STRUCTURAL SAFETY ASSESSMENT OF BANGHABANDHU MULTIPURPOSE BRIDGE FOR TRAIN ACCIDENT AND ITS SOCIO-ECONOMIC IMPACT IN BANGLADESH

Shahab Uddin*[1] and Md. Kobir Hossain[2]

[1]*Undergraduate student, DUET Gazipur/American Society of Civil Engineers (ASCE) student chapter Bangladesh, Bangladesh, e-mail: shahab.civil97@yahoo.com*
[2] *Assistant Prof. Civil Engineering Department, DUET Gazipur, Bangladesh, e-mail: kobir.ce@duet.ac.bd*

ABSTRACT

The Banghabandhu Multipurpose Bridge (BMB) was constructed in 1998 aimed at contributing to accelerate economic development in Bangladesh. In recent years, however, the high incidence of traffic accidents and injuries at the bridge sites looms as a great safety concern. The train accident in Bridge will be deep concern for both structural safety of bridge and people rather than others accident. The train accident may occur for mechanical error of bogies and engine, error of rail and components, storm, cyclone and others climate change impact. Investigation into the derailment of nine bogies of a Dinajpur-bound train of 14 bogies on the Banghabandhu Bridge is underway on 28 April 2014. Satellite images have indicated that the train was caught in a sudden cyclone over the bridge around 11.15pm and 7-Dec 2014, derailment halts train services through Banghabandhu Bridge had also occurred, if the train became derailment along river side the train may be fallen down according to series pattern of bogies so Bridge must be collapsed for acting series of bogies load at a certain point by shearing or flexural failure, but for others vehicle accidents supporting member have no impact, vehicles may be fallen down in the river by braking railings. If the Bridge collapse then communication between north bound and south bound will be stopped completely, Bangladesh has no ability to remake it quickly and impact on economic will be a major concern. The main purpose of this report is to present the current state of the art regarding protection system for train accident and to perceive the authorities about the disaster of Bridge for train accident and its socio-economic impact in Bangladesh.

Keywords: *Train accident, Derailment, April, Series, Socio-economic*

1. INTRODUCTION

Being a riverine country, bridges provide a significant role in achieving an efficient road based transport system in Bangladesh. The Banghabandhu Multipurpose Bridge (BMB), the 12th longest bridge in the world, was constructed in 1998 aimed at contributing to accelerate economic development in Bangladesh by extruding the bottleneck to the east-west corridor and activating economic exchanges between the regions. Indeed, the construction of the bridge has originated huge accessibility and mobility potential and thereby has increased the prospects of socio-economic development of the people of North-Bengal. In recent years, however, the high incidence of traffic accidents and injuries at the bridge sites (the main bridge and its approach roads) has become of increasing concern with an average of nearly 100 accidents taking place each year on the 38 km road segment of national highways consisting of the bridge and approaches (Hoque et al 2008). The collapse of Bridge will not be occurred for those high incidence of traffic accidents but train accident in the Bridge will be deep concern for both structural safety of bridge and people rather than others accident, if the train became derailment along river side the train may be fallen down according to series pattern of bogies and Bridge must be collapsed for acting series of bogies load at a certain point by shearing or flexural failure, but for others vehicle accidents supporting member have no impact, vehicles may be fallen down in the river by braking railings. If the Bridge collapse then communication between north bound and south bound will be stopped completely, Bangladesh has no ability to remake it quickly and impact on economic will also be a major concern. The bridge authorities are required to put up appropriate programs for reducing the number as well as the severity of accidents to maintain an acceptable level of safety.

2. THE JAMUNA MULTIPURPOSE BRIDGE IN BRIEF

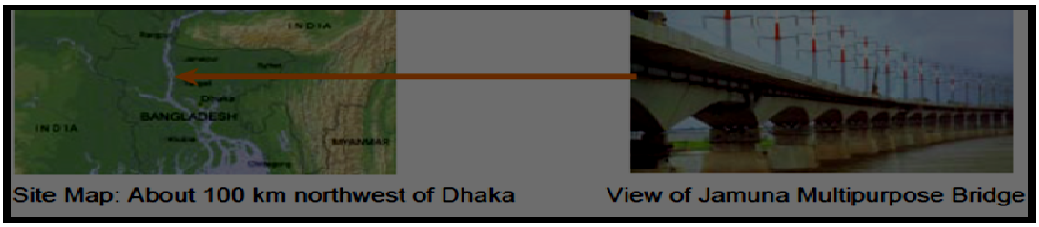

Figure 1: Map of Bangladesh and the location of Banghabandhu Multipurpose Bridge.

The Banghabandhu Multipurpose Bridge is now situated near Sirajganj and Bhuapur, connecting the eastern part of the country to the northwestern part. The total length of the bridge is about 4.8 kilometers. It is the longest bridge in Bangladesh and South Asia and the 12th longest bridge in the world. The bridge construction involved a wide array of works: the main bridge, the bridge end facilities at the east and west banks of the Jamuna river, the approach roads connecting the bridge with the existing road network, the river training works. The end facilities enhance smooth traffic flow, provide travellers aids, have bus stations, parking areas, rest areas, toll booths, staff housings etc. The approach roads were built to lead cars to enter the bridge. The Bridge is 16 kilometers from the east side and 17 kilometers from the west. In the east, the approach road connects to the existing Tangail-Madhupur road near Elenga and in the west it joins the Hatikamrul-Sirajganjroad at new Nalka Bridge (Youm 2006). The bridge contains two lanes of road on each side, as well as railroad tracks, gas pipelines and power lines. The main bridge is a Multi-span girder-type structure with 100 m spans and a total of 48 spans. The main bridge has pile foundation consisting of 90 m long steel tubular piles driven into the riverbed and the superstructure of the bridge consists of steel box girders with a concrete deck or pre-stressed concrete box girders.

3. STRUCTURAL SAFETY ASSESSMENT

3.1 History of Construction

The river Jamuna (Brahmaputra), along with the lower stretch of the Padma (Ganges) divides Bangladesh into nearly two equal halves. Until now all road and rail communication between the two parts of the country has had to rely on time-consuming ferry services that were often disrupted because of navigability problems. The need for a bridge over the Jamuna River was felt, especially by the people living in northwestern Bangladesh, for a long time. This perceived need did not go unnoticed by the policy makers. The people and successive governments longed to bridge the mighty Jamuna and thereby integrate the communication systems of the region. Popular leader Maulana Abdul Hamid Khan Bhashani first raised the demand for construction of the Banghabandhu Bridge at a political level in 1949. In the 1954 provincial elections of East Pakistan, the 21-point manifesto of the united front contained a demand for the bridge. On January 6, 1964, Mohammad Saifur Rahman, a member from Rangpur in the Provincial Assembly inquired about government's intentions with regard to the construction of a bridge over the Jamuna. On July 11, 1966, Shamsul Haque, another member from Rangpur in the same Assembly, moved a resolution for the construction of the bridge and the house adopted it unanimously. Accordingly, a preliminary feasibility study was carried out in 1969 by Freeman Fox and Partners of UK. They recommended a rail-cum-road bridge near Sirajganj with an estimated cost of $175 million. The estimates were preliminary and a more detailed study was recommended. On the other hand, in his address to the nation over radio and television on the eve of general election in Pakistan in 1970, the Awami League leader Sheikh Mujibur Rahman mentioned the construction of Banghabandhu Bridge as an election pledge of his party. But all efforts were interrupted due to political unrest and liberation war. After Bangladesh attained independence in 1971, the new government publicly stated its intention in 1972 to construct a bridge over the Jamuna and budgetary provisions were kept for the purpose in the 1972-73 budget. On being invited by the Bangladesh government, the Japan International Cooperation Agency (JICA) funded a feasibility study through Nippon Koei Co. Ltd. in 1973 on the construction of a road-cum-rail bridge over the Jamuna. The JICA study, completed in 1976, concluded that the Jamuna project would cost $683 million with an economic rate of return (ERR) of only 2.6%. Considering that the project was not technically and economically viable, the government abandoned it. The government revived it in 1982 and commissioned a new study to determine the feasibility of transferring natural gas to western parts of the country across the Jamuna. The study concluded that an independent gas connector was not economically viable. However, the consultants made an assessment of the engineering feasibility and cost of a combined road-cum-gas transmission bridge, which introduced the concept

of a multipurpose bridge. It was estimated that a 12-km long bridge with three road lanes would cost $420 million. Upon consideration of the report, the cabinet made a decision to take immediate steps in pursuit of the project. The Jamuna Multipurpose Bridge Authority (JMBA) was set up by an ordinance promulgated by the then President Hussain Muhammad Ershad on July 3, 1985 to implement the project. For mobilisation of domestic resources, another ordinance was promulgated by which a Banghabandhu Bridge surcharge and levy were introduced. A total of Tk 5.08 billion was mobilized in the process till its abolition. In 1986, phase-I feasibility study for the bridge was carried out when the site between Sirajganj and Bhuapur (Tangail) was found to be the best. Between 1987 and 1989, the phase-II feasibility study was carried out when a road-cum-rail-cum-power bridge was found both economically and technically viable. Funding arrangements were finally made with IDA, ADB and JBIC (formerly known as OECF) of Japan by the government of Bangladesh in 1992. Tenders were invited through international bidding for construction contracts in 1993. Contracts for the bridge, river training work and two approach roads were awarded in March 1994. The foundation stone of the bridge was laid on April 10, 1994 by the then Prime Minister Begum Khaleda Zia. Physical implementation of the project commenced on October 15, 1994, and all the components except gas transmission line were completed by June 1998. The bridge was opened for traffic on June 23, 1998 by the then Prime Minister Sheikh Hasina the daughter of Banghabandhu Sheikh Mujibur Rahman. Jamuna Multipurpose Bridge was constructed by Hyundai Heavy Industries at a cost of $696 million. The cost was shared by IDA, ADB, OECD, and the government of Bangladesh. Of the total, IDA, ADB and OECD supplied $200 million each through a loan with 1% nominal interest, and the remaining $96 million was borne by Bangladesh. The main bridge is 5.63 km long with 47 main spans of approximately 100 metres and two end spans of approximately 65 metres. Connected to the bridge are east and west approach viaducts each with 12 spans of 10 metres length and transition spans of 8 metres. The total width of the bridge deck is 18.5 metres. The river crossing was designed to carry a dual two-lane carriageway, a dual gauge (broad and metre) railway, a high voltage (230 kV) electrical interconnector, telecommunication cables and a 750 mm diameter high pressure natural gas pipeline. The carriageways are 6.315 metres wide separated by a 0.57 metre width central barrier; the rail track is along the north side of the deck. On the main bridge, electrical interconnector pylons are positioned on brackets cantilevered from the north side of the deck. Telecommunication ducts run through the box girder deck and the gas pipeline is under the south cantilever of the box section. The bridge has been built by Hyundai Engineering and Construction (Korea) as a 'design and build' contract. TY Lin Assoc. of San Francisco carried out the design as a sub-contractor for Hyundai. The approach roads were constructed by Samwhan Corporation (Korea) (wikipedia.org/wiki/Bangabandhu_Bridge).

3.2 Railing capacity Assessment for Protecting Train

Figure 2: Showing the railing condition beside the MG rail and underway of train on 28 April 2014. (newagebd.net April 2014)

The bridge has been built by Hyundai Engineering and Construction (Korea) as a 'design and build' contract. Actually the bridge was design for only road way. In order to fulfill increasing communication demand between eastern part of the country to the north western part for generating multifarious benefits for the people and especially promotes inter-regional trade in the country railway was involved. Apart from quick movement of goods and passenger traffic by road and rail, it facilitated transmission of electricity and natural gas, and integration of telecommunication links. The authorities have provided light metal pipe as railing without design for protecting train such railing has no capability to protect the train, if the train is underway along riverside instead roadside alike the train accident in which nine bogies of a Dinajpur-bound train of 14 bogies on the Banghabandhu Bridge is underway on 28 April 2014 along roadside.

3.3 Structural safety assessment for Train accident

Investigation into the derailment of nine bogies of a Dinajpur-bound train of 14 bogies on the Banghabandhu Bridge is underway on 28 April 2014 along roadside (newagebd.net April 2014) is whether the train is underway along riverside the train may be fallen down according to series pattern of bogies and Bridge may be collapsed for acting series of bogies (Engines) load at a certain point as shocked load (W) by shearing or flexural failure.

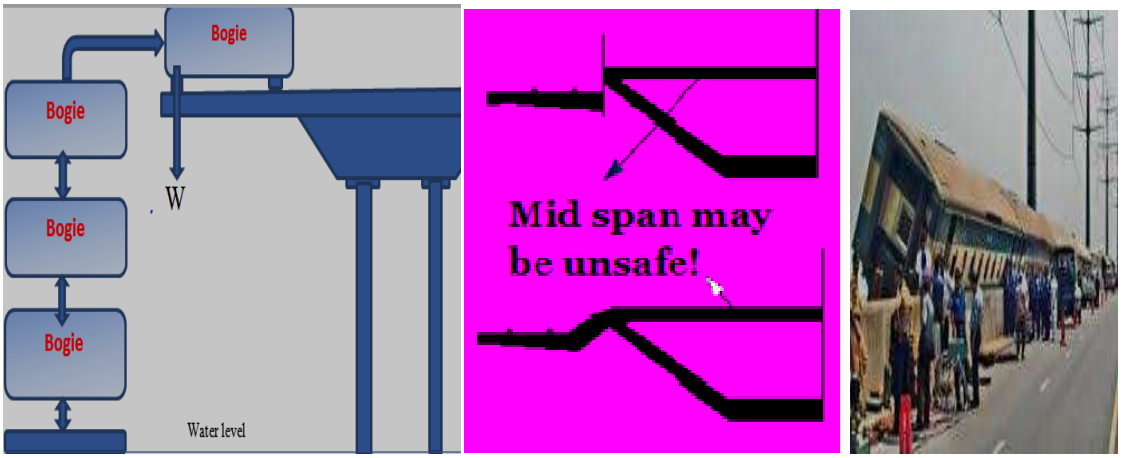

Figure 3: Showing probable impact mode for Train accident if the train is underway along riverside instead roadside.

The designer of the bridge does not consider that the bridge has to bear such shocked load (W) at a certain point. From the statistic of underway of train due to accident it is proved that all the bogies and locomotive are not underway together, if the train is underway together then the train may be fallen down as a single vehicle and single vehicle could not apply such shocked load at any certain point of the Bridge. Therefore the probability of acting shocked load at a certain point in The Banghabandhu Multipurpose Bridge will be max, when train will become underway along riverside.

3.4 Structural safety assessment for other vehicles

The toll collection system in the bridge classifies vehicles into seven categories are large bus (LB), small bus (SB), large Truck (LT), medium truck (MT), small truck (ST), light vehicles (LV) and motorcycle (MC) for these vehicles accidents supporting member have no impact, vehicles either will be fallen down in the river by braking railing or protected by railing in the Bridge.

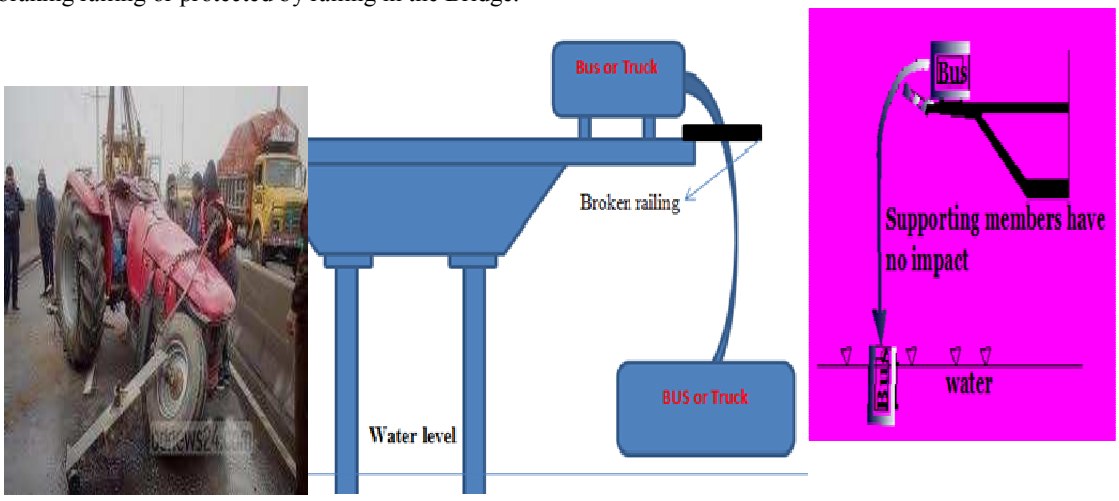

Figure 4: Typical accident hazards at bridge and probable impact on bridge.

4. SOCIO-ECONOMIC IMPACT OF THE BRIDGE

4.1 The Goals of Bridge

A circumstantial overview of socio-economic impacts has been given by Youm (2006). The most fascinating impacts are highlighted in this section. The project had multiple purposes. The two main dimensions were economical and technological. Its main goal was to achieve economic equality between the east and west zones of Bangladesh. Jamuna River was a hindrance for development of the western zone and building the Banghabandhu Multipurpose Bridge was the right solution to equalize the levels of development between eastern and western zones. Other purposes were to provide numerous benefits to people on both sides and to enhance inter-regional activities such as trading. The bridge provided faster transportation for people, products, electricity and natural gas. The project also developed the communication level between places. It enabled people on either side to communicate faster through phone links on the bridge. The bridge has led to the creation of more job opportunities for people on the western side. Now, people who used to be unemployed are working and earning enough money to take care of their family. The bridge has led to an increase in country's gross domestic product (GDP), and has lowered the country's poverty level (Hoque et al 2008). One example of a new business is the opening up of Jamuna Resort which is placed a few kilometres away from the bridge. The resort provides job opportunities for tourists visit the area to look at the bridge. Banghabandhu Bridge is not only impacting its own nation in a positive way but it is also impacting the surrounding nations, such as India and Myanmar. The Asian Highway and Trans-Asian Railway are going to be built to connect most of the countries in South Asia and South East Asia. When it goes through Bangladesh they are going to take advantage of the bridge and use it instead of building a new structure. The new highway will be beneficial for Bangladesh by opening up access to foreign countries. Trading with the countries in these regions will be easier, therefore Bangladesh will be able to develop further (Youm 2006). Another question that looms large in this respect is whether Bridge collapses Bangladesh will be muffed from mentioned all opportunities.

4.2 Vehicular Involvements and Importance

The toll collection system of Banghabandhu Multipurpose Bridge authority has provided two Plazas namely East Plaza and West Plaza for vehicles assessment along both directions separately. The toll collection system in the bridge classifies vehicles into seven categories are large bus (LB), small bus (SB), large Truck (LT), medium truck (MT), small truck (ST), light vehicles (LV) and motorcycle (MC). These categories of vehicles including train are allowed to cross the bridge.

Table1: Hourly Traffic Flow (East & West Plaza) on July 2015

	MC	LV	SB	LB	ST	MT	LT	Total
Total (28days)	19,061	105,606	2,179	112,075	58,205	94,041	4,471	359,638
Average (per day)	681	3,772	78	4,003	2,079	3,359	160	14,130

(Source: JMBA July 2015)

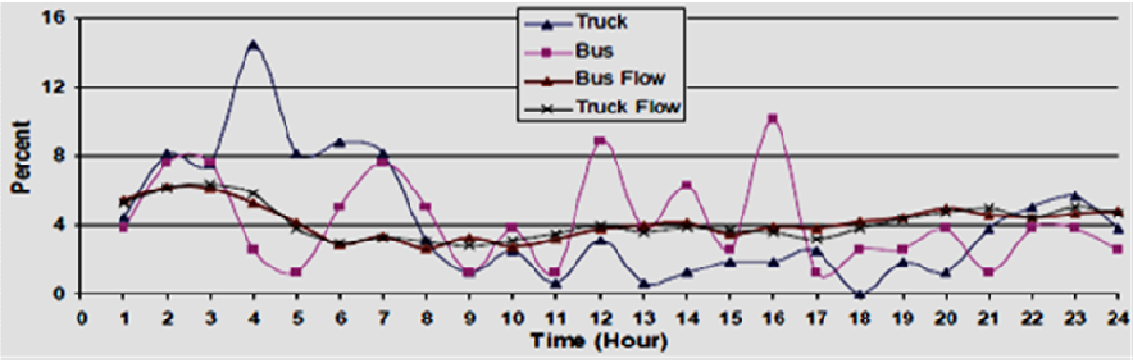

Figure 5: Hourly Distribution of Vehicle Involvement and Traffic Flow (Hoque et al 2008)

Table 2: Daily Train flow on July 2015

	North to South (per day)	South to North (per day)	Total (per day)
Direction	18	18	36

(Source: JMBA July 2015)

The bridge established a strategic link between the eastern and western parts of Bangladesh. It generates multifarious benefits for the people and, especially, promotes inter-regional trade in the country; the vehicles including train are providing such multifarious benefits. Apart from quick movement of goods and passenger traffic by road and rail, it facilitated transmission of electricity and natural gas, and integration of telecommunication links. The bridge has paved the way for easy communication between the two parts of the same land. The products, mainly agricultural and other items of raw food now find easy way for marketing. The importance of this bridge is so high that it beggar's description. The construction of Banghabandhu Bridge has ushered is a new era in the transport and communication systems of Bangladesh. It has paved the way for harmonious development of agriculture, industry, electricity, forest and natural wealth in both the regions. The Banghabandhu Multipurpose Bridge has added a new dimension in the national, social and economic life of the people. The bridge is on the Asian Highway and the Trans-Asian Railway which, when fully developed, will provide uninterrupted international road and railway links from Southeast Asia through Central Asia to northwest Europe.

4.3 Digest of socio-economic impact

1. Communication between north bound and south bound will be stopped and Bangladesh will be divided into two parts namely north bound and south bound.
2. Total estimated cost was $ 175 million in 1998 hence Bangladesh has no ability to remake it quickly.
3. Its main goal is to achieve economic equality between the east and west zones of Bangladesh will not be possible.
4. The bridge has led to an increase in country's gross domestic product (GDP), and has lowered the country's poverty level.
5. Food, unemployment, educational, treatment problems will be deep concern.

5. STUDY CONCLUSIONS AND RECOMMENDATIONS

The Bridge Authority has been increasingly concerned with the alarming nature of prevailing structural safety of Bridge especially for train accident and road safety problems at the bridge and its approach roads and has been keen to provide a high level of safety by minimizing accidents and casualties. At present, however, there is a lack of detailed knowledge about the problem characteristics, based on which remedial measures could be developed. Systematic studies and investigation of train accidents in this regard can indeed lead to produce such and most cost-effective countermeasures relating to aspects of the bridge environment, behavioral and vehicle issues. The analyses and results of the accident study documented in this paper demonstrated the value of train accident characteristics particularly in terms of structural failure. Importantly the benefits of such bridge safety engineering and behavioral measures could be best achieved by the understanding of and constant reference to the fundamental safety principles and operational elements of safer bridge designs. The main principles of a safe bridge environment that should be considered are as follows:

- To provide guidance: guide the driver through unusual sections
- To provide information: inform the driver of conditions to be encountered
- To warn: warn the driver of any substandard or unusual features
- To control: control the driver's passage through conflict points or sections and
- To forgive: forgive the driver's errant or inappropriate behavior.
- To observe: regularly observe rail, fitting and fastenings.
- To inform: inform the driver about weather (cyclone) condition before entering the bridge.
- To perceive: perceive the bridge authority as they make another bridge for train beside the Banghabandhu Multipurpose Bridge.

All of those principles are overwhelmingly important in the context of safety improvement programs at the Banghabandhu Bridge and its approach roads. Apart from the remedial improvements (reactive approach), the application of pro-active bridge safety approach is vitally important and demands priority consideration.

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