Bamboo House for China

竹子在中国住宅中的应用
——昆明世博INTEGER生态城多层竹结构住宅

客户 世博兴云房地产有限公司（HEXY）
地点 中国云南省昆明世博INTEGER生态城
建筑师 欧华尔顾问有限公司（The Oval Partnership Ltd）
INTGER绿色智能有限公司（Integer Intelligent & green Ltd）
规模 180m²

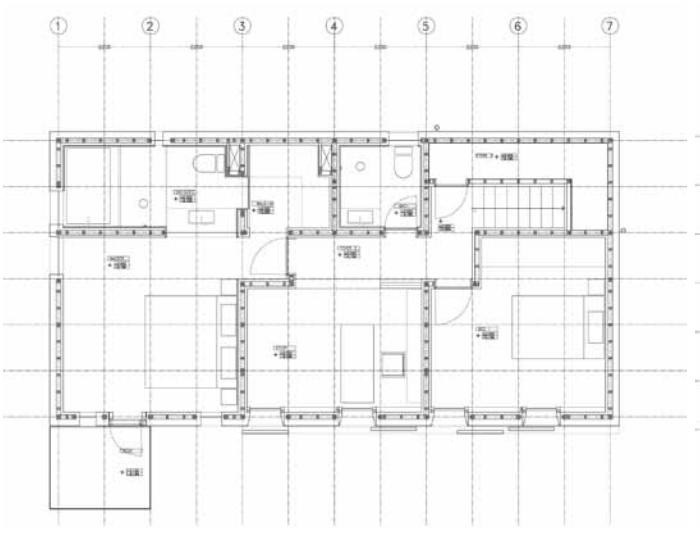
竹子生长在中国的大部分地区，是中国最基本的可持续建筑材料。它生长快速并持续吸收二氧化碳，不仅能为乡村住宅提供低碳、安全和经济的解决方案，而且能创造经济发展的契机。

昆明世博INTEGER生态城的四栋示范屋中的一座是以竹复合建材为结构，是中国竹结构现代住宅的先驱。它是通过INTEGER与日本竹建造专家、香港结构工程师以及云南地方大学研究机构的合作实现的。在没有现行竹结构建筑规范的情况下，这栋住宅提供了研究这一类新型结构体系和建材的基础。现在研究团队正在对竹结构屋进行综合的性能评估，为这一实验留下宝贵的数据。

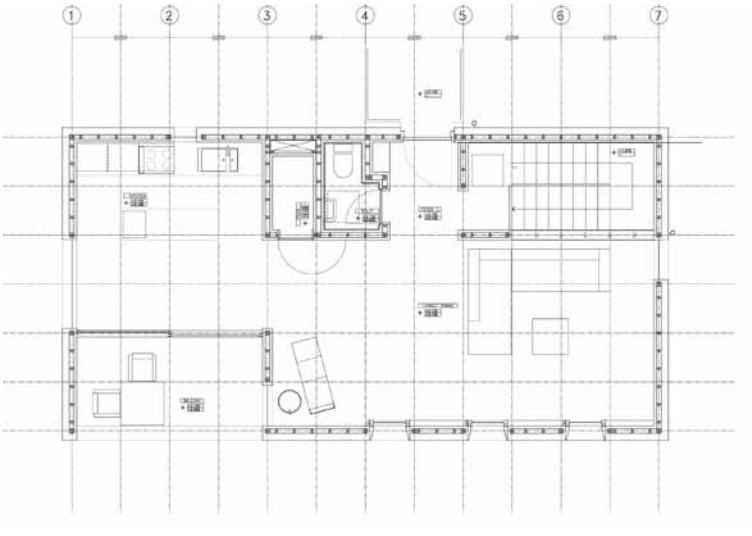
竹子的建筑用途分为两类：一类是天然竹材的使用，另一类是合成竹子的使用。由于第二类竹子具有稳定性、一致性和形成永久性结构的潜力，INTEGER将研发实践的重点放在第二类竹子建造的特性上。早在2002年，中国就开始生产并向美国出口竹胶合板，作为高规格公共建筑工程钢筋混凝土的模板。后中国开始为一些大型国际项目提供竹板，如获得了英国皇家建筑师学会奖的西班牙巴拉哈斯航站楼项目。

这栋两层楼的结构是为中国西部山区地形设计的，结构、内外墙板全部用竹制成。使用竹材的原因是它可能是这一带对生态最有利的建筑材料，并且竹结构很轻，比沉重的混凝土结构更能有效地抗震。另外竹屋可由当地村民建造，而不需要重型的、昂贵的施工设备。昆明世博INTEGER生态城竹屋所使用的技术是基于一个遮雨系统的复合板，隔热性能很高。这一技术的应用潜力不可估量，它为中国的新乡镇提供可以负担得起的、生态的建造方式。建筑师还应用最新技术生产截面尺寸2英寸×4英寸的合成竹竿组件。这座住宅建造在一种在澳大利亚和北美很常见的平台框架上。昆明理工大学的科研人员对竹结构样品进行了可能的破坏实验，如拉伸、压缩、扭曲等。工程师准确计算出房子的结构构件大小，并依据加拿大木制房屋设计规范设计了连接件。这栋住宅还设计了企口竹面板制成的雨屏覆面系统，获得了由中国住宅产业协会颁发的创新金奖。建筑师和当地学术机构（包括昆明理工大学）的科学家、工程师们一起，开展这个研究实践和技术转让项目。

目前在中国的家具制造行业，文物和竹简中常见的竹子有超过100种。材料的最终强度取决于竹子的品种和加工工艺，因此，测试不同种类的竹材和不同的加工工艺十分必要，其研究成果将是制定竹制材料规范的基础。为了编制竹建筑的设计规范，一种策略是从参考木材应用规范开始，然后将它调整到适合竹子的独特属性；另一种策略是从头开始为竹子设计一种新的规范。INTEGER正通过实践协助有关部门发展关于竹子在中国乡村住宅中实际应用的建筑规范，为此需要对材料进行进一步的测试，并对竹制乡村住宅模型进行监测以反映竹屋的实际性能。在这一阶段发展应用中，我们已经与包括中国少年儿童基金会、剑桥大学在内的学术机构和竹材料供应商进行此项可持续建造的合作。



一层平面

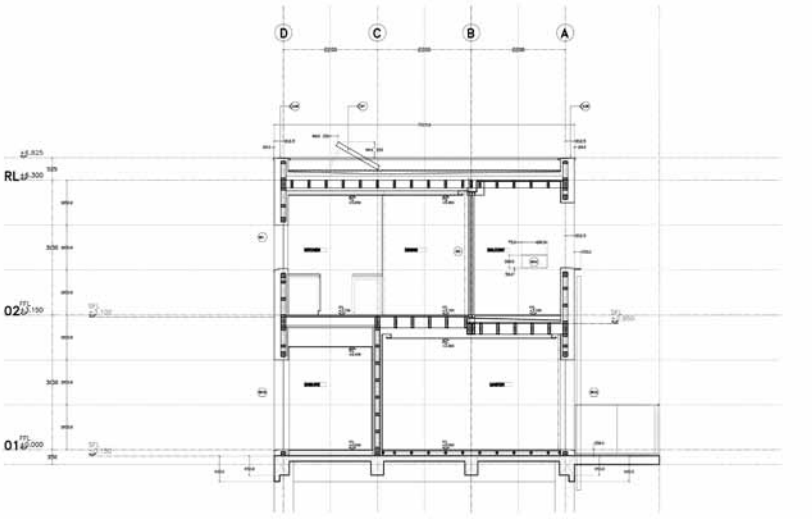


二层平面

Bamboo is the ultimate sustainable building material. It is fast growing and absorbs carbon dioxide during its lifetime. Bamboo grows in most parts of China, notably in Fujian, Zhejiang, Hunan, Sichuan and Yunnan provinces. The use of structural bamboo will provide a low carbon, safe and affordable solution for village housing and will generate economic opportunities for the villages. The Oval Partnership has been building demonstration bamboo housing in Yunnan province. The next step is to facilitate the establishment of a Chinese National Code of Practice for the Structural Use of Bamboo for Village Housing. We need to conduct further testing of the material and to monitor the performance in use of a prototype bamboo village house.

The findings from the action research become the basis of a report on the Structural Use of Bamboo for Village Housing. We propose to conduct the next phase of the development of the structural use of bamboo in conjunction with universities and suppliers such as Cambridge University.

The structural use of bamboo falls into two categories. The first category is the use of natural bamboo poles. The second category is the use of re-constituted bamboo. This paper focuses on the second category because of its stability, consistency and potential in permanent structure. As early as 2002, China started to produce and export bamboo plywood planks to America as formwork for high grade civil engineering reinforced concrete. China has started to export bamboo veneer for major international projects such as RIBA award winning Barajas terminal in Spain. Partnership made use of the latest technology to produce reconstituted bamboo poles of 2(inches) by 4(inches) sections to build the first two storey reconstituted bamboo house in the world. The construction of the house was based on a platform frame (similar to balloon frame), common in Australia and North America. The researchers at the Kunming University of Science and Technology tested the reconstituted bamboo sample



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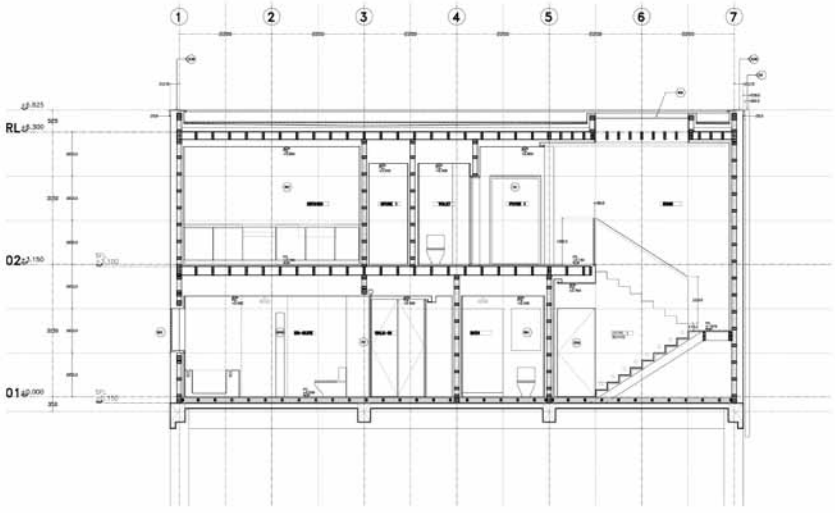

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to destructions on various aspects such as tension, compression, buckling, etc. The engineers sized the structural members of the house and designed the connections based on the Canadian Code of Practice for Timber Housing. The house has a bamboo rain screen cladding system with tongued and grooved bamboo panels.

The bamboo house action research project is located at the Expo INTEGER site，in Kunming, Yunnan Province, China. The two storey structure is designed for the hilly terrain in the western part of China.

The structure, the external and the internal wall panels are all made of bamboo. The reason why bamboo is used is that it is probably the most ecological building material around, having a growth cycle of four years, and absorbs carbon dioxide in its lifetime. Bamboo can be grown almost anywhere in China. Bamboo structure is light and, as a result, more effective in resisting earthquake than heavy concrete structure. The bamboo house can be constructed by local villagers without the need for heavy and expensive construction equipment. The technology used in the Kunming INTEGER bamboo house is based on a rain screen system and sandwich panels which provides very high thermal insulation value. The potential of this technology is immense. It can provide an affordable and ecological way of building for the new townships and villages in China.

There are over 100 species of bamboo currently popular with manufacturers of furniture, artefacts and bamboo ply in China. The final strength of the material depends on the species and the manufacturing process. It is necessary to test a wide variety of species and manufacturing process to define the range that are suitable for structural use. The result will be the foundation of a bamboo material code. A strategy to derive a design code for bamboo is to start with a code of practice for timber, then adjust it to suit the special properties of bamboo. Another strategy is to design a code of practice for bamboo from scratch. The building of a prototype bamboo village house is an important step to test the application of the code in a real life situation. The researchers will continue to monitor the performance in use of the house for one year after its completion.AT