FLOOD MITIGATION OF A RURAL ROAD IN BATTICALOA DISTRICT

*T. Kajenthiran, S. Premananthan, J. Pratheep, K. S. Weerasekera**

Department of Civil Engineering, The Open University of Sri Lanka

1. INTRODUCTION

A rural road stretch of 6 kms in length in Vellavali division in Batticaloa district prone to constant flooding was selected for improvement and flood mitigation design. More than 40,000 people from 43 Grama Niladhari divisions use this road for the day-to-day activities (to access hospital, market, school, police station etc.). The existing road pavement is of penetration Macadam type construction and exhibits a moderate to poor surface condition. Surface deformations, potholes, edge break and surface cracks were observed along the road at some locations. The road alignment is mostly straight, and the terrain is flat predominantly. In order to overcome the issues caused by the damages of this road due to the constant flooding, it is important and mandatory to provide a suitable level formation with required widths to accommodate the expected heavy traffic 20 years from now. A Similar study was demonstrated by Nicholas and Lester (2010) in Cengage Learning, USA.

2. METHODOLOGY

2.1. Data collection

The flooding history of up to twenty years of the study area was collected from Department of Irrigation and disaster management unit of Batticaloa and indicated in Table 1 below. Chainage at Paddiruppu (0 + 000 km). The road stretch from (0 + 350 km) to (2 + 000 km) is damaged frequently due to flooding and both sides of the road are surrounded by paddy fields bounded by a river.

Table 1. Flooding history (2000 to 2020)

Year	Maximum flood level on the road (in feet)
2000	2 ft. flood level at (0+660 km)
2002	1 ft. flood level at (1+230 km)
2005	4 ft. flood level at (0+660 km)
2008	2 ft. flood level at (1+230 km)
2009	2 ft. flood level at (0+660 km)
2011 (3 times)	4 ft. flood level at (0+330 km)
2012	1 ft. flood level at (0+660 km)
2013	3 ft. flood level at (0+330 km)
2015	2 ft. flood level at (0+660 km)
2017	1 ft. flood level at (1+230 km)
2018	3 ft. flood level at (0+330 km)
2019	2.5 ft. flood level at (0+660 km)
2020	3 ft. flood level at (0+330 km)

(Source – Disaster Management Unit – Batticaloa)

2.2. Traffic survey

As the first step, the traffic volume study was conducted on a mid-week day by manual count method for a period of 12 hours from morning 6.30 am to evening 6.30 pm. Different vehicle categories were counted in both directions in intervals of 15 minutes. From collected data, the peak hours were identified by converting vehicle numbers to passenger car units (PCU), 6.45am - 7.45am as morning peak and 1.30pm – 2.30pm as evening peak. Then the maximum peak hour was identified as 1.30pm -2.30 pm and which was used for the vehicle growth projection for future 20 years with the use of vehicle growth rate of Eastern province.

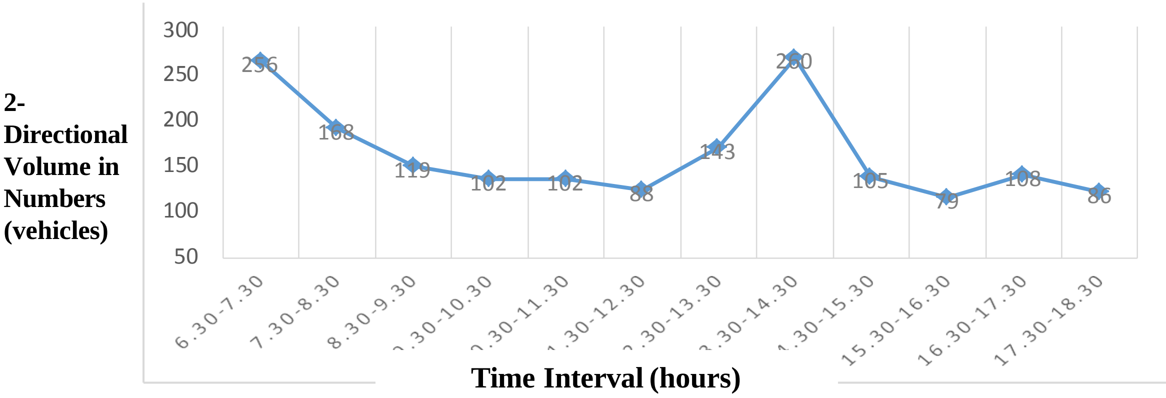

Figure 1. 12-hour vehicle volume

Figure 2. Flooding in 2019 - Location at (0+330 km)

Traffic volume growth rates of Eastern province was used to calculate the annual traffic growth rates of cars, buses and other vehicles. Table 2 shows the overall calculation of the growth of the vehicles in 20 years (Mannering et al., 1997).

Table 2. Passenger Car Units (PCU) conversation for the peak hour OUT Flow (INTO PADDIRUPPU) - peak 01 (1.30 pm to 2.30 pm)

	2019			2022		2027		2032		2037		2042
Vehicle Type	**V**	**PCU**	**A.G. R**	**V1**	**A.G. R**	**V2**	**A.G. R**	**V3**	**A.G. R**	**V4**	**A.G. R**	**V5**
Passenger Car	6	6.0	7.4	7	5.9	9	4.8	12	4.9	15	4.5	18.0
Small Bus	4	7.2	3.4	8	3.4	9	3.4	11	3.4	13	3.4	14.9
Bus	6	14.4	3.4	16	3.4	19	3.4	22	3.5	26	3.5	30.0
Light Truck (4 Wheels)	5	7.5	9.4	10	6.2	13	6.3	17	6.2	22	5.8	28.0
Medium Truck (6 Wheels)	1	2.0	9.4	3	6.2	3	6.3	4	6.2	6	5.8	7.5
Heavy Truck (8 Wheels)	0	0.0	9.4	0	6.2	0	6.3	0	6.2	0	5.8	0.0
Motor Cycle	44	17.6	7.1	21	6.1	28	5.2	35	4.5	43	3.8	51.2
Three-Wheeler	33	26.4	4.3	30	3.2	35	2.5	39	1.8	42	1.3	45.2
Land Vehicle	1	3.8	9.4	5	6.2	6	6.3	8	6.2	11	5.8	14.2
Total	**100**	**84.9**		**99**		**122**		**148**		**177**		**208.8**

Table 3. Passenger Car Units (PCU) conversation for the peak hour IN Flow (INTO VELLAVELI) - peak 02 (1.30 pm to 2.30 pm)

	2019			2022		2027		2032		2037		2042
Vehicle Type	V	PCU	A.G. R	V1	A.G. R	V2	A.G. R	V3	A.G. R	V4	A.G. R	V5
Passenger Car	4	4.0	7.4	5	5.9	6	4.8	8	4.9	10	4.5	12.0
Small Bus	6	10.8	3.4	12	3.4	14	3.4	16	3.4	19	3.4	22.3
Bus	4	9.6	3.4	11	3.4	12	3.4	14	3.5	17	3.5	20.0
Light Truck (4 Wheels)	3	4.5	9.4	6	6.2	8	6.3	10	6.2	13	5.8	16.8
Medium Truck (6 Wheels)	1	2.0	9.4	3	6.2	3	6.3	4	6.2	6	5.8	7.5
Heavy Truck (8 Wheels)	0	0.0	9.4	0	6.2	0	6.3	0	6.2	0	5.8	0.0
Motor Cycle	51	20.4	7.1	25	6.1	32	5.2	41	4.5	50	3.8	59.3
Three-Wheeler	41	32.8	4.3	37	3.2	43	2.5	48	1.8	53	1.3	56.1
Land Vehicle	1	3.8	9.4	5	6.2	6	6.3	8	6.2	11	5.8	14.2
Total	**111**	**87.9**		**102**		**125**		**150**		**178**		**208.1**

A.G.R: Average Growth Rate

From the projected traffic growth in upcoming 20 years, it was calculated that the road will have a level of service of B with two-way-two-lane stretch to cater the future traffic [Highway Capacity manual (1985)].

2.3. Field Levelling works

The study and the analysis of the existing road section is very important for the design of the road to overcome the issues by flooding. The Paddiruppu – Vellaveli road section is 6 km long and out of that 1.63 km from Paddiruppu towards Vellaveli constitutes of the critical length that mostly get inundated during the flooding time. In order to get the details of longitudinal and the cross sections of the road, proper land surveys were conducted using levelling instrument according to the Road Development Authority specifications.

3. RESULTS AND DISCUSSION

As planned, it was expected to mitigate the flooding of the road in a cost-effective manner, hence from the existing cross sections and the longitudinal sections the new road section was planned to be designed with flexible pavement to overcome the problems due to flooding. A flexible pavement was proposed over rigid pavement due to economic reasons. On both sides of the road 1.5 m shoulders were provided for pedestrians. From the past flooding history, a flood frequency analysis was conducted, and for a 20-year flood return it was found that a maximum of 4 feet above the top of the existing highest level of road was satisfactory. Hence it is need to avoid that flooding height in the future and it was needed to design the road with a freeboard. In order to increase the reduced level of the road a new formation line was selected. As a feasible suggestion, it was planned to elevate the road section with a reduced level of 99.68 m. And the road section from 0 chainage to 1620 m will be of a same elevation and it was proposed that the proper culverts plan from a hydrological analysis for the flow of water from one site to another. The flexible pavement design was conducted using method of design by Road Note 29 of Research Laboratory, UK and the thickness of sub-base, base and surface layer were calculated. Through a hydraulic flow analysis the culvert drainage opening sizes were obtained. It was proposed to construct a proper drainage system along with the placement five culverts across the critical section of the road stretch with the opening size of 2.0 x 2.5 m with a thickness of 150 mm. Culverts were placed 1 m below the top of the proposed road level and the bottom level of the culverts were placed 1.5 m below the existing ground level.

Success of a highway project is totally dependent on the completion of the project within an effective cost and time. The cost estimate for this project was prepared based on the quantities worked out from the field surveys and design of the culverts. The rates have been taken from Highway Schedule Rate, 2019 of RDA – Eastern Province. The total estimated cost for this project is SL Rs. 154,050,000 including the costs of preliminaries, road work, structural work, road marking work and transport charges.

4. CONCLUSIONS/ RECOMMENDATIONS

In this study details of the current traffic volume were collected by manual count method and projected for the future 20 years (2019–2039). Also, information on flooding history of the study area; flooding damage and topographical information were collected from relevant institutions. From the expected future 20 years traffic volume, the peak hour volume was identified and the level of service of the road section was found to be LOS B and number of lanes required to cater to the traffic in 20 years was calculated as two-way two lanes. And also, the existing level of the road has been elevated with the required elevation in order to avoid the flooding problems in the road stretch with adequate drainage systems. The increase in the elevation of the road surface is not only a solution to arrest the flooding problems in the road stretch, a proper drainage system and proper discharge opening of the flood water is essential to allow the flood water to flow to the nearest river. It has been decided to place five culverts in the critical areas with 2.5m x 2.0 m opening size.

5. ACKNOLEDGMENT

Authors would like to express their deep and sincere gratitude to numerous residents living along the Paddiruppu – Vellaveli road who provided them with very valuable information regarding the flooding in the area and the support offered during the field surveys. They are also thankful to the officers at Batticaloa Disaster Management Unit of the Irrigation Department, design engineers of the Highway Design Unit of the Road Development Authority and Provincial Road Development Authority (Eastern province) for the tremendous support extended to them during the study.

6. REFERENCES

Highway Capacity manual (1985), Special Report 209, Transportation Research Board, National Research Council, Washington, D. C.

Mannering, Fred L., Kilareski, Walter P., Washburn, Scott, S. (1997), ‘*Highway Engineering and Traffic Analysis*’, 3rd ed. New Delhi: Wiley India (P) Ltd.

Nicholas, J. G. and Lester, A. H. (2010), Principles of Traffic and Highway Engineering, Cengage Learning, United States.