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Recent trend and futuristic vision of bridge development in Bangladesh

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ABSTRACT: As of today, Bridge is not merely a structural element; rather it is an element of the society. The aim of this paper is to enhance and further energize the different disciplines of civil engineering and architecture that can improve the performance and economic return of a bridge in the long run. To this end, the paper takes a note of current trend of bridge engineering in Bangladesh and attempts to provide a futuristic vision for development in the coming decades by keeping a match with the socio-economic development status of the country.

1 INTRODUCTION

The flood plains of the Ganges, the Brahmaputra, and the Meghna cover approximately 40% of the total geo-political area of Bangladesh. The Ganges builds up, by far the largest area of this Indo-Bangla delta. The Ganges, the Brahmaputra-Jamuna, the Surma-Kushiyara-Meghna and the Padma and their numerous tributaries and distributaries are the arteries of the drainage system for the country. In such a geological formation, the construction and maintenance of an uninterrupted road-rail network across the country posed to be the biggest challenge for the civil engineers, even more for the bridge engineers. Soon after independence of this land from British India in 1947 and emergence of Bangladesh from Pakistan in 1971, the engineers passed through various phases of transfer of technology and authority in designing, constructing and maintaining numerous medium and short span bridges of Bangladesh in the continual change of techno-economic scenarios. The construction of the longest bridge (4.8 km) of the country over the mighty Jamuna was abandoned as the feasibility study by JICA in 1976 judged the project to be nonviable both technically and economically. The advancement of Bangladesh economy and the world knowledge on bridge engineering made it feasible subsequently when the Bongobondhu Jamuna Multipurpose Bridge was constructed and finally opened to road and rail traffic on 23rd June 1998. Now, Bangladesh is going to start construction of even a longer bridge over the Padma (Islam 2010 and see also the other dedicated papers on different aspects of the Padma Bridge) and also to have her first extradose cable stayed bridge over the Karnaphuly very recently (Nuruzzaman 2010; Astin 2010). To alleviate the traffic congestion of Dhaka and Chittagong Cities, the design and construction proposals of a number of flyovers and underpasses are now at the design desk (Kader and Hoque 2010). Our engineers are quite ambitious to complete these works during next five years. Once completed, the bridge network will be important not only for the economy of Bangladesh but also for the region. We hope this will remove the technological hindrance of crossing the Himalayas to access east and the west of Asia and open further surface corridor towards the Europe.

The Authorities responsible for development and maintenance of bridges in Bangladesh are the Roads and Highways Department (RHD) for national (Type NH), regional Type R), and selected district roads (Type Z),, Local government Engineering department (LGED) for the bridges under the Zila and other rural roads and for some selected urban bridges, the different Development authorities e.g., RAJUK in Dhaka, Chittagong Development Authority (CDA) in Chittagong, the different cities and municipal corporations e.g., Dhaka City Corporation (DCC), Chittagong City Corporation (CCC), and the different port development authorities within their respective jurisdictions. Bangladesh Army also constructs bridges. Bangladesh Bridge Authority (BBA) is responsible for long bridges exceeding 1,500 meters length.

The paper narrating the current trend of the bridge geometry, loading, analysis and design methods based on different codes and standards followed for the above bridges gives the futuristic vision and guidelines how to harmonize and improve the bridge construction practices in Bangladesh.

2 CURRENT TREND

2.1 *Bridge geometry*

2.1.1 *Planning commission-recommended deck geometry*

The Planning Commission of the Government of Bangladesh (GOB) through Gazette notification has issued "Road Design Standards" (2004), which gives 8 (eight) Design Types for the geometric design of roads, out of which Design types 1 and 2 are reserved for National Highways (Types 1 and 2) for which Roads and Highways department (RHD) under the Ministry of Communications (MOC) of GOB are mainly responsible.

Types 8 and 7 of the above "Road Design Standards" (2004) for Union Level road bridges recommend the single lane of 3.7m carriageway width for smaller than 30 m lengths. For larger than 30m lengths, it recommends for Types 6, 5 and 4 Upazila Level roads, the narrow 5.5m carriageways. For Types 5, 4 and 3 Zila Level roads, it recommends 7.3m dual carriageways. Further, it recommends 0.9m sidewalks on both sides for almost all the above types of bridges.

2.1.2 *RHD-recommended Deck Geometry for NH, R and Z Type Highways/Roads*

Type NH roads connect the metropolitan capital with the divisional and old 21 district/Zila head quarters; the Type R roads connect the Zila headquarters with the Upazila headquarters. Type Z roads connect the Zila headquarter with the nearest highway. RHD is responsible for one Type Z road par district only.

RHD's Geometric Design Standard (2001) gives the standard cross sections for the RHD roads. It specifies 6 (six) types of cross sections: Type 1: 3 lane carriageway with Non-motorized Vehicular (NMV) lanes with 39.4m crest width excluding the central median; Type 2: Dual Carriageway with NMV lanes having 14.4m crest width; Type 3a: 7.3m carriageway with NMV lanes, having 16.3m crest width (for use where many NMVs exist, such as through towns and villages,); Type 3: 7.3m carriageway, with provision of future NMV lanes, also having 16.3m crest width; Type 4a: 6.2m carriageway with NMV lanes, having 12.1m crest width; Type 5: 5.5m carriageway with future provision of upgrading to Type 4, having 11.0m crest width; Type 6: 3.7m carriageway, with future provision of upgrading to Type 5, having 9.8m crest width.

To ensure adequate road safety and road capacity, the above Geometric Design standard (2001) advises not to reduce the road cross sections over the bridges/culverts. To ensure adequate safety, it recommends providing reinforced concrete (RC) safety barrier between carriageway and footway or NMV lanes. It also recommends providing well-designed pedestrian parapets at the deck edges.

2.1.3 *LGED practices*

The LGED generally follows their Road Structures Manual (2008), which covers the reinforced concrete (RC) and prestressed concrete (PC) bridges, and RC culverts for double lane bridges.

2.1.4 *Deck geometry used by other agencies*

The other agencies generally do not have their own design manuals. They follow the deck geometry comprising carriageway width, footpath, and railings, customized based on their past practices, the AASHTO/IRC provisions, the practices followed by RHD/LGED, etc. The budget also occasionally dictates on use of either narrow or standard lanes, use of footpaths and their widths, etc. without duly considering traffic count and forecast as needed.

2.2 *Bridge foundations and hydraulic design*

2.2.1 *Deep foundations for bridges*

Generally deep foundations are provided for bridges and shallow foundations are provided for culverts. Previously up to the decade of 1970s, caisson foundations were mostly used for bridges. Simultaneously, precast raker piles were frequently used for pile lengths below about 20.00m or within the handling capacity of the piling rigs. Occasionally cast-in-situ raker piles with inclinations less than 1(H):5(V) were also tried. Subsequently after the decade of 1970s, as the geotechnical behavior of laterally-loaded piles were better developed, their analytical and computing skill improved, vertical cast-in-place concrete piles became popular. But their quality of construction, integrity of the buried piles, and proper use of bentonite slurry remained doubtful. Although the recent pile integrity tests and pile load tests using both kentledge method and dynamic loading method are giving better assurance of quality of the piles, till then construction quality of this type of bored piles remain doubtful.

2.2.2 *Geotechnical challenges for Bangladesh bridges*

Bangladesh being the deltaic formation created by the alluvium and the sediment deposition carried by the three mighty rivers e.g., the Ganges/Padma, Brahmaputra/Jamuna, Meghna and their tributaries and distributaries, it contains variable subsurface soil conditions for the bridge foundations. The major field testing for the subsurface investigation in the country is the Standard Penetration Tests (SPT). Disturbed and undisturbed samples are collected at about 1.5m intervals and the necessary laboratory tests specified by the designers are done on those samples. The pile bearing capacity combining the shaft resistance and the end bearing of piles are determined and pile settlement is assessed based on the above test results. But SPT equipment used in the country generally isn't standard type; size, shape and materials of its cutters are improper to allow quality sampling and give representative SPT values, which in turn is likely to generate unrealistic estimated pile bearing capacity.

Safiullah (2005) gives an account of geotechnical problems associated with bridge construction in Bangladesh. He mentions the existence of mica, thin-sand sized plates, generally biotite in the soil strata. Grain counting indicated mica contents of 5-10% whereas SPT tests at the site suggested that a relative density of these micaceous sands was between 40% and 60%. It was resolved that the typical presence of mica is to adversely affect the slope stability and bearing capacity of deep foundations. This has been found particularly affecting the slope stability and causing failure of the river training works of the Jamuna river at Sirajganj. The Padma Bridge Project is also facing similar challenges.

2.2.3 *Geomorphology, clear passageway and scour concerning river bridges*

The river system of Bangladesh generally carries excessive monsoon sediment-laden discharge and very little dry season flow. The ratio of the maximum and the minimum discharges of the Bangladesh Rivers are high; it's generally greater than 10. This year round excessive variation of flows charged with excessive sediment load beyond the river's dominant transportation capacity, generates unstable geomorphology of the river. Thus the country's prominent rivers e.g., the Jamuna, the Padma Rivers, etc. are generally braided forming shoals, chars, etc. and they shift banks frequently. Thus, determining the regime width of the river and accordingly determining the optimum clear passageway of water for the bridges and locating the bridge abutments require careful analysis and judgment by the experienced hydraulic and geotechnical specialists. Hydraulic/hydrodynamic mathematical model studies are nowadays done for the important river bridges. For important bridges these are verified through physical models by the River Research Institute (RRI), Faridpur.

The scour zone material of the river bed around bridge abutments and piers generally contains soft cohesive or loose granular soil. Special guidelines are required to estimate the local scour depth around bridge supports for all types of soil and the varied hydraulic and hydrodynamic conditions.

2.2.4 *Bridge loading*

The RHD in their Type NH, R and Z highways/roads uses the AASHTO HS20-44 truck and the associated lane loads in designing their bridges. They check the design using IRC Class A train of vehicles, based on IRC: 6-2000.

AASHTO (2007) Bridge Specifications has upgraded their design live loading to designated Type HL-93. In it the design truck remains the same as the HS20-44 truck. In addition, one design tandem consisting of a pair of 110.00 kN axles, spaced 1200 mm longitudinally and 1800 mm in transverse direction is used. The load combination follows design truck or design tandem in association with design lane load, whichever gives higher load.

For Bangladesh bridges, bridge loadings need to be standardized considering all sorts of vehicles including military vehicles.

2.3 *Construction materials, their properties, and the construction methodology*

2.3.1 *General*

The construction materials for the permanent concrete bridges are coarse and fine aggregates, cement, reinforcing and prestressing steel, admixture, bridge bearings and joints, railings, deck drainage system and its accessories, clay bricks, etc. For coarse aggregate, the stone and conglomerate quarries are located in the northern and northeastern Bangladesh. These are of variable crushing strength and thermal expansion/contraction properties. Cement and reinforcing steel are manufactured in the country. The high tensile (HT) wires, strand and bars are imported.

2.3.2 *Material properties for prestressed concrete (PC) members*

In PC bridges of Bangladesh, post-tensioned PC girders with concrete of characteristic cylinder strength at 28 days (fc′ = 30/35 MPa) is generally used. Minimizing prestressing losses is the real concern here because of the available construction material properties and the construction methodology adopted using the local technology. The creep modified shrinkage and creep losses of prestressing are generally high here, this being dependent on the mineral types of the coarse and fine aggregates. Main sources of coarse aggregate in the country are Bholaganj and Jaflong quarries in Sylhet district and the Panchagarh quarries. These are generally of quartz stone for which the coefficient of thermal expansion/contraction is $\alpha = 12x10^{-6}/^{0}C$, whereas for lime stone aggregate this figure is about $\alpha = 8x10^{-6}/^{0}C$ but lime stone is generally not available in the above quarries. The other sources e.g., Madhyapara hard rock at Dinajpur is better in this respect but is considerably expensive under today's market condition. Selected imported stone may be the other alternative and sometimes it's found cheaper.

Further, to reduce the shrinkage losses, amount of cement used and the water/cement (w/c) ratio of concrete are important. The country's cement factories now produce quality cement. Bangladesh Standard (BDS), which has adopted EN197-1 (2003) that specifies 11 types of cement, and the country's cement factories are capable of producing all these types. The dilemma of the designers is in adopting the option between the high early strength and the high performance concrete. The use of composite cement using fly ash contributes to give durable concrete but this doesn't provide the required early strength to allow prestressing within 7 days of concreting. The compatibility of the water reducing admixtures with the cement types need to be resolved. Reducing the w/c ratio using right cement type, aggregates, and admixture will reduce both shrinkage and creep losses, and may give durable structure within the reasonable construction period and cost. Adequate research-based guidance using the local construction materials and concrete technology are needed.

2.3.3 *Achievements in developing innovative construction methodology*

The Bangladesh contractors besides adopting traditional construction methodology for bridges have started using relatively superior construction methodologies. For example, in recent past, Project Builders Ltd. (PBL), a Bangladeshi Contractor successfully constructed the bridge piers using the "jack-down" method of pile cap lowering in the Dapdapia Bridge over the Kirtonkhola River at Barisal. Earlier, the "jack-down" method to lower pile caps below water was practiced in Bangladesh-UK Friendship Bridge over the Meghna River at Bhairab Bazar by the expatriate contractor. Mir Akhtar Hossain Ltd. (MAHL), another Bangladeshi Contractor recently completed construction of the Third Buriganga Bridge comprising simply-supported PC box girder spans, adopting the launching truss method. Another Bangladeshi Contractor, Monico Ltd. completed construction of the Second Sitalakhya Bridge using the in-house design and site fabrication of the travelers form for the segmental cantilever construction of the continuous span (each span of 90 meter length) of PC Box girder form of superstructure. They also used permeable coffer dam, a new concept adopted for construction of the 8.00 meter diameter concrete caissons for the same bridge, which proved to be structurally adequate, safe and at the same time cost-effective also. There are many other promising contractors in the country who can take the future challenges in the field.

2.3.4 *Construction methodology-related secondary stresses for PC I-, T-girder bridges*

In PC bridges of the country, for span length up to about 45.00m, I- and T-girders are mostly used. These are normally constructed as precast non-composite girders either at the precast yard adjacent to the bridge or at the span locations. After full or partial prestressing to sustain the dead load stresses, these are transported, lifted, shifted and placed in position over the bearings at their exact locations. The time gap generally required for of deck shear-connected to the non-composite girders is more than a month, which generates excessive differential shrinkage unless shrinkage strain in the deck girders is controlled. Adequate design code and construction guides are needed in this regard.

2.4 *Codes, standards and construction guides*

At present, no independent national design code/standard for bridges in Bangladesh exist. The current trend is to use mainly the American Association of States Highway and Transportation Officials (AASHTO) Specifications; in which the different designers use different editions varying between 1992 and 2007. The other specialist literatures are also used. In special cases, the British Standard (BS) 5400 (1978) has been followed, for example, in preparing the Jamuna Design Specification for the Jamuna Multipurpose Bridge.

Bangladesh National Building Code 1993 (BNBC'93) is generally used for the wind and earthquake loading of bridges, but the analysis is done using the above standards.

The separate national design codes/standards addressing the particular issues related to Bangladesh condition is needed.

2.5 *Structural forms*

Structural forms of bridges constructed so far in different parts of the country are either of simply-supported deck girders, slabs or balanced cantilevers in some longer spans. The Bongobondhu Jamuna Bridge over the Jamuna is also a segmental balanced cantilever construction. Some foot bridges in Dhaka and Chittagong Hill Tracts were supported with hangers from curved arches or stay cables in Cable Stayed form. RHD constructed elegant-looking elevated concrete tied arch bridges on Dhum-Ramgarh Highway during 1965. Very recently, RHD completed the construction of the first cable-supported extradose bridge over the Karnaphuly River (Nuruzzaman 2010; Astin 2010).

2.6 *Bridge administration, maintenance and monitoring*

The bridges in Bangladesh are maintained and operated by the respective bridge owners e.g. RHD, BBA, LGED, City Corporations, City Development Authorities, and Bangladesh Army as well. It is a well known speculation that most of the bridges suffer from loadings much higher than the design loads. Only a few bridges in Bangladesh do have the weighing devices to regulate the vehicle loads. This causes maintenance costs much higher than the expected due to damages from overloads. In addition, design and construction deficiencies also exist in some cases.

In addition, it is quite clear that most of the new and replaced bridges of Bangladesh were constructed soon after the liberation war of 1971. Thus, the bearings and bridge seats for these bridges are now near to the end of their respective design lives. This may give the concerned Authorities a wake-up call to foresee forthcoming challenge in regard to replacing these bearings to ensure the service life of the super-and substructures connected through those devices. The Bongobondhu Jamuna Bridge has seismic monitoring devices whereas the Third Karnaphuly Bridge has devices to monitor the cable strength. Except these two bridges, no other bridge in Bangladesh does have any device to monitor the health and performance.

3 FUTURISTIC VISION OF BRIDGE DEVELOPMENT IN BANGLADESH CONTEXT

3.1 *Bridge development should match with future socio-economic growth*

The current economic growth rate of the gross domestic product (GDP) is about 6%, in spite of many odds including the frequent natural calamities and adverse effect of climate change. It's possible to raise this to the sustainable 8% growth rate. The main source of growth is the industrial development including further growth of the export-oriented garments, pharmaceutical industries, etc. The growth of agro-fisheries and related industries by small and medium enterprises (SME) has very good potential all over the country. Already the entrepreneurs have started agricultural, poultry, dairy, herbal growth and many other types of farming at village levels also.

The country due to its advantageous location in South Asia has natural potential to connect with the east, west and central Asia. The Asian Highway will connect Bangladesh with both the east and west. The tourist industry has also good potential to develop. The Teknaf to Cox's Bazar sea beach is more than about 76 km length, its natural setting with sea on one side and green forest covered hills on the other side provides a very attractive panoramic scenario. The long Cornish road with elegant bridges may attract many tourists. The Sundarbans with Mangroove Forest is another panoramic tourist area. The tourism development will also need upgradation, widening and beautification of the highways/roads and bridges all over Bangladesh. The entire Chittagong Hill tracts can be world class tourist spots. This will require plenty of rope ways, arch bridges of different forms, cable-stayed bridges, and foot over bridges of innovative shapes and forms.

Bangladesh under this futuristic economic scenario needs the changed mind set of infrastructure development including the development of bridge engineering sector. Bangladesh being a deltaic country as described earlier, is criss-crossed with small and large rivers. The innumerable bridges constructed earlier will need up-gradation both as regards higher bridge loading, and widening to enhance road traffic carrying capacities including accommodating heavy goods containers, trailers, heavy equipment and machineries. Bridge development of the country should match with this potential future economic development. All concerned bridge development authorities, agencies, institutions, and professionals should get ready accordingly.

4 WHAT'S TO BE DONE?

4.1 *Harmonization is needed*

4.1.1 *Bridge geometry*

Bridge carriageway geometry for all kinds of roads need to be reviewed and its shapes & sizes should be standardized considering the future economic growth and growth of the tourism industry. Bridge Architecture needs to be addressed. In the planning stage, it is to be kept in mind that bridge is not merely a structural element generally designed, but it is indeed an element of the society. The Internal Rate of Return (IRR) from a bridge shall have to be determined considering the tourism industry in addition to the other economic values.

4.1.2 *Bridge loading*

The trucks, trailers, construction equipment and machineries are imported from different countries complying with the heterogeneous standards. This should be reviewed, implemented with a coherent import policy so that the designers can have rational bridge loadings to use in the bridge design.

4.1.3 *Standardizing the bridge deck girder framing plan*

Composite I- and T-girders are commonly used up to the medium span (span <45.00m) river bridges. The girder shapes and sizes may be standardized to reduce the cost of girder form works. In case of continuous long span PC box girder bridges where segmental balanced cantilever method of construction is adopted, similar design should be repeated in several other bridges also so that the travelers forms may be re-used several times to achieve economy. The decision on the requirement of the repetitive use of the girder forms, etc. should be attempted at the Planning Commission level to reduce the construction cost and time. This will reduce social cost also. However, bridges in other areas at and en-route to tourism attractions shall have architectural considerations.

4.2 *Bridge codes and standards*

4.2.1 *Bangladesh needs separate bridge design codes and standards*

At present the country has for its building infrastructure the separate Bangladesh national Building Code 1993, which is now under up-gradation now. Similarly, Bangladesh National Bridge Standard 2011 (BNBS'11) needs to be developed and brought to use immediately, incorporating guidelines of bridge deck geometry, girder framing plan, uniform bridge loading classes, analysis methods and design standards.

4.2.2 *The National Bridge standards may follow ACMC 2006 template*

Asian Concrete Model Code 2006 (ACMC 2006) is under up-gradation now. It's a 3-level document template for preparing the comprehensive code, which is applicable for the national bridge standards also.

Its first volume is the Common Level 1 document. It contains definition of terms, general principles e.g., design procedures, quality control (QC) and quality assurance (QA), performance requirements e.g., serviceability, restorability, safety etc., materials, different actions e.g., actions in normal use, wind actions, seismic actions, environmental actions, etc., analysis methods and models, verification and evaluation of performance, general principles of construction and maintenance, etc.. Its second volume contains Level 2, Part I - Design, Part II – Materials and Construction and Part III – Maintenance. These are country specific documents. Its Level 3 documents shall provide examples how to design or construct or maintain high quality RC/PC bridges.

4.2.3 *Partial load factors, load combinations, etc. of the codes/standards*

BS5400:1978, AASHTO: 2007 and other international standards have been developed depending upon the construction materials, workmanship, technology, environmental actions e.g., earthquake, wind loading, etc. Bangladesh National Bridge Standards 2011 may develop country-specific practical load factors, etc.

4.2.4 *Who should prepare the national bridge standards?*

The responsibility of preparing Bangladesh National Bridge Standards 2011 may be entrusted to an independent professional body, similar to the Indian Roads Congress (IRC). For Bangladesh bridges, the Civil Engineering Division (CED) of the Institution of Engineers Bangladesh (IEB) may be strengthened adequately and given this responsibility. They may then form a bridge code sub-committee co-opting members from the RHD, LGED, Bangladesh University of Engineering & Technology (BUET) and other technical universities, Consulting firms, construction industries and individuals. The sub-committee will then identify the right experts to draft the code. This will then be circulated to the all IEB Members for comments. The Bridge Code Sub-Committee will then organize seminars, workshops, etc. before finalizing the standards. IEB will need a mandate from the Government authorizing them to prepare such codes/standards, design, construction and maintenance guides. Its fund may be mobilized from the beneficiary industries and the Government subsidies.

4.3 *Bridge forms*

The structural forms for bridges constructed so far in Bangladesh were basically chosen to transport people and vehicles. The architectural design and the compatibility with the surroundings are seldom considered. The cost calculations perhaps dictated such decisions in the country where tourism industry had not boomed and the possibility of use of such bridges as regional transport corridor was also not in the vision. However, in the changed global scenario it's advisable to consider these two aspects to harness the best possible return from the investment and maintenance of the bridges in a deltaic country like Bangladesh with full of rivers and tributaries and the associated panoramic view. The problems of bridges hydraulics and associated sedimentation can perhaps be evaded or minimized if the span lengths could be increased by choosing extra- dozed, cable-stayed and arch forms wherever feasible considering the economy also (Okui 2002; Nuruzzaman 2010; Astin 2010; Alam and Amin, 2010; Islam and Ahsan 2010). Use of steel composite construction as emphasized on the first conference of Advances in Bridge Engineering (Amin et al. 2005) was found suitable and is adequately adopted for the Padma Bridge where road and rail traffic will run in a single system.

4.4 *Use of new generation materials*

In the past two decades enormous research and development activities (Amin 2002; Amin et al. 2002, 2003, 2006a, 2006b, 2010; Bhuiyan et al. 2009; 2010) have established improved design principles and guidelines for rubber bearings, base isolation systems and shock transmission units for bridges. The participation of Bangladesh researchers in the international domain of science and engineering was remarkable. Perhaps it is now the time to address the issue for bridges of Bangladesh and come forward with appropriate technologies not only for retrofitting the bridges for the present day loads but also for designing the new bridges of the country. The Bridge Experts from BUET (Amanat et al. 2010) and the independent consultant of Bangladesh Bridge Authority proposed univocally to repair the cracks of Bongobondhu Jamuna Bridge with fiber- reinforced polymers and mastic asphalts (Sobhan 2005). We need to harness the advantages of these advanced materials in our bridge maintenance program that we expect to be emerging issue in the coming years.

4.5 *Bridge administration and bridge health monitoring*

To harness the maximum benefit of investment and also to ensure safety, there exists an obvious necessity to monitor the major structural and foundation elements of the bridges under static and dynamic loads (Matsumoto et al 2010, Spuler et al. 2010, Amanat et al. 2010). To reduce the damage of bridge from overloaded vehicles, the health monitoring system can accommodate the weighing and surveillance mechanism to identify the overloaded vehicles.

4.6 *Participation of stakeholders for development and transfer of technology*

Bangladesh is a country where potential for development is high but research budget is somewhat low. In such circumstances, Bangladesh perhaps need expertise to learn improved technologies from abroad and translate the same for improving the knowledgebase of the country. The organization and formalization of the Bridge Engineering discipline of the country can go a long way for the technology transfer. The aims of this conference, the second one in the row (Amin et al. 2005) thus have a long standing goal to unite and energize the stakeholders working in different disciplines of bridge engineering.

5 DISCUSSION AND CONCLUSION

Bangladesh economy is growing in spite of the sustained global recession. The economy is likely to grow further. New kinds of entrepreneur class has developed, they can think creatively and can take risks. New management thinking is coming up. Agro-fisheries and related industries have come up with new ideas. Tourism industry has much potential to grow. The country needs good communication system besides other development to support the growth rate, which has penetrated deep in to the village levels.

Under this scenario, the country will need either widening of the existing bridges or constructing new bridges to enhance road capacities. To attract tourists, the beautification of the roads and bridges should be looked at. Different types of aesthetically beautiful foot over bridges, and new structural forms in bridges need also to be introduced.

Further, bridge loadings should be harmonized to accommodate all kinds of loads that may pass by the respective categories of the roads. The vehicles imported need also to be standardized looking to the bridge load carrying capacity and durability. Use of new generation materials for retrofitting the old bridges and also to resist the expected dynamic forces have to looked into.

The futuristic vision is needed to cope with the future potential socio-economic advancement.

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