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Recurrent Road Collapse Problem in Kapasia-Sreepur Link Road of Gazipur District, Bangladesh: Consideration of Quaternary Geology, Geomorphology, and Clay Mineralogy for Risk Assessment

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1. Introduction and Problem Definition

Several news reports of recurrent collapses on the Kapasia-Sreepur link road and nearby areas from 2003 to 2020 have attracted curious minds. According to local inhabitants, illegal sand lifting from the River Shitalakhya and the Banar River may have caused these collapses. The Shitalakhya River is the main drainage system of the locality which originated from the Old Brahmaputra River and bifurcates into two courses near Toke village of Gazipur district. The southwest flow is known as the Banar River; in the Lakhpur area, it has been designated as the Shitalakhya River. Around 5 am on February 12, 2018, about 120 m of the Shitalakhya River road collapsed (Figure 1a), causing serious communication problems for people heading to Kapasia. Locals said they were awakened at 5 am by the noise and chaos of trees. They went outside their house and witnessed land subsidence (The Daily Asian Age, 13 February 2018).

In addition, at least 760 m of land (Figure 1b), affecting a part of the road connecting Kapasia and Sreepur and adjacent areas, collapsed into the Banar River in Gazipur on 10 December 2020 at 2 am (The Dhaka Tribune, 11 December 2020). The same area collapsed previously in February 1964 and February 2003. Mr. Saif Uddin, the Executive Engineer of the Local Government Engineering Department (LGED) in Gazipur said: "Development works of the Sreepur-Kapasia road were completed last year. We have not estimated any risk of collapse during the six-month monitoring period of the road" (The Dhaka Tribune, 11 December 2020). Prior fieldwork experiences and sample analysis results guided an alternative way to re-think the root cause of the problem. Quaternary geology, geomorphology, and clay mineralogy have been considered as the broad parameters to delineate the road collapse risk assessment.

2. Geology and Geomorphology

The Kapasia-Sreepur areas of Gazipur district, Bangladesh can be attributed to the Holocene alluvial sequence, which is underlaid mainly by the Pleistocene Madhupur Clay Formation. Kapasia-Sreepur area (Figure 2) has been characterized using field checking and ArcGIS operation and categorized into several geological subunits for instance, Madhupur Clay Deposits, Gully fill Deposits, Natural Levee Deposits, Lateral Bar Deposits, Channel Bar Deposits, Point Bar Deposits, Active Channel Deposits, Valley fill Deposits/Abandoned Channel Deposits, Old Bar Deposits. Madhupur Clay deposits have been deeply weathered in Sreepur Upazila (Hasan et al. 2022).

Figure 1 a) (Photo credit: The Daily Asian Age) Road collapse between Kapasia-Sreepur on 13 February 2018, b) (Photo credit: The Dhaka Tribune) Part of the Kapasia-Sreepur road collapsed in Kapasia Upazila of Gazipur District, December 11, 2020.

3. Materials and Method

During the field investigation, cracks and fissures have also been recorded in local earthen houses (made up of Madhupur clay), iron-manganese concretions (Figure 3), and bluish-gray silty clay (Figure 4). Samples have been collected from the cracked surfaces surroundings and X-ray diffractogram (XRD) (clay mineral analysis), X-ray Fluorescence (XRF) (elemental composition), and Field Emission Scanning Electron Microscope (FESEM) (imaging and mineral mapping) have been carried out.

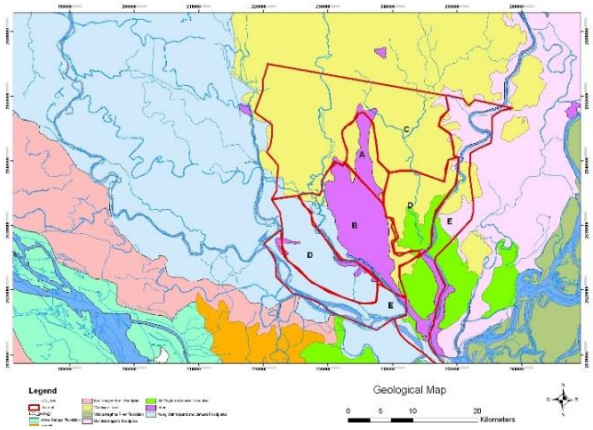

Figure 2 Geological map of the lower part of the Shitalakhya River and adjacent area (revised from Hasan et al. 2022)

Figure 3 Iron-manganese concretions in deeply weathered Madhupur Clay

Figure 4 Presence of bluish-gray silty clay in oxidized Madhupur Clay

4. Conclusions

Mineralogical properties of the Madhupur clay vary significantly both horizontally and vertically. Madhupur Clay consists mainly of silt and clay, which become sticky when wet and shrink after drying. Bangladesh's weather can be categorized broadly by a warm, rainy summer monsoon and a short cold, dry winter with a sparse rain season. All the road collapse events occurred in December and February (the winter season in Bangladesh). The geotechnical parameters of Quaternary deposits of the study area solely depend on the nature and percentages of the clay content and clay mineralogy. Based on the observations, it is evident that Madhupur clay is enriched with a high content of clay and higher inherent potentiality of kaolinite-smectite, chlorite, illite, and vermiculite-smectite (Saha, 2011) along with considerable percentages of montmorillonite. The montmorillonite has swelling properties during the rainy season and shrinkage during winter, it creates exchangeable cations which might be responsible for recurrent road collapses during winter (the majority of events in December maximum events and one in February). The study suggests that geological risk assessment is necessary to design appropriate and rational development plans for sustainable road construction and maintenance.

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