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# Slope Stability and Drainage Challenges in Hilly Road Construction: A Case Study of Ranchi, Jharkhand

Harsh Raj
B. Tech (NIT Warangal, Telangana)

**Abstract - Hilly road construction in Ranchi faces serious challenges due to steep slopes, lateritic soil, and heavy monsoon rainfall. One of the main problems is the inefficient local drainage system, which causes water accumulation along road slopes and surfaces. When rainwater is not properly drained, it infiltrates into the soil, increases pore water pressure, and reduces soil strength. This condition leads to slope instability, soil erosion, landslides, and damage to road structures. This study focuses on understanding how local drainage systems affect slope stability in hilly road sections of Ranchi. Field observations and basic soil investigations help identify problems such as blocked side drains, insufficient culverts, and poor surface runoff management. The study suggests that proper drainage planning, along with slope protection methods like vegetation cover, retaining structures, and regular maintenance, can significantly reduce these problems. Improving local drainage systems is essential for safe, durable, and sustainable road infrastructure in the hilly terrain of Ranchi'**

## INTRODUCTION:

A good drainage system is very important in road construction, especially in hilly areas like Ranchi where the terrain is uneven and rainfall during the monsoon season is very high. Ranchi lies on the Chotanagpur Plateau, which has many slopes, lateritic soil, and rocky surfaces. During heavy rainfall, large amounts of water flow down the slopes. If this rainwater is not properly drained, it can accumulate on the road surface and inside the soil, which weakens the ground and damages the road structure. Soil in hilly areas becomes softer and unstable when it absorbs excess rainwater. This increases the chances of soil erosion, slope failure, and landslides. Poor drainage systems can also cause waterlogging, pavement damage, and weakening of road foundations. Therefore, an efficient drainage system helps to safely remove rainwater from roads and surrounding slopes. Proper drainage structures such as side drains, catch water drains, and cross drainage culverts play an important role in controlling surface runoff and protecting the road from damage. In regions with high rainfall and steep slopes**,** drainage planning becomes essential to maintain road stability and safety. Thus, designing and maintaining an effective drainage system is necessary to ensure long-term durability, safety, and sustainability of roads in hilly areas like Ranchi**.**

**Keywords:** Slope Stability, Drainage System, Soil Erosion, Monsoon Rainfall.

## METHODOLOGY:

1. **Study Area Selection.**
   The study focuses on hilly road sections in **Ranchi, Jharkhand**, where drainage problems and slope instability are commonly observed during the monsoon season.
2. **Field Investigation.**
   Field surveys were conducted to observe slope conditions, soil type, road geometry**,** and existing drainage structures such as side drains and culverts.
3. **Soil and Rainfall Data Collection.**
   Basic soil properties and rainfall data of the Ranchi region were analyzed to understand their impact on slope stability and drainage performance.
4. **Analysis and Evaluation.**
   The collected data were analyzed to identify drainage deficiencies, erosion problems**,** and slope failure risks, and suitable engineering solutions were suggested.

### Study Area:

Ranchi is the capital city of Jharkhand, located on the Chotanagpur Plateau at an elevation of about 651 meters above sea level. The region has undulating and hilly terrain, which makes road construction challenging. The soil in Ranchi is mainly lateritic soil, which becomes weak when it absorbs excess rainwater. The area receives high rainfall during the monsoon season, which increases

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surface runoff and creates drainage problems on hilly roads. Due to steep slopes and heavy rainfall, roads in this region often face soil erosion, slope instability, and drainage issues, making proper drainage planning and slope protection very important.

**Problem Identification:**

In the hilly areas of Ranchi, several problems are observed in road construction due to poor drainage and unstable slopes. During the monsoon season, heavy rainfall causes large amounts of runoff water to flow down the slopes. If the drainage system is not properly designed, water accumulates near the road surface and weakens the soil. Many road sections also face problems such as blocked side drains, insufficient culverts, and improper slope cutting. These issues increase the risk of soil erosion, slope failure, and pavement damage. As a result, roads in hilly areas of Ranchi often require frequent maintenance and repair, which increases construction and maintenance costs. Therefore, identifying drainage and slope stability problems is important for improving road safety and durability.

**Case Study Comparison: Drainage and Slope Stability in Ranchi Area:**

| Area / Location (Ranchi) | Observed Problem | Impact on Road & Slope | Suggested Solution |
|---|---|---|---|
| Kanke Road (Hilly Section) | Poorly maintained side drains and water accumulation during monsoon | Soil erosion and pavement damage | Proper lined side drains and regular cleaning |
| Ratu Road Hill Slopes | Absence of catch water drains on hill slopes | Rainwater directly flows to road causing slope instability | Construction of catch water drains above slope |
| Morabadi Hill Area | Steep slope cutting without protection | Risk of slope failure and landslides | Slope benching and retaining walls |
| Ring Road (Hilly Sections) | Blocked culverts and improper drainage outlets | Water stagnation and road damage | Increase culvert capacity and proper drainage outlet |

**Table 01**: Drainage and Slope Stability in Ranchi Area**:**

**Discussion**:

The study of hilly road sections in Ranchi shows that poor drainage systems are one of the main reasons for slope instability and road damage. During the monsoon season, heavy rainfall generates large surface runoff which flows down the hill slopes and accumulates near road surfaces. Field observations indicate that many areas have blocked side drains, insufficient culverts, and absence of catch water drains. Due to this, rainwater infiltrates into the soil, increasing pore water pressure and reducing soil strength, which leads to soil erosion and slope failure. The analysis also shows that roads with proper drainage structures experience less erosion and better slope stability. Therefore, improving drainage systems and providing slope protection measures are necessary for maintaining safe and durable roads in hilly areas like Ranchi.

**Conclusion:**

The study of hilly road sections in Ranchi shows that local drainage conditions play a very important role in maintaining slope stability and road safety. During the monsoon season, heavy rainfall generates large surface runoff in hilly areas such as Kanke, Ratu Road, and Morabadi hill sections, where drainage systems are often blocked or insufficient. Field observations indicate that poor maintenance of side drains, lack of catch water drains, and improper slope cutting increase the risk of soil erosion, slope failure, and pavement damage. These problems make roads unsafe and increase maintenance costs. The study suggests that improving local drainage systems, regular cleaning of drains, proper slope protection, and vegetation cover can significantly reduce these problems. Therefore, effective drainage management is essential for ensuring safe, durable, and sustainable road infrastructure in the hilly terrain of Ranchi.

**Duration of Case Study:**

This table shows the timeline, work duration, planning stages, and overall progress of the case study conducted to analyze drainage systems and slope stability issues in hilly road areas of Ranchi.

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| Work Stag.e | Duration. |
|---|---|
| Topic Selection & Planning. | Week 1. |
| Literature Review. | Week 2–3. |
| Field Observation (Ranchi Areas). | Week 4. |
| Data Collection & Analysis. | Week 5–6. |
| Report Writing & Conclusion | Week 7. |

**Table-02**. Timeline, and overall progress of the case study.

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