



# Post-earthquake Reconstruction with Bamboo in Bhutan

## 不丹震后竹屋重建

材料提供 INBAR（国际竹藤组织）

1997年国际竹藤组织（INBAR）成立，这是世界上唯一一个致力于竹与藤可持续发展和利用的国际政府间组织。自成立以来，一直在推动竹子在建造中的运用。INBAR近期最新完成的是位于不丹的项目，利用竹子的建造技术很好地满足了当地的需求。

2009年，6.1级地震袭击了距不丹首都廷布东部约180km的蒙加尔地区，地震造成了这个地区大量寺院和住宅的损害。为此，INBAR给予了援助，在2011年9月与不丹皇家政府共同完成了一座竹屋的建造，向当地人们展示了竹子作为一种低成本建筑材料，其可再生性与抗震性非常适宜用于建筑中。

在不丹，传统木结构房子都利用竹子作为填充材料。但随着木材成本的逐渐上升和供应相对不足，人们转而采用混凝土，因此放弃了原有丰富的建筑材料。通过与当地工程师仔细考量，INBAR建筑师决定采用具有传统建筑特征的方式，同时将用材由木材改为竹子。项目负责人建筑师Nripal Adhikary曾说，这不仅仅在于竹子本身的优势和成本，更在于对传统文化的认同。最终整个竹结构为100m<sup>2</sup>，造价约为\$140/m<sup>2</sup>，相当于同等木建筑造价的一半。所有竹子都采用改良的端部压注法体系，注入硼以防虫破坏，这种改良后的体系提供了一种相对简单、高效的方法。建筑墙体采用红土抹灰，不仅可以达到良好的保温性能，而且还能防止竹子潮湿滋生甲虫。实际建造是比较艰苦的，很多小木作都是用竹、藤临时制作的，许多当地人也参与了建造。

近来，这一地区又发生了一次大地震，震中在印度锡金，离这里比较近。但我们建造的房子没有任何损害，正体现了竹子抗震的特点。2011年12月，不丹皇家政府在此竹屋举办了落成典礼，并将此作为廷布政府领导人的永久住宅。基于此竹屋的成功，政府正开始计划明年建造更多类似结构的住宅。（译/吴春花）





Since its establishment in 1997, the International Network for Bamboo and Rattan (INBAR), the world's only intergovernmental organization dedicated to sustainable development and utilization of the world's bamboo and rattan resources, has played a major role in promoting bamboo as a construction material. INBAR's latest construction project in Bhutan provides an excellent example of how INBAR supports the transfer and adaptation of bamboo construction technologies to meet local needs.

In 2009, a 6.1 magnitude earthquake hit Mongar District of Bhutan, about 180 km east of the capital Thimpu. The earthquake caused extensive damage to many monasteries and residential houses in the district. In response to this event, INBAR contributed to reconstruction efforts in Bhutan, an INBAR member country, by demonstrating the suitability of bamboo as a low-cost building material with earthquake resistant properties.

INBAR's support culminated in construction of a demonstration bamboo house in Tingtibi, Bhutan in September 2011. The project was implemented by INBAR in partnership with the Royal Government of Bhutan to promote local bamboo resources as an energy-efficient, renewable and earthquake-resistant building material that could blend into rich existing Bhutanese architectural practices.

In Bhutan, bamboo is traditionally used as an infill material for timber-framed house. However, as the cost of timber is going up and supply is limited, people are switching over to concrete, thereby abandoning a rich architectural tradition. After an intense deliberation with local engineers, INBAR came created a design that retained traditional Bhutanese architectural features, while





replacing timber with bamboo as structural element. "More than the strength and cost of the material, the most important part is the cultural acceptability; that is why we preserved the traditional architectural form," claims Nripal Adhikary, an INBAR architect and project manager. The size of the final bamboo structure is 100m<sup>2</sup>, which at a cost of approximately US\$140/m<sup>2</sup> is roughly half the price of an equivalent local timber building.

For the construction, all bamboo was treated using a Modified Boucherie System, which impregnated boron compound into the bamboo as a prophylactic against pests. Modified Boucherie System offers a fairly simple but effective preservation treatment. The house was also plastered with red laterite soil, which, not only provides good thermal comfort, but also preserves bamboo by reducing moisture content to a level at which borer beetles cannot thrive. "The nearest hardware store was three hours away so we had to improvise and use local materials like rattan and wood for joinery, in the end this house is a synthesis of hard work, use of local resources and public participation" says Adhikary.

Recently, there was another big earthquake in the region, with its epicenter in Sikkim, India being very close to the location of this demonstration house. The house suffered no damage, thus demonstrating bamboo's earthquake-resistance properties. In December 2011, an inauguration for the bamboo house was conducted by the Royal Government of Bhutan, with the house now set to become the permanent residence of the Tingtibi Community Chief. Based on the success of this project, the government now plans to build more similar structures in the next fiscal year. **AT**