Factors influencing the bridge structures in cold seasons

S.Khasnavch and B. Jambaldorj

The Department of the Traffic Road and Construction Industry of the Construction University at the University of Science and Technology.

E-mail: khas@mtu.edu.mn

Abstract

Issues of providing reliable explanation of the new bridge and road structures, defining the cause of their break and precise examination of factors decreasing their utility period are emerging in a relation to the construction of above facilities in the country of Mongolia that has a harsh climate.

Definition of main cause for the breaks in those facilities by examining their structural features and details' properties has the importance for increasing the efficiency of an investment for the fixing, renovation and extension activities of them.

Key words: Capacity, downward bent, load bearing capacity, span, crack, resistance to the coldness and distortion of the form.

Foreword

Adoption of progressive technology for the construction of the traffic road facilities has an importance in using the appropriate amount of materials, decreasing the application of workforce, saving the fuel and energy and for the further development of the transportation network on the vast territory of Mongolia.

Application of the scientific and technical new discoveries for projecting and constructing the road facilities is essential to build the traffic network facilities with preferable properties at the smaller expenses and by extension of their exploitation period.

Due to the recent years' increase of the traffic roads in urban and rural areas of our country besides of execution of the renovation of the bridges, there many new bridges were built throughout our country. Therefore, it could be considerable as the progressive advancement in the field of the construction of the bridge facility.

1. Prerequisite

According to the recent technical and technological progresses, the following necessities for the precise definition of calculation concepts for a bridge structure and parts and working out of the projects and drawings at the up-to-date level and improvement of supervision on materials' usage and performances of the works are appearing:

- Currently, the bridges built in urban area for the traffic roads with two directions pass 3-4 lines traffic of vehicles and/or bridges with the 22 tons of load bearing capacity are overloaded by exploitation of 33-44 tons of load passage of vehicles. Thus it is necessary to apply A11 classification instead of A8 and the classification with more capacity to existing A11.
- In order to provide the reliability norm for the materials' strength of bridge construction, it is strictly required to abide for the achievement of its 95% of strength and improvement of supervision on them.
- In the last century, the project preparing and construction entities have widely used such recommendations and directives worked out from the analyses. But, currently, it is more preferred to apply or adopt up-to-date technology of developed countries, though couldn't fully provide the projects with norms and technical requirements in proceeding of bridge construction. And it is almost safe to say that there were not applied or adopted new norms, standards and up-to-date technologies in the bridge construction sector of our country. Thus, in order to keep abreast of the world development and accepting the trend of globalization, it is required to learn about the development of the projects' standards for the road facilities there.
- It is proved that the research and examination activities are immediately connected with the process of providing the reliable proceedings to the carrying out of considerable big projects.
- The issues of stabilizing the care of the bridge facilities, planning of the extension, renovation and capital repair works with the research basis and paying more attention to improving the efficiency of the investments are newly encountered.

2. Factors influencing to the bridges and the state of considering them

Following factors has effect to the bridge facilities:

I. Constant load

1. Weight of the bridge construction
2. The effect of before estimated tension
3. The effect of solid pressure
4. Hydrostatic pressure
5. The effects of the concrete swell or setting down

II. Temporary dynamic load and its effects

6. Vertical load (transport vehicles and pedestrians)
7. Soil pressure effect influenced by the temporary dynamic load (prism of crashes).
8. Horizontal load of centrifugal power
9. Horizontal impact of dynamic load.
10. Horizontal power of braking or load pulling.

III. Other temporary loads and their effects

11. Wind effect
12. Ice effect
13. Wave impact
14. The effects of ambient temperature change
15. The effects of land bulging
16. Structural weight
17. Earthquake effect

All above indicated factors except of 13 are effects that happen in cold seasons.

Following three types of basic conditional requirements are put on the development of the bridge construction projects drafting and pertaining calculations:

1. Projecting by alternatives: Cross-section types and their sizes in the drawing are chosen by adjusting them to the standards, numbers and property of reinforcement bars and the areas required to the concrete formation are defined by them. Thus, the reliability condition of the cross-sections is defined firmly. Otherwise it should be $M_{max} \leq M_{lim}$.

   According to the Construction Standards on the basis of calculating all of the coefficients of dynamic and reliability, the M_{max} is assessed with given condition of stability.

   M_{lim} is calculated according to the chosen design, limits of its stability using the indications of the materials resistance. After this calculation, all of the static indices should be reliably utilized. (as resistance to appearance of cracks, bending down, capacity and all calculations of the resistance to the horizontal power effects)
2. States before the break: Due to the serious blunder of the project developer or construction contractor, such breaks could happen. Such deviations and mistakes obtained from the technological process as a choice of a wrong scheme of the construction and calculation, refusing to abide by their given sizes and amounts and making of the technological processing method etc.
3. To test the real construction on examination platform by adding of load until its break. Basing on this test, defined the deformation possibility and capacity limit of the construction.

Currently exploited or building the bridges are mostly have reinforced concrete or aided by the stainless steel beams reinforced the concrete girders in spans and reinforced concrete supporting pillars' structures.

Following breaks and damages as crack, peeling up of siding, deformations, reinforcement bars' damage and sliding of supporting points occur in the bridge construction works. Although, considering of above indicated factors in order to prevent such breaks and damages, the strength calculations are made for every certain cross-sections of the bridge structures, these accidents still occur.

3. The cause of breaks and damages

Following items could be causes of breaks and damages that occur in bridge facilities of our country traffic road network in urban and rural places:

- Bridges span detail breaks mostly occur during their building process and these occur resulting from the wrong placing of supporting details other than the defined ones by the project specifications. And due to this, unstable tensions appear throughout the structure decreasing its capacity besides of breaking and the span girder detail loses its fluctuation, free formation property and shifting ability.
- Due to the neglectfully leaving the structure sutures open instead of closing it by mortars, it can be filled up by water, earth and other sediments and accumulation of dampness in them cause the breaks, swell and peeling up concrete.
- Because of exceeding from their load bearing capacity, the structure bends down more than its permitted amount causing to shift resistance to the lower edge parts of the girder and the lower side concrete siding is pilled up or the thwarting cracks appear.
- Due to the inappropriate putting of drainage system as pointed out in the Construction Standards 84^{th} item of 2.05.03 water penetrates to the structure arrangements causing to appear cracks in concrete bridges.
- Because of a wrong use of the concrete mixture ingredients and not defining of applied filling materials and endurance to the coldness mark of the concrete considerable degradation of the bridge resistance to above factors are noticed. So for the determination of the acceptable to our country harsh climate conditions concrete mark resistant to $+35^{o}C$ - $-65^{o}C$ it is required to define pertaining to it freezing-thawing cycles and use highly resistant aired concrete.
- Due to the inappropriate putting of drainage system on the abutment part of the bridge with the road and pure compression of earth occurs setting down.
- Due to the mistakes in the solution of the end edge abutment hind wall of bridges with the road dams last supporting pillars shift aside.
- Wrong determination of the bridge free interval, flooding of bridge span details and appearance of shallow water spots at meeting point of bridge with road occur due to the erosion and water drainage with mistakes (Photo 2). And in some places due to the lack of competently made research works pertaining to the bridge constructed site natural peculiarities, hydrological and geological formation of the terrain appear mounts of the earth or ice accumulations in cold seasons.

  By taking into account the following factors, we can see how devastatingly harmful could be the effects of the appeared cracks unpredicted by the due calculation of the bridge structure.
- Causes for appearing of cracks;
- The effects of appeared cracks on the capacity indices of entire structure (as tension of reinforcement, exploitation capacity of the facility, change of operation at the cross-sections and etc.).
- Breaks and erosions of reinforcement details at the crack area.

Photo 1. The cracked state of the bridge spans detail-supporting edge

Now lets see the damages and breaks appeared from cracks in the bridge structure:

1. Due to the cracks in the girder detail extended area of bridge, the concrete looses its ability to bear the loads.

2. Appearance of cracks during the construction process at the tension bearing sutures of the bridge structure (because reinforcement details and concrete not appropriately firm stuck) affects the capacity of it and becomes dangerous.
3. In reinforcement iron works of the structural details appearance of 0.5 mm of clearance between the iron work bar with cross unevenness and 0.7 mm of clearance between the even surfaced reinforcement bar and concrete affect them to be mutually loose or water flowing state along the reinforcement bars becomes possible.
4. In high tension bearing constructions due to the sufficiently stiff arrangement of reinforcement bars in form works appear cracks thwarting across the detail.
5. The cracks arisen along with the reinforcement bars are related to the rusting of the reinforcement bars. Resulting from the rusting of the reinforcement bars, load bearing capacity of the girders and pillars decrease.
6. The crack and breaks in the reinforced concrete structures make the reinforcement bars unprotected from the rusting and degradations make the appearance of the structure pure.
7. Due to the pure performance of the water insulation in the bridge constructions occur water penetration and rusting spots that could be noticed on the reinforced concrete details' surface.

II. Supports

8. The general shape of the bridge supports deformed in a relation to the soil bulging and sliding downs and the utility property of the facility is decreased. For instance, shift of the supporting sections/points, crack of girder edge on lower side of bridge, worsening the road plan and profile and etc. (Photo 1)
9. The vertical cracks appear in the concrete support with the complicated structures due to the setting down of the influence of the temperature and the danger for the pillar to loose the completeness is faced when the size of its crack reaches 1-1.5 mm.
10. Due to the degradation of the surface and the edge of the concrete support with the complicated structures in the size more than 1 mm per year by the ice and stream of the water, the load bearing capacity of the pillar will decrease and the usage period will be shortened.

4. Conclusion

It is correct to make inspections not less than two times per year, clean the garbage and dusts, make diagnostics for the newly built bridges and check whether the real indications are meeting the project data and to improve controlling system on the materials in order to prolong the usage period of the bridge facility and to provide with comfortable and convenient travels of passengers. Although the documenting the bridge objects furthermore is the work requiring a lot of capital, it can be a precious materials for the researches on the other hand.

It will be possible to determine the cause of the break and damages with the theoretical basis basing on the research materials and make the maintenance and repair work more efficiently and appropriately.

Photo 2. State of appeared shallow water spot