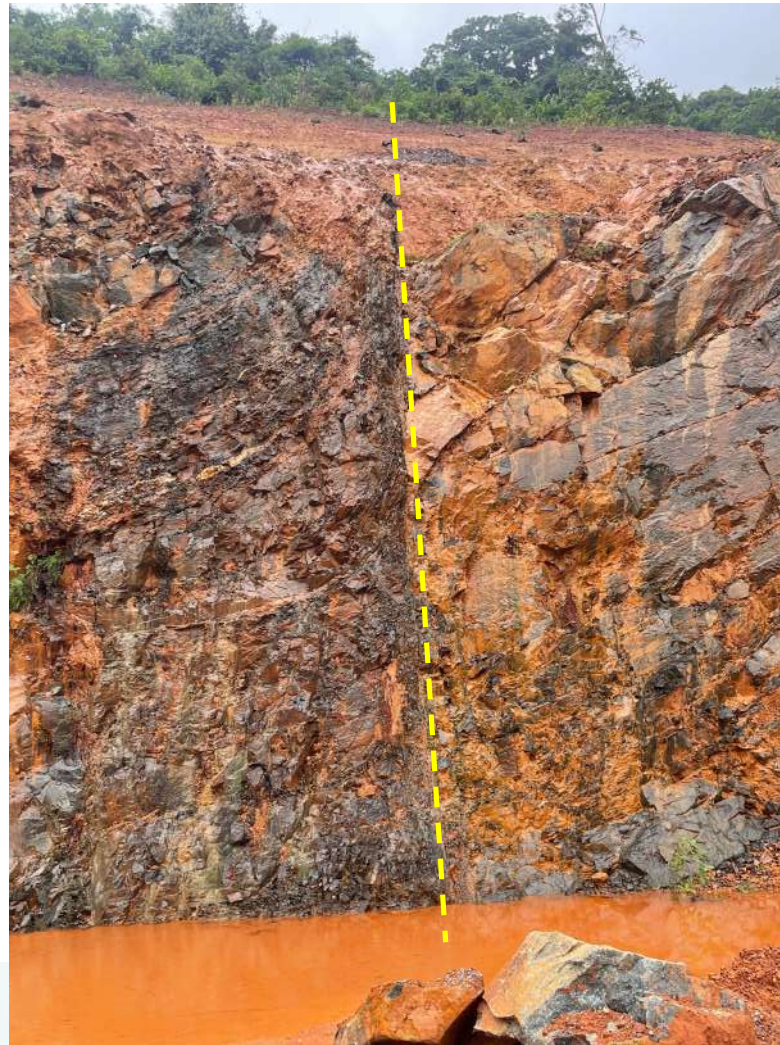
The rock strata is highly fractured and permeable and water can be seen trickling through it, and also through the overburden and rock strata junction.



Observations, Root Cause, & Interim Mitigation Suggestions



A local fault was clearly visible at the adjacent cut with folding strata



**Observations, Root Cause, & Interim Mitigation Suggestions**

Overburden slide has already been triggered at this adjacent location with visible crown and scarps.

A judgement needs to be taken after accessing behind the present crown whether a larger mass movement is expected.

A top down cutting with geometric corrections may be needed before deciding on removing the toe debris.



Observations, Root Cause, & Interim Mitigation Suggestions



Picture showing the right flank of the slide.

The dark coloured soil zone may be holding water

The crown and scarp of adjacent slope is visible.

The cut slope angle is also visible.



Observations, Root Cause, & Interim Mitigation Suggestions



Charged hills can be provided with ample sub-surface drainage arrangements. Some sub-surface pipe drains can be seen here.

Low permeability Lithomargic clays create obstructions to otherwise porous and permeable lateritic matrix and can cause excess water pressure behind it and subsequent collapse.

Such clay masses are difficult to anticipate when in substrata. Some Geophysical tests may spot it.



Observations, Root Cause, & Interim Mitigation Suggestions



Various stages of piping phenomenon due to heterogeneous soil strata can be seen at different stage of evolution. At extreme stage even sink-holes are caused in similar strata.

The slope failure can be termed as Debris Avalanche with following definition

**Debris Avalanche** (Ref: USGS Landslide Handbook)

“Debris avalanches are essentially large, extremely rapid, often open-slope flows formed when an unstable slope collapses and the resulting fragmented debris is rapidly transported away from the slope”

It further says under “*Corrective Measures / Mitigation*”

“Debris avalanches cannot be stopped or prevented by engineering means because the associated triggering mechanisms are not preventable.”

While above is true, we need to remember that it was not a natural landslide and by cutting steep, a critical triggering possibility was introduced.

Usually “case hardening” phenomenon happens in lateritic deposits due to alternating wetting and drying; and strong and durable surface emerges although there could be weak slushy soil underneath. A careful judgement needed on measures to adopt with local situations (hill charging in monsoon, presence of clay concentration, distance from utility, total cut height, aspect, fault zone, rainfall, etc.)

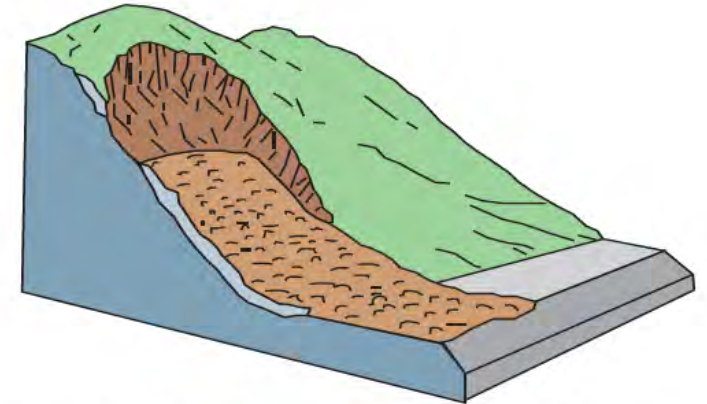


Figure 17. Schematic of a debris avalanche. (Schematic modified from Reference 9.)

Observations, Root Cause, & Interim Mitigation Suggestions



All Surrounding Hills are flat sloped and thus depict that natural repose angle of the formation matrix is low





**“Ideal”** Way Forward for the **other slopes along the highway stretches** would be

1. Identification of sub-surface **clay deposits** & subsurface water flow path through geo-physical tests
2. Getting Geotechnical properties of “Lithomargic clay” and the “Porous Lateritic Strata”
3. Identification of catchment for each slope, rainfall input, and determining CWD size and disposal point with cascade drains to merge the surface run-off to natural streams or road-side drain.
4. Geometric corrections of slope as needed based on geotech properties, locations of concentrated clay deposits, sub-surface flow paths’ exit gradients. This can be done along with internal reinforcement and surface protection as needed.
5. Make a toe wall to give sufficient confinement and drainage arrangement wherever exit gradients are steep. The toe could be overall slope’s toe in case there is no rock strata at the base; Or, at the junction of overburden and rock strata.

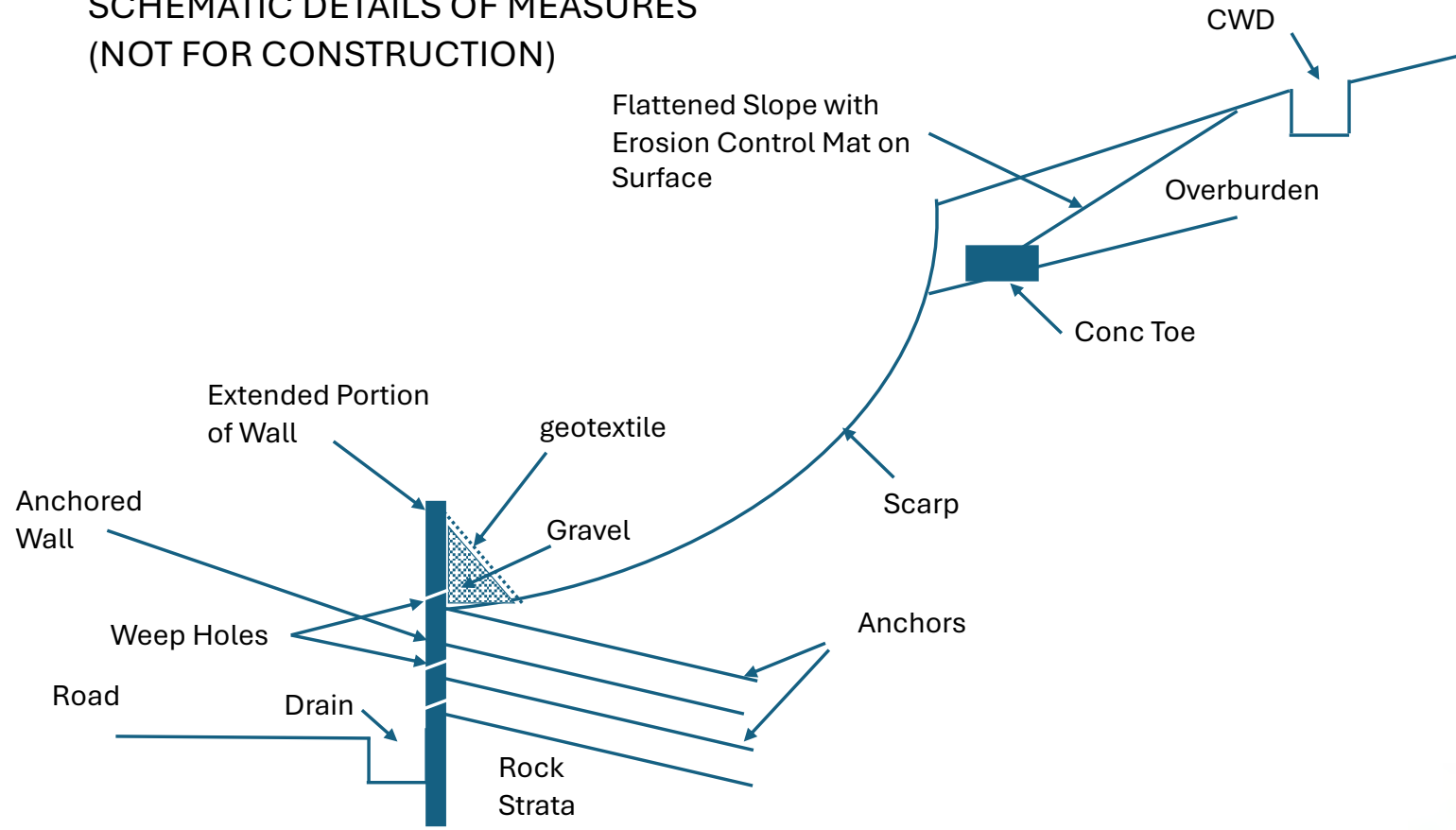
**For failed slope at 148 –**

1. Flattening the top overburden portion to 2H:1V slope and greening it
2. Providing small toe structure at the junction of overburden and rock strata with drainage arrangement
3. Making berm at intermediate level with berm drain for collecting surface and sub-surface water and bringing it down with a cascade to merge with road side drain.
4. Once the rock strata cut is cleared explore a possibility of making anchored wall extending above the rock strata so that in case of future sloughing from top the failed mass can be contained behind the extended portion of wall.
5. A schematic section for mitigation measure is enclosed. Detailed design and further detailing on drainage and sizing etc will be required for implementation.

Observations, Root Cause, & Interim Mitigation Suggestions



SCHEMATIC DETAILS OF MEASURES  
(NOT FOR CONSTRUCTION)



**Report on Shiroor Landslide (Ankola Taluka, Karwar, Karnataka) along the NH-66 @147/950 to 148/100 milestone.**

Your ref.: NHAI/Phase-III/Kun-Goa\_KNT/2024/E-255649/1559 dated 22.7.2024

**Submitted to**

**National Highway Authority of India**

(Ministry of Road Transport and Highways, Govt of India)

Regional Office: Beside Nagasandra Metro Station, Bengaluru 560073

By

**डा.आनंद कुमार पांडेय /Dr. Anand Kumar Pandey**

मुख्य वैज्ञानिक/Chief Scientist, Group Head- Geology

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## Background

NHAI (Bengaluru office), the abovementioned letter dated 22.7.2024 and through telephonic conversation, has informed the occurrence of Landslide on NH-66 near Shirur in Ankola Taluk on 16.07.2024. A request for a field visit and a report on the cause of landslides to be submitted, with suggestions for remedial measures. Prof. D.N. Singh of Dept. of Civil Engg., IIT Bombay will coordinate.

Due to scheduling issues, all the experts visited the site separately. Dr. Anand K Pandey (NGRI, Hyderabad) conducted a field investigation and discussion with the site engineers from 28th -29th July 2024. All the experts interacted online on 30th July 2024 from 17.00 hrs to share their observations, interpretations, and feedback.

The observations by Dr. Anand K Pandey (NGRI) are summarized as follows:

### **A. The development of Shirur Landslide (Karwar, Karnataka) along the NH-66 @147/950 to 148/100 milestone**

On 16<sup>th</sup> July 2024, a portion of the northern slope of the NH-66 between CH 147.950 km to 148.100 km developed a mudflow, which covered the road with the oversaturated mud-debris moving as far as >200m into the adjoining river. The rapid outburst of the Mud-debris flow has overwhelmed and buried/washed away a hut and a truck, along with ~10 people, into the river bed. The velocity and mass of the debris flow created a splash of water across the river with a wave height of >5m, affecting the southern bank (Fig. 1).

To understand the slope instability, it is imperative to understand the evolution of the slope vis a vis the construction of the NH-66. The historical Google images for the last ten years have been analyzed, which clearly points towards the removal of slope toe for extensions/construction of the NH-66 (Fig. 1). The pristine slope with the local watershed (21.4.2015) shows highly vegetated west-facing slope experienced toe cutting and modification (during 21.12.2021) and degradation of the lower slope. The expansion of vegetation cover in the catchment is also evident during the period. By 21.12.2022, the slope toe was further degraded with the excavation (following TSC-17 guidelines), and Mud (debris) flow during 16th July 2024 removed >50000 m<sup>3</sup> of highly saturated clay-lateritic soil.

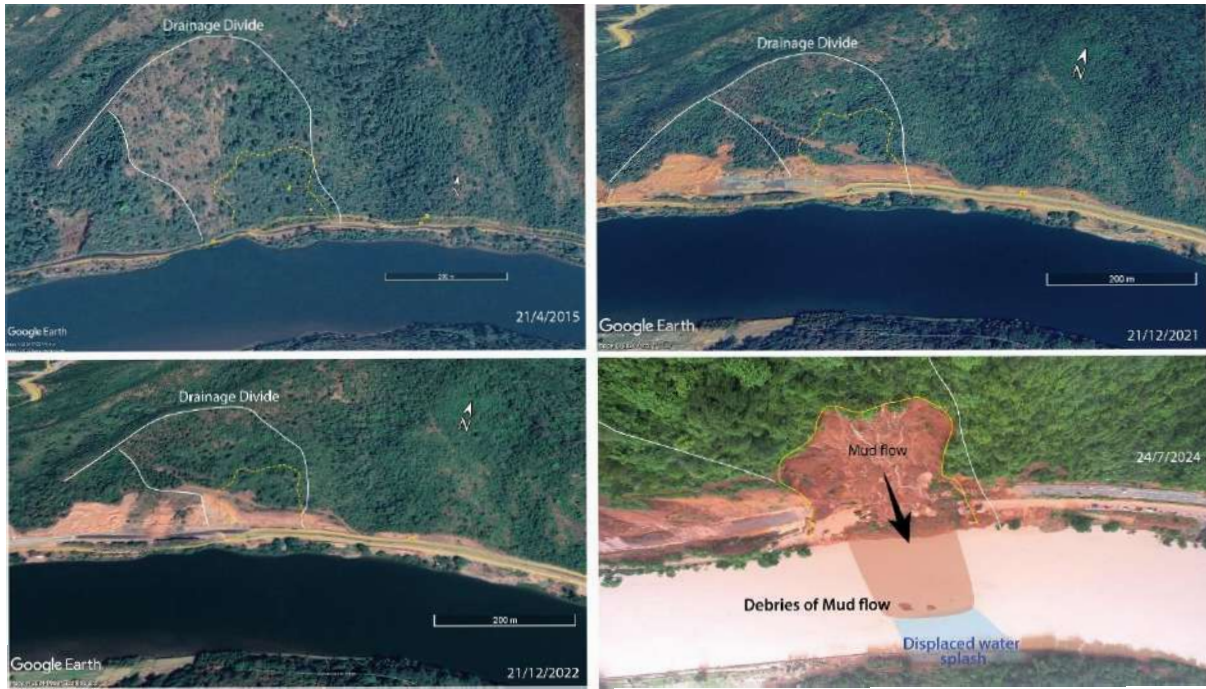


Figure 1: The slope growth in the past decade with the construction of NH-66. (a) The pristine slope with the local watershed (21.4.2015) shows a highly vegetated west-facing slope, which was affected by slope failure during 2024 (marked with a dotted line). (b) The toe cutting and modification of the slope during 21.12.2021 clearly show degradation of the lower slope and expansion of vegetation cover. (c) The slope toe was further degraded during 21.12.2022 by excavation (following TCS-17 guidelines). (d) the occurrence of Mud (debris) flow during 16<sup>th</sup> July 2024, removing >50000 m<sup>3</sup> of highly saturated lithomarge clay

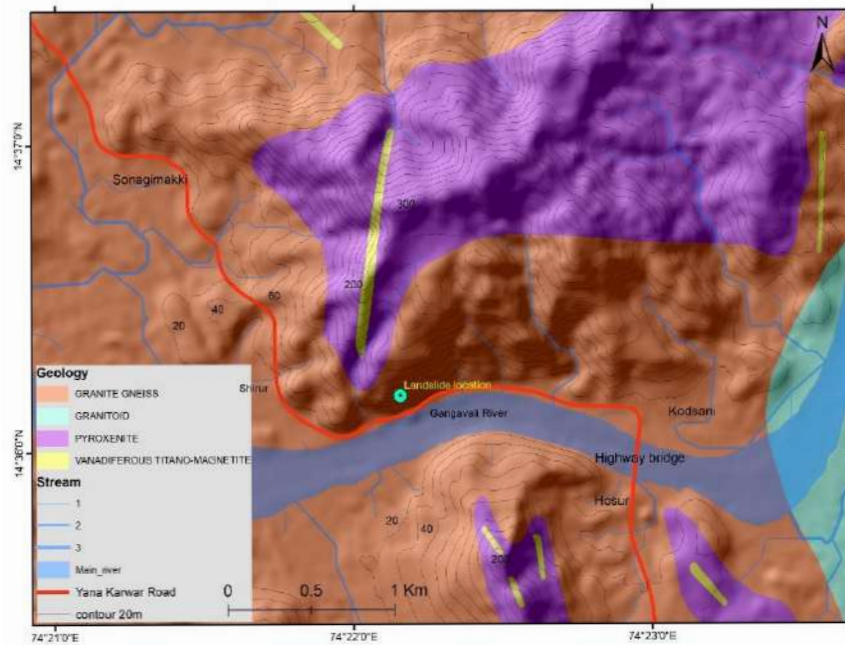


Figure 2: Geology of the landslide affected area.

The Lithomarge (lateritic soil) has well developed over the Precambrian granitic-gneissic basement in the affected region (Fig. 2). The presence of pyroxenite has highly ferruginous lithology, susceptible to weathering. The granitoids also occur in the upstream region.

The landslide (mud-debris flow) occurs in the rugged northern slope of the Gangavali River, affecting areas up to >80m amsl (Fig. 3). The area constitutes of

pedimented basement rocks of granite gneissic composition covered by lateritic soil (Lithomarge).

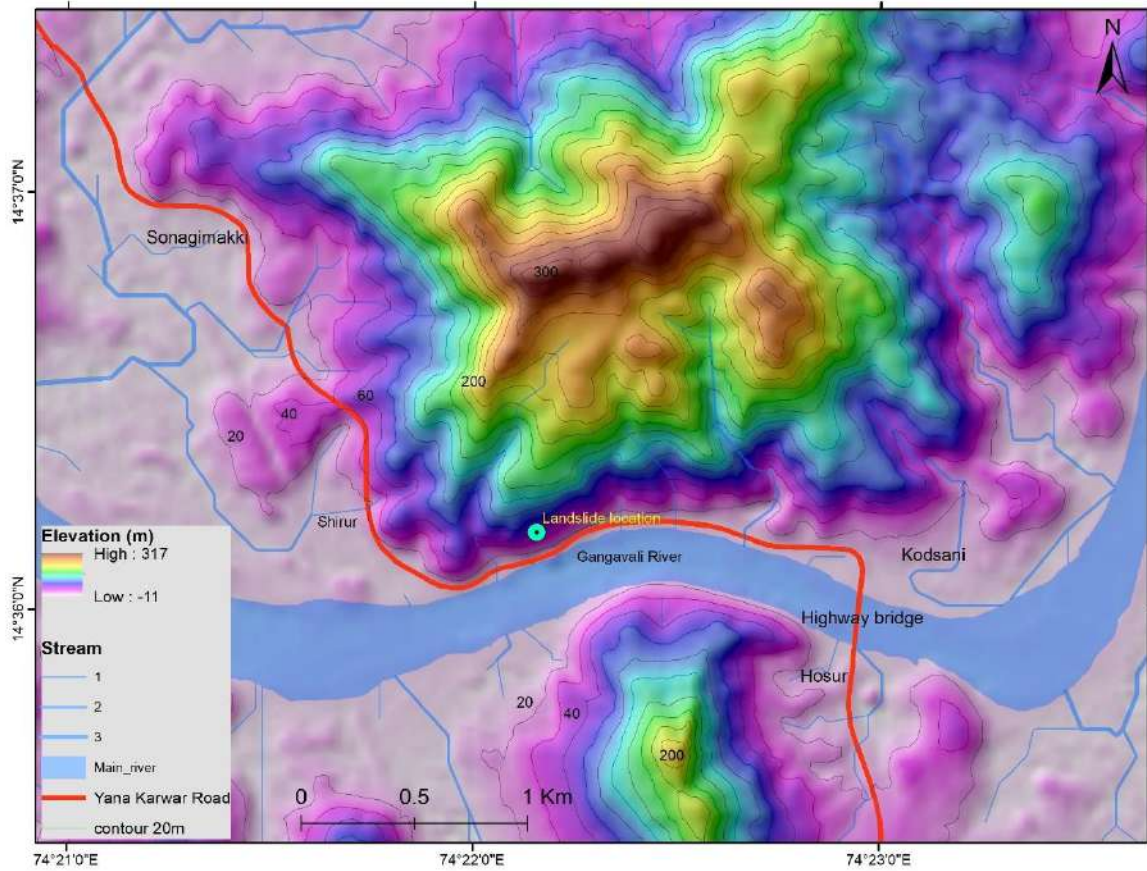


Figure 3: The SRTM DEM of the Shirur area overlaid with the road alignment of NH-66.

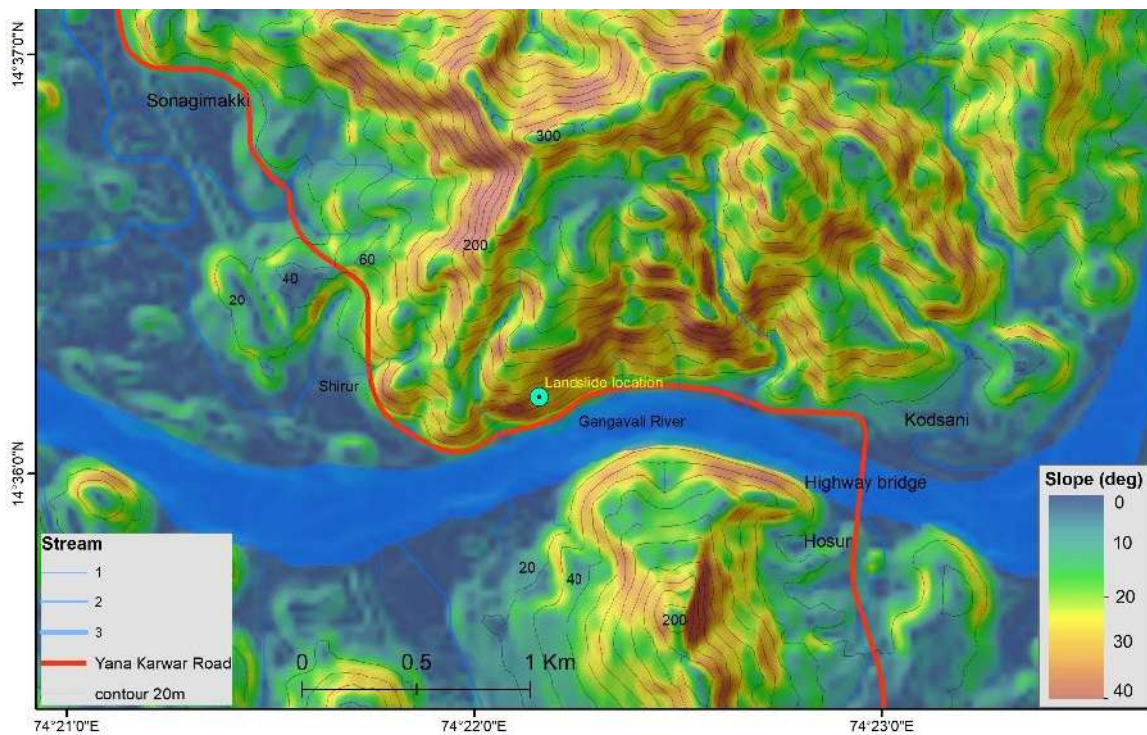


Figure 4: Slope map of the region derived from SRTM DEM data.

- The area affected by the landslide has, in general, a high slope.
- The aspect of the slope in landslide-affected regions is the S-SE direction.

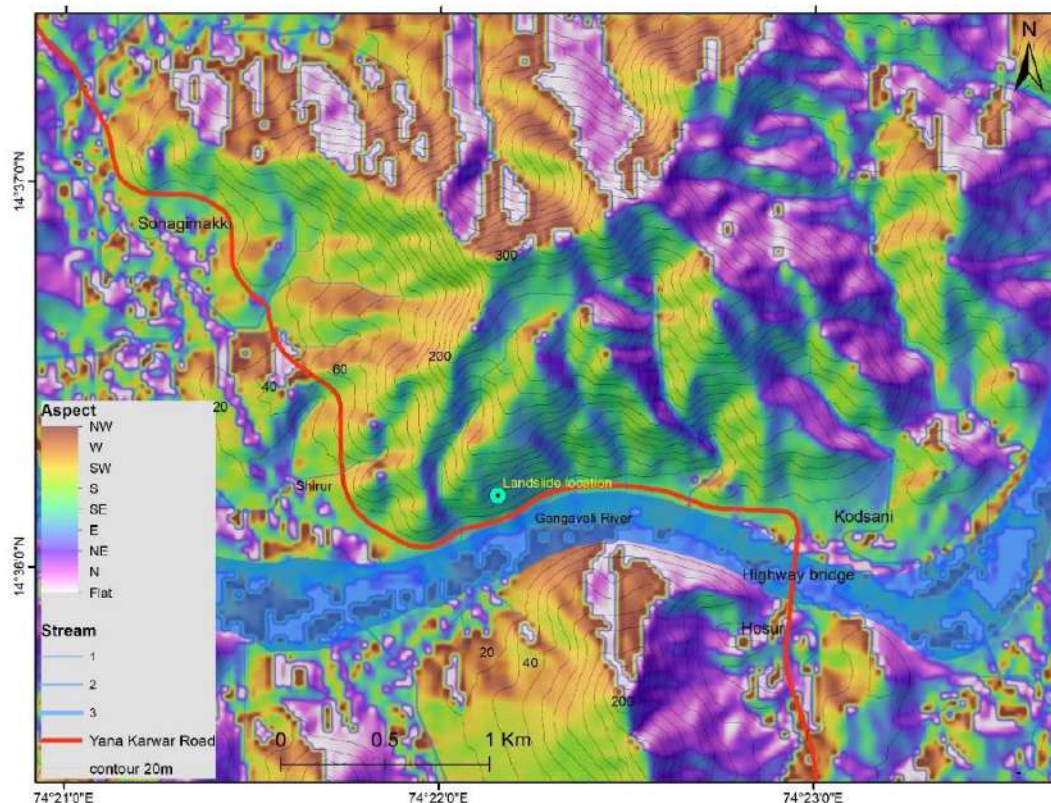


Figure 5: Slope aspect map of the region. Please note the landslide occurred in the S-SE facing slope.

## B. Shirur Landslide (Fig. 6)

- The Shirur landslide is ~150m wide, extending between 147/950 to 148/100 milestone on the NH-66, in the west-east direction, and has developed on the northern slope of the Gangavali river.
- The Granitic gneiss, forming the base or substrate, is exposed at the toe of the landslide zone at ~15.45m and ~17.65 m amsl towards the western and eastern extent of the landslide.
- The region experienced very high precipitation in the early fortnight of July 2024, which exceeded the limits of the past ten years.
- The landslide zone is being fed by infiltration from the upstream region.
- The continuous seepage has washed and concentrated the fine-grained sediments and clay particles on top of the rock beds, forming an impermeable layer inhibiting the downward percolation of seepage.
- This water-saturated layer acted as a detachment surface where the pore water pressure becomes load pressure. The saturated lithomarge/lateritic soil failed under the influence of gravity, thereby facilitating the mud-debris flow.
- The body of the landslide is primarily constituted of the heavily saturated Lithomarge (lateritic soil).
- The highly saturated Lithomarge glided down the slope, breaking through the frontal toe region constituted of granitic rock, which was largely fresh.

- The residual slope is constituted of the weathered rock and experiences seepage even after the debris-mud flow (Fig. 6).
- At places, the piping phenomenon is observed in the surrounding slope, suggesting the channelization of seepage water, though the piping is not well developed.
- Adjoining slopes are experiencing seepage of percolating water above the hard rocks exposed at the slope toe. This suggests a similar saturation loading of the slope prior to failure.



Figure 6: The basic morphological features of the Shirur landslide zone.

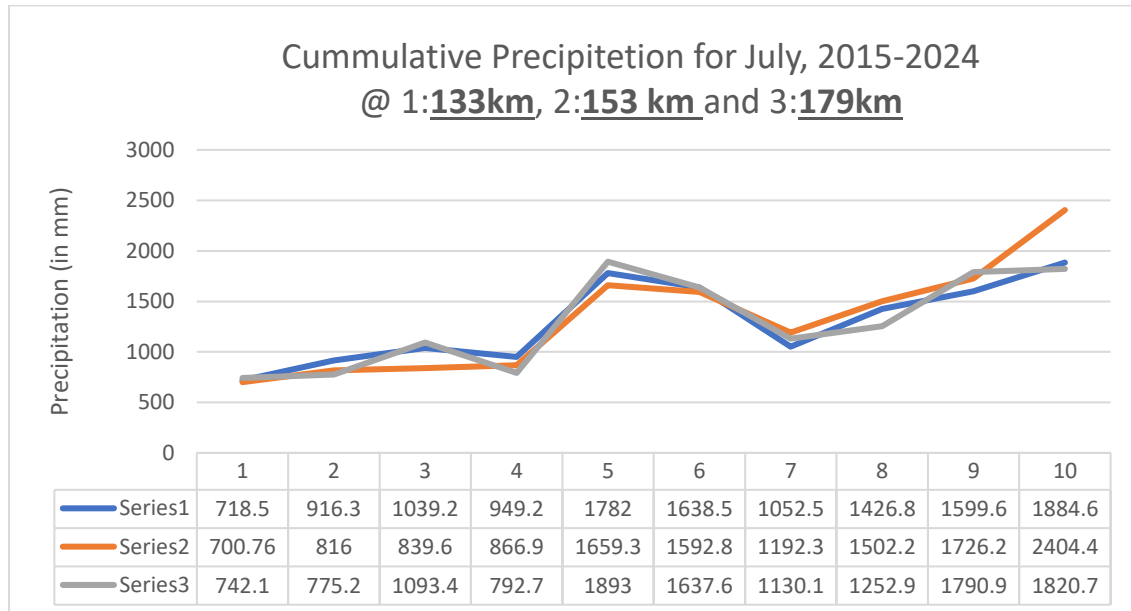


Figure 7: Cummulative precipitation for the month of July from 2015 to 2024 at locations surrounding the landslide zone. Please note the high rain in the series 2. Also, note that the data for July 2024 is only for 24 days.

### C. Slope geometry and composition

- The slope has been previously modified for road construction and expansion at the landslide location (between CH 147.950 to 148.100 km) following TCS 17 guidelines for Highway construction (Fig. 8).
- The slope has been further modified by excavating and removing Lithomarge, a vulnerable lithology for the slope instability.
- It is also important to note that at CH 148.000, the slope has been modified several times to make it gentler over a period, which is good for slope stability.
- However, in July 2024, the oversaturation of the Lithomarge (lateritic soil) made the slope vulnerable and produced the Mud (debris) flow with a smaller debris load.
- The slip surface has developed at the interface of the Lithomarge with the basement rock, where the seepage and mass movement of the oversaturated Lithomarge soil was channelized down the slope under the influence of gravity.
- The Mud (debris) flow material was predominantly fine-grained with blocks of weathered rocks, pointing towards oversaturation of the mud and failure and mass movement down the slope under gravity.
- The adjoining slope (CH 147.500) shows frequent seepages through piping and at the lithomarge-rock interface at the toe of the hill slope. This channelization of seepage is suitable for slope stability.
- Any oversaturation of lateritic soil forms an adverse condition for slope instability.

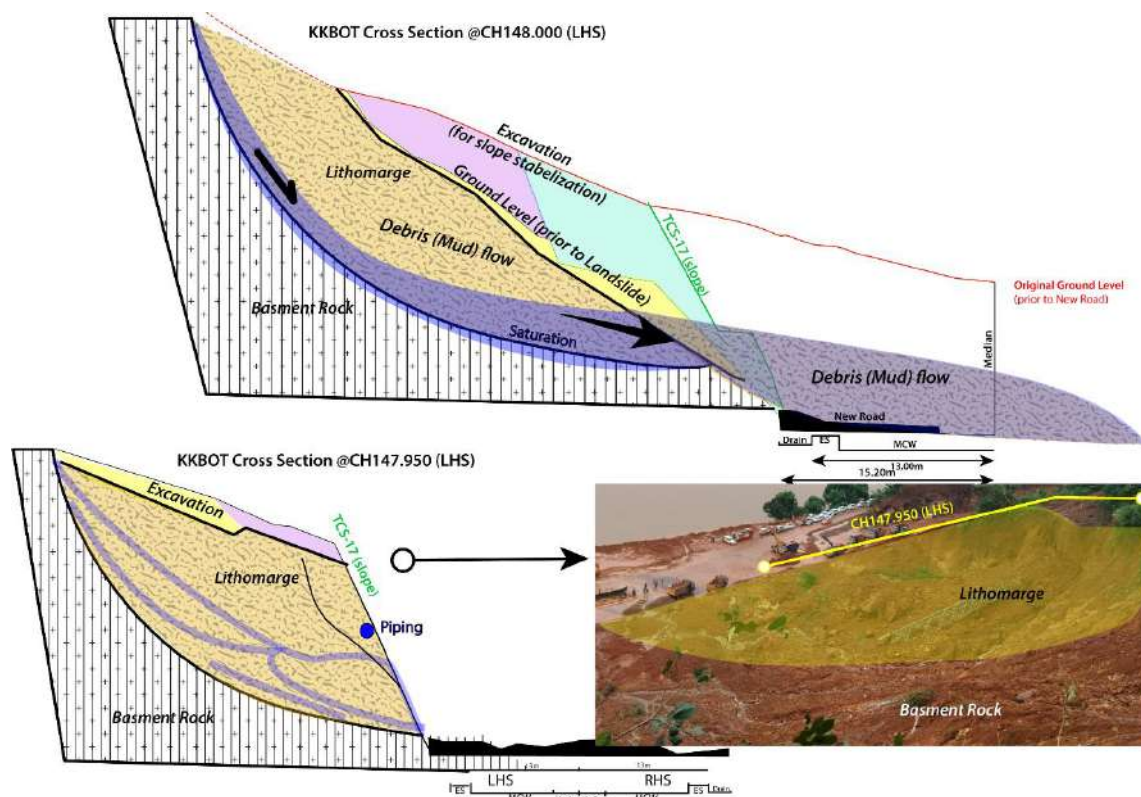


Figure 8: Slope profiles across the landslide zone (CH 148.000) and existing slope (CH 147.950). Please note the episodic removal of Lithomarge soil (marked in blue, purple, and yellow colors) to stabilize the slope by reducing the gradient. Also note the channelization of the seepage along the Lithomarge (soil) and rock interface, which acted as a slip surface facilitating the mass movement of saturated lateritic soil. The adjoining slope with several seepages by piping and at the rock-soil interface at the toe of the hill slope is also stressed, subject to the removal of excess water in the Lithomarge soil.

## D. Summary

- The devastating Mud (debris) flow primarily occurred due to oversaturation of the Lithomarge (lateritic) soil during heavy rains and concentration of seepage along the soil-rock interface, facilitating a gravity flow of the lateritic soil.
- The mud flow occurred even though the steepness of the slope was reduced by repeated removal of the soil column before the present event.
- Since the Mud (debris) flow has removed a large part of the soil column and the bare rocky slope is still experiencing subsurface seepage from the upstream soil column (Fig. 9), It makes the upstream section with a very high slope gradient vulnerable to future slope failure.
- Further, the adjoining slopes with seepages are also vulnerable to slope failure and, at places, show signs of the development of slope failure scars.
- The mud flow has a large (>150m wide) toe region with variable mass movement. It is difficult to consider the section as one unit, and therefore, the preventive measures have to be designed.



Figure 9: A schematic diagram of the landslide zone stabilization strategy. The **Disjointed Retaining wall, anchored to the hard rock**, should have provisions for dewatering and **extra protection** by putting a **two-layered configuration in the middle of the landslide zone**. Perforated pipes are among the most commonly employed dewatering strategies for reducing the oversaturation in the soil.

## E. Recommendations for Preventive Measures

The vulnerable slopes are constituted of Lithomarge soil, which lacks cohesion and has a high potential for mass movement when oversaturated.

- Therefore, slopes should be **dewatered** by implementing **perforated pipe insertion at regular intervals** and **blocking upstream seepages** wherever possible.

- The **disjointed retaining walls** with adequate provisions for dewatering should be built and **anchored on the hard rocks** exposed at the toe of the hill slope.
  - Since the landslide is large and the mass flow is variable, the **disjointed retaining walls with alternate openings** should be built with extra protection (**two lines**) towards the middle of the landslide zone. This will also reduce the force of any mass movement arising out of future slope failure from the upslope region.
  - The back of the retaining wall in the landslide zone should not be filled with Mud or debris, as it provides a vacancy for accommodating material arising from further mass movements from the upslope region.
  - The dewatering from the adjoining slopes should be prioritized, which will delay lateral expansion of the landslide zone and reduce the chances of slope instability and mass movement.
  - The steep slopes should be made gentler as per the standard guidelines.
-



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Geological Survey of India

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REPORT ON  
SHIRUR LANDSLIDE, ANKOLA TALUK, UTTARA KANNADA DISTRICT,  
KARNATAKA  
&  
LANDSLIDE SUSCEPTIBILITY ALONG NH-66 (KARWAR TO NORTH OF BAINDUR)

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कार्य सत्र 2024-25  
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MISSION-IV

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State Unit: Karnataka & Goa  
Southern Region

जुलाई, 2024  
July 2024

महानिदेशक, भारतीय भूवैज्ञानिक सर्वेक्षण, कोलकाता की पूर्वानुमति के बिना आंशिक या पूर्ण किसी भी रूप में उद्धरित ना किया जाये  
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**REPORT ON  
SHIRUR LANDSLIDE, ANKOLA TALUK, UTTARA KANNADA DISTRICT,  
KARNATAKA &  
LANDSLIDE SUSCEPTIBILITY ALONG NH-66 (KARWAR TO NORTH OF BAINBUR)**

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# 1. SHIRUR LANDSLIDE, ANKOLA TALUK, UTTARA KANNADA DISTRICT, KARNATAKA

## 1.1 Introduction

This report presents the findings from a slope stability investigation conducted at Shirur landslide, by the Geological Survey of India (GSI). A team led by Dr. R Sajeev, Director, Shri. Rahul Vadakkedath and Shri. Achan Konyak Senior Geologists carried out the investigation. On July 16, 2024, at 8:30 AM, a large debris flow occurred on the left-hand side of Chainage number 148.000 ( $14.603554^{\circ}\text{N} / 74.371219^{\circ}\text{E}$ ) of NH-66, in Shirur village, Ankola Taluk, Uttara Kannada District, Karnataka. This event caused severe disruptions, including the loss of 10 lives, and substantial damage to infrastructure and property (Fig. 1.1, Fig. 1.2). This report provides an overview of the landslide, its causes, and recommended remedial measures.

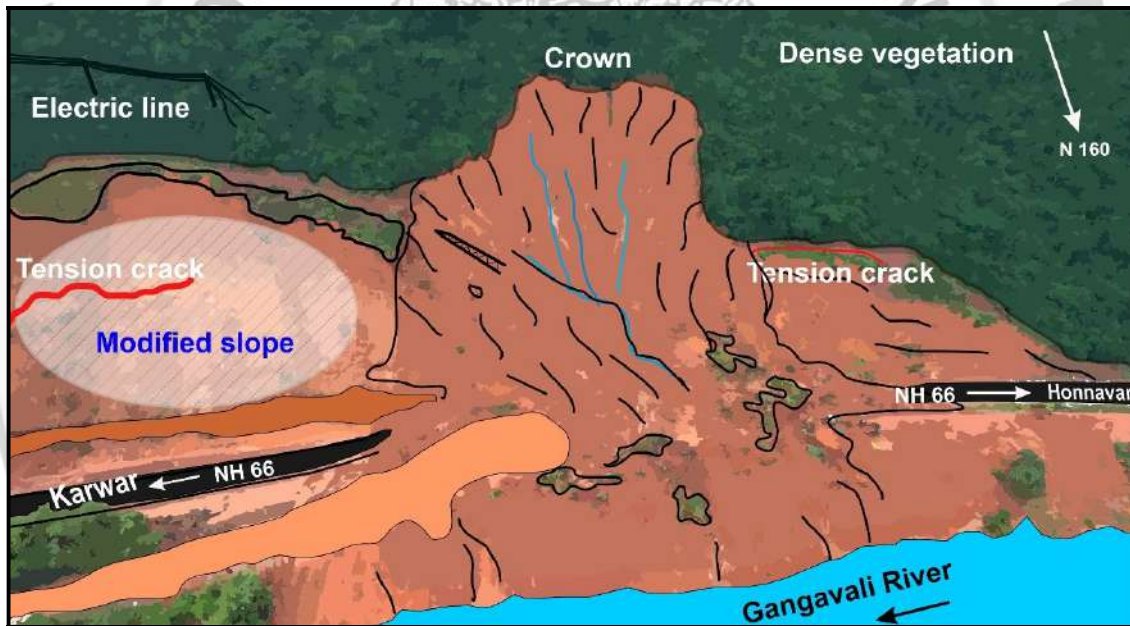


Fig. 1.1: Schematic sketch of Shirur landslide (Not to scale)

The preliminary assessment of the Shirur landslide was conducted by GSI on the 17th and 18th of July 2024. The primary objectives were to understand the geogenic causes of the landslide, assess the potential for reactivation, and develop temporary remedial measures to restore communication that the district administration can implement. The initial findings were submitted to the district administration on the 19th of July. A subsequent site visit was conducted from the 24th to the 26th of July, 2024, to observe the activity and distribution of the landslide, and to assess the condition of the adjoining slopes, including the crown and flanks for signs of potential enlargement.



Fig. 1.2: Aerial view of Shirur landslide blocking the communication corridor NH-66 (courtesy IRB)

### 1.2 Casualties and Damage

The landslide resulted in ten fatalities and washed away two gas tankers and one truck. Additionally, a semi-permanent hotel structure was destroyed. The debris from the landslide travelled over 200 meters, eventually depositing into the Ganagavali River, creating an impact wave that demolished four houses on the opposite bank. The scar left by the landslide measured approximately 150 meters in length, 120 meters in width, and 60 meters in height, with the total volume of debris exceeding 100,000 cubic meters (Fig. 1.2).

### 1.3 Lithology

The site is mainly comprised of Pyroxenite of the Motimakki Ultramafites (Fig. 1.3). The base of the landslide exposes medium to coarse-grained, dark green to black pyroxenite with high specific gravity, dominated by pyroxenes that exhibit a characteristic luster on the cleavage surfaces. Intermittent pegmatite intrusions, 5-10 meters wide, are present on both flanks of the slide. These pegmatites are highly weathered, forming whitish clay (Fig. 1.4). The depleted zone of the landslide has greenish-tinted, medium to coarse-grained boulders, rich in olivine, and showing serpentinization. Vanadiferous titanomagnetite bodies are observed at higher elevations above the landslide, composed mainly of magnetite with subordinate plagioclase, exhibiting banding and high specific gravity. The flanks and crown area also expose large laterite boulders.



Fig. 1.3: Pyroxenite exposed at the base of cut slope section near Shirur landslide



Fig. 1.4: Weathered pegmatite forming whitish clay Kaolinite

#### 1.4 Structure

The toe area of the right flank exposes hard, compact pyroxenite, with rock mass quality assessed as fair according to  $RMR_{basic}$  (Bieniawski, 1989). The area features at least four prominent joint sets, i.e. two sub-vertical (NW-SE, NE-SW) and two moderately dipping (NE-SW, NW-SE) along with numerous fractures allowing free water flow. Open folding is observed, with the left limb oriented  $155^{\circ}/30^{\circ}$  (Strike/Dip) and the right limb  $335^{\circ}/10^{\circ}$  and affected by radial fractures along the hinges. Localized faults trending NW-SE are present on both the left and right flanks of the landslide (Fig. 1.5).



Fig. 1.5: Minor Fault observed at the base of the cut slope on the right flank of the slide

#### 1.5 Susceptibility Status as per NLSM

The slope sector from Chainage 147.400 to 148.200 shows moderate to high susceptibility according to the National Landslide Susceptibility Map (NLSM) of GSI (Fig. 1.6). Multi-temporal satellite imagery indicates anthropogenic interference on the slopes from

Chainage 147.400 to 148.200 since 2017, exacerbating some landslide scars above the slopes (Fig.1.7).

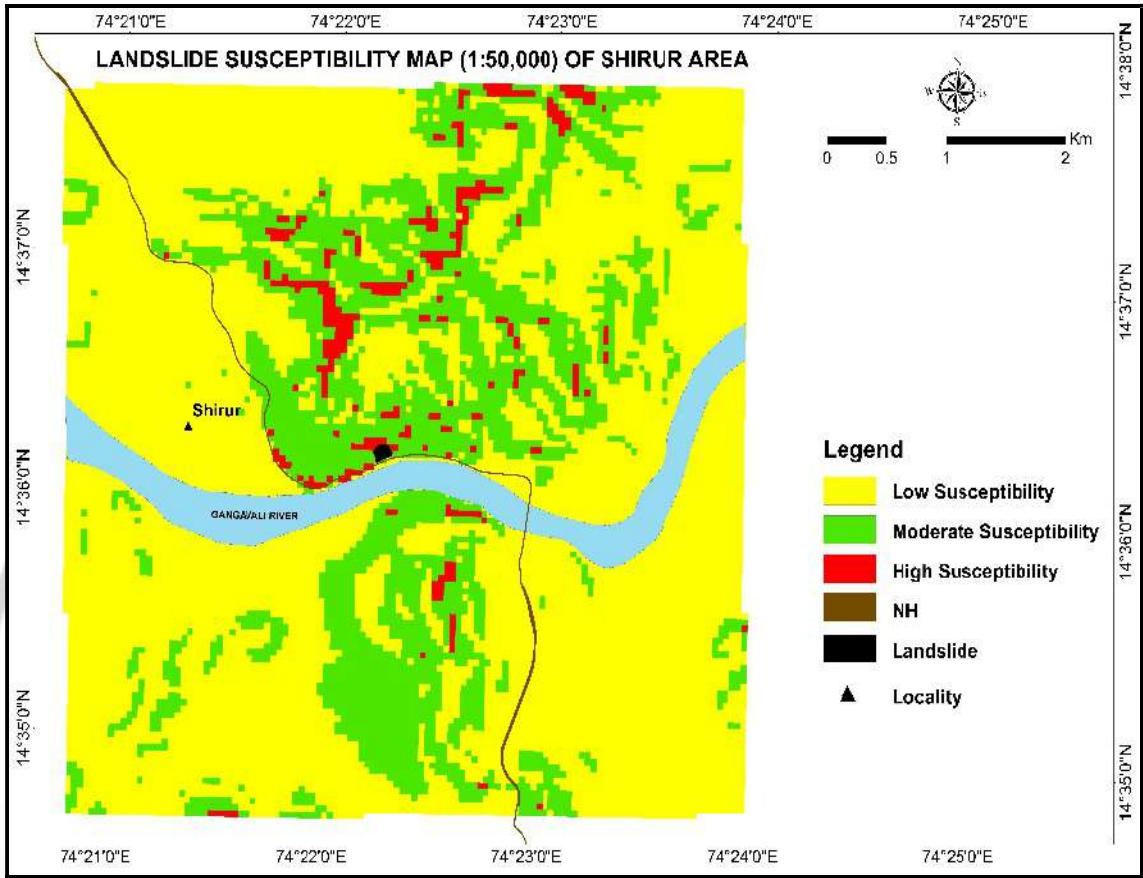


Fig. 1.6: Landslide Susceptibility Map of Shirur area, (NLSM GSI)

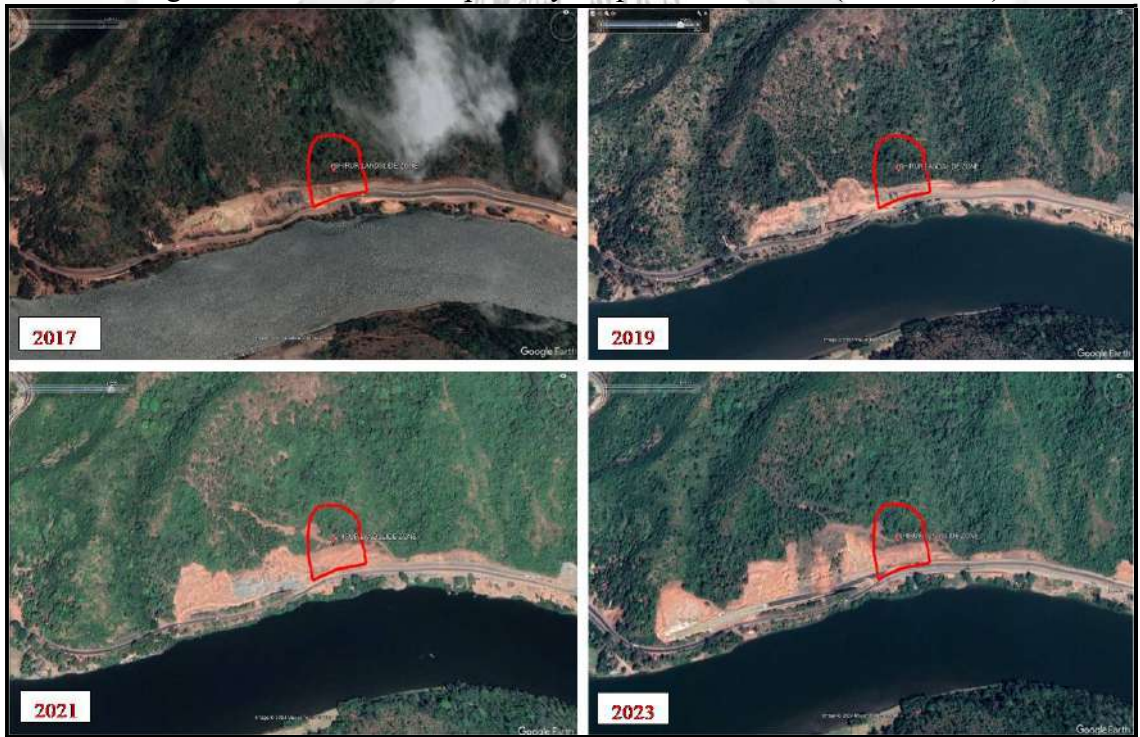


Fig. 1.7: Multi-temporal satellite imageries of Shirur

## 1.6 Observations

- a. **Chainage 148.000:** Prior signs of slope instability include at least two minor slumps observed in Google Street View (Fig. 1.8 & 1.9).



Fig. 1.8: Slump as seen through Google Street View of the Shirur landslide site



Fig. 1.9: Slump as seen through Google Street View of the Shirur landslide site

- b. **Right Flank:** Fresh pyroxenite at the base tapers towards the toe of the rupture, providing minimal natural buttress due to rock unit warping and thick soil development. Extensive rill erosion was observed pre-landslide.
- c. **Slope Material:** The site investigation of the slopes shows that the slope-forming material has a striking variation both along the depth and the lateral extension of the cut slope section. The upper part is hard ferruginous laterite while the lower sections expose mottled clay-rich horizons where hydrostatic pressure has built up. The hard rock is inconsistently present only at the toe area.
- d. **Tension Cracks:** The left flank has two transverse cracks at different elevations – a crack at a higher elevation (Fig. 1.10) trending N120° (20m long, 1.5m deep) and also

at a lower elevation (Fig. 1.11) trending N80° (30m long, 2 ft deep), with no visible expansion by 25<sup>th</sup> July 2024. The Crack in the right flank (Fig. 1.12) trends N15° (15m long, 2m behind the scarp). Here, in the right flank there is relatively thicker soil with 6-7 m while the left flank exposes at least 3-4m of soil. No visible cracks were noticed on the crown area. The main scarp exposes soil of about 3-4 m (Fig. 1.13).



Fig. 1.10: Tension cracks behind the side scar of the slide trending N120°



Fig. 1.11: Tension cracks at lower elevation of the left flank of the slide



Fig. 1.12: Transverse cracks at the right flank of the landslide trending N15°



Fig. 1.13: Thickness of overburden at the main scarp

- e. **Rupture Surface:** The rupture surface also exposes moderately weathered rock which is highly jointed and favours displacement of slope material along the overburden-rock interface. The right flank exposes a vulnerable joint plane of 70:75 (Dip: Direction).
- f. **Water seepages:** The water seepages are pronounced along the soil-rock interface on the main scarp area of the landslide and also observed along the interface of ferruginous and clay-rich laterite horizons
- g. **Slope Morphometry:** A non-perennial stream is observed on the upslope above the crown. The immediate upslope has a concave morphometry which facilitates water infiltration thereby increasing the probability of slope failure.

### 1.7 Factors Contributing to the Landslide

It is imperative to understand the multifaceted factors contributing to the Shirur landslide. Key elements include anthropogenic activities, geological characteristics, and meteorological conditions, all of which played critical roles in the event.

### 1.7.1 Anthropogenic Activities

Multi-temporal satellite imagery has shown significant anthropogenic interference with the slopes since 2017. Continuous slope modifications and the presence of landslide scars above the cut slopes have exacerbated the slope's vulnerability. The lack of proper retaining structures further destabilized the area, increasing the risk of slope failure.

### 1.7.2 Meteorological Conditions

Intense and prolonged rainfall acted as the immediate trigger for the landslide. Specifically, a three-day antecedent rainfall totalling 503 mm led to the saturation of debris material, increasing pore water pressure and reducing shear strength (Fig.1.14). This intense rainfall significantly weakened the slope's stability, and acted as a trigger.

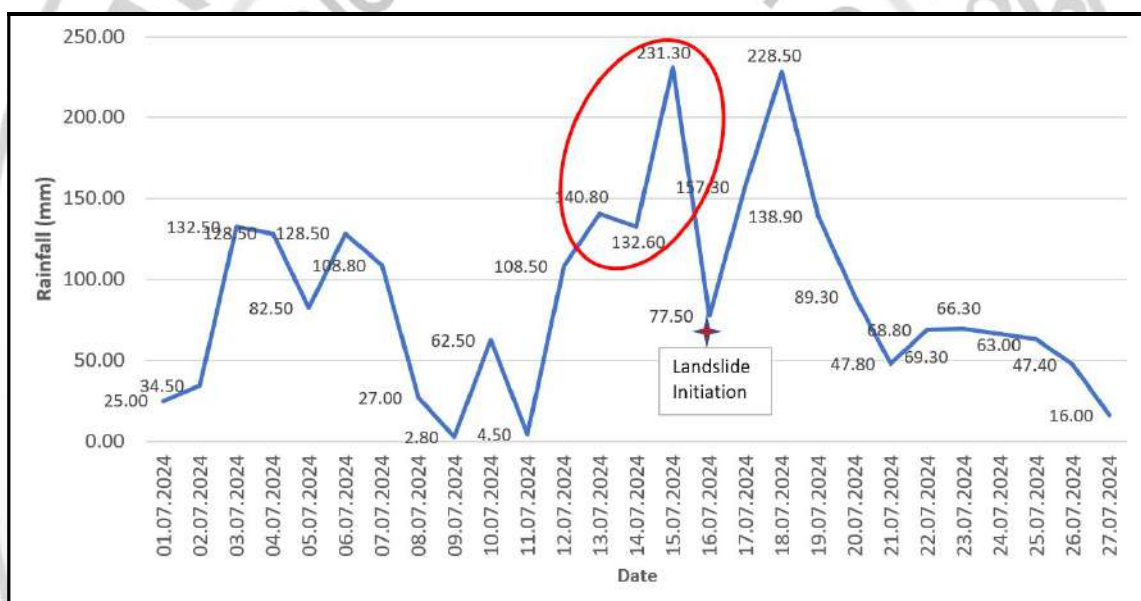


Fig. 1.14: Rainfall distribution near Shirur during July 2024 (source:IRB)

### 1.7.3 Geological Characteristics

The site features a complex lithology with a combination of hard ferruginous laterite and clay-rich horizons, creating variations in slope material along both depth and lateral extensions. The steep gradient of the cut slope combined with thick, highly porous slope material was a major contributing factor. The fresh pyroxenite rock exposed at the base of the right flank of the Shirur landslide is observed to taper towards the toe of rupture of the slide thereby providing minimal natural toe buttress. This tapering of the rock is attributed partly due to the warping of the rock unit over which thick soil has developed. There is also a considerable subsurface water flow which could have played a major role in saturating the soil column.

#### 1.7.4 Slope Morphometry

The concave slope morphometry at the crown area and thick overburden material at the site facilitated the convergence of surface and subsurface water flow. This morphometric characteristic increased the probability of slope failure, suggesting a potential for further widening or retrogression during prolonged rainfall events.

#### 1.8 Recommendations for the Shirur Landslide and Adjoining Slopes

1. **Road alignment, Slope Gradient and Benching:** At the Shirur area, since the road is under construction, an alignment shift towards RHS from chainage 147.300 to 147.800 is proposed if the land is available. This would reduce the height of the slope cut of the currently undisturbed or unmodified slope from 147.300 to 147.500 to a minimum and shift the carriageway from the toe of the disturbed horizon from 147.500 to 148.100. For any slope modification at the site, a detailed investigation is necessary. Ensure compliance with BIS codes for slope modification with appropriate benching, based on geotechnical properties of the soil. Bench width should be adequate to enable slope segments to act independently (IS code 14680:1999).
2. **Drainage:** Trenches (Fig. 1.15) above Ch. 147.500 should be lined. It is observed that the surface water is draining freely (Fig. 1.16) along the boundary wall towards the slope which should be diverted or provided with stepped chute drains on the slope face.
3. **Erosion Control:** Install adequate surface drainage channels along with slope reinforcement and erosion control measures.
4. **Culvert Installation:** The convergence of natural drainage is anticipated at the landslide face with time. A culvert with sufficient diameter pre-cast pipes should be provided to accommodate water and debris discharge at the toe of the landslide at Ch. No. 148. 000. Else the water may be diverted by lined toe drainage.
5. **Monitoring and Surveying:** It is recommended to monitor and survey for signs of instabilities even above the Right of Way especially for slope sections with higher relative relief on the right and left flanks of Shirur landslide. Shirur landslide is a classic case where the rupture surface extended beyond the ROW due to higher relief above the cut slope. Deploy flaggers for traffic control and restrict access to high-risk areas.



Fig. 1.15: Trenches observed above the Ch. no. 147.500



Fig. 1.16: Unguided surface water flowing along the slope above the Ch. no. 147.500

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6. **Subsurface Water Drainage:** Include perforated horizontal pipes of appropriate diameter and sufficient length in engineered slopes to manage subsurface water flow.
  7. **Geotechnical Investigation:** Conduct comprehensive investigations to determine suitable stabilization strategies for the Shirur landslide, considering potential landslide enlargement due to the considerable thickness of soil in the crown and hydrological conditions.

## 1.9 Conclusion

The Shirur landslide was the result of a combination of anthropogenic activities, geological characteristics, and meteorological conditions. Understanding these factors is crucial for implementing effective monitoring, stabilization, and remedial measures to mitigate future risks and ensure slope stability. Anthropogenic activities, including slope modifications and the absence of proper retaining structures, have significantly destabilized the area while the key geological factors include the variability in soil strata, sub-surface hydrological conditions, and a weathered, deformed rock mass. Meteorological factors, particularly intense and prolonged rainfall, contributed to the saturation and weakening of the soil. The concave slope morphometry, with higher relative relief, facilitated the convergence of surface and subsurface water flow, increasing the probability of slope failure. Despite the challenges in predicting the magnitude and timing of such deep-seated landslides, it is crucial to implement comprehensive monitoring and stabilization measures.

Recommendations include strict adherence to slope gradient and benching guidelines, improved drainage systems, regular monitoring for signs of instability, and comprehensive geotechnical investigations. Public safety measures should continue, with restricted access to high-risk areas and the deployment of traffic control measures. Long-term monitoring using advanced technologies and periodic inspections of remedial measures are essential to mitigate future risks and ensure the stability of the affected slopes.

## 2. LANDSLIDE SUSCEPTIBILITY ALONG NH-66 (KARWAR <sup>232</sup> NORTH OF BAINDUR)

### 2.1 Introduction

A slope stability investigation was conducted from July 27 to July 29, 2024 along NH-66 covering chainages 109.9 to 245.6 from Karwar to the north of Baidur, focusing on the Shirur sector and other landslide-vulnerable sections of NH-66. The primary objectives were to identify landslide-prone areas, evaluate the contributing factors, and develop strategic mitigation measures to enhance the stability and safety of the highway corridor. The team was accompanied by National Highway Authority of India (NHAI) officials and engineers from IRB Infrastructure Developers Ltd.

The highway passes through the western margin of Western Ghat mountain ranges and has a few sections where the hill slopes had to be cut to make way for the road corridor. The major geological unit exposed in the corridor is the Peninsular Gneissic Complex (PGC), a suite of rocks with mainly granitic composition. The corridor also cut through various mafic and ultramafic rock units at different locations (Fig. 2.10).

The landslide susceptibility map, produced after the National Landslide Susceptibility Mapping (NLSM) of GSI in 1:50,000 scale, is available for the road corridor up to 220.000 chainages (Fig. 2.11). Most of the landslide incidences in the corridor have occurred in moderate to high landslide susceptibility areas. The road corridor was divided into four sectors, each with unique slope instability scenarios and contributing factors.

### 2.2 Sector-1 (Chainage 109.500 to 129.000)

#### 2.2.1 Geological Characteristics:

The corridor passes through Granitoids and Granite Gneisses of the PGC and some basic intrusive rocks. The typical road section in this corridor consists of hard granitic rocks at the bottom, overlain by weathered lithomarge and soil cover of varying thickness.

#### 2.2.2 Slope Instability Factors

- The debris thickness is high and is cut at a steeper angle where minor failures are observed along the exposed debris face (Fig. 2.1).
- Drainage from the upslope saturates the debris thereby reducing its strength and resulting in a rotational failure (Fig. 2.2)
- The groundwater is seeping between the rock-debris interface and debris is sliding down the interface due to a reduction in friction between the layers.



Fig. 2.1: Typical cut section in the sector showing rock-debris interface



Fig. 2.2: Deep rotational failure with possible piping at chainage 160.080

### 2.2.3 Recommendations

- Reducing the debris thickness exposed by maintaining a shallower cut slope angle along with benching and proper drainage.

- Arrest surface water erosion by channelling the streams to proper drainage systems. Geo jutes installation with suitable grass (Vetiver) varieties can also be implemented.
- Reducing debris saturation by providing effective horizontal drainage systems. The existing horizontal drainage systems installed in the corridor are observed to be ineffective in discharging water.

It is to be noted that the soil thickness and composition vary considerably across the slope and to suggest a uniform solution for the entire corridor is not possible. The vulnerable sectors should be identified and site-specific engineering solutions should be provided depending on the site conditions.

At chainages 111.300 to 111.400 where the relative relief is very high and the road cut is steep, the rocks are highly jointed with some having near vertical dips. The rocks also exhibit exfoliation joints which are formed due to repeated heating and thawing of the rocks. The intersection of these two planes produces blocks, which fall along the slope (Fig. 2.3). The stretch requires a detailed study to figure out engineering solutions such as rock bolting intervals, shotcreting, etc. However, if the land is available, a slight deviation (20m) in the road alignment towards the south western side away from the vertical slope cut can be considered after detailed studies to minimize the risk factor associated with rock falls (Fig. 2.4).



Fig. 2.3: Rockfall incidence at chainage 111.400



Fig. 2.4: Proposed alignment to mitigate the direct risk of rockfalls

## 2.3 Sector-2 (Chainage 141.600 to 153.600)

### 2.3.1 Geological Characteristics

This sector exposes Gneisses of PGC, Pyroxenites of Layered Ultramafic Complex and Hornblende Actinolite Chlorite schist of Dharwar Supergroups. The areas where the road corridor intersects rocks of the Layered Ultramafic Complex were observed to cause complex slope instability problems.

### 2.3.2 Slope Instability Factors

The ultramafic rocks are susceptible to a high degree of weathering. The thickness of debris and lithomarge would be higher as compared to areas occupied by granitic rocks. There is also a considerable variability in the litho units exposed from bottom to top as is typical in such layered complexes. The weathered rock horizon and soil also show vertical variability where the top of the hill is characterized by ferruginous laterite and the middle part shows lateritic clay-rich horizons. The clay layers have lesser permeability, leading to water accumulation in the column. Slope cuts in this region should be kept to a minimal height as possible so that the exposed cut slopes can be stabilized by providing good drainage and retaining structures. Benching of slopes alone is not an effective slope stabilization method as observed in the Shirur site. Shotcreting in such thick debris cover also would be ineffective. The landslide management strategy in such cases should be to minimize the slope cut height

by shifting the alignment wherever land is available and providing efficient surface and subsurface drainage solutions. 236



Fig. 2.5: Variability in lithounits near the right flank of the Shirur landslide

### 2.3.3 Recommendations

At the Shirur area, since the road is still under construction, an alignment shift from chainage 147.300 to 147.800 can be considered after detailed studies, and if the land is available (Fig.2.6). This would also reduce the height of the planned slope cut for the current undisturbed slope from 147.300 to 147.500 to a minimum and shift the carriageway from the toe of the disturbed horizon along 147.500 to 148.100 chainages.

Geomorphologically, the planned slope cut from chainages 147.300 to 147.500 will be cutting across a “spur” which could cause slope instability issues post-modification. If the alignment shift is not feasible, it is recommended to provide the newly cut slope with adequate drainage management and support measures immediately. However, it is advised to avoid or minimize slope cuts in the location as far as possible.



Fig. 2.6: Proposed alignment shift to prevent further slope failures at the Shirur site.

## 2.4 Sector-3 Chainage 163.000 to 170.000

### 2.4.1 Geological Characteristics

This sector exposes Gneisses of PGC, Gabbro of Layered Ultramafic Complex and Hornblende Actinolite Chlorite schist of Dharwar Supergroups.

### 2.4.2 Slope Instability Factors

There are three major vulnerable zones in this sector at **166.250, 168.200 and 168.700** chainages respectively.

The landslide at 166.250 is a 90m in length and 120m in width debris slump that has occurred in the cut slope made for the road (Fig.2.7). The cut slope exposes a thick lithomarge and laterite cover developed over Gabbroic rocks. The laterite layer is not strong enough to withstand the existing overburden slope profile which resulted in a slump. A drone survey was conducted at the site by IRB which revealed a large crack at the top of the cut slope. Widening of the slide parallel to the slope is possible due to the similar lithology and slope cut on the southern side. A detailed study in the zone is recommended to analyse possible slope stabilization measures or road alignment changes.

Another potentially vulnerable zone was observed at 168.200 where the slope has been cut almost vertically for a length of approximately 60m (Fig. 2.8). During the field visit, minor tension cracks were observed on the slope. The road passes right beneath the slope and

there are settlements opposite to the slope cut. It is recommended to monitor the slope for any crack development and take immediate action if any movement is noticed. It is also recommended to sensitize the local population regarding the potential hazard and the families living just opposite the slope may be shifted in case of any crack development. Detailed studies for proper slope grading, drainage provisions and to arrest gully erosion are recommended.



Fig. 2.7: Drone footage showing the recent landslide scar at 166.250



Fig. 2.8: Slope cut at chainage 168.200 exposing lithomarge and debris

Another similar slope cut was observed at chainage 168.700 where a 50 m horizon of lithomarge and debris is exposed in the slope cut (Fig. 2.9). There are approximately 12 buildings opposite to the slope cut. It is recommended to conduct a detailed site-specific study to provide mitigation measures for the slope.



Fig. 2.9: Slope cut at chainage 168.700 showing the debris and minor scars

The zones at 168.200 and 168.700 have settlements in the down-slope area which significantly increases the risk involved in case of any slope failures. The residents may be made aware of early slope failure signatures and instructed to inform local authorities in case of any observed movement. They may also be instructed to shift to safer locations in case of any observed movement in the slope.

## 2.5 Sector 4 (Chainages 198.100 to 205.400)

This sector is characterized by flat-topped laterite-covered hills and the slope instabilities are smaller in dimensions mainly involving the soil layer. The hill slopes from this sector to chainage 245.600 have minor instabilities that do not pose a major risk to the traffic and local population.

The landslide incidences recorded all along the NH-66 route in Uttara Kannada have been elaborated in Annexure-1.

## 2.6 General Recommendations

- Proper drainage management is of paramount importance in any such project. Water flow from the slopes should be diverted using lined drainage and culverts. Subsurface water management is also a crucial part of slope stability.
- The horizontal drainages at most of the slopes are observed to be clogged. Alternative designs for the drainage pipes have to be adopted for efficient drainage of subsurface water.
- It should be noted that planning in the DPR stage and construction stage would significantly reduce the cost and risk during the operational phase. Sufficient time and budgetary allocation should be made for the DPR stage of any project.
- Landslide susceptibility map is a free database from GSI that can be consulted during the planning of any large-scale project in mountainous terrains to avoid potentially vulnerable zones and minimize the associated risks.
- The best mitigation strategy for landslides is to avoid it. Extensive slope cuts should be minimized as far as possible by shifting the alignment during the planning stage.

## 2.7 Acknowledgment

The GSI team extends its gratitude to the District Administration of Karwar for their essential logistical support during the two spells of landslide studies. We also acknowledge the valuable coordination provided by the NHAI and IRB officials during our visits to the Shirur landslide site and other critical sectors of NH-66. Our thanks go to the state government's Forest officials for accommodating us at the Guest House during the field visits. Finally, we gratefully acknowledge the support of Dr. S. Ravi, DDG, SU: KG, Shri. K V Maruthi, DDG & RMH-IV, GSI, SR, and Shri. S.D. Patbhaje, ADG & HoD, SR, whose contributions were indispensable to our efforts.

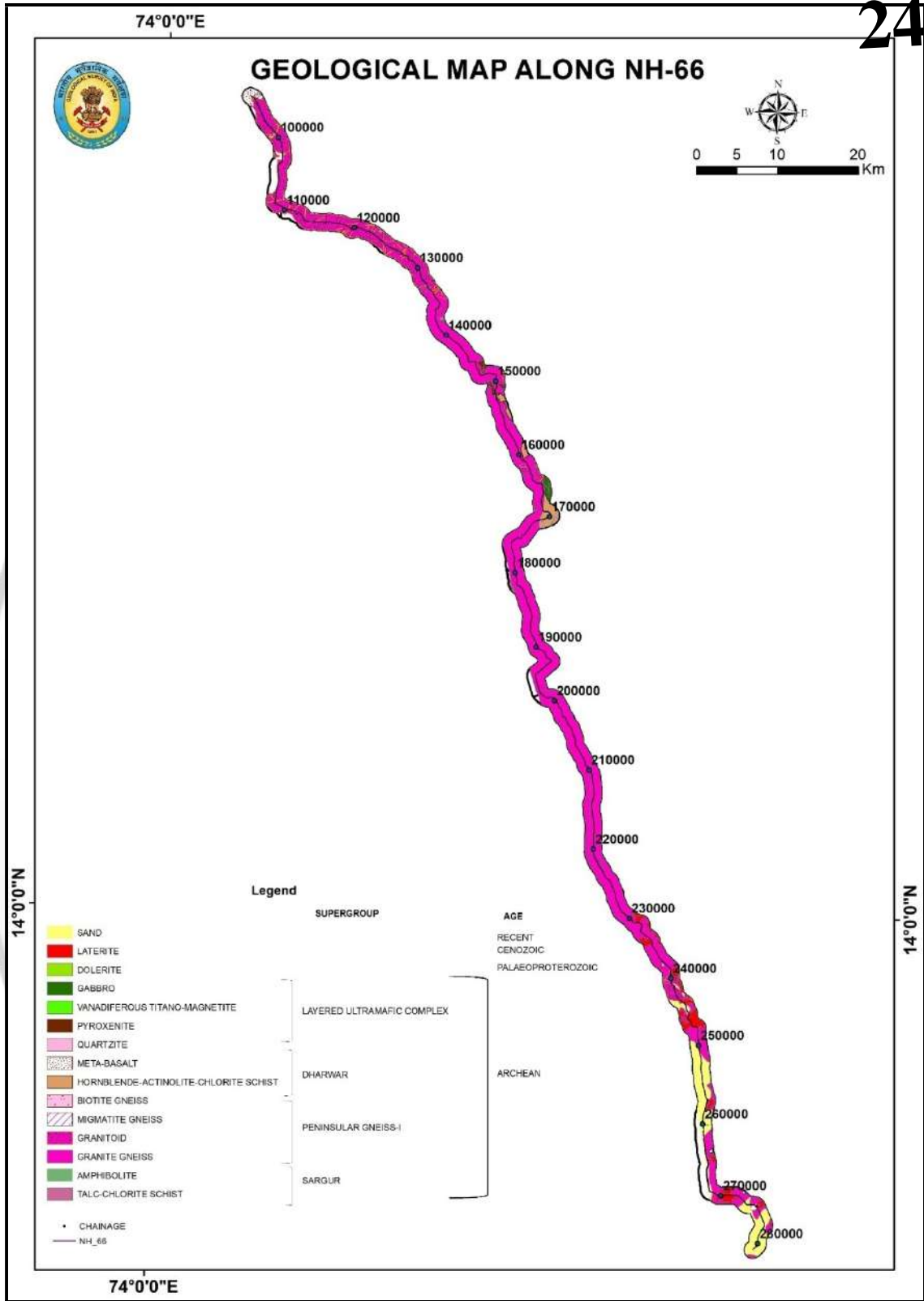


Fig. 2.10: Geological map of the road corridor

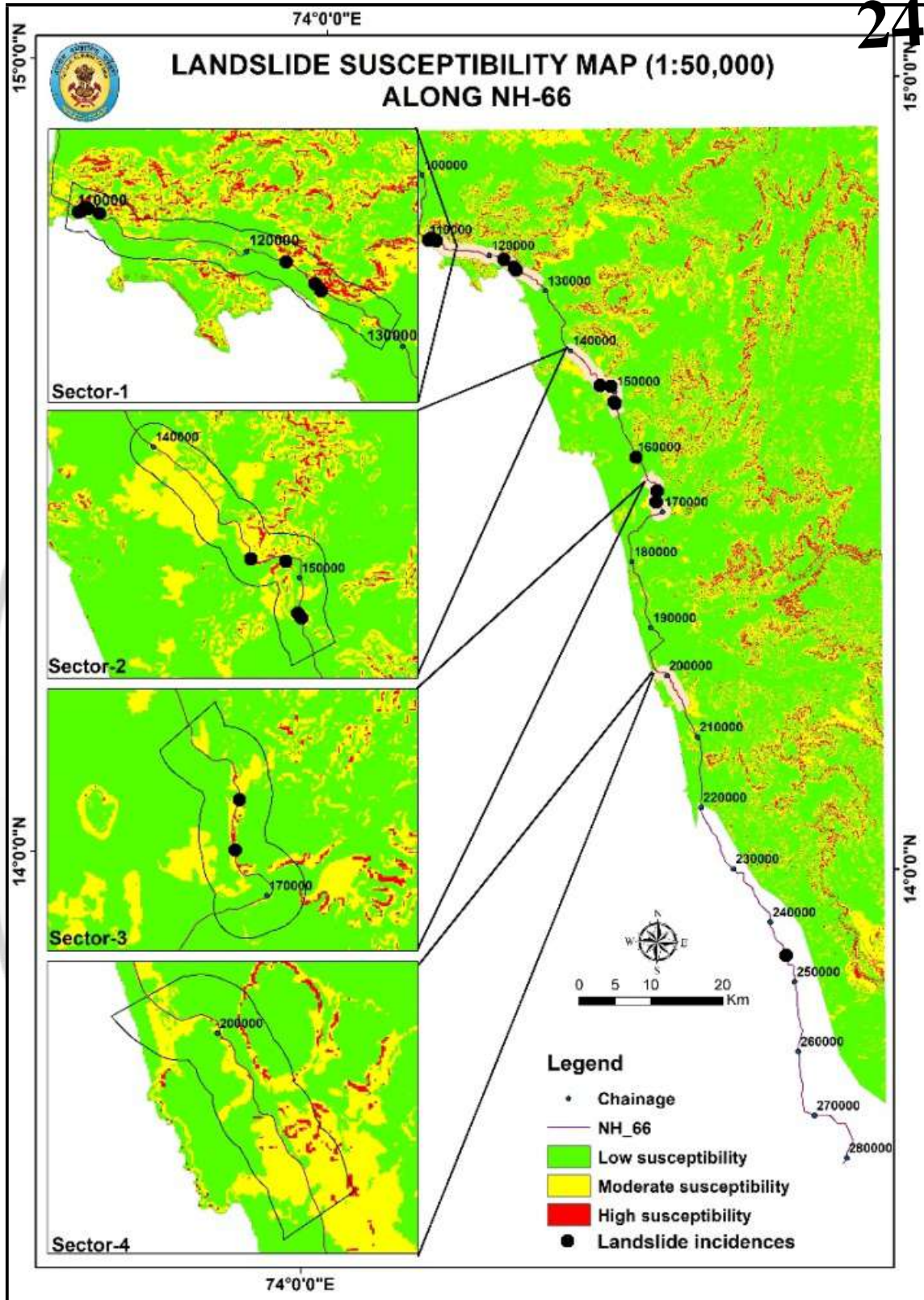



Fig. 2.11: Landslide susceptibility map of the road corridor


## GEO PARAMETRIC DATA FOR LANDSLIDES

Annexure  
**243**


| No | Field                     | Description   |
|----|---------------------------|---|
| 1  | Slide No (LS .No.)        | KA/UK/48J01/2024/01   |
| 2  | State                     | Karnataka   |
| 3  | District                  | Uttara Kannada  |
| 4  | Toposheet                 | 48J/01  |
| 5  | Name of the slide         | --  |
| 6  | NH/SH/Locality            | NH-66 (Chainage – 110.200)                                      |
| 7  | Latitude                  | 14.781677° N  |
| 8  | Longitude                 | 74.136913° E  |
| 9  | Length                    | ~ 40m   |
| 10 | Width                     | ~ 60m   |
| 11 | Height                    | ~ 35m   |
| 12 | Area                      | ~ 2400m <sup>2</sup>  |
| 13 | Depth                     | ~2-5m   |
| 14 | Volume                    | --  |
| 15 | Run out distance          | NA  |
| 16 | Type of Material          | Debris  |
| 17 | Type of movement          | Slide   |
| 18 | Rate of movement          | Very rapid  |
| 19 | Activity                  | Suspended   |
| 20 | Distribution              | Retrogressive   |
| 21 | Style                     | Single  |
| 22 | Failure mechanism         | Shallow rotational failure                                      |
| 23 | History                   | Old landslide   |
| 24 | Geomorphology             | Low dissected hills   |
| 25 | Geology                   | Granitoids of Peninsular Gneissic Complex                       |
| 26 | Structure                 | Foliation - 55°→30° ; J1- 78° →135 ; J2- 80° →85° ; J3- 6° →25° |
| 27 | Land use/ Land cover      | Forest  |
| 28 | Hydrological condition    | Flowing   |
| 29 | Triggering Factor         | Rainfall  |
| 30 | Death of persons          | Nil   |
| 31 | People affected           | Nil   |
| 32 | Live-stock loss           | Nil   |
| 33 | Communication             | Road  |
| 34 | Infrastructure            | Nil   |
| 35 | Agriculture/forest/Barren | Forest  |

|    |   |  |
|----|---|--|
| 36 | Geo-scientific Causes                         | Slope cut has been done in a high-relief area exposing the rock-debris interface. The landslide has occurred in the debris due to saturation of the material.      |
| 37 | Remedial measures                             | Monitor the slide area regularly for any movement. Any further slope modification might contribute to further instability  |
| 38 | Remarks, if any                               | The debris has been depleted from the slide area. Debris exposed on the crown and the flanks of the slide may lead to minor slides during intense rainfall events. |
| 39 | Photos. Sketch of Plan & section of the slide |   |
| 40 | Summary/Abstract                              | --   |
| 41 | Pdf   | --   |
| 42 | Landslide category                            | II   |


| No | Field                      | Description                        |
|----|----------------------------|------------------------------------|
| 1  | Slide No (LS .No.)         | KA/UK/48J01/2024/02                |
| 2  | State                      | Karnataka                          |
| 3  | District                   | Uttara Kannada                     |
| 4  | Toposheet                  | 48J/01                             |
| 5  | Name of the slide          | --                                 |
| 6  | NH/SH/Locality             | NH-66 (Chainage 110.340)           |
| 7  | Latitude                   | 14.782055° N                       |
| 8  | Longitude                  | 74.138237° E                       |
| 9  | Length                     | ~ 6m                               |
| 10 | Width                      | ~ 10m                              |
| 11 | Height                     | ~ 5m                               |
| 12 | Area                       | ~60m <sup>2</sup>                  |
| 13 | Depth                      | ~ 1-2m                             |
| 14 | Volume                     | --                                 |
| 15 | Run out distance           | ~ 25m                              |
| 16 | Type of Material           | Debris                             |
| 17 | Type of movement           | Slide                              |
| 18 | Rate of movement           | Extremely rapid                    |
| 19 | Activity                   | Active                             |
| 20 | Distribution               | Retrogressive                      |
| 21 | Style                      | Single                             |
| 22 | Failure mechanism          | Shallow rotational failure         |
| 23 | History                    | Initiated in 07/2024               |
| 24 | Geomorphology              | Low dissected hills                |
| 25 | Geology                    | Peninsular Gneissic Complex        |
| 26 | Structure                  | J1-75:240, J2 – 18:10, J3 - 78:145 |
| 27 | Land use/ Land cover       | Forest                             |
| 28 | Hydrological condition     | Dripping                           |
| 29 | Triggering Factor          | Rainfall                           |
| 30 | Death of persons           | Nil                                |
| 31 | People affected            | Nil                                |
| 32 | Live-stock loss            | Nil                                |
| 33 | Communication              | Road blocked                       |
| 34 | Infrastructure             | Nil                                |
| 35 | Agriculture/forest/Barr en | Forest                             |

|    |   |   |
|----|---|---|
| 36 | Geo-scientific Causes                         | The road cut is along a 25m thick rock layer overlain by lithomarge and soil. The steep cut in the soil layer has caused the slide. |
| 37 | Remedial measures                             | Easing of the soil layer and providing adequate drainage measures.  |
| 38 | Remarks, if any                               | --  |
| 39 | Photos. Sketch of Plan & section of the slide |    |
| 40 | Summary/Abstract                              | --  |
| 41 | Pdf   | --  |
| 42 | Landslide category                            | II  |


| No | Field                     | Description   |
|----|---------------------------|---|
| 1  | Slide No (LS .No.)        | KA/UK/48J01/2024/03   |
| 2  | State                     | Karnataka   |
| 3  | District                  | Uttara Kannada  |
| 4  | Toposheet                 | 48J/01  |
| 5  | Name of the slide         | --  |
| 6  | NH/SH/Locality            | NH-66 (Chainage 110.430)  |
| 7  | Latitude                  | 14.782712° N  |
| 8  | Longitude                 | 74.138830° E  |
| 9  | Length                    | ~ 8m  |
| 10 | Width                     | ~ 12m   |
| 11 | Height                    | ~ 7m  |
| 12 | Area                      | ~ 96m <sup>2</sup>  |
| 13 | Depth                     | ~ 2-4m  |
| 14 | Volume                    | --  |
| 15 | Run out distance          | ~ 20m   |
| 16 | Type of Material          | Debris  |
| 17 | Type of movement          | Slide   |
| 18 | Rate of movement          | Very rapid  |
| 19 | Activity                  | Active  |
| 20 | Distribution              | Retrogressive   |
| 21 | Style                     | Single  |
| 22 | Failure mechanism         | Shallow rotational failure  |
| 23 | History                   | Initiated on 07/2024  |
| 24 | Geomorphology             | Low dissected hills   |
| 25 | Geology                   | Peninsular Gneissic Complex   |
| 26 | Structure                 | --  |
| 27 | Land use/ Land cover      | Forest  |
| 28 | Hydrological condition    | Flowing   |
| 29 | Triggering Factor         | Rainfall  |
| 30 | Death of persons          | Nil   |
| 31 | People affected           | Nil   |
| 32 | Live-stock loss           | Nil   |
| 33 | Communication             | Road blocked  |
| 34 | Infrastructure            | --  |
| 35 | Agriculture/forest/Barren | Forest  |
| 36 | Geo-scientific Causes     | Reduction of strength of soil layer due to saturation and steep slope gradient. |

|    |   |  |
|----|---|--|
| 37 | Remedial measures                             | Slide movement should be monitored. Detailed studies should be carried out before any future slope modification. |
| 38 | Remarks, if any                               | --   |
| 39 | Photos. Sketch of Plan & section of the slide |                               |
| 40 | Summary/Abstract                              | --   |
| 41 | Pdf   | --   |
| 42 | Landslide category                            | II   |


| No | Field                     | Description                 |
|----|---------------------------|-----------------------------|
| 1  | Slide No (LS .No.)        | KA/UK/48J01/2024/04         |
| 2  | State                     | Karnataka                   |
| 3  | District                  | Uttara Kannada              |
| 4  | Toposheet                 | 48J/01                      |
| 5  | Name of the slide         | --                          |
| 6  | NH/SH/Locality            | NH-66 (Chainage- 110.530)   |
| 7  | Latitude                  | 14.783218° N                |
| 8  | Longitude                 | 74.139477° E                |
| 9  | Length                    | ~ 15m                       |
| 10 | Width                     | ~ 20m                       |
| 11 | Height                    | ~ 12m                       |
| 12 | Area                      | ~ 300m <sup>2</sup>         |
| 13 | Depth                     | >5m                         |
| 14 | Volume                    | --                          |
| 15 | Run out distance          | ~ 25-30m                    |
| 16 | Type of Material          | Debris                      |
| 17 | Type of movement          | Slide                       |
| 18 | Rate of movement          | Rapid                       |
| 19 | Activity                  | Active                      |
| 20 | Distribution              | Enlarging                   |
| 21 | Style                     | Single                      |
| 22 | Failure mechanism         | Deep rotational failure     |
| 23 | History                   | Initiated prior to 2024     |
| 24 | Geomorphology             | Low dissected hills         |
| 25 | Geology                   | Peninsular Gneissic Complex |
| 26 | Structure                 |                             |
| 27 | Land use/ Land cover      | Forest                      |
| 28 | Hydrological condition    | Flowing                     |
| 29 | Triggering Factor         | Rainfall                    |
| 30 | Death of persons          | Nil                         |
| 31 | People affected           | Nil                         |
| 32 | Live-stock loss           | Nil                         |
| 33 | Communication             | --                          |
| 34 | Infrastructure            | --                          |
| 35 | Agriculture/forest/Barren | Forest                      |

|    |   |  |
|----|---|--|
| 36 | Geo-scientific Causes                         | Reduction of strength by saturation of debris in the slope which has been cut steeply.                           |
| 37 | Remedial measures                             | Slide movement should be monitored. Detailed studies should be carried out before any future slope modification. |
| 38 | Remarks, if any                               | --   |
| 39 | Photos. Sketch of Plan & section of the slide |                               |
| 40 | Summary/Abstract                              | --   |
| 41 | Pdf   | --   |
| 42 | Landslide category                            | II   |


| No | Field                     | Description                        |
|----|---------------------------|------------------------------------|
| 1  | Slide No (LS .No.)        | KA/UK/48J01/2024/05                |
| 2  | State                     | Karnataka                          |
| 3  | District                  | Uttara Kannada                     |
| 4  | Toposheet                 | 48J/01                             |
| 5  | Name of the slide         | --                                 |
| 6  | NH/SH/Locality            | NH-66 (Chainage- 110.620)          |
| 7  | Latitude                  | 14.783530° N                       |
| 8  | Longitude                 | 74.140167° E                       |
| 9  | Length                    | ~ 15m                              |
| 10 | Width                     | ~ 40-45m                           |
| 11 | Height                    | ~ 10-12m                           |
| 12 | Area                      | --                                 |
| 13 | Depth                     | >5m                                |
| 14 | Volume                    | --                                 |
| 15 | Run out distance          | ~ 25-30m                           |
| 16 | Type of Material          | Debris                             |
| 17 | Type of movement          | Slide                              |
| 18 | Rate of movement          | Extremely rapid                    |
| 19 | Activity                  | Active                             |
| 20 | Distribution              | Enlarging                          |
| 21 | Style                     | Single                             |
| 22 | Failure mechanism         | Deep rotational failure            |
| 23 | History                   | Initiated during 2022              |
| 24 | Geomorphology             | Low dissected hills                |
| 25 | Geology                   | Peninsular Gneissic Complex        |
| 26 | Structure                 | J1-68:40, J2 – 89:110, J3 - 20:180 |
| 27 | Land use/ Land cover      | Forest                             |
| 28 | Hydrological condition    | Flowing                            |
| 29 | Triggering Factor         | Rainfall                           |
| 30 | Death of persons          | Nil                                |
| 31 | People affected           | Nil                                |
| 32 | Live-stock loss           | Nil                                |
| 33 | Communication             | Road blocked                       |
| 34 | Infrastructure            | --                                 |
| 35 | Agriculture/forest/Barren | Forest                             |

|    |   |  |
|----|---|--|
| 36 | Geo-scientific Causes                         | Saturation of debris in a steeply cut slope.   |
| 37 | Remedial measures                             | Slide movement should be monitored. Detailed studies should be carried out before any future slope modification. |
| 38 | Remarks, if any                               | --   |
| 39 | Photos. Sketch of Plan & section of the slide |                               |
| 40 | Summary/Abstract                              | --   |
| 41 | Pdf   | --   |
| 42 | Landslide category                            | II   |


| No | Field                     | Description                       |
|----|---------------------------|-----------------------------------|
| 1  | Slide No (LS .No.)        | KA/UK/48J01/2024/06               |
| 2  | State                     | Karnataka                         |
| 3  | District                  | Uttara Kannada                    |
| 4  | Toposheet                 | 48J/01                            |
| 5  | Name of the slide         | --                                |
| 6  | NH/SH/Locality            | NH-66 (Chainage- 110.690)         |
| 7  | Latitude                  | 14.783522° N                      |
| 8  | Longitude                 | 74.140903° E                      |
| 9  | Length                    | ~ 10-15m                          |
| 10 | Width                     | ~ 20m                             |
| 11 | Height                    | ~ 12m                             |
| 12 | Area                      | ~ 200m <sup>2</sup>               |
| 13 | Depth                     | <5m                               |
| 14 | Volume                    | --                                |
| 15 | Run out distance          | ~ 25-30m                          |
| 16 | Type of Material          | Debris                            |
| 17 | Type of movement          | Slide                             |
| 18 | Rate of movement          | Very rapid                        |
| 19 | Activity                  | Active                            |
| 20 | Distribution              | Retrogressive                     |
| 21 | Style                     | Single                            |
| 22 | Failure mechanism         | Shallow rotational failure        |
| 23 | History                   | 3 <sup>rd</sup> week of July 2024 |
| 24 | Geomorphology             | Low dissected hills               |
| 25 | Geology                   | Peninsular Gneissic Complex       |
| 26 | Structure                 | J1-78:18, J2 – 70:70, J3 - 15:150 |
| 27 | Land use/ Land cover      | Forest                            |
| 28 | Hydrological condition    | Flowing                           |
| 29 | Triggering Factor         | Rainfall                          |
| 30 | Death of persons          | Nil                               |
| 31 | People affected           | Nil                               |
| 32 | Live-stock loss           | Nil                               |
| 33 | Communication             | Road blocked                      |
| 34 | Infrastructure            | --                                |
| 35 | Agriculture/forest/Barren | Forest                            |

|    |   |   |
|----|---|---|
| 36 | Geo-scientific Causes                         | Saturation of debris in a steeply cut slope.  |
| 37 | Remedial measures                             | Detailed analysis of the slope is required for long term remedial measures.         |
| 38 | Remarks, if any                               | --  |
| 39 | Photos. Sketch of Plan & section of the slide |  |
| 40 | Summary/Abstract                              | --  |
| 41 | Pdf   | --  |
| 42 | Landslide category                            | II  |


| No | Field                     | Description                        |
|----|---------------------------|------------------------------------|
| 1  | Slide No (LS .No.)        | KA/UK/48J01/2024/07                |
| 2  | State                     | Karnataka                          |
| 3  | District                  | Uttara Kannada                     |
| 4  | Toposheet                 | 48J/01                             |
| 5  | Name of the slide         | --                                 |
| 6  | NH/SH/Locality            | NH-66 (Chainage- 110.750)          |
| 7  | Latitude                  | 14.783217                          |
| 8  | Longitude                 | 74.141485                          |
| 9  | Length                    | ~ 15m                              |
| 10 | Width                     | ~ 25m                              |
| 11 | Height                    | ~ 10m                              |
| 12 | Area                      | --                                 |
| 13 | Depth                     | <5m                                |
| 14 | Volume                    | --                                 |
| 15 | Run out distance          | ~ 40-50m                           |
| 16 | Type of Material          | Debris                             |
| 17 | Type of movement          | Slide                              |
| 18 | Rate of movement          | Extremely rapid                    |
| 19 | Activity                  | Active                             |
| 20 | Distribution              | Enlarging                          |
| 21 | Style                     | Single                             |
| 22 | Failure mechanism         | Shallow rotational failure         |
| 23 | History                   | July 2024                          |
| 24 | Geomorphology             | Low dissected hills                |
| 25 | Geology                   | Basic intrusives                   |
| 26 | Structure                 | J1-85:10, J2 – 78:145, J3 - 80:255 |
| 27 | Land use/ Land cover      | Forest                             |
| 28 | Hydrological condition    | Dripping                           |
| 29 | Triggering Factor         | Rainfall                           |
| 30 | Death of persons          | Nil                                |
| 31 | People affected           | Nil                                |
| 32 | Live-stock loss           | Nil                                |
| 33 | Communication             | Road blocked                       |
| 34 | Infrastructure            | --                                 |
| 35 | Agriculture/forest/Barren | Forest                             |

|    |   |  |
|----|---|--|
| 36 | Geo-scientific Causes                         | Saturation of debris in a steeply cut slope. Failure is at the rock-debris interface   |
| 37 | Remedial measures                             | Adequate drainage measures like horizontal perforated pipes for discharging the water from the debris. Detailed geotechnical study is required for long term stabilization measures. |
| 38 | Remarks, if any                               | --   |
| 39 | Photos. Sketch of Plan & section of the slide |   |
| 40 | Summary/Abstract                              | --   |
| 41 | Pdf   | --   |
| 42 | Landslide category                            | II   |


| No | Field                     | Description  |
|----|---------------------------|--|
| 1  | Slide No (LS .No.)        | KA/UK/48J01/2024/08  |
| 2  | State                     | Karnataka  |
| 3  | District                  | Uttara Kannada   |
| 4  | Toposheet                 | 48J/01   |
| 5  | Name of the slide         | --   |
| 6  | NH/SH/Locality            | NH-66 (Chainage 111.380)   |
| 7  | Latitude                  | 14.781229° N   |
| 8  | Longitude                 | 74.146864° E   |
| 9  | Length                    | ~ 40m  |
| 10 | Width                     | ~ 81 m   |
| 11 | Height                    | ~ 40m  |
| 12 | Area                      | ~  |
| 13 | Depth                     | ~ >5m  |
| 14 | Volume                    | ~  |
| 15 | Run out distance          | ~ 40m  |
| 16 | Type of Material          | Rock   |
| 17 | Type of movement          | Fall   |
| 18 | Rate of movement          | Extremely rapid  |
| 19 | Activity                  | Active   |
| 20 | Distribution              | Widening   |
| 21 | Style                     | Multiple   |
| 22 | Failure mechanism         | Deep translational   |
| 23 | History                   |  |
| 24 | Geomorphology             | Low dissected hills  |
| 25 | Geology                   | Peninsular Gneissic Complex  |
| 26 | Structure                 | Slope direction → N200° ; Exfoliation joints parallel to the slope |
| 27 | Land use/ Land cover      | Forest   |
| 28 | Hydrological condition    | Dripping   |
| 29 | Triggering Factor         | --   |
| 30 | Death of persons          | Nil  |
| 31 | People affected           | Nil  |
| 32 | Live-stock loss           | Nil  |
| 33 | Communication             | Road blocked and damaged   |
| 34 | Infrastructure            | --   |
| 35 | Agriculture/forest/Barren | forest   |

|    |   |   |
|----|---|---|
| 36 | Geo-scientific Causes                         | The slope has a road cut of approximately 30m in height. The cut has exposed highly jointed rock mass. The thick exfoliation joints in the rock surface dip sub parallel to the slope. This along with the vertical joints in the rock creates blocks of rocks without support. The rock falls occur along the exfoliation joint plane. |
| 37 | Remedial measures                             | Detailed studies are required along the Chainage 111.300 to 111.450. Precarious blocks may be removed and adequate support measures like proper netting should be provided for the slope.   |
| 38 | Remarks, if any                               | The area is highly susceptible to rock falls. Traffic may continue in the old parallel alignment and only be resumed after geotechnical interventions are made in the slope   |
| 39 | Photos. Sketch of Plan & section of the slide |    |
| 40 | Summary/Abstract                              | --  |
| 41 | Pdf   | --  |
| 42 | Landslide category                            | I   |


| No | Field                     | Description                        |
|----|---------------------------|------------------------------------|
| 1  | Slide No (LS .No.)        | KA/UK/48J01/2024/09                |
| 2  | State                     | Karnataka                          |
| 3  | District                  | Uttara Kannada                     |
| 4  | Toposheet                 | 48J/01                             |
| 5  | Name of the slide         | --                                 |
| 6  | NH/SH/Locality            | NH-66 (Chainage 122.220)           |
| 7  | Latitude                  | 14.759265° N                       |
| 8  | Longitude                 | 74.234887° E                       |
| 9  | Length                    | ~ 10-12m                           |
| 10 | Width                     | ~ 15m                              |
| 11 | Height                    | ~ 10m                              |
| 12 | Area                      | --                                 |
| 13 | Depth                     | <5m                                |
| 14 | Volume                    | --                                 |
| 15 | Run out distance          | --                                 |
| 16 | Type of Material          | Debris                             |
| 17 | Type of movement          | Slide                              |
| 18 | Rate of movement          | Rapid                              |
| 19 | Activity                  | Active                             |
| 20 | Distribution              | Widening                           |
| 21 | Style                     | Single                             |
| 22 | Failure mechanism         | Shallow rotational                 |
| 23 | History                   | --                                 |
| 24 | Geomorphology             | Low dissected hills                |
| 25 | Geology                   | Peninsular Gneissic Complex        |
| 26 | Structure                 | J1-80:130, J2 – 50:230, J3 - 20:20 |
| 27 | Land use/ Land cover      | Forest                             |
| 28 | Hydrological condition    | Flowing                            |
| 29 | Triggering Factor         | Rainfall                           |
| 30 | Death of persons          | Nil                                |
| 31 | People affected           | Nil                                |
| 32 | Live-stock loss           | Nil                                |
| 33 | Communication             | Road blocked                       |
| 34 | Infrastructure            | --                                 |
| 35 | Agriculture/forest/Barren | Forest                             |

|    |   |   |
|----|---|---|
| 36 | Geo-scientific Causes                         | Saturation and lack of support for the debris mass exposed after steep slope cut.   |
| 37 | Remedial measures                             | Remove the precarious boulders mechanically. Easing of the slope.                   |
| 38 | Remarks, if any                               | --  |
| 39 | Photos. Sketch of Plan & section of the slide |  |
| 40 | Summary/Abstract                              | --  |
| 41 | Pdf   | --  |
| 42 | Landslide category                            | II  |


| No | Field                     | Description                         |
|----|---------------------------|-------------------------------------|
| 1  | Slide No (LS .No.)        | KA/UK/48J01/2024/10                 |
| 2  | State                     | Karnataka                           |
| 3  | District                  | Uttara Kannada                      |
| 4  | Toposheet                 | 48J/02                              |
| 5  | Name of the slide         | --                                  |
| 6  | NH/SH/Locality            | NH-66 (Chainage-124.090)            |
| 7  | Latitude                  | 14.749197° N                        |
| 8  | Longitude                 | 74.248513° E                        |
| 9  | Length                    | ~ 20m                               |
| 10 | Width                     | ~ 40m                               |
| 11 | Height                    | ~ 15m                               |
| 12 | Area                      | --                                  |
| 13 | Depth                     | >5m                                 |
| 14 | Volume                    | --                                  |
| 15 | Run out distance          | --                                  |
| 16 | Type of Material          | Debris                              |
| 17 | Type of movement          | Slide                               |
| 18 | Rate of movement          | Very rapid                          |
| 19 | Activity                  | Active                              |
| 20 | Distribution              | Enlarging                           |
| 21 | Style                     | Single                              |
| 22 | Failure mechanism         | Deep rotational failure             |
| 23 | History                   | Initiated during 2024               |
| 24 | Geomorphology             | Low dissected hills                 |
| 25 | Geology                   | Peninsular Gneissic Complex         |
| 26 | Structure                 | J1-20:195, J2 – 89:110, J3 - 70:340 |
| 27 | Land use/ Land cover      | Forest                              |
| 28 | Hydrological condition    | Dripping                            |
| 29 | Triggering Factor         | Rainfall                            |
| 30 | Death of persons          | Nil                                 |
| 31 | People affected           | Nil                                 |
| 32 | Live-stock loss           | Nil                                 |
| 33 | Communication             | Road blocked                        |
| 34 | Infrastructure            | --                                  |
| 35 | Agriculture/forest/Barren | Forest                              |

|    |   |   |
|----|---|---|
| 36 | Geo-scientific Causes                         | Saturation and lack of support for the debris material exposed after steep slope cut.   |
| 37 | Remedial measures                             | Easing of the slope of the debris layer. Providing erosion control mats like geo jute with suitable grass variety plantation can be an effective solution for such slopes |
| 38 | Remarks, if any                               | The location has chances for further landslides   |
| 39 | Photos. Sketch of Plan & section of the slide |    |
| 40 | Summary/Abstract                              | --  |
| 41 | Pdf   | --  |
| 42 | Landslide category                            | II  |


| No | Field                     | Description                       |
|----|---------------------------|-----------------------------------|
| 1  | Slide No (LS .No.)        | KA/UK/48J01/2024/11               |
| 2  | State                     | Karnataka                         |
| 3  | District                  | Uttara Kannada                    |
| 4  | Toposheet                 | 48J/06                            |
| 5  | Name of the slide         | --                                |
| 6  | NH/SH/Locality            | NH-66 (Chainage-124.620)          |
| 7  | Latitude                  | 14.745973° N                      |
| 8  | Longitude                 | 74.251330° E                      |
| 9  | Length                    | ~ 25m                             |
| 10 | Width                     | ~ 20m                             |
| 11 | Height                    | ~ 22m                             |
| 12 | Area                      | --                                |
| 13 | Depth                     | >5m                               |
| 14 | Volume                    | --                                |
| 15 | Run out distance          | ~ 30-40m                          |
| 16 | Type of Material          | Rock and debris                   |
| 17 | Type of movement          | Slide                             |
| 18 | Rate of movement          | Extremely rapid                   |
| 19 | Activity                  | Active                            |
| 20 | Distribution              | Confined                          |
| 21 | Style                     | Single                            |
| 22 | Failure mechanism         | Shallow planar failure            |
| 23 | History                   | --                                |
| 24 | Geomorphology             | Low dissected hills               |
| 25 | Geology                   | Peninsular Gneissic Complex       |
| 26 | Structure                 | J1-40:40, J2 – 60:220, J3 - 75:95 |
| 27 | Land use/ Land cover      | Forest                            |
| 28 | Hydrological condition    | Dripping                          |
| 29 | Triggering Factor         | Rainfall                          |
| 30 | Death of persons          | Nil                               |
| 31 | People affected           | Nil                               |
| 32 | Live-stock loss           | Nil                               |
| 33 | Communication             | Road blocked                      |
| 34 | Infrastructure            | --                                |
| 35 | Agriculture/forest/Barren | Forest                            |

|    |   |   |
|----|---|---|
| 36 | Geo-scientific Causes                         | Lithomarge and soil layer exposed in a vertical slope                               |
| 37 | Remedial measures                             | Easing of the slope   |
| 38 | Remarks, if any                               | --  |
| 39 | Photos. Sketch of Plan & section of the slide |  |
| 40 | Summary/Abstract                              | --  |
| 41 | Pdf   | --  |
| 42 | Landslide category                            | II  |


| No | Field                     | Description              |
|----|---------------------------|--------------------------|
| 1  | Slide No (LS .No.)        | KA/UK/48J01/2024/12      |
| 2  | State                     | Karnataka                |
| 3  | District                  | Uttara Kannada           |
| 4  | Toposheet                 | 48J/06                   |
| 5  | Name of the slide         | --                       |
| 6  | NH/SH/Locality            | NH-66 (Chainage 147.030) |
| 7  | Latitude                  | 14.602864° N             |
| 8  | Longitude                 | 74.362828° E             |
| 9  | Length                    | ~ 80m                    |
| 10 | Width                     | ~ 100m                   |
| 11 | Height                    | ~ 60m                    |
| 12 | Area                      | --                       |
| 13 | Depth                     | >5m                      |
| 14 | Volume                    | --                       |
| 15 | Run out distance          | ~ 40m                    |
| 16 | Type of Material          | Debris                   |
| 17 | Type of movement          | Slide                    |
| 18 | Rate of movement          | Rapid                    |
| 19 | Activity                  | Active                   |
| 20 | Distribution              | Enlarging                |
| 21 | Style                     | Single                   |
| 22 | Failure mechanism         | Deep rotational failure  |
| 23 | History                   | August 2023              |
| 24 | Geomorphology             | Low dissected hills      |
| 25 | Geology                   | Ultramafic rocks         |
| 26 | Structure                 | --                       |
| 27 | Land use/ Land cover      | Forest                   |
| 28 | Hydrological condition    | Dripping                 |
| 29 | Triggering Factor         | Rainfall                 |
| 30 | Death of persons          | Nil                      |
| 31 | People affected           | Nil                      |
| 32 | Live-stock loss           | Nil                      |
| 33 | Communication             | Road blocked             |
| 34 | Infrastructure            | --                       |
| 35 | Agriculture/forest/Barren | Forest                   |

|    |   |  |
|----|---|--|
| 36 | Geo-scientific Causes                         | The thick lithomarge and soil layer which is clay rich is exposed after slope modification. Saturation of the material resulted in reduction of strength. The benches provided in the slope have also been failed. |
| 37 | Remedial measures                             | Detailed assessment is required for stabilization of the slope   |
| 38 | Remarks, if any                               | --   |
| 39 | Photos. Sketch of Plan & section of the slide |   |
| 40 | Summary/Abstract                              | --   |
| 41 | Pdf   | --   |
| 42 | Landslide category                            | II   |


| No | Field                         | Description                                  |
|----|-------------------------------|--|
| 1  | Slide No (LS .No.)            | KA/UK/48J01/2024/13                          |
| 2  | State                         | Karnataka                                    |
| 3  | District                      | Uttara Kannada                               |
| 4  | Toposheet                     | 48J/06                                       |
| 5  | Name of the slide             | --   |
| 6  | NH/SH/Locality                | NH-66 (Chainage 151.580)                     |
| 7  | Latitude                      | 14.582058° N                                 |
| 8  | Longitude                     | 74.381403° E                                 |
| 9  | Length                        | ~ 6m   |
| 10 | Width                         | ~ 40m  |
| 11 | Height                        | ~ 5m   |
| 12 | Area                          | --   |
| 13 | Depth                         | ~ 3-4m                                       |
| 14 | Volume                        | --   |
| 15 | Run out distance              | ~ 5m   |
| 16 | Type of Material              | Debris                                       |
| 17 | Type of movement              | Slide  |
| 18 | Rate of movement              | Rapid  |
| 19 | Activity                      | Active                                       |
| 20 | Distribution                  | Widening                                     |
| 21 | Style                         | Multiple                                     |
| 22 | Failure mechanism             | Shallow rotational failure                   |
| 23 | History                       | NA   |
| 24 | Geomorphology                 | Low dissected hills                          |
| 25 | Geology                       | Peninsular Gneissic Complex                  |
| 26 | Structure                     | Initiated prior to 2024. Reactivated on 2024 |
| 27 | Land use/ Land cover          | Forest                                       |
| 28 | Hydrological condition        | Wet  |
| 29 | Triggering Factor             | Rainfall                                     |
| 30 | Death of persons              | Nil  |
| 31 | People affected               | Nil  |
| 32 | Live-stock loss               | Nil  |
| 33 | Communication                 | Road (Has been cleared)                      |
| 34 | Infrastructure                | Nil  |
| 35 | Agriculture/forest/Barr<br>en | Forest                                       |

|    |   |   |
|----|---|---|
| 36 | Geo-scientific Causes                         | Landslide occurred due to saturation of debris exposed in steep cut.                |
| 37 | Remedial measures                             | Easing of slope   |
| 38 | Remarks, if any                               | --  |
| 39 | Photos. Sketch of Plan & section of the slide |  |
| 40 | Summary/Abstract                              | --  |
| 41 | Pdf   | --  |
| 42 | Landslide category                            | III   |


| No | Field                     | Description                                  |
|----|---------------------------|--|
| 1  | Slide No (LS .No.)        | KA/UK/48J01/2024/14                          |
| 2  | State                     | Karnataka                                    |
| 3  | District                  | Uttara Kannada                               |
| 4  | Toposheet                 | 48J/06                                       |
| 5  | Name of the slide         | --   |
| 6  | NH/SH/Locality            | NH-66 (Chainage 151.800)                     |
| 7  | Latitude                  | 14.580318° N                                 |
| 8  | Longitude                 | 74.382860° E                                 |
| 9  | Length                    | ~ 10-12 m                                    |
| 10 | Width                     | ~15-20 m                                     |
| 11 | Height                    | ~ 10m  |
| 12 | Area                      | --   |
| 13 | Depth                     | ~ 1-2 m                                      |
| 14 | Volume                    | --   |
| 15 | Run out distance          | --   |
| 16 | Type of Material          | Earth  |
| 17 | Type of movement          | Slide  |
| 18 | Rate of movement          | Very rapid                                   |
| 19 | Activity                  | Active                                       |
| 20 | Distribution              | Enlarging                                    |
| 21 | Style                     | Single                                       |
| 22 | Failure mechanism         | Shallow rotational failure                   |
| 23 | History                   | Initiated prior to 2024, Reactivated on 2024 |
| 24 | Geomorphology             | Low dissected hills                          |
| 25 | Geology                   | Peninsular Gneissic Complex                  |
| 26 | Structure                 | J1-75:315, J2 – 88:235, J3 - 8:260           |
| 27 | Land use/ Land cover      | Forest                                       |
| 28 | Hydrological condition    | Flowing                                      |
| 29 | Triggering Factor         | Rainfall                                     |
| 30 | Death of persons          | Nil  |
| 31 | People affected           | Nil  |
| 32 | Live-stock loss           | Nil  |
| 33 | Communication             | Road (cleared)                               |
| 34 | Infrastructure            | --   |
| 35 | Agriculture/forest/Barren | Forest                                       |

|    |   |  |
|----|---|--|
| 36 | Geo-scientific Causes                         | The road cut is along an approximately 15 m height section which exposed granite gneiss at the bottom and clay rich laterite at the top. The failure is due to the saturation of the laterite layer due to rainfall. |
| 37 | Remedial measures                             | The slope may not be disturbed by any excavation as it may further destabilize the slope.  |
| 38 | Remarks, if any                               | The area is susceptible to minor slope failures from the laterite layer.   |
| 39 | Photos. Sketch of Plan & section of the slide |   |
| 40 | Summary/Abstract                              | --   |
| 41 | Pdf   | --   |
| 42 | Landslide category                            | II   |


| No | Field                     | Description                 |
|----|---------------------------|-----------------------------|
| 1  | Slide No (LS .No.)        | KA/UK/48J01/2024/15         |
| 2  | State                     | Karnataka                   |
| 3  | District                  | Uttara Kannada              |
| 4  | Toposheet                 | 48J/06                      |
| 5  | Name of the slide         | --                          |
| 6  | NH/SH/Locality            | NH-66                       |
| 7  | Latitude                  | 14.521306° N                |
| 8  | Longitude                 | 75.409556° E                |
| 9  | Length                    | ~ 7m                        |
| 10 | Width                     | ~20m                        |
| 11 | Height                    | ~ 6m                        |
| 12 | Area                      | --                          |
| 13 | Depth                     | ~1-2m                       |
| 14 | Volume                    | --                          |
| 15 | Run out distance          | --                          |
| 16 | Type of Material          | Earth                       |
| 17 | Type of movement          | Slide                       |
| 18 | Rate of movement          | Rapid                       |
| 19 | Activity                  | Active                      |
| 20 | Distribution              | Enlarging                   |
| 21 | Style                     | Single                      |
| 22 | Failure mechanism         | Shallow rotational failure  |
| 23 | History                   | Reactivated on 2024         |
| 24 | Geomorphology             | Low dissected hills         |
| 25 | Geology                   | Peninsular Gneissic Complex |
| 26 | Structure                 | --                          |
| 27 | Land use/ Land cover      | Forest                      |
| 28 | Hydrological condition    | Dripping                    |
| 29 | Triggering Factor         | Rainfall                    |
| 30 | Death of persons          | Nil                         |
| 31 | People affected           | Nil                         |
| 32 | Live-stock loss           | Nil                         |
| 33 | Communication             | Road (cleared)              |
| 34 | Infrastructure            | Nil                         |
| 35 | Agriculture/forest/Barren | Forest                      |

|    |   |   |
|----|---|---|
| 36 | Geo-scientific Causes                         | The section exposes a 6-7 m thick lithomarge and clay-rich lateritic soil over the granite gneiss. The section is vertically cut, thereby facilitating minor slides in the unsupported soil horizon |
| 37 | Remedial measures                             | The slope may not be disturbed by any excavation as it may further destabilize the slope.   |
| 38 | Remarks, if any                               | The area is susceptible to minor slope failures from the laterite layer.  |
| 39 | Photos. Sketch of Plan & section of the slide |    |
| 40 | Summary/Abstract                              | --  |
| 41 | Pdf   | --  |
| 42 | Landslide category                            | II  |


| No | Field                     | Description                       |
|----|---------------------------|-----------------------------------|
| 1  | Slide No (LS .No.)        | KA/UK/48J01/2024/16               |
| 2  | State                     | Karnataka                         |
| 3  | District                  | Uttara Kannada                    |
| 4  | Toposheet                 | 48J/06                            |
| 5  | Name of the slide         | --                                |
| 6  | NH/SH/Locality            | NH-66 (Chainage 160.080)          |
| 7  | Latitude                  | 14.513155° N                      |
| 8  | Longitude                 | 74.411225° E                      |
| 9  | Length                    | ~ 20m                             |
| 10 | Width                     | ~ 10m                             |
| 11 | Height                    | ~10m                              |
| 12 | Area                      | ~                                 |
| 13 | Depth                     | >5m                               |
| 14 | Volume                    | ~                                 |
| 15 | Run out distance          | ~ 40m                             |
| 16 | Type of Material          | Debris                            |
| 17 | Type of movement          | Flow                              |
| 18 | Rate of movement          | Rapid                             |
| 19 | Activity                  | Active                            |
| 20 | Distribution              | Retrogressive                     |
| 21 | Style                     | Single                            |
| 22 | Failure mechanism         | Deep rotational                   |
| 23 | History                   | Reactivation on 18/07/2024        |
| 24 | Geomorphology             | Low dissected hills               |
| 25 | Geology                   | Peninsular Gneissic Complex       |
| 26 | Structure                 | J1-80:30, J2 – 60:50, J3 - 80:260 |
| 27 | Land use/ Land cover      | Forest                            |
| 28 | Hydrological condition    | Flowing                           |
| 29 | Triggering Factor         | Rainfall                          |
| 30 | Death of persons          | Nil                               |
| 31 | People affected           | Nil                               |
| 32 | Live-stock loss           | Nil                               |
| 33 | Communication             | Road blocked                      |
| 34 | Infrastructure            | Nil                               |
| 35 | Agriculture/forest/Barren | Forest                            |

|    |   |  |
|----|---|--|
| 36 | Geo-scientific Causes                         | The debris flow is caused by oversaturation and resultant piping in the soil layer                                   |
| 37 | Remedial measures                             | Remove the debris from the run-out zone. Any further slope modification without detailed studies is not recommended. |
| 38 | Remarks, if any                               | The area is susceptible to similar failures in the future.   |
| 39 | Photos. Sketch of Plan & section of the slide |                                   |
| 40 | Summary/Abstract                              | --   |
| 41 | Pdf   | --   |
| 42 | Landslide category                            | II   |


| No | Field                      | Description                          |
|----|----------------------------|--------------------------------------|
| 1  | Slide No (LS .No.)         | KA/UK/48J01/2024/17                  |
| 2  | State                      | Karnataka                            |
| 3  | District                   | Uttara Kannada                       |
| 4  | Toposheet                  | 48J/07                               |
| 5  | Name of the slide          | --                                   |
| 6  | NH/SH/Locality             | NH-66 (Chainage 166.250)             |
| 7  | Latitude                   | 14.470933° N                         |
| 8  | Longitude                  | 74.439445° E                         |
| 9  | Length                     | ~ 80-90m                             |
| 10 | Width                      | ~ 120m                               |
| 11 | Height                     | ~ 30-40m                             |
| 12 | Area                       | --                                   |
| 13 | Depth                      | >5m                                  |
| 14 | Volume                     | --                                   |
| 15 | Run out distance           | --                                   |
| 16 | Type of Material           | Debris                               |
| 17 | Type of movement           | Slide                                |
| 18 | Rate of movement           | Moderate                             |
| 19 | Activity                   | Active                               |
| 20 | Distribution               | Enlarging                            |
| 21 | Style                      | Multiple                             |
| 22 | Failure mechanism          | Deep rotational failure              |
| 23 | History                    | Reactivated on 2024                  |
| 24 | Geomorphology              | Low dissected hills                  |
| 25 | Geology                    | Vanadiferous Titano-Magnetite Gabbro |
| 26 | Structure                  | --                                   |
| 27 | Land use/ Land cover       | Forest                               |
| 28 | Hydrological condition     | Damp                                 |
| 29 | Triggering Factor          | Rainfall                             |
| 30 | Death of persons           | Nil                                  |
| 31 | People affected            | Nil                                  |
| 32 | Live-stock loss            | Nil                                  |
| 33 | Communication              | Road blocked                         |
| 34 | Infrastructure             | --                                   |
| 35 | Agriculture/forest/Barr en | Forest                               |

|    |   |   |
|----|---|---|
| 36 | Geo-scientific Causes                         | The road cut is through a thick lithomarge and laterite cover developed over Gabbroic rocks. The laterite layer is not strong enough to withstand the existing slope profile resulting in a slump.  |
| 37 | Remedial measures                             | A detailed study on the slope section is recommended with emphasis on drainage management, slope geometry modification and structural support measures. Since the slide scar has almost reached the hilltop, major retrogression may not occur, but widening of the slide is likely |
| 38 | Remarks, if any                               | The latest drone footage has revealed a major scar developed.   |
| 39 | Photos. Sketch of Plan & section of the slide |    |
| 40 | Summary/Abstract                              | --  |
| 41 | Pdf   | --  |
| 42 | Landslide category                            | II  |

| No | Field                     | Description                           |
|----|---------------------------|---------------------------------------|
| 1  | Slide No (LS .No.)        | KA/UK/48J01/2024/18                   |
| 2  | State                     | Karnataka                             |
| 3  | District                  | Uttara Kannada                        |
| 4  | Toposheet                 | 48J/06 (Chainage 167.800)             |
| 5  | Name of the slide         | --                                    |
| 6  | NH/SH/Locality            | NH-66                                 |
| 7  | Latitude                  | 14.457233° N                          |
| 8  | Longitude                 | 74.438342° E                          |
| 9  | Length                    | ~ 35m                                 |
| 10 | Width                     | ~ 40m                                 |
| 11 | Height                    | ~ 30m                                 |
| 12 | Area                      | --                                    |
| 13 | Depth                     | ~ 1-2m                                |
| 14 | Volume                    | --                                    |
| 15 | Run out distance          | --                                    |
| 16 | Type of Material          | Debris                                |
| 17 | Type of movement          | Slide                                 |
| 18 | Rate of movement          | Rapid                                 |
| 19 | Activity                  | Active                                |
| 20 | Distribution              | Enlarging                             |
| 21 | Style                     | Single                                |
| 22 | Failure mechanism         | Shallow translational failure         |
| 23 | History                   | --                                    |
| 24 | Geomorphology             | Low dissected hills                   |
| 25 | Geology                   | Hornblende-Chlorite-Actinolite Schist |
| 26 | Structure                 | --                                    |
| 27 | Land use/ Land cover      | Forest                                |
| 28 | Hydrological condition    | Wet                                   |
| 29 | Triggering Factor         | Rainfall                              |
| 30 | Death of persons          | Nil                                   |
| 31 | People affected           | Nil                                   |
| 32 | Live-stock loss           | Nil                                   |
| 33 | Communication             | Road                                  |
| 34 | Infrastructure            | --                                    |
| 35 | Agriculture/forest/Barren | Forest                                |

|    |   |  |
|----|---|--|
| 36 | Geo-scientific Causes                         | Steep cut in lateritic horizon. The shotcrete provided in the slope is observed to be falling off due to the development of pore water pressure in the laterite. <span style="float: right; font-size: 2em; font-weight: bold;">278</span> |
| 37 | Remedial measures                             | Adequate horizontal drainage measures may be provided for the slope.   |
| 38 | Remarks, if any                               | --   |
| 39 | Photos. Sketch of Plan & section of the slide |   |
| 40 | Summary/Abstract                              | --   |
| 41 | Pdf   | --   |
| 42 | Landslide category                            | II   |

| No | Field                      | Description             |
|----|----------------------------|-------------------------|
| 1  | Slide No (LS .No.)         | KA/UK/48J01/2024/19     |
| 2  | State                      | Karnataka               |
| 3  | District                   | Uttara Kannada          |
| 4  | Toposheet                  | 48K/09                  |
| 5  | Name of the slide          | --                      |
| 6  | NH/SH/Locality             | NH-66 (Chainage245.500) |
| 7  | Latitude                   | 13.888483° N            |
| 8  | Longitude                  | 74.617990° E            |
| 9  | Length                     | ~ 30m                   |
| 10 | Width                      | ~ 100m                  |
| 11 | Height                     | ~ 25m                   |
| 12 | Area                       | ~                       |
| 13 | Depth                      | >5m                     |
| 14 | Volume                     | --                      |
| 15 | Run out distance           | ~ 15m                   |
| 16 | Type of Material           | Earth                   |
| 17 | Type of movement           | Slide                   |
| 18 | Rate of movement           | Rapid                   |
| 19 | Activity                   | Suspended               |
| 20 | Distribution               | Enlarging               |
| 21 | Style                      | Multiple                |
| 22 | Failure mechanism          | --                      |
| 23 | History                    | Reactivated on 2024     |
| 24 | Geomorphology              | Low dissected hill      |
| 25 | Geology                    |                         |
| 26 | Structure                  |                         |
| 27 | Land use/ Land cover       | Vegetation              |
| 28 | Hydrological condition     | Dripping                |
| 29 | Triggering Factor          | Rainfall                |
| 30 | Death of persons           | Nil                     |
| 31 | People affected            | Nil                     |
| 32 | Live-stock loss            | Nil                     |
| 33 | Communication              | Nil                     |
| 34 | Infrastructure             | Nil                     |
| 35 | Agriculture/forest/Barr en |                         |

|    |   |  |
|----|---|--|
| 36 | Geo-scientific Causes                         | The hard and ferruginous blocks of laterite in the upslope have fractures within them. The blocks of laterite are sliding down after being detached from the surface.  |
| 37 | Remedial measures                             | The existing retaining wall may be continued till the slide location to arrest the movement of the blocks till the road. Else steel piles may also be erected instead of the RCC wall. Enough provisions should be provided for the unhindered flow of the subsurface water. |
| 38 | Remarks, if any                               | The slope is not susceptible to deep rotational failure  |
| 39 | Photos. Sketch of Plan & section of the slide |   |
| 40 | Summary/Abstract                              | --   |
| 41 | Pdf   | --   |
| 42 | Landslide category                            | II   |

| No | Field                  | Description   |
|----|------------------------|---|
| 1  | Slide No (LS .No.)     | KA/UK/48J06/2024/01   |
| 2  | State                  | Karnataka   |
| 3  | District               | Uttara Kannada  |
| 4  | Toposheet              | 48J06   |
| 5  | Name of the slide      | Shirur Slide  |
| 6  | NH/SH/Locality         | NH-66   |
| 7  | Latitude               | 14.603554° N  |
| 8  | Longitude              | 74.371219° E  |
| 9  | Length                 | ~150m   |
| 10 | Width                  | ~120m   |
| 11 | Height                 | ~60m  |
| 12 | Area                   | ~18000m <sup>2</sup>  |
| 13 | Depth                  | ~10m  |
| 14 | Volume                 | >1,00,000 m <sup>3</sup>  |
| 15 | Run out distance       | ~200 m  |
| 16 | Type of Material       | Debris  |
| 17 | Type of movement       | Flow  |
| 18 | Rate of movement       | Extremely Rapid   |
| 19 | Activity               | Active  |
| 20 | Distribution           | Enlarging   |
| 21 | Style                  | Single  |
| 22 | Failure mechanism      | Deep rotational   |
| 23 | History                | Initiation-16-07-2024, 08:30 am                                 |
| 24 | Geomorphology          | Low dissected hill  |
| 25 | Geology                | Pyroxenite  |
| 26 | Structure              | Foliation - 210°/45°; J1- 35°:30°; J2 – 80°:295°; J3 - 80°:230° |
| 27 | Land use/ Land cover   | Dense vegetation  |
| 28 | Hydrological condition | Flowing   |

|    |                           |   |
|----|---------------------------|---|
| 29 | Triggering Factor         | Rainfall  |
| 30 | Death of persons          | 10 at the time of investigation   |
| 31 | People affected           | 4 people critically injured on the opposite bank  |
| 32 | Live-stock loss           | NA  |
| 33 | Communication             | Road blockage   |
| 34 | Infrastructure            | Road damaged, 4 houses destroyed, one tea stall washed away, two high tension power transmission towers destroyed, 3 trucks washed away   |
| 35 | Agriculture/forest/Barren | Forest  |
| 36 | Geo-scientific Causes     | <ol style="list-style-type: none"> <li>1. The site has a very thick weathered rock and in-situ clay-rich lateritic soil exposed by slope cutting.</li> <li>2. The pyroxenite rock in the area is highly weathered, topped by a thick soil cover. The fresh pyroxenite rock exposed at the toe tapers, providing minimal natural toe buttress.</li> <li>3. Natural drainage flows have been disturbed due to slope modifications.</li> <li>4. The slide area and the left flank are structurally deformed, presenting friable and gouge-like material.</li> <li>5. <b><i>The steep gradient of the cut slope, presence of highly weathered rock, thick debris, saturation due to rainfall, and lack of toe support are the primary causative factors of the debris flow</i></b></li> </ol> |
| 37 | Remedial measures         | <p><b>1. Road alignment, Slope Gradient and Benching:</b> At the Shirur area, since the road is under construction, an alignment shift from chainage 147300 till 147800 is proposed if the land is available. This would reduce the height of slope cut of the currently undisturbed slope from 147300 to 147500 to a minimum and shift the carriageway from the toe of the disturbed horizon from 147500 to 148100 For any slope modification at the site, ensure compliance with BIS codes for slope gradient with appropriate benching, based on geotechnical properties of the soil. Bench width should be adequate to enable slope segments to act</p>   |

|    |                 |  |
|----|-----------------|--|
|    |                 | <p>independently (IS code 14680:1999).</p> <p>2. <b>Drainage Improvements:</b> Contour drains (Fig. 13) above Ch. 147.500 should be lined and provide stepped chute drains on slope faces depending on hydrological conditions.</p> <p>3. <b>Erosion Control:</b> Install lined ditches or drainage on benches, along with slope reinforcement measures.</p> <p>4. <b>Culvert Installation:</b> The convergence of natural drainage is anticipated at the landslide face with time. A culvert with sufficient diameter pre-cast pipes should be provided to accommodate water and debris discharge at the toe of the landslide at Ch. No. 148.000.</p> <p>5. <b>Monitoring and Surveying:</b> It is recommended to monitor and survey for signs of instabilities even above Right of Way especially for slope sections with higher relative relief on the right and left flanks of Shirur landslide. Shirur landslide is a classic case where the rupture surface extended beyond the ROW due to higher relief above the cut slope. Deploy flaggers for traffic control and restrict access to high-risk areas.</p> <p>6. <b>Subsurface Water Drainage:</b> Include perforated horizontal pipes of appropriate diameter and sufficient length in engineered slopes to manage subsurface water flow.</p> <p>7. <b>Geotechnical Investigation:</b> Conduct comprehensive investigations to determine suitable stabilization strategies for Shirur landslide, considering potential landslide enlargement due to considerable thickness of soil in the crown and hydrological conditions.</p> |
| 38 | Remarks, if any | Detailed geotechnical studies should be carried out before implementation of recommended remedial measures.  |

|           |  |  |
|-----------|--|--|
| <p>39</p> | <p>Photos. Sketch of Plan &amp; section of the slide</p> |  |
| <p>40</p> | <p>Summary/Abstract</p>                                  | <p><i>The landslide incident at Shirur village, Ankola Taluk, in Uttara Kannada district occurred on 16th July 2024 at approximately 08:30 Hrs. The steep gradient of the cut slope, presence of highly weathered rock, thick debris, saturation due to rainfall, and lack of natural toe support are the primary causative factors of the debris flow. A comprehensive geotechnical investigation is recommended to determine appropriate slope stabilization strategies for the Shirur site.</i></p> |
| <p>41</p> | <p>Pdf</p>   | <p>Attached</p>  |
| <p>42</p> | <p>Landslide category</p>                                | <p>I</p>   |

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**BEFORE THE HON'BLE NATIONAL GREEN TRIBUNAL  
SOUTHERN ZONE, CHENNAI**

**ORIGINAL APPLICATION NO. 261/2024  
(EARLIER ORIGINAL APPLICATION NO. 1055/2024- PB)**

**In the matter of:**

Tribunal on its own motion Suo Moto based on News Item titled "Unscientific work by NHAI led to Shirur landslide Geological Survey of India report" appearing in the Indian Express dated 02.08.2024

VERSUS

National Highways Authority of India & Ors.

...Respondent(s)

**VAKALATNAMA**

KNOW ALL to whom these presents shall come that I, M. Shivakumar, s/o B. Madaiah, aged about 54 years, working as Project Director, PIU- Honnavar, National Highways Authority of India, office at 2<sup>nd</sup> Floor, Under Construction Building, Adjacent to HDFC Bank, Masthikatte, Part-1, Vasudeva Business Park, Honnavar do hereby appoint MITAL & MITAL ADVOCATES having its office at C-347, First Floor, Defence Colony, New Delhi- 24 (hereinafter called the advocate/s) to be my/our Advocate in the above-noted case authorise them: -

To act, appear and plead in the above-noted case in this court or in any other court in which the same may be tried or heard and also in the appellate court, including the High Court and Supreme Court, subject to payment of fees separately for each court by me/us.

To sign, file, verify and present pleadings, appeals, cross-objections or petitions for execution review, revision, withdrawal, compromise or other petitions or affidavits or other documents as may be deemed necessary or proper for the prosecution of the said case in all its stages subjects to payment of fees for each stage.

To file and take back documents, to admit and/or deny the documents of the Opposite Party/Other Respondents.

To withdraw or compromise the said case or submit to arbitration any differences or disputes that may arise touching or in any manner relating to the said case.

To take execution proceedings.

The deposit, draw and receive money, cheques, cash and grant receipts hereof and to do all other acts and things which may be necessary to be done for the progress and in the course of the prosecution of the said case.

To appoint and instruct any other legal practitioner authorizing him to exercise the power and authority hereby confirmed upon the advocate whenever he may think fit to do so and to sign the power of attorney on our behalf, with prior consent from the client.

And I/We, the undersigned, do hereby agree to ratify and confirm all acts done by the advocate or his substitute in the matter as May/our own acts as if done by me/us to all intents and purposes.

And I/We undertake that I/We or my/our duly authorised agent will appear in court on all hearings and will inform the advocate for appearance when the case is called.

And I/We, the undersigned, do hereby agree not to hold the advocate or his substitute responsible for the result of the said case. The adjournment costs, whenever ordered by the court, shall be of the advocate, which he shall receive and retain for himself.

And I/We undersigned do hereby agree that in the event of the whole or part of the fee agreed by me/us to be paid to the advocate remaining unpaid, he shall be entitled to withdraw from the prosecution of the

  
**DGM (T) & Project Director  
NHAI, PIU-Honnava**

said case until the same is paid up. The fee Settled is only for the above case and the above court. I/We hereby agree that once the fee is paid, I/We will not be entitled to the refund of the same in any case whatsoever, and if the case prolongs for more than three years, the original fee shall be paid again by me/us.

IN WITNESS WHEREOF I/We do hereunto set my/our hand to these presents the contents of which have been understood by me/us on this 23 day September 2024

Accepted & identified subject to the terms of the fees.

*[Handwritten Signature]* 23/9/24  
CLIENT  
**DGM (T) & Project Director**  
**NHAI, PIU-Honnavar**

*[Handwritten Signature]*  
**Ankur Mittal**  
Advocate  
D/900/2003

*[Handwritten Signature]*  
**Abhay Gupta**  
Advocate  
UP/7507/12

*[Handwritten Signature]*  
**Nidhi Mittal**  
Advocate  
D/2804/12

*[Handwritten Signature]*  
**Aviraj Pandey**  
Advocate  
CG/635/2020

*[Handwritten Signature]*  
**Ankur Saboo**  
Advocate  
MAH/6411/2015

*[Handwritten Signature]*  
**Ikshita Parihar**  
Advocate  
D/2212/2019

*[Handwritten Signature]*  
**Sanjivan Chakraborty**  
Advocate  
1147/2021

*[Handwritten Signature]*  
**Simranjeet**  
Advocate  
D/636/2024

*[Handwritten Signature]*  
**Shalini Singhal**  
Advocate  
D/3801/2013

*[Handwritten Signature]*  
**Ashish Gajwani**  
Advocate  
D/5948/2022

