

Structural Engineering Reconnaissance for the Damaged Bridges Subsequent to 2017 Flood in Central and Eastern Nepal

PRELIMINARY REPORT (V1)

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1. Background

Nepal is designated to be the 30th most vulnerable country in terms of flood hazards ([UNDP/BCPR, 2004](#)), meanwhile the changing climate and annual torrential precipitation have been leading to extreme flood cases as in 1993, 2008 and 2017. Of late, between August 11-14, 2017, eastern and central Nepal observed torrential precipitation and the subsequent flooding affected 31 out of 75 districts: mainly in the southern plains of Nepal ([MoHA, 2017](#)). The continuous degradation in the Siwalik forest area is leading to the greater surface runoff instead of infiltration thus the enhanced quantity of surface runoff is the major cause of flooding in the southern Indo-Gangetic plains of Nepal. Nepal gets annually around 1700 mm precipitation and most of the part of this occur in between June to September. During this monsoon season, most of the areas in the southern Indo-Gangetic plains are inundated for several days to weeks due to low topographical relief as well as high discharge. The fragile and unconsolidated deposits in the Siwalik are transported by the water current as Siwalik is in relatively higher relief than the Indo-Gangetic plain. The debris transported by the water current ultimately travel down to the Indo-Gangetic plains and sometimes affect the structures leading to various types of damages. In general, bridges, human settlements (buildings),

lifelines (electricity poles, irrigation canals and so on) are affected due to either storm surge or water current (hydrodynamic forces with debris).

In Nepal, considerable attention has been paid for the seismic safety of structures, especially the highway bridges, however effect of the multi-hazards is not well accounted in contemporary design approaches. Although multi-hazard is crucial aspect to include in designs, as Nepal is designated to be the 20th most vulnerable country by UNDP/BCPR (2004) in terms of multi-hazards, future events may have serious impacts in highway bridges. To this end, it is important to have the insights of inundation depth and associated damage to the highway bridges. Moreover, highway bridges are the backbones of national economy and transportation thus malfunction of such bridges may lead to enormous losses in economy as well. This field reconnaissance mission aims to identify the damages occurred due to the 2017 flood in central and eastern Nepal. Apart from this, it is aimed to perform the vulnerability analysis of the assessed bridges under multiple independent events (earthquakes and floods). The preliminary version of this report will present the preliminary findings and field observations and the detailed volume to be produced in near future would have the details of each bridges including multi-hazards vulnerability analysis based on the data collected in-situ.

2. Summary of the Field Investigation

A field reconnaissance was conducted between 2-5 September 2017 in the affected areas. The East-West Highway was covered from Amlekhgunj, Bara to Inaruwa, Sunsari as shown in Fig. 1.



Fig. 1 The section of East-West Highway covered during field reconnaissance

During the field reconnaissance, following eight districts were covered:

- Bara
- Rautahat
- Sarlahi
- Mahottari
- Dhanusha
- Siraha
- Saptari
- Sunsari

A brief overview of the field reconnaissance in each district is presented in the following section:

Bara: Altogether 14 bridges were assessed for flood damage. Majority of the bridges were found to be sustaining minor damage whereas two bridges were heavily damaged due to settlement and scouring.

Rautahat: Six bridges in Rautahat district along the East-West Highway were assessed during the field reconnaissance. All the bridges were found to be sustaining minor to moderate damage level.

Sarlahi: Four bridges affected by the flood along the East-West Highway were assessed in Sarlahi district. All the assessed bridges were found to be under minor to moderate damage extent.

Mahottari: Five bridges along the East-West Highway were assessed in Mahottari district. One of the assessed bridge was heavily damaged and the traffic was obstructed and diverted from the bridge. During the field reconnaissance, the traffic was found to be passing through the river directly.

Dhanusha: Three bridges were assessed in Dhanusha district. All the assessed bridges were under minor to moderate damage state due to flood.

Siraha: Six affected bridges were assessed along the East-West Highway in Siraha district. The damage due to flooding in the assessed bridges was

limited to minor to moderate damage state. In addition, some non-destructive tests to a bridge were also performed in Siraha district.

Saptari: Eight significant bridges from Saptari were assessed during the field reconnaissance in Saptari district. The damage was limited to minor to moderate state in the district.

Sunsari: Six bridges in Sunsari district were assessed during the field reconnaissance. The damage to the bridges was limited to minor to moderate state in Sunsari district too.

The insights of bridge damage due to flooding is presented in more details in the following section of this report.

3. Preliminary findings

During the field reconnaissance, altogether 52 bridges were assessed. Two of the bridges along the East-West Highway were severely damaged due to settlement and scouring. Dudhaura bridge in Bara district (Fig. 2) and Ratu bridge in Mahottari (Fig. 3) were severely damaged due to settlement of piers as a consequence of flooding. The traffic was diverted through the rivers in these two cases.



Fig. 2 Dudhaura bridge damaged due to settlement and scouring in Bara district



Fig. 3 Ratu bridge damaged due to settlement and scouring in Mahottari district

Apart from severe damage cases, almost all bridges sustained localized damages in terms of spalling of concrete, rebar exposure, scouring of piers, scouring of aprons for abutments, sedimentation and other damage modes as shown in Figs. 4, 5 and 6.



Fig. 4 a) Spalling of plaster due to 2017 flood, b) exposed re-rebar due to flooding



Fig. 5 a) Approach slab damage due to the flood, b) scouring of pier bed

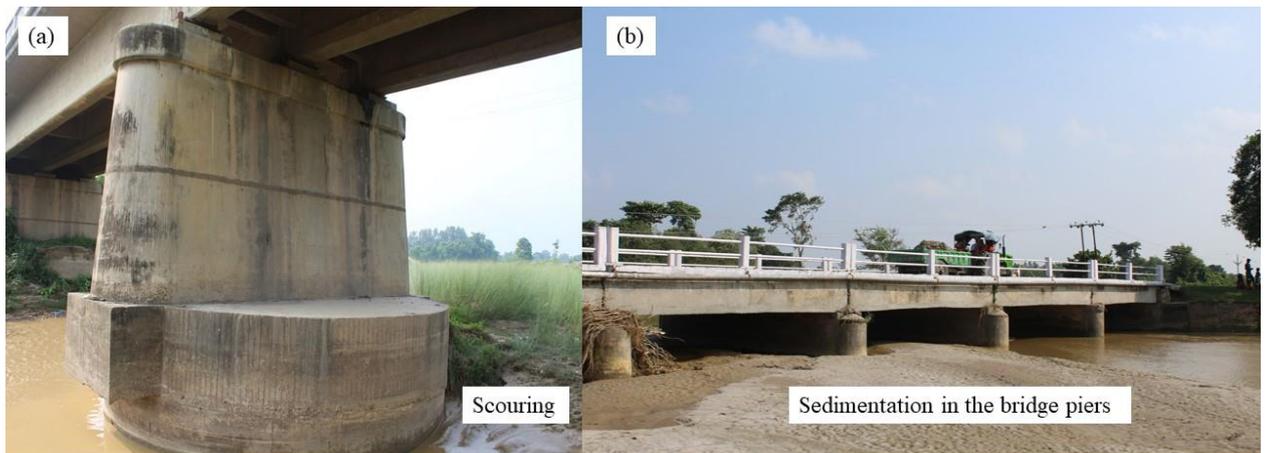


Fig. 6 a) Scouring of bed, b) Sedimentation of the piers and raised river bed along with deposited debris

4. Summary

The sum of observations depicts that the severe damage in the case of bridges is the consequence of hydrodynamic forces and higher depth of inundation. Above 90% of the total assessed bridges were damaged in minor to moderate extent. The common damage was observed in terms of scouring, re-bar exposure, spalling and so on, whereas in the case of severe damage, the damage was attributed to the settlement and scouring largely. The details of the observations in each bridges along with discussions of multi-hazards vulnerability will be disseminated in the detailed volume of this report.

References

- United Nations Development Program/Bureau of Crisis Prevention and Recovery (UNDP/BCPR): Reducing disaster risk, A challenge for development, New York, 2004.
- Ministry of Home Affairs Nepal, 2017. Available at: <http://drrportal.gov.np/> (accessed 07 September 2017).

Appendix

Itinerary

02 Sep.: Departure from Kathmandu; assessment in Bara district

03 Sep.: Assessment in Bara, Rautahat, Sarlahi and Mahottari districts

04 Sep.: Assessment in Sunsari and Saptari districts

05 Sep.: Assessment in Saptari, Siraha and Dhanusha districts; return to Kathmandu