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Structural condition assessment of bridges and culverts in national highway N7

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ABSTRACT: Deterioration of structures with the passes of time especially for bridges and culverts is a common phenomenon all over the world. Deterioration may happen due to different reasons like poor construction quality, overloading, and structural inadequacy, lack of maintenance and monitoring, ground settlement and weathering effect. Due to lack of timely mitigation measures, deterioration often causes the severe structural dam-age and warrant untimely expensive repair or replacement of the structures. In Bangladesh, the growth of economy is consistent for the last few years and accordingly blooming in transportation sector happened. To meet the future traffic and transport demand some of the road structures mainly bridges and culverts are being structurally inadequate. Recently a survey has conducted to assess the structural conditions of bridges and culverts on National Highway N7. On the basis of which, an up-to-date inventory was prepared. The survey results signify that some of the bridges and culverts are inadequate to carry the increased traffic load. Some of them are at slightly deteriorate condition and need immediate retrofitting or structural capacity enhancement to keep them in operation. The assessment result emphasizes on the need of regular health monitoring and necessary maintenance program to reduce the structural deterioration over the service life of the structure.

1 INTRODUCTION

National Highways of Bangladesh are the major highways which connect capital city or land and sea port with divisional headquarters. National Highway N7 starts with Daulatdia ferry ghat and ends at second largest sea port Mongla. This highway is the major link connecting south-west part of Bangladesh to capital city Dhaka. Also this corridor plays a crucial role in establishing regional connectivity with neighboring countries Nepal and Bhutan. For the current study the structures on the stretch of Daulatdia-Magura-Jhenaidah-Jessore-Khulna road (N7) was taken into consideration. As south-west part of Bangladesh carries numerous water bodies, hence this corridor supports structure like RCC girder bridges, PC girder bridges, truss with RCC slab bridges, arch masonry, slab culverts, box culverts etc in a large number than any other major highways. Some of this structure is as old as mid 20^{th} century and some are relatively new construction. Hereby they show various level of structural damage, which should be address as soon as possible. Technical Assistance for Subregional Road Transport Project Preparatory Facility was designed to perform the feasibility study and the detailed design of some major road corridors of Bangladesh with a view of regional connectivity. National highway N7 was studied under this project and an inventory of all the structures was made by field investigation.

2 LOCATION AND METHODOLOGY

2.1 *Location*

National highway N7 is located at the south-western part of the country. Daulatdia-Magura-Jhenaidah-Jessore-Khulna road (N7) stretch under study has the mighty river the Padma (Daulatdia Ferry Ghat) at one end and the sea port Mongla at the other end. The structures situated along the selected corridor are at Rajbari, Faridpur, Magura, Jhenaidah, Jessore and Khulna districts.

2.2 *Traffic Data Collection*

In order to establish the present traffic and calculate the base year traffic, different traffic surveys for the selected locations of the road corridors were undertaken and segments were identified. The traffic surveys included: (i) classified vehicle volume counts and (ii) origin-destination survey. While classified traffic counts provide the present existing traffic, the O-D surveys provide information on the movement patterns of freight and passenger and route preference by the road users. Traffic surveys were organized for a period of three weeks starting from 2nd week of July till the end of the month. Special emphasis was given to select the counting stations so that traffic volume can be collected for homogeneous sections identified earlier and to be consistent with Highway Development and Management (HDM) stations. Survey locations were selected outside the towns and cities to avoid influence of local traffic, so that counting and intercepting the through traffic using the project roads could take place. However, some survey locations were selected purposively close to the towns or markets to see the influence of local traffic particularly Slow Moving Vehicular Traffic on the road.

2.3 *Structural Data Collection*

Secondary data on various structures were collected from Roads and Highways Department to formulate an inventory of the existing bridges and culverts along the road. Data were recorded like structural identification no., chainage, longitude, latitude, types of structure. After that a survey was done in August 2013 for reviewing the secondary data and assessing the conditions of the structure by field investigation. By visual inspection the current status of each structure was recorded. The structural inventory was categorized as RCC Girder Bridges, PC Girder Bridges, Box Culverts, Slab Culverts, Arch Masonry bridges and truss with RCC Slab Bridge.

3 DATA ANALYSIS AND DISCUSSIONS

3.1 *Traffic Profile*

The traffic data which was collected on selected locations of the road corridor is presented in Figure-1. This provides information on the existing and projected movement patterns of freight and passenger and also provides information on the existing and expected loads on the structures.

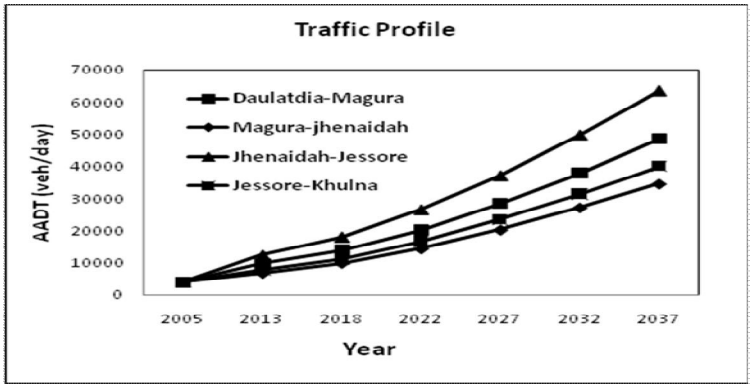

Figure 1. Traffic profile on Daulatdia-Magura-Jhenaidah-Jessore-Khulna (N7) road

3.2 *Structural Condition Analysis*

The secondary data on various structures which were collected from Roads and Highways Department on Daulatdia-Magura-Jhenaidah-Jessore-Khulna (N 7) road to formulate an inventory of the existing bridges and culverts was reviewed through a survey (field investigation, visual inspection etc.) in August 2013 that gave an assessment on the conditions of the structures. The structural inventory and overall structural condition is presented in Figure-2 and Figure-3. The performance of different types of structures subjected to the existing traffic load also presented in Table-1.

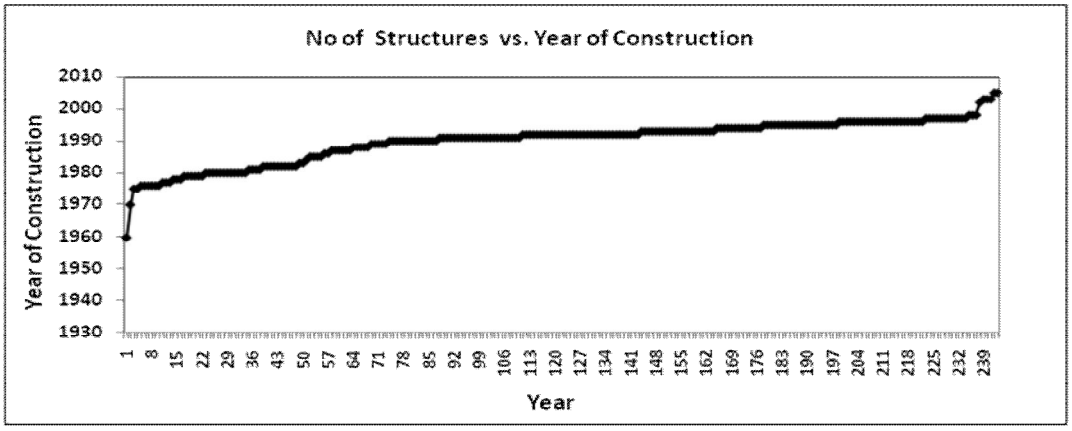

Figure 2. Structural inventory on Daulatdia-Magura-Jhenaidah-Jessore-Khulna (N 7) road

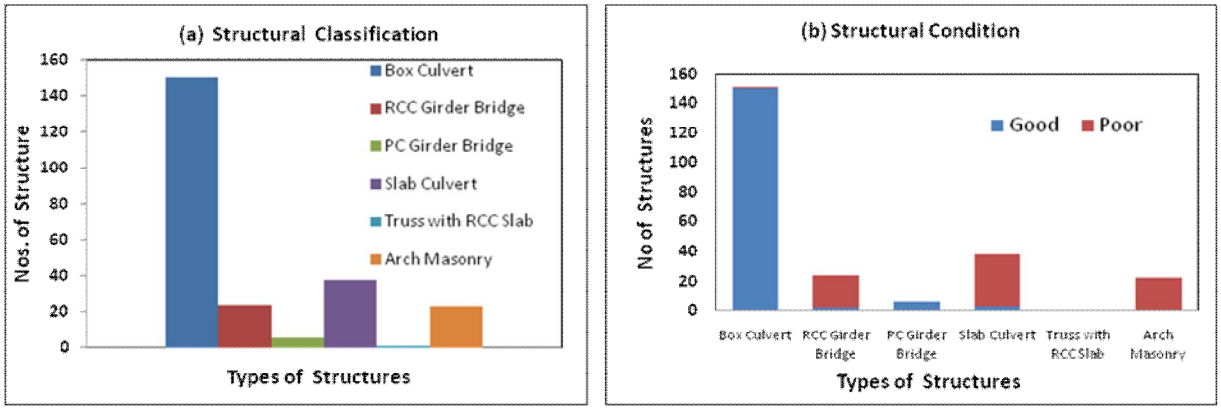

Figure 3. Structural classification in (a) and structural condition in (b)

It was observed that a good number of structures deteriorated over the years after construction due to different factors. It was clearly observed that Box Culvert, PC Girder Bridge, Arch Masonry and Truss structures performed well than RCC Bridge and Slab Culvert. The actual deteriorated condition of these structures is presented in Figure-4. The deterioration may be occurred due to different conditions like repeated overloading, unexpected extra loading before the life expiry period, quality control during construction, inappropriate maintenance and lack of regular inspection as well as monitoring, weather conditions, improper drainage and gradient and reinforcement corrosion etc.

Table 1. Structural condition percentage for different types of structures

Types of Structures	Total Number	Structure in good condition		Structure in poor condition	
		nos.	%	nos.	%
Box Culvert	151	150	99.34	1	0.66
RCC Girder Bridge	24	2	8.33	22	91.67
PC Girder Bridge	6	6	100.00	0	0.00
Slab Culvert	38	3	7.89	35	92.11
Truss with RCC Slab	1	1	100.00	0	0.00
Arch Masonry	23	0	0.00	23	100.00
Total	243	162	-	81	-

Figure 4. Deteriorated structural condition in (a) Slab Culvert at chainage 211+018 and in (b) Arch Masonry at chainage 5+028

4 LESSONS LEARNT

4.1 *Planning and Design*

During the study it was felt that some of the structures were designed calculating the normal traffic without further projection and when they were to carry the repeated extra load then those structures deteriorated earlier than it was expected. So this study recommended the projected traffic growth to count on that the design for replacement of deteriorated structures as well as for new structures. Also recommended to consider the AASHTO/ LRFD design load (AASTHO-96 and HL-93 Loading), Bangladesh National Building Code 1993 /2013 and AASHTO bridge design specification 2007/2010 with longitudinal gradient 0-3% having minimum provision of 2% Cross slope.

4.2 *Construction, Maintenance and Monitoring*

As it was observed that a good number of structures including RCC Bridge and Slab Culvert deteriorated over the years after construction due to different factors and question on construction quality comes first. On the other hand irregular and inappropriate maintenance and lack of structural health monitoring also deteriorated structures.

5 CONCLUSIONS

According to the study and investigation, some major conclusions can be derived: Firstly, in case of early structural deterioration of different structures, it might be the repeated traffic loading exceeding the legal limit Secondly, the improper quality control during construction might create some structural defects and cracks on the structures which was further aggravated by the cyclic loading caused the structural damages beyond the expectation. And finally, it can be concluded that, the deterioration might be occurred due to inappropriate maintenance and lack of regular inspection as well as monitoring, weather conditions, improper drainage and gradient and reinforcement corrosion etc. So, the proper design, quality control and regular health monitoring are very much effective in reducing and restraining structural deterioration.

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