QUICK-LAUNCH BRIDGES : FOR SAFER, SMOOTHER TRAFFIC ON HILL ROADS

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ABSTRACT

Bottle-necks on hill roads due to bridges of inadequate width or load-classification as also unsafe bridges are many and increasing by the day. These are due to a variety of reasons. A random survey of this on hill roads shows the gravity of the problem. It leads to sub-optimal utilization of the National Highways (NHs) and related problems of increased transportation costs. It also affects road safety. The reason for the numbers increasing and the issues not being addressed urgently enough is because of using conventional bridge construction techniques that are slow in the mountains, coupled with using obsolete bridges in emergencies. Modern Quick-launch bridges are an answer to address the more critical bottle-necks; a concept that is less understood and has therefore lagged behind in India and most of the developing World. These will improve both safety on hill roads and result in optimal utilization of the NH Network, paying for the investment almost immediately.

INTRODUCTION

Bridges on hill roads in India have lagged behind the road construction for more than one reason. It is not uncommon to see bridges below specifications even on National Highways (NHs). This is not peculiar to any one state or region. It is typical of every state along our Northern Borders. The urgency for up gradation of these has been low and with each year, the number of such bridges below specifications has in fact increased in some regions. What we are left with are NHs that are utilized well below their intended capacity, directly affecting both development and commercial activity in these areas. These routes connect not only to townships but also are to troops deployed on sensitive border posts. This has operational implications. Yet we see that the problem has not been addressed.

A sampling of data of NHs shows that the problem of sub-optimal utilization of NHs along the Northern Border States of India is a reality. The reasons need to be understood to curb this trend. The effects on the road traffic both in regard to loss of revenue and safety underline the urgency to correct this. With this as the back-drop, the paper gives an overview of New Generation Quick Launch Bridges and their potential to correct the existing problem. The paper has accordingly been laid out under the following heads:-

a. State of Bridges on NHs along Northern Borders in India.
b. Reasons for and Effect of Sub-Optimal Bridges.
c. New Generation Quick Launch Bridges for Hill Roads.

STATE OF BRIDGES ON NHs ALONG NORTHERN BORDER STATES IN INDIA

The urgency of roads in the Northern Border States was realized in the 1960s. While efforts were made to develop them speedily, they were always constrained by resources. The first set of roads connecting even to State Capitals came up as single lane roads. These roads had a number of Bailey Bridges, equipment bridges that can be launched quickly but allow only single lane traffic, often restricted to loads between 18-24 Tons. This was because of the typical problem of constructing roads in the mountains. To deploy equipment along an alignment, bridges had to come up even as the formation was being cut and in quick time. The Bailey Bridges served this purpose. But once the road was made these remained till the permanent bridges were made. That took time.

The urgency of construction of roads by the Border Roads actually took a dip in the 90s till the country was shaken out of its lethargy by the Kargil War in 1999. What followed were ambitious plans to upgrade roads in the Border States. Single lane roads were widened to double lane. Existing Bridges were used to deploy road construction equipment for widening to double lane, but upgrading the bridges lagged behind. What you had in many cases were two lane roads with only part of the bridges upgraded. Many Bailey Bridges continued to remain on the two lane roads, waiting their turn to be replaced by a permanent two lane bridge. These single lane bridges while they remained became permanent bottle necks.

Data was collected by a team from ICT (International Consultants and Technocrats), to confirm this. Four double- lane NHs in the State of Uttarakhand, roads that form a part of the famous Char Dham Yatra routes, a network of 700 Km were surveyed (see Plate 1). They carry heavy traffic from May to Oct each year, when Yamnotri, Gangotri, Kedernath and Badrinath are open to the public. These are popular destinations for religious tourism. It was found that on these routes there were 32 bridges that were single lane or restricted to loads below 18 Tons (Table 1). Two lane NHs need double lane bridges, designed for 70 R loading; two lanes Class A (trucks) or a single load of 100 Tons whichever is higher.

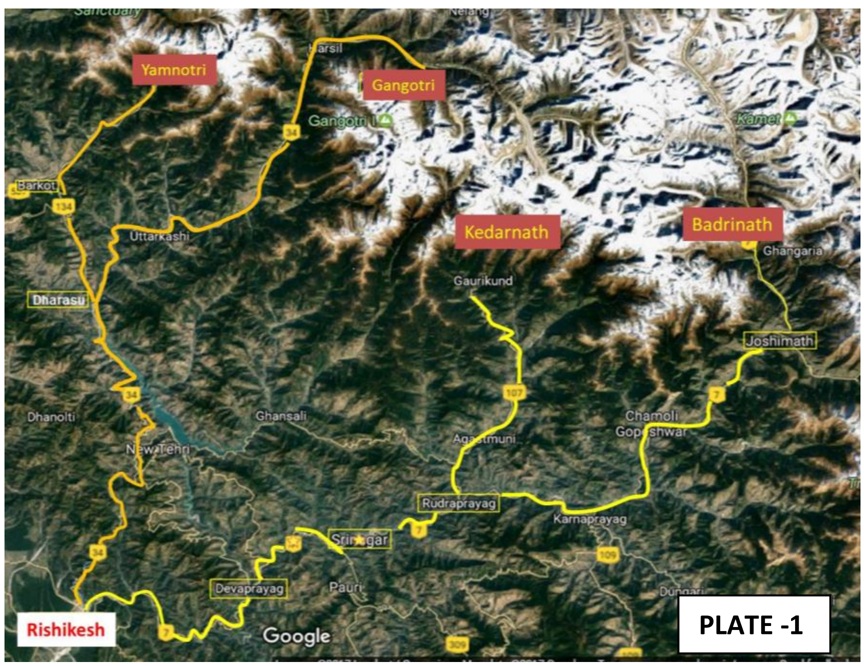


TABLE 1: Bridges on Char Dham Route

Ser No	National Highway (NH)	NO OF MAJOR BRIDGES, & LOAD CLASS											Total
		Class 70R		Class B		Class 40 R		Class 24 R		18 T and Below		Total SL	
		D L	SL	DL	SL	DL	SL	DL	SL	DL	SL		
1	NH 134: Dharasu - Yamnotri	01	-	-	-	-	-	-	-	-	13	**13**	14
2	NH 34: Dharasu - Gangotri	18	-	-	02	-	-	-	01	-	02	**05**	23
3	NH 107: Rudraprayag - Gaurikund	12	-	-	-	-	-	-	-	-	08	**08**	20
4	NH 7: Rishikesh - Badrinath	38	-	-	-	-	01	-	02	-	03	**06**	44
	Total	69	-	-	02	-	01	-	03	-	26	**32**	101

DL: Double Lane; SL: Single Lane *Data collected by Team from ICT*

Three of the single lane bridges in the list were added when permanent bridges were washed away in floods, one each year, from 2010 to 2012. A look at the picture will show how restrictive these Bailey Bridges are (Plate 2). When permanent bridges were washed away, the only available bridge for quick connectivity was the Bailey Bridge; excellent equipment that has seen armies through World War II, but unsuited for NHs today, being single lane and of a very low load classification. Clearly the number of bridges that were below par has grown in this region over the last three years.

PLATE -2

The Savari Gad Bridge launched when the permanent bridge was washed away in 2012 continues as a bottle neck- single lane; allowing one vehicle at a time and limited to 18 Tons. Similarly Bailey Bridges remain at Gangori Gad since 2011 and at Lam Bagad since 2010, after the original bridges were washed away. Such bottle-necks have in fact increased with time.

A similar exercise on the 130 Km Dhar-Udhampur Road in J & K showed critical bottle-necks restricting the use of the road on a daily basis. Of the 47 bridges on this road 35 Bridges are single lane; only three are for 70 R loading. This restricts the movement of vehicles on an important artery for logistics and deployment of troops in the Northern Borders. The story in other Border States such as Sikkim or those in the North East are similar.

To sum up, it is a reality that roads in these states have numerous permanent bottle-necks because of under par bridges. The load a road can take is dictated by the weakest bridge, resulting in underutilization of these roads. This increases transportation costs and so much else, discussed in the next part.

REASONS FOR AND EFFECT OF SUB-OPTIMAL BRIDGES

Effect of Sub-optimal Bridges on NHs

The effect of having sub-optimal bridges is easy to perceive and is discussed first. Broadly these effect commercial activity and revenue to the State; impact environment negatively and have safety implications.

Effect on Commercial Activity. Underutilization of the NHs due to sub-par bridges directly affects the cost of transportation. Loads on the highway are restricted to 18 to 24 Tons as against a max of 100 Tons as per specifications. This implies having to ply smaller vehicles for transportation of goods and people; less efficient loading; more vehicles and more transportation costs. More important heavy machinery cannot be transported to work sites without breaking loads even for moving it to short distances. Where a load cannot be broken down to be carried in smaller vehicle, detours have to be made at the weak bridges. This is possible only when the streams permit during 3-4 months in a year when water flow is less. In some places even this is not possible due to the depth of the gap. One such bridge on the roadway is enough to deny the movement of heavier equipment on the entire route. This directly impinges on development activity in the area. Together, sub-par bridges effect revenue and development in these border-states.

Environmental Impact. Frequent bottlenecks because of single lane bridges on a two lane highway causes vehicles to wait at each bridge to allow traffic to pass, first one way and then the other. The average travel time goes up by 20 to 30% due to this. The resultant fuel consumption goes up proportionately. The inefficient utilization due to lesser loads also adds to more vehicles plying for carrying loads and people, and thereby to more fuel consumption. Altogether the carbon foot print due to higher fuel expenditure leaves a greater negative impact on the environment. To upgrade the bridge an alternate site is normally required which means a detour, more cutting into the hills, more construction, which should be avoided.

Safety Implications. Frequent bunching of vehicles at each bottle-neck due to these bridges leads to speeding after crossing the bottle-neck, to catch up with traffic ahead. This concertina effect is particularly undesirable on hill roads and is a safety hazard. Most Bailey Bridges are not just one way but allow only one vehicle at a time. This can easily be violated if drivers get impatient. Fatal bridge collapses have occurred due to drivers ignoring such restrictions when in a hurry. On bridges closer to towns, the traffic is more and perforce traffic points-men are required to be positioned on both sides of the bridge to control movement and avoid accident. This was noticed at 5 bridges during the survey by ICT. It implies 10 people deployed over say three shifts, a total of 30 for 5 bridges. On some days the numbers could be more with additional bridges having to be manned. A heavy investment in manpower daily to ensure safety and smooth traffic can be avoided if these critical bridges are made two-lane.

Reasons for Large Numbers of Sub-optimal Bridges on NHs

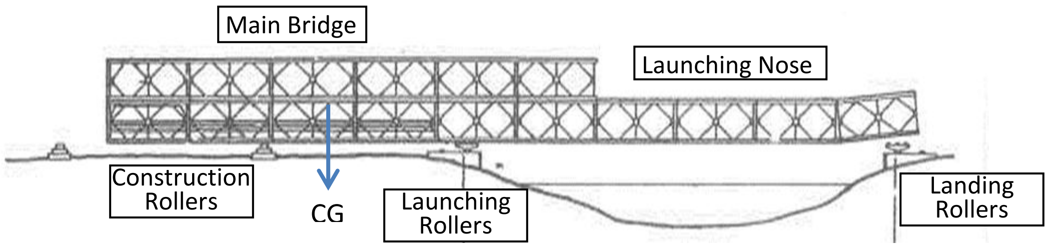
The reason for such a large number of single lane bridges flow from the earlier discussion and can be briefly summed up as :-

a. ***Bridges Not Upgraded After Widening the Road.*** The majority of the roads have been widened from single lane to double lane and the bridges have not kept pace with the widening of the road.

b. ***Availability of Alternate Site for Existing Weak Bridges*.** The Greater and Lesser Himalayas being young fold mountains are relatively more unstable. They also take the brunt of the monsoons making them more slide prone and susceptible to accident. Bridges initially launched are on the most preferred site. If these bridges are temporary or below specifications, an alternate site for a new bridge requires extensive detours, not easy in the mountains. With traffic movement through the year, to upgrade the bridge at the same site is a daunting proposition. With conventional solutions it can take 2 to 3 years.

c. ***Replacement of Bridges Affected by Natural Disasters*.** Natural disasters are an annual occurrence along the borders due to monsoons or earthquakes. The most critical is connectivity in such situations. Connectivity by air is more a morale booster. Substantial aid and restoration of commercial traffic only happens by opening roads. Therefore when bridges are damaged, their repair or replacement becomes most critical to establish connectivity. Emergency quick launch bridges are required to restore normalcy. Unfortunately, in India we are still stuck with the Bailey Bridge as the only option. As mentioned earlier these are only single lane and allow restricted loading. Once launched, replacing is difficult because of site constraints, and one is stuck with a half solution. Typical examples are the three Bridges discussed in Para 6 and shown in Plate-2.

d. ***Problems of Launching Bridges in the Mountains*.** As compared to the plains, hill roads allow restricted access to plant and machinery for construction. Most important is the need for back-space at the site for launch and the problems of deep gaps not permitting intermediate supports or use of scaffolding for construction. Concrete bridges across such gaps get ruled out because of lack of intermediate support and heavy girders. Steel truss bridges are therefore preferred. Figure-1 below, shows a classic launch of a steel truss bridge negotiate the gap with a launching nose before the main bridge is positioned. A certain back space is required to keep the CG away from the gap. This would be approximately 65% of the gap, unless counterweight is enhanced as a part of the launching scheme. This may make the launching loads more critical than the maximum live loads and needs to be checked for safety. In emergencies pre-engineered modular bridges are used. This has been limited to Bailey Bridges in India, with their inherent limitations. The more versatile New Generation alternatives are not available in the country.



Bridge launched on rollers ensuring CG is behind the launching rollers. Where the 'back space' is limited, additional Counter Weight is added.

FIGURE 1

e. ***No Planning for Double Lane Bridges for Disaster Management.*** As has been mentioned, the only bridge available in the country for emergencies is the Bailey Bridge. Double lane bridges for emergencies are not on the inventory of any agency dealing with such situations. They would help respond to disasters with a more optimal bridge in almost the same time frame and avoid having single lane bridges as bottle-necks.

To sum up the discussion on the Reasons and the Effects; having so many bridges that are below the designed loads or of a single lane, lead to underutilization of the NHs. This directly affects development and revenue to the State. Along with this they have adverse impact on the environment and on safety. The reasons boil down to primarily not addressing it urgently enough and not using better equipment for launching bridges during emergencies on hill roads. The New Generation Emergency Bridges that have replaced use of Bailey Bridges in most of the developed countries can be used to great advantage here.

NEW GENERATION EMERGENCY BRIDGES

As discussed earlier the Bailey bridge has been the standard response for emergencies on NHs and this must be upgraded to New Generation Emergency Bridges in the country. Before we look at the New Generation Emergency Bridges and their advantages we need first, to understand the basic characteristics of the Bailey Bridge as the New Generation Emergency Bridges are similar in concept but upgraded for the heavier traffic experienced today.

The Bailey Bridge- A Brief Overview

The Bailey Bridge designed by Sir Donald Bailey is a concept that has truly stood the test of time since its inception in WW II. Acclaimed as a Bridge without which the War could not have been won, it is a modular bridge consisting of Panels that can be used to build trusses depending on the load and span of the bridge (see Plate 3). These panels that are 10 ft (3.05m) long and 5 ft (1.5m) high, have a male and female end to connect to the next panel with pins. Bays of 3.05m can thus be added to get the required span. The two trusses are connected by Transoms and bracing over which the stringers and deck are secured. The construction requires no welding or riveting.

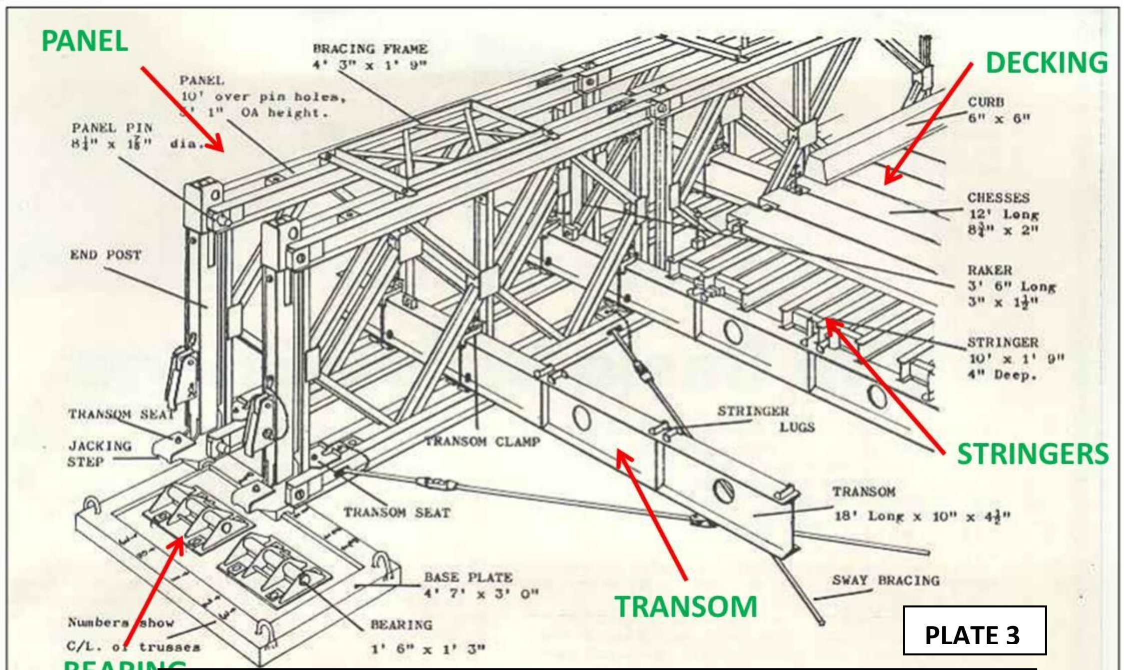


Diagram of Double Panel Truss- Single Storey (DS), Bailey Bridge (BB)

The bridges can have trusses with different number of panels. Panels can be added as a second storey or as three storeys. Plate 4 shows various combinations; a Single Panel as a Single Storey labled as Single- Single (SS); next is Double- Single (DS). The third is DD ie double panel trusses and double storey; the fourth is Triple-Triple (TT). Trusses can thus be made heavier and deeper to take more laods or span larger gaps.

What makes the Bailey Bridge system so versatile is the simplicity of design and the ability to launch it from one bank to the other without any supports, using a launching nose (Figure 1, Page 6) all using the same standard panels. The parts are light and can be handled manually without any crane or support equipment. The bridge is standardised for two road way widths, the standard being 3.25m wide and the Extra Wide being 4.2m. Both allow only single lane traffic. The life of these bridges is assessed at 20 years making them temporary structures. Experience has been that they have remained for far longer, close to twice their life for want of a permanent two lane bridge on most hill roads.

New Generation Quick Launch Bridges (Evolved from the Bailey Bridge)

The New Generation Quick Launch Bridges have replaced the Bailey Bridges in developed countries . The robustness and the clever design of the Bailey Bridge have been retained in the NewBridge System and from a distance the New Bridge can easily be mistaken for the Bailey

Bridge.. However the designs are more suitable for heavier two lane and higher traffic. This has been possible by some simple changes in design. The panels are now 2.29m deep as against 1.5m for the Bailey Bridge, while keeping the length of each panel and thus each bay the same 3.05m (10 ft). The size of the panel sections and other members have been enhanced to take 70 R loading. By having heavier transoms it is now possible to launch two lane and even three lane bridges. USA based ACROW that manufactures such bridges, has further enhanced their bridge's standard capability by having up to four panels in each truss, allowing configrations like Quadruple-Double, the second storey fastened with improved chord bolts. This allows spans up to and beyond 60m with 7.35m roadway for 70 R two lane traffic. As suspension bridges they can take 70 R double lane loading for even longer spans. Use of 450 Grade steel has made these bridges stronger yet lighter.

PLATE 5

A Quadruple Panel Two Storey Truss Bridge being launched, with the launching nose leading.

PLATE 6

Problem of back space overcome with an intermediate pier and suitable counter weight.

The Sonprayag New Generation Quick Launch Bridge (Plate 7). The first of these New Genreation Bridges to be launched in India was at Sonprayag, to replace a bridge washed away during the disastrous floods in Jun 2013 in the Kedarnath Valley in Uttrakhand. It is a 60 m, Quadruple- Double with Reinforcement Chords designed for two lane, 70 R loading. 5.5m road width was preferred as the existing road was an Intermediate Lane of 5.5m, and considering the limited traffic on the road and site conditions. The bridge was ordered when the temporary Bailey Bridge was washed away in Jun 2015, demanding urgent replacment. The ACROW bridge was moved from New Jersey in two months to the site. It was launched in a months time under very restricted conditions, demonstrating how quickly such bridges can be deployed; their ease in construction with a local crew and the robust design. This enabled the bridge to be utilsed by tourists to Kedarnath in the following season. The cost of the bridge was recovered in one tourist season itself by restoring traffic in time.

PLATE 7

ACROW Bridge at Sonprayag in position, 60m Span, for double lane, 70 R loading, launched in one month with restricted back-space; the first of its kind in India.

Typically the major specifications of the New Genration bridges like the ACROW as compared to the Bailey Bridge are greatly enhanced as can be seen in Table 2

TABLE 2 Comparision of Bailey Bridge and New Genration Quick Launch Bridges

Specification	Bailey Bridge	New Gen Quick Launch Bridges
Roadway	3.25m and 4.2m Only Single lane	3.7m,4.2m,5.5m, 7.35m, 9.1m, 11m & 12.8m (Up to 4 or 5 lanes).
Span	54 m with Load Class 24	60 m +; 70 R, Double Lane
Life	20 years	Over 70 years with Dip galvanised surface finish.
Construction	Normaly manual	Normally Plant Assisted
Time for launch	One to two weeks	One to four weeks

PLATE -8

A Rail Bridge with the same equipment.

PLATE -9

Movable Bridge; to allow passage of ships.

The new genration bridges are more versatile and better suited to current traffic requirments. They have been developed for a large range of uses as can be seen from some of their special uses, as follows:-

a. ***Multiple Uses***. They can be used for road bridges, rail bridges and even moveable bridges to allow ships to pass. The bridges have been used extensively in natural calamaties all over the world.

b. ***Mechanical Handling***. Launching can be speeded up by use of cranes.

PLATE -10

c. ***Launching With Limited Back Space.*** This characteristic of the Bailey Bridge is faithfuly retained, allowing multiple options to launch in the mountains.

d. ***Using Existing Bailey Bridge as Launching Nose***. ACROW Bridges have even developed a connector between their double lane bridge and a Bailey Bridge, allowing the Bailey Bridge in situ to be jacked up, used as a nose and pushed out even as the new double lane bridge eases into place. This is invaluable when Bailey Bridges have to be upgraded in restricted sites with minimum break in traffic.

Using New Generation Quick Launch Bridges on Hill Roads. How would these Bridges help address the issue of large number of single lane bridges with inadequate load class presently existing on hill roads? The following major advantages come to the fore:-

a. ***Quick Upgradation of Existing Sub-par Bridges.*** This can be done expeditiously in one season, launching two lane bridges in the existing site after working on the abutments while traffic passes. The disruption to traffic can be kept to the minimum, as less as a few weeks, using these bridges,. If done in the lean season when detours are possible, it will be with almost no disruption. Where existing Bailey Bridges have to be replaced, the change could be even faster using the special connector with the existing single lane bridge and employing it as a launching nose for the new two lane bridge..

b. ***Reserve Bridges for Disasters.*** Keeping these bridges stocked as reserves for any unforeseen damage to existing bridges will pay dividends. It will ensure that the replacement is not only quick but permanent, since these bridges have a life of 70 years and meet the NH requirement of double lane and 70R loading. This would prevent the present situation where, with every disaster you have the number of sub-par bridges increasing.

c. ***Use During Initial Road Construction/upgradation.*** This would prevent bridges from lagging behind road construction as at present. Where heavy equipment has to be deployed ahead, a double lane bridge can initally be launched. This is preferable to a Bailey Bridge being launched first and then replaced later. These would be quickly in place and yet be permanent.

d. ***Saving in Cost.*** While the cost of these bridges may be upto 1.75 times the Bailey Bridge, they give a four fold advantage of carrying two lane traffic, with more than twice the maximum load. They allow longer spans, a much longer life and with almost zero maintenance. Apart from this, it allows full utilization of the capacity of the double lane NH which will reduce transportation costs and enhance commercial activity. This would easily pay for the entire cost of the bridge in less than a year. Launching a conventional bridge in three years would never thereafter be considered a preferred option.

CONCLUSION

The problem of under utilization of NHs along the Indian Borders is real. The sampling of data confirms this and shows to what extent it affects movement. It is affecting comercial activity and revenue to the state, has a negative impact on both the environment and safety and needs to be addressed urgently. It has been ignored because of a perceived helplessness in speeding up bridging in these areas and the problem appears to have been accepted as a fait-accompli. The fact that the number of such bridges keeps increasing with each disaster, so frequent in these mountains, only adds to the problem.

The New Generation Quick Launch Bridges are more versatile and designed for the present day traffic requirements. These need to urgently replace use of Bailey Bridges. It will facilitate replacing the existing sub-optimal bridges in quick time and afford a more optimal solution during disasters, by launching a permanent bridge that does not require to be replaced unlike the Bailey Bridge. The discussion on the relative merits clearly points to their use.

The first such bridge launched at Sonprayag has demonstrated the speed with which it can be deployed and how it can be adapted to local conditions, launching them using local manpower. More of these need to be stocked by those responsible for roads and those required to respond to natural disasters. The costs will be recouped in a season considering the commercial activity generated and the multiple benefits to the State - of additional revenue by better utilization of the road; more safety on roads and a smaller carbon foot print. Better operational preparedness by efficient connectivity to border posts will also be achieved, enhancing National Security.

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