Emergency response to Baige Landslide Dam on the Jinsha River in China

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1. Dam formed by landslide on Jinsha River

2. Emergency Decision-making Support

3. Considerations related to river basin safety
On Oct. 10 and Nov. 3, 2018, twice, landslides blocked the Jinsha River, which is the upper reaches of the Yangtze River.

The big river was blocked by the landslide at Baige village, it caused widely societal concerns.
The 1st time: Baige Landslide Dam

The 1st landslide occurred on Oct.10 at 22:00. It is caused by the left bank landslides without rain and without earthquake.

The barrier roughly 1000m long and 200m wide and 60 to 120m high with volume of 25 million m³.
The 1st time: Baige Landslide Dam
The 1st time: Baige Landslide Dam

According to the assessment of the barrier and the inflow, the Barrier will be break naturally soon when overtopping.

The overflow began at 17:20 on Oct. 12, and peak discharge 10,000m³/s occurred at 5:00 on the next day.
As the flood routing to downstream, the peak discharge gradually decreases. It impact totally lasted 5 days.

The flood routing hydrograph at each station were measured and recorded.

The 1st time: Baige Landslide Dam

Measured flood Hygrograph after the Barrier break on Nov. 13
The 1st time: Baige Landslide Dam

The 1st Baige landslide dam break caused locally some damages and losses.

Two diversion tunnels under constr. at the Yebatan were forced to flow through, flooding some roads and tunnels in the area.

The peak discharge reduced to 5,700 m³/s from 7,700 m³/s, due to the Suwalong cofferdam retains flood.
The 2nd time: Baige Landslide Dam

The 2nd landslide occurred at 17:40 on Nov. 3, 2018 at the same site on Jinsha River.

The volume of landslides 310 million m$^3$ with the residual material of 1st landslide. The top El. of the Barrier is 2,966m, water storage capacity 775 million m$^3$, which will be 3.5 times of the 1st barrier lake.

Much more danger!
1. Dam formed by landslide on Big River

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Hydropower stations on the Jinsha-Yangtze River

32 cascades with an installed capacity of 100GW on the River.
Emergency Decision-making Support

Dams on the Jiansha River

Landslide dam break flood

13 cascades on the upstream section and 8 on the middle section of the Jinsha River
Meteorological, hydrological, topography, geological, Multi-sensor satellite remote sensing information......
After the risk analysis, it is predicted that the flood peak is about 37,000 to 45,000 m³/s without manual intervention.
On Nov. 4, main three suggestions:

1) Artificial intervention---Excavation diversion Channel
2) Suwalong cofferdam dismantle
3) Liyuan reservoir emptying in advance.
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Legend:
- Site
- Barrier
- Under constr.
- In operation

Excavation diversion channel
Cofferdam dismantle
Lower water level
it is predicted that the barrier will not collapse naturally. Greater risks is gathering day by day. So a man-made diversion channel scheme is essential and indispensable for Emergency treatment.
After cutting the ditch, the landslide dam breach flood max. 30,000 m$^3$/s.

Flood hydrograph calculated by Xingbo Zhou on Nov 4, 2018

Calculated water level and bottom level of the trench by Xingbo Zhou
Emergency Decision-making Support

✓ Landslide dam risk analysis

Then, analyzed the flood routing hydrography downstream.

![Graph showing flood progress hyrograph during the Barrier break with max flood 31,000 cu m/s](image)

According to Saint Venant’s principle:

\[
\frac{\partial A}{\partial t} + \frac{\partial Q}{\partial x} = 0 \tag{2-1}
\]

\[
\frac{\partial Z}{\partial t} = S_g + \frac{1}{g} \frac{\partial}{\partial x} \left( \frac{Q^2}{2g} + gH \right) \tag{2-2}
\]
The government issued an emergency evacuation notice from very beginning based on the results calculated.

The information about the emergency treatment to the Barrier, rescue and evacuate were updated at any time by Newspaper, Wechat, Network, Radio and Mobile phone.
5 days later (on 8\textsuperscript{th} Nov), first machine arrived at the top of the Barrier. The man-made diversion channel was built at 17:00 on 11\textsuperscript{th} Nov., 2018.
Emergency Decision-making Support

✓ Implementation process

Man-made diversion channel under construction from 8th to 11th Nov.

November 11, 2018
If the cofferdam is not removed, it will be also breach, and the water volume will be superimposed to the Barrier breach flood. Dismantle began on 7th November.
Emergency Decision-making Support

✓ Implementation process  Suwalong Cofferdam dismantle
Emergency Decision-making Support

✅ Implementation process Suwalong Cofferdam dismantle

It was finished to remove cofferdam on Nov.10
At 5:00 am on 12th, the water level of the Baige barrier lake rose to the bottom of the man-made diversion channel.

At 8:00 on 13th, the Dam came into the breach stage, corresponding to the water level of 2955.76m with water storage of 0.6 billion cu m.

At 18:20 on 13th, the dam breach flood reached the peak discharge, measured to be 33,900 m³/s. in 10hr of the beginning of overtopping.)
Baige Landslide dam Break 13 Nov 2018
Emergency Decision-making Support

✓ Flood routing

Yebatan HPS site

far away 54km to the Barrier
Suwalong far away 224km to the Barrier

Fmax 19,800m³/s at 3:50 am on 14th Nov.
Suwalong site after peak flood, all washed away
Emergency Decision-making Support

✓ Flood routing

Benzilan Hydrologic station

far away 380km to the Barrier
Emergency Decision-making Support

✓ Flood routing

Shigu Town

far away 560km to the Barrier
✓ Flood routing
At least 7 bridges on the Jinsha River, hundreds national roads and other major infrastructures by the side of the River were damaged during 13-15 Nov., 2018.
The flood rapidly advanced to the downstream. The flood peak discharge to the Yebatan reached 28,300 m³/s at 20:00 on 13th. At 1:00 am on 14th, the flood peak discharge at the Batan station was 20,900 m³/s. The flood at Suwalong reached its peak at 19,800 m³/s at 3:50 am on 14th Nov. The inflow to Liyuan reservoir reached the maximum flood of 7200 m³/s at 12:30 on 15 Nov.
Yunnan Province suffered the most losses, followed by Sichuan and Tibet, approximately 1.2 billion, 0.6 billion and 0.5 billion USD respectively. With losses of hydropower stations under construction, the totally losses were 3.0 billion USD.
Consequences
1. Dam formed by landslide on Big River

2. Emergency Decision-making Support

3. Considerations related to the river safety
Considerations related to the river safety

No fatalities during the flood.
Considerations related to the river safety

✓ Effective emergency management mechanism is critical.
Considerations related to the river safety

✓ Rethink to the flood standard

The maximum flood peak 33,900 m³/s occurred after landslide dam breach Nov. 12, 2018. The Max. flood much more than PMF for the upstream reaches and more than 1000 year flood for the middle reaches of the Jinsha river.

<table>
<thead>
<tr>
<th>Station</th>
<th>Stage</th>
<th>Dam type</th>
<th>Check flood standard</th>
<th>Check peak discharge (m³/s)</th>
<th>Dam breach discharge (m³/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yebatan</td>
<td>Under Constr.</td>
<td>Concrete arc dam</td>
<td>5000y</td>
<td>10100</td>
<td>28300</td>
</tr>
<tr>
<td>Lawa</td>
<td>Prepare Constr.</td>
<td>CFRD</td>
<td>PMF</td>
<td>11900</td>
<td>22000</td>
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<tr>
<td>Batan</td>
<td>Under Constr.</td>
<td>asphalt concrete core dam</td>
<td>5000y</td>
<td>10500</td>
<td>20900</td>
</tr>
<tr>
<td>Suwalong</td>
<td>Under Constr.</td>
<td>asphalt concrete core dam</td>
<td>PMF</td>
<td>12500</td>
<td>19800</td>
</tr>
</tbody>
</table>
Considerations related to the river safety

✓ Strengthening emergency response capacity

There was higher calculation accuracy of the landslide dam break flood hydrograph, but a big deviation in the flood routing of the downstream channel, which needs to be improved.
Building dams and reservoirs on the Rivers, It is not only beneficial for providing the safety for flood control, water supply, but also beneficial for prevention and mitigation of geological hazards unascertained.

Better dams, better life!
Thanks for your time