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Seasonal deterioration of the Rajshahi-Natore Highway has been studied to find out the possible causes and their remedial measures. It has been found that the soil erosion along highway flanks is one of the major problems of this plain land highway in rainy season. Systematic observation and laboratory analyses revealed that the soil masses are moderately cohesive containing considerable amount of void spaces and moisture content. The erosion rate along highway flanks was considerable in some places like Tarapur (1.46m/year), Baneswar (0.19m/year) and Kapashia (0.23m/year). The soil mass at these places was less compacted than other places. These places were marked as severely erosion prone areas. There was certain level of differential compression in Belpukur Rail-Crossing. Loosening of soil particles due to successive wetting and drying, local streamlets, canals and other water bodies along the flank of highway were the main causes of erosion. The vehicles load also enhanced the erosional activities along the said highway, especially after loosening the soil.

Finally, the places like Tarapur, Baneswar, Pullapara, Kapashia of highway needs timely repair works in order to prevent the soil losses along the flanks. Construction of concrete protection of flanks in places adjacent to the water bodies is strongly recommended

Key Words: Seasonal deterioration, Rajshahi-Natore Highway, erosion.

1. Introduction

Generally, soil erosion along any road is the detachment or movement of topsoil or soil material from the flanks by the action of wind, rainfall, rivers and especially as a result of changes brought by the improper human activities along roadsides. The studied Rajshahi-Natore Highway (Fig. 1) is a national highway of northern region of Bangladesh. It connects Rajshahi with Dhaka and other cities of Bangladesh. The traffic load of this road is increasing day by day. The Rajshahi-Natore Highway runs on plain land topography consisting of numerous rivers, canals, streamlets and ponds. All these water bodies become saturated during rainy season. The unprotected flanks of the highway in some places come under contact with such water bodies seasonally. It can be mentioned here that the moisture susceptible aggregates or soils of roads rapidly produced considerable amount of deterioration (Cawsey and Massey, 1988). For the last several years, the soil in and around of this road is continuously facing erosion as a result road deteriorates rapidly. In such situation, a geotechnical investigation aiming the causes of soil erosion along this highway is done during 2002-2003. This paper figure out several locations of severe soil erosion with respective erosion rates, erosion agents and possible recommendations in order to protect this highway from erosion.
2. Field observation and analyses

Highway strike, height, width and dip of flanks are measured by compass clinometers and tape. Erosions were marked on the route map and width, depth and distance of erosion from highway were measured by tape. The amount of erosion prone areas of highway flanks were measured by visual estimation and measuring tape. The observation done during these two years was effectively incorporated in order to evaluate the erosion potentialities of the highway. Samples from erosion-prone areas were taken for analysis of physical properties in laboratory. Total length of the studied highway is 35 Km. Average width of the highway is 7.31m of carpeting and 2.43m of hard shoulders in each side. Pavement width is about12.19m with average height of 3.65 m from the surface. Average slope of the both flanks is about 32°. The construction material used in the road was sand, brick and stone chips and earth-fill materials.

Erosional areas along highway flanks

During the field observation, there were found six bridges and three box culverts. The box culverts at Tarapur, Kapashia, Shibpur and bridge of Pullapara were found with non-protected flanks. During rainy season these parts of the road’s flanks came in contact with adjacent water bodies as a result erosion occurred. Some culverts were found near Binodpur and in Rajshahi town of the studied area as concrete protected. Very
little or no erosion was occurred in these areas.

Erosion in the hard shoulder part of the highway near Binodpur, Chaddapai, Katakhal, Kapashia, Belpukur Rail-cross, Pullapara, Baneshwar (Fig-2), Shibpur and Tarapur (Fig-2) was observed at the end of rainy season of 2002. Erosion was severe at the Kuja River site of road’s flanks near Jhalmalia. In the following year of 2003, erosion was more severe in almost all of these areas. The main affected parts of the highway were the hard shoulder (footpath) and the open flanks near culverts and bridges (Fig-3). Observed erosion-prone areas were marked (as A3, B2, etc) in the figure 4. The areas marked with A1..A3 were not deteriorated significantly, but the areas marked with B1..B4 etc were damaged remarkably. The descriptions of some of these damaged areas are described here. At Dewanpara (B2), near Cancer Shelter erosion was much intense and only 1.37m away from the main carpeting part of the road. The depth of the erosion was 0.304m. Local depression with water was very close to the southern flank of the road at this location. At eastern side of the culvert near Kapashia (B4), there was an eroded road flank. The erosional area at this place was about 1.74 square meters, average depth was 0.3 m and the distance from the carpeting
was 1.74 m. Erosion was also occurred in Bhangra area in 2003 although there was no erosion in the previous year.

In the railroad crossing of Belpukur there was certain amount of differential compression causing undulating of the carpeting area. Subsequently this part was affected and resulting the stripping off of carpeting of road.

### Table 1: Results of Soil physical properties

<table>
<thead>
<tr>
<th>Properties</th>
<th>Kapashia</th>
<th>Baneshwar</th>
<th>Pullapara</th>
<th>Tarapur</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coarser Soil size (0.48 to 0.25 mm) wt. %</td>
<td>14.4</td>
<td>32.93</td>
<td>14.20</td>
<td>19.5</td>
<td>20.25</td>
</tr>
<tr>
<td>Finer Soil size (0.25 to &gt;0.04 mm) wt. %</td>
<td>85.45</td>
<td>67.02</td>
<td>85.7</td>
<td>80.41</td>
<td>79.64</td>
</tr>
<tr>
<td>Water content (%)</td>
<td>12.05</td>
<td>12.71</td>
<td>13.69</td>
<td>17.14</td>
<td>13.90</td>
</tr>
<tr>
<td>Void ratio</td>
<td>0.59</td>
<td>0.782</td>
<td>0.625</td>
<td>0.81</td>
<td>0.70</td>
</tr>
<tr>
<td>Porosity (%)</td>
<td>37.26</td>
<td>42.26</td>
<td>38.71</td>
<td>45.0</td>
<td>40.80</td>
</tr>
<tr>
<td>Erosion rate (m/yr)</td>
<td>0.23</td>
<td>0.19</td>
<td>1.46</td>
<td>0.62</td>
<td></td>
</tr>
</tbody>
</table>

**Laboratory Analyses**

In order to find out the relative effects of soil physical properties on the deterioration of the road the collected soil samples were analyzed in the laboratory. The physical properties (Table-1) include moisture content, void ratio, and porosity and grain sizes of different grades. The laboratory tests were done using the procedures described in text by Cernica (1995).

**3. Results and discussion**

Laboratory analyses revealed that the soil contained about 80 per cent of finer particles indicating cohesive nature of the soil. Cohesion acts as bonding among the grains. It was found that the moisture content ranges from 12 to 17 % in wet season. The average sunshine of the studied area was 6.948 hour (Bangladesh Meteorological department, 2003). The soil was not compacted as well since the average void ratio was about 0.70. So, the soil masses were drying and wetting from time to time causing loosening of soil particles. In rainy season the dislodged particles of the soil mass washed out by run off water. As a result the void space increased as well as the bounding capacity of soil grains deteriorates. In dry season, the soil mass weathered and finer particles also replaced by wind action. So, the soils were easily eroded in rainy season by rainfall and in dry season by wind action. The water bodies, like rivers, canals, ponds, streamlets etc. subsequently filled up with water in rainy days and let the open flank of
the road to be saturated with water. So the water exerts pressure, which ultimately enhanced the erosional activities at that location. As a result, the soils were easily eroded and slumping the road flanks. At Tapapur and Baneshwar part of the road had considerably higher void ratio (Table -1) reflecting lack of proper compaction of soil.

4. Conclusion

The studied Rajshahi-Natore highway was mainly constructed by sand, stone and brick clips, selected earth, bitumen and cement. During field investigation several erosional sites were observed in different places along the highway, some of those were tremendously eroded in Tarapur (1.46m/yr), Baneswar (0.19m/yr), Pullapara and Kapashia (1.46m/yr). In Tarapur, Pullapara and Kapashia area of the highway, the box culvert's flanks were open. These open flanks of culverts also deteriorated rapidly and subsequently these areas faced severe soil erosion, especially during the rainy days.

The laboratory analyses showed that the soil masses were less compacted and the bounding capacity of grain to grain of soils were very weak. The undulated nature of the road at Belpukur rail-road crossing was resulted due to the differential compaction of the soil. The soil masses were continuously facing wetting and drying and finally weathered. In rainy season, the finer particles of soil masses also washed out by water and ultimately decrease the compactness of soil. The water also infiltrated into the soil mass from the water bearing areas.

Finally it is suggested that the eroded places of highway flanks especially at Tarapur, Baneswar, Pullapara and Kapashia should be repaired each year and filed the water bearing area, if possible. The open flanks of the culverts in Tarapur, Pullapara and Kapashia areas must be protected by concrete structures. The flanks of highway should be grass-carpeted.

5. References

