Evaluation the current specifications for bridge in mountainous area of Vietnam

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Abstract : Vietnam area is more than 320,000 square kilometers and three – forth are mountainous area. The transportation in this mountainous is very hard. Due to the mountainous geography, there is a lack of bridge which allow pedestrian or low – loading vehicle passing through. Besides the technical specification that was officially issued only cover the bridge on Highway and rural road. In this paper, the results of survey of bridge condition at 3 mountainous provinces is introduced and the evaluation of current specification, the basic technical specifications for mountainous bridges are also proposed.

1. INTRODUCTION

The network of local roads in Vietnam has more than 450,000 km of a total of more than 570,000 km of the national road network (equivalent to 88%) and more than 4300 bridges serving about 80% of the population and 90% of the poor in the country.

Lack of this network and low quality roads and bridges in rural and mountainous areas is one of the causes of poverty in Vietnam. This has reduced ability to access to social services, especially welfare services (healthcare, education ...), increased transportation costs, limited production transactions. In order to achieve the goal of poverty reduction and rural modernization, our Government has focused on building and sustaining the local transportation system through programs and projects, especially is the national target program on New Rural Construction.

The Ministry of Transport has taken the initiative in creating a scheme to build local bridges to ensure traffic safety in ethnic minority areas with a study area of 50 provinces, with priority being given to building over 4,000 local bridges. The first phase of 186 suspension bridges has been implemented using the state budget from 2014 to 2015, initially contributing to changing the face of the countryside. The Ministry of Transport also established and published the design of a suspension bridge with a span of 40-120 meters; bridge width of 1.5 meter and 2 meter to apply on designing and construction of the Phase 2 including 295 suspension bridges and 3,664 concrete bridges with a total investment of 7,407 billion VND (excluding the cost of construction of the road of bridgeheads, clearance cost, etc.) is expected to be implemented over a period of 5 years, from 2018 to the end of 2023. The number of bridges built in 14 Northern Mountainous provinces which is summarized in Table 1. According to the general orientation, the project is partially sponsored by loans from the World Bank, the rest using local capital.
### Table 1. Summary of the number of bridges expected to be built in the northern mountainous region according to the Decision 622/QĐ-BGTVT on March 2nd, 2016 by The Ministry of Transport.

| No | Province     | Number of local bridges | Length (meter) |
|----|--------------|-------------------------|----------------|
| 1  | Bac Giang   | 35                      | 2163           |
| 2  | Bac Can     | 57                      | 1639           |
| 3  | Cao Bang    | 52                      | 1583           |
| 4  | Dien Bien   | 63                      | 4335           |
| 5  | Ha Giang    | 69                      | 2283           |
| 6  | Hoa Binh    | 41                      | 1892           |
| 7  | Lai Chau    | 90                      | 5405           |
| 8  | Lang Son    | 63                      | 3872           |
| 9  | Lao Cai     | 130                     | 3300           |
| 10 | Phu Tho     | 65                      | 2066           |
| 11 | Son La      | 56                      | 2765           |
| 12 | Thai Nguyen | 34                      | 1906           |
| 13 | Tuyen Quang | 47                      | 3409           |
| 14 | Yen Bai     | 49                      | 1757           |

In order to ensure the design process, it is necessary to conduct research to identify a set of technical criteria for building local bridges: design scale, design load, natural loads (wind, earthquake, colliding force, flood, etc), requirements of life cycle, durability of the bridges for people living in remote areas in the northern region is essential.

There are currently two reference specifications in defining technical criteria for the construction of rural roads: Specification TCVN 10380: 2014 Rural roads – Requirements of design bridges [1] and Specification for highway bridge design TCVN 11823-2017 [2]. These two specifications have regulations relating to local bridges, but there are still many shortcomings that need to be further studied such as follows:

- There is no regulation on the design lifespan of pedestrian bridges.
- The loads such as: wind load, earthquake, flood, colliding force, etc… of local bridge have not determined yet.
- There is no requirement on design loads for local bridges, especially the local bridges serving education needs. Whereas, if we design with the designed truck load as it is specified in the bridge design standard TCVN11823-2017, the cost of the project may be raised unnecessarily.

### 2. BRIDGE IN MOUNTAINOUS AREAS OF VIETNAM

During the last two years, bridge scenario in 3 mountainous provinces have been surveyed for the current conditions, they are Hoabinh, Tuyen Quang and Ha Giang. In these 3 provices, the Program named 135 (1998-2018) has allocated central capital for construction of infrastructures of electricity, roads, schools, stations and support the development of production of plants, animal breeds, machinery, training to improve the capacity of commune officials, maintain works after investment. By capital sources, Hoa Binh province has invested in construction of 24 infrastructure works, including traffic, suspension bridges, electricity, irrigation, domestic water and community houses. In Ha giang the Government's programs 30a and 135 was funded for investment in infrastructure includes 258 works such as roads, irrigation works; electrical works, cultural houses, schools, suspension bridges [3]. The bridges scenario of the 3 provinces and several damage types are shown in Table 2 and Figure 1, respectively.
Table 2. Bridge scenario of Hoa Binh, Tuyen Quang and Ha Giang.

| No. | Province   | Concrete bridge | Steel bridge | Total bridge |
|-----|------------|-----------------|--------------|--------------|
| 1   | Hoa Binh   | 32              | 3            | 35           |
| 2   | Tuyen Quang| 76              | 18           | 94           |
| 3   | Ha Giang   | 37              | 2            | 39           |
| Total|            | 145             | 23           | 168          |

Figure 1. Damage types in mountainous area of Vietnam.

3. SPECIFICATION FOR BRIDGE IN MOUNTAINOUS AREA

3.1 Specification for rural areas in some countries

In Ethiopia, the government has issued a separate standard for rural transport bridges designed to ensure detailed guidance for the design of bridges for rural transport in the country. Road levels in Ethiopia are as shown in table 3.

When it comes to design parameters: Ethiopia has national standards issued for the design of road works on the network of main roads and national highways. However, these standards are not suitable for the scale and level of traffic on rural roads, where there is often a low exploitation load belonging to mountainous or remoted roads. If the designs are based on these standards, they will often incur relatively high construction costs, leading to the waste of state budget. Therefore, the rural transport design standards (including the design of rural roads) was issued by the government and used from very early time. Regarding the life cycle of structure: the design life of a rural bridge structure in Ethiopia is from 10 to 40 years.
Figure 2. H20-S16 truck Load. [4]

Table 3. Levels of road in Ethiopia. [4]

| Road Functional Classification | Geometric Standard | Level of Service | AADT |
|-------------------------------|-------------------|-----------------|------|
| Collector                    | D/C8              | A               | >10,000 |
| Main Access                  | D/C7              | A               | 3,000 - 10,000 |
| Link                         | D/C6              | A               | 1,000 - 3,000 |
| Trunk                        | D/C5              | A               | 300 - 1,000 |
| Link                         | D/C4              | B               | 150 - 300 |
| Trunk                        | D/C3              | B               | 75 - 150 |
| Collector                    | D/C2              | B               | 25 - 75 |
| Main Access                  | D/C1              | B               | <25 |
| Link                         | Track             | D               | <25 |

For rural transport works in Bangladesh, people use box culvert or small bridges to overcome obstacles. Box culvert have span that is not exceeding 6meters. For bridges, it is used to span over 6meters.

Designed load for box culvert and small bridges is H20-S16 truck as shown in Figure 2:

In Bangladesh's rural traffic bridge design standard, it is recommended to use prefabricated box culvert and bridges for rural bridges as shown in table 4.

Table 4. Specifications of box culverts width in Bangladesh.[4]

| Type of design | Type of road | Standard width (meter) | Optional width (meter) |
|----------------|--------------|------------------------|------------------------|
| 8,7            | Village Road | 5.5 (18’)              | 3.7 (12’)              |
| 6,5,4          | Town Road    | 7.3 (24’)              | 5.5 (18’)              |

For bridges, Bangladesh recommends using prefabricated steel bridges (PSBs) for small span, and for roads with a width of more than 3.7m, stone arch bridges are recommended. Bridge width parameters are as in table 5.

Table 5. Width specifications of bridges in Bangladesh.[4]

| Type of design | Type of road | Length of span under 30 meter (meter) | Length of span over 30 meter (meter) |
|----------------|--------------|---------------------------------------|--------------------------------------|
| 8,7            | Village Road | 3.7 (12’)                             | 5.5 (18’)                            |
| 6,5,4          | Town Road    | 5.5 (18’)                             | 5.5 (18’)                            |

While in Myanmar road design standards, road’s levels are divided into A, B, and C level corresponding to the traffic. The width of a road or bridge specified through traffic flow prescribed as in table 6:
Table 6. Regulations on dimensions of bridge cross-sections in Myanmar.[5]

| Levels of road | Vehicle flow (ADT) | Deck width | Ballast shoulder width |
|----------------|--------------------|------------|------------------------|
| Level A        | <50                | 3.65       | 3                      |
| Level A        | 50<ADT<500         | 5.5        | 3                      |
| Level C        |                    | 3.65       | 1.2                    |
| Level D        |                    | -          | -                      |

Designs for rural transport bridges in Myanmar are also recommended to use shaped designs. On that basis, designed loads and the span are proposed as shown in Table 7:

Table 7. Specifications of rural prefabricated bridges in Myanmar. [5]

| Type of bridge | Concrete bridge (Type 1) | Beiley truss bridge (Type 2) | Steel girder bridge (Type 3) | Timber bridge (Type 4) |
|----------------|--------------------------|-----------------------------|-------------------------------|------------------------|
| Applied standard | AASHTO, HS20-44         | AASHTO, HS20-44             |                               |                        |
| Load design | 20T                      | 13T                         | 36T                           | 13T                    |
| Span length | 14ft                     | 12ft                        | 14ft                          | 14ft                   |

The designed load for rural bridges in Myanmar is HS20-44. For smaller bridges, it is up to the decision of the level of investment and the consultancy the load of the vehicles must not be less than 13 Tons.

The following Figures from 3 to 6 are some of the types of rural transport bridges that are applicable in Myanmar:

Figure 3. Load applied for rural bridge in Myanmar. [5]

Figure 4. Rural transport bridge in Myanmar (type 1). [5]
Type of a bridge: Concrete; Width: 4.26m in which the sidewalk is 0.91 cm; Load design: HS 20-44 (vehicle weight 20 tons)

![Figure 5. Rural transport bridge in Myanmar (type 2).][5]

Type of a bridge: Bailey; Width: 3.65m; Load design: vehicle weight 13 tons

![Figure 6. Unrequired navigation clearance (type 3).][5]

Type of a bridge: Bailey; Width: 4.26m; Load design: vehicle weight 13 tons

3.2 Specification for rural areas in Vietnam

Rural roads are leveled in accordance with current standards TCVN 10380: 2014, Specification for rural roads design in Vietnam. The level of road depends on the connection of district, village or commune roads.

Since 1992, Vietnam has issued standards to apply the design to rural roads. In particular, there are technical standards used to design bridges and culverts of local roads, roads used to move, circulate between provinces, and connect with the national road system for serving agriculture, forestry and fishery production [6].

According to this standard, local roads (or rural roads) are divided into 2 levels, from which there are also corresponding technical standards for bridges and culverts with road levels.

The specifications of the bridge are prescribed in 2 levels: level A and level B.

Bridges on the road should use local materials such as bricks, stones, wood, etc. to suit the local people’s supplement. In addition, it also uses various kinds of shaped steel materials, reinforced concrete.

Types of bridges include reinforced concrete bridges, steel-reinforced concrete I bridges, stone arches, brick arches, wooden bridges, suspension bridges, overflow bridges, pontoon bridges.
Dimensions and size of bridge are prescribed as follows:

- For road level A: bridge’s width 3.5m
- For road level B: bridge’s width 2.5 m
- Wheel guard height: at least 0.3m
- Navigation clearance elevation: at least 3.5m for road level A and 3m for road level B

In order to serve the new rural development program, the Ministry of Transport and communications issued Decision 315 / QD-BGTVT on February 23, 2011 “Issuing the Guidelines for Selection of Technical Scale of Rural Roads. serving the National Program on building new rural areas for the period 2010-2020”, [7] for this program, the technical scale for a number of bridge and road constructions in service of rural traffic is determined based on the road levels, as follows:

- Rural road’s levels include 4 levels: AH, A, B và C.
- Roads level AH are the road connecting the district administrative center with the administrative center of the commune, commune cluster or administrative center of the neighboring district. The road plays an important role in the socio-economic development of the district. AH roads are classified into two types: plain terrain (AH) and mountainous areas (AHMN)

3.3 Recommendations for mountainous bridge of Vietnam

Based on the current specification for bridges and refer the specification for bridge of several countries, some recommendations have been proposed as follow:

- Keep 4 bridge levels as the current design specifications TCVN10380: 2014. The designed load proposing to apply loads in designing of mountainous bridges for education in the Northern region corresponding to road levels as follow:
  - Local bridges on roads level A: Use the designed truck load (or designed tandem load) multiplied by 0.65 with lane load (specified in Clause 6.1.2 of TCVN 11823: 2017)
  - Local bridges on roads level B: use the designed truck load (or designed tandem load) multiplied by 0.5 with the lane load (specified in Clause 6.1.2 of TCVN 11823: 2017)
  - Local roads level C and D: Use the pedestrian load 3kN/m² in combination with the centre concentrated load of 5kN taking into account the problem of deck puncture.

- Bridge width:
  - For bridges with connecting roads of level A and B: The width of the bridge equals to the road width.
  - For connection roads level C: The width of the bridge is 2.0m for a hard bridge (the bridge has an initial traffic volume> 500 people/day (or a bridge length > 70m); (bridge level C) for a suspension bridge. In the case of low traffic volume<50 people the width can chose equal to 1.5m.
  - For connection roads level D:
    o The width of the bridge is 1.0m (traffic volume <50 people/day);
    o The width of the bridge is 1.5m (traffic volume 50-500 people/day);
    o The calculation and inspection of structures comply with the current bridge design specification TCVN 10380: 2017.

- For Hydrology, designed frequency base on specification TCVN 9845:2013, [8]: Calculation of flood flow characteristics.
  - L < 25m: Flood frequency is 4%
  - L > 25m: Flood frequency is 1%

- Designed life cycle is 20 years.
4. CONCLUSION

From the discussion and recommendations above, there are several conclusions as follow:

- The current conditions of bridge in the mountainous provinces were surveyed and the results have been shown off, most of them need to be inspected deeply for further maintenance.
- The lack of the specification for mountainous bridges and it needs to be researched and issued officially for meeting the need of designing bridges in remote and rural areas.
- Based on the current specifications and the survey results in the mountainous areas, the basic technical specification for mountainous bridges has been proposed.

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