Jingxiang Zhu

Constructing Critically

Prefabricated Systems with Soul

Prefabrication is an obvious solution for the building needs of remote, economically deprived or disaster-stricken regions. But must it mean soulless standardisation? Certainly not – as the AIIA (Architecture Integration and Innovation Association) team at the Chinese University of Hong Kong has demonstrated. The team's leader, architect and associate professor **Jingxiang Zhu**, explains how they have developed flexible, easy-to-erect prefabricated systems that can adapt successfully to different settings and programmes, providing spaces that are not only functional, comfortable and resilient but also stimulating and even playful.

Wooden buildings in the gardens of Suzhou, log farmhouses in Yunnan, post-and-tie dwellings in Sichuan, and quickly assembled temporary shelters made of bamboo in contemporary Hong Kong – there are plenty of vernacular building types and products in China. However, in the minds of Chinese practitioners of the past three decades they are either too perfect to evolve, or too old to save.

China has held the record for the fastest-developing major country for years. Construction is going on at an unprecedented pace. Unfortunately, while using half of the world's concrete and a third of the world's steel, the design industry has not been contributing much on building integration, system invention or the definition of new issues.

Modern pioneers unveiled very broad potentials of the vernacular tradition. Konrad Wachsmann started from traditional wooden construction and shifted his research to sophisticated metal joints which are critical to rapid assembly and mass production. Frank Lloyd Wright designed affordable Usonian houses during the Great Depression. Jean Prouvé explored structures in plywood and aluminium, presenting his solution for the housing shortage after the Second World War. At the same time, Richard Buckminster Fuller extended his concern to the planet and invented new habitats for humankind. However, none of these experiments that originated from innovators' insight were responding to the actual needs of the time and place.

With a focus on buildings that serve the community, the AIIA (Architecture Integration and Innovation Association) research team at the Chinese University of Hong Kong (CUHK) – comprising professors, PhD researchers, designers, charity supporters and manufacturers – has been examining radical challenges in contemporary China: construction without quality control, income inequality, environmental pollution, lack of social security etc. It has produced experimental solutions to extreme projects, based on its members' long-term research on building systems and customised prefabrication.

Unlike the classical avant-garde's claim to the 'new', these experimental projects – a selection of which are presented below – have a non-theoretical, reconciliatory quality: the precarious but natural relationship between the experimental, industrial and regional directions. The built works are testimony to the fact that the intelligence of the constructional concepts and their regional adaptability are surprisingly parallel, as long as design knowhow and financial resources are concentrated towards the critical issues.

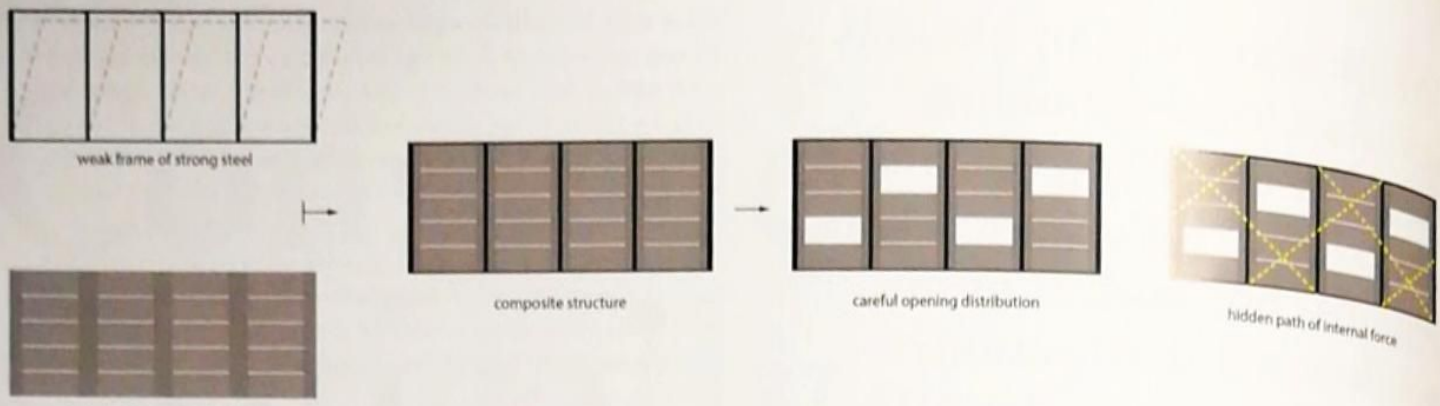
The New Bud System

After the catastrophic 2008 Sichuan earthquake, a barrack building type commonly used on construction sites was erected widely to accommodate large numbers of refugees, because of its rapid assembly. However, its very poor thermal performance did not allow people to use it as a long-term habitat.

This prompted me – with some assistance from a PhD student at CUHK and an engineer friend – to devise the 'New Bud System'. A strong composite system, it keeps the light-gauge steel frame of the barrack-type buildings but replaces their filling material with structural insulated panels (SIP), using a diaphragm effect and eliminating most diagonal braces or rods. SIP cuts off all thermal bridges and guarantees indoor comfort in both winter and summer. The New Bud System can be prefabricated in a factory, transported over a long distance and rapidly constructed on site with unskilled workers, while the design restriction has been reduced to a minimum.

AIIA research team,
CUHK,
Grameen Bank,
Lukou village,
Xuzhou,
Jiangsu province,
China,
2014

The steel 'letter wall' at the southeast entrance of the Grameen Bank spells out 'Grameen China' in Chinese. The building, constructed with the New Bud System, adapts a double-pitched roof which is commonly found in the local village.



Jingxiang Zhu,
New Bud System structural diagram,
2008

The structural diagram explains how the post framework with panel elements addresses seismic forces. Openings and surface skin are also distributed according to structural considerations.

After applying the New Bud System in a school reconstruction project with standard barrack form for a quake area in 2009, the CUHK team – which officially became AIIA in 2010 – continued to customise the design in subsequent projects, to demonstrate the system's potential for various programmes or site conditions.

A remote village, Dazu, at an altitude of 2,600 metres (8,500 feet) in a mountainous region on the southern border of Sichuan province, that is home to a minority ethnic group, became the second site for the system's application. With a simple timber-trellis cladding design, this modern building blends in with the rural ambiance of the log dwellings.

AIIA (Architecture Integration and Innovation Association) research team,
Chinese University of Hong Kong (CUHK),
Mcedo Beijing School,
Dali, Nairobi, Kenya,
2014

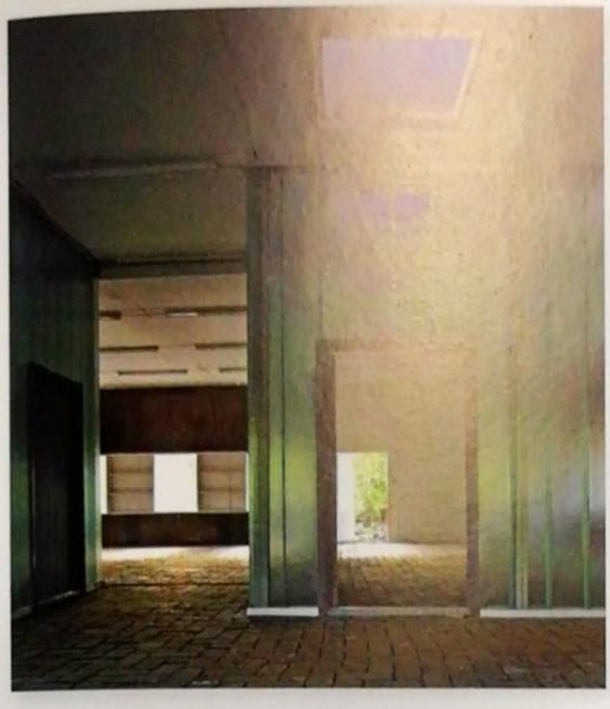
A classroom interior. The foldable steel structure of the frame system appears as 'inverted Y' columns.

AIIA research team, CUHK,
Dazu Study Hall, Dazu village,
Yanyuan county, Sichuan province,
China, 2010

Viewed here from the ground to the southeast, the red mass of this second 'New Bud System' school stands out from its surroundings. The shelves on either side of the windows provide an illusion of a heavy wall. Although a lightweight structure, it feels like a castle to the local students.

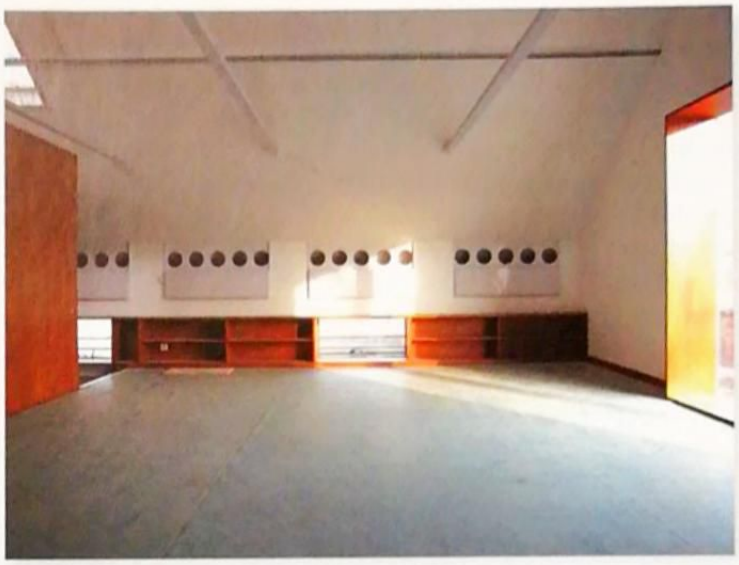
Seen from an elevated viewpoint, the flat building merges with the nearby farmhouses, respecting the mountains beyond.

With a simple timber-trellis cladding design, this modern building blends in with the rural ambiance of the log dwellings.



The glass partitions define the classrooms, ensure sound insulation and allow light to be diffused, enriching the interior spatial experience.

AIIA research team, CUHK,
Grameen Bank, Lukou village,
Xuzhou, Jiangsu province,
China, 2014



Multipurpose space at the second floor. The large glass viewing panel at the right facing east allows sunshine to enter in the morning. The circular holes are specially designed vents for adjustable natural ventilation.

The 260-square-metre (2,800-square-foot) single-storey structure compactly houses three classrooms and a reading space, without wasting any space on corridors. All four areas are uniquely designed with different sizes, proportions and orientations, giving students a clear sense of location. Teachers can also make good use of the space by adjusting the doors.

Translucent partition walls are used to block noise, without hindering light penetration. Skylights help to light up areas far from the windows. Vents are well positioned and the stack effect is manipulated carefully to keep indoor space cool in summer and warm in winter.

Shelves near windows give the illusion of a heavy wall. This 'heavy' and modern school is a 'castle' in the mental world of the elementary students. Actually it is a very lightweight structure with a wall thickness of 16 centimetres (6 inches) and weight only one quarter that of a typical building with the same volume. The Study Hall has earthquake resistance up to the top intensity level of X (extreme shaking) on the Mercalli Intensity Scale. Over 90 per cent of the components are prefabricated in factories, reducing the time taken to assemble the superstructure to only 14 days. Skilful workers, teachers and volunteers erected the building in the rainy season of summer 2010. With a low construction cost, this project demonstrates an ideal option for buildings in areas threatened by natural disasters or stricken areas needing reconstruction.

After several other successful charity school projects and work stations for national nature reserves, the AIIA team was invited in November 2014 to build the office of Grameen Bank in the village of Lukou, Jiangsu province. The commission came from the Yunus China Centre, founded by Professor Muhammad Yunus – a banker and economist from Bangladesh who was awarded the 2006 Nobel Peace Prize – who had launched the 'Grameen China Project', supervising Chinese finance companies to operate in accordance with Yunus's social enterprise model.

In a blend of hand craft and industrial production, or low tech and high tech respectively, the villagers assembled the new building with simple tools.

The two-storey, 220-square-metre (2,400-square-foot) building not only provides office space for rural financial operations, but accommodates multiple activities such as gathering, performing, exhibiting and training. Together with outdoor space available to the villagers, this building became a true centre for Lukou village.

The building adapted volumetric forms commonly found in rural areas of northern Jiangsu province, but was built in a brand-new way: through well-organised distributed manufacturing. Large factories, small workshops and village builders all contributed to the component and material supply. Ninety per cent of the expenditure remained inside Jiangsu province. In a blend of hand craft and industrial production, or low tech and high tech respectively, the villagers assembled the new building with simple tools. Laymen and women from the village worked happily with the professional builders and university experts.

The thermally insulated surfaces with precisely designed openings guarantee winter insulation and summer ventilation. Equipped with a warm water supply and shower devices, this building also exemplifies an affordable rural dwelling prototype.

Checkered Playrooms

Dou Pavilion brought prefab building technology and its social impact to the forefront of the 2016 Venice Biennale. It was one of the few buildings in the exhibition that were built on a 1:1 scale to their original models, and became an important spot in Venice's Arsenale. Components of the wood pavilion were manufactured in mainland China, packed carefully and shipped to Venice. The precision in its design enabled it to be assembled on site within three days.

The pavilion originated in another recent project, a kindergarten model built in China's Gansu province, which had been adapted to the Mediterranean climate and shipping requirements. The model is composed of concave and convex squares, both inside and out, which create a fluctuant interface for visitors to discover individual relations with the structure.

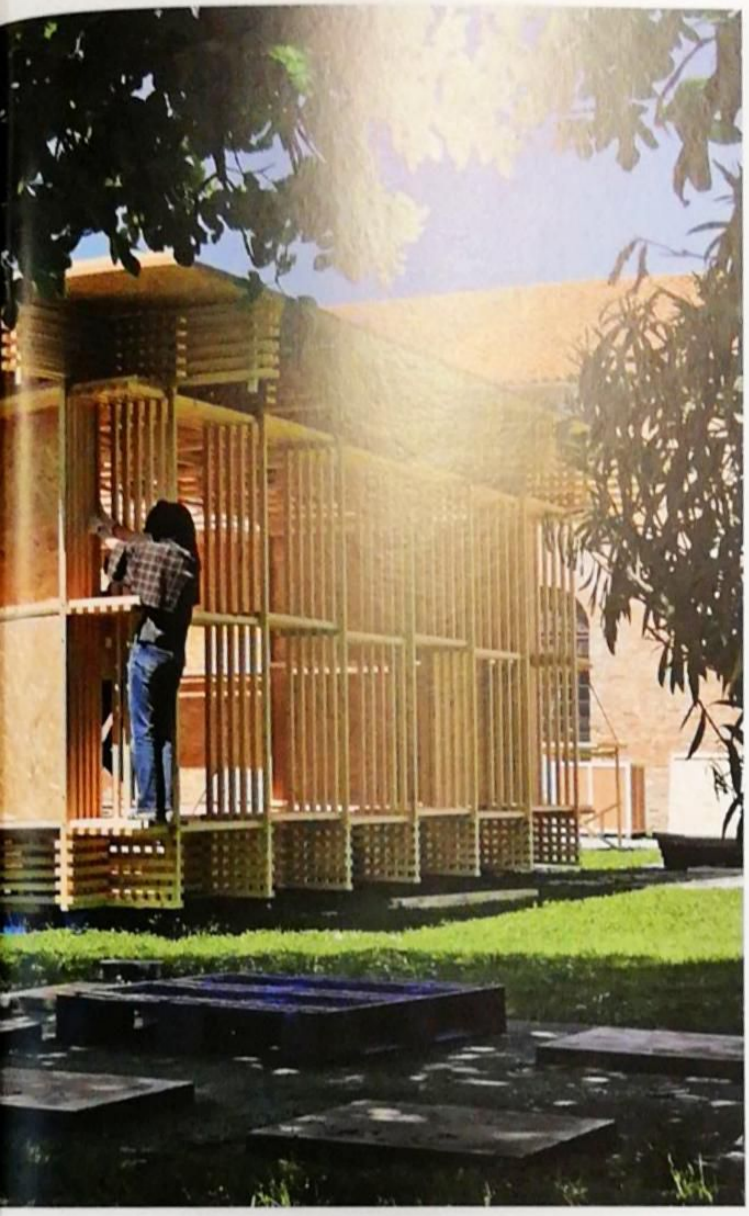
Since 2015, a number of these structures, known also as Checkered Playrooms, were assembled by the AIIA team in remote villages in Gansu, in collaboration with the Western Sunshine Rural Development Foundation, to promote basic preschool education for more than 5,000 children between ages two and six. In the rural areas of the western provinces in China, thousands of children have insufficient pre-education facilities, as well as too few teachers. The Checkered Playrooms are intended to attract more teachers to these areas and provide modern facilities for the children.

The playful design makes these playrooms a hit with their users. Children enjoy hanging out in them, even without any toys. Different from traditional classroom design, the 'boxes' on the walls and on the floor are made child-friendly, and the children always love to sit or lie in these boxes and to explore other ways to occupy the spaces. Spatial exploration in the playrooms has become an important supplement to the original school curriculum, because it has proved to be helpful to the children's physical and mental development.

Equally significant is the playrooms' impact on community building. The components of the structure were made so light and user-friendly that assembling the buildings created opportunities to involve members of the local community and bring them together. By spring 2018, more than 110 playrooms had been built in various places in mainland China.

AIIA research team,
CUHK,
Checkered Playroom,
Huining,
Gansu province,
China,
2015

The first Checkered Playroom in Gansu province. The geometry offers an interesting comparison to nearby traditional buildings.



Agile Development

The CUHK AIIA team has been working on prefab lightweight constructions for a decade and has developed a group of prototypes which have been applied successfully in various projects in mainland China and overseas. To work with restricted resources or at extreme locations, the structure has to be robust but flexible, allowing it to be manufactured, packed, moved, mounted and jointed modularly. In addition to this, it should finally present sensual, haptic features such as the warmth of the material or its sculptural, tectonic quality. Such bipolar demands can be fulfilled exclusively through 'constructing critically' – a method embracing system integration, understanding of the vernacular, seeking out and planning resources, and iterative evolution.

In parallel with open and decisive dialogue between professionals and clients, the construction challenge and the agenda on necessity have navigated the team to a point of clarity in each individual project, regardless of the chaotically ever-changing reality of the vast developing areas. These applied projects and collected data consistently demonstrate a distinctive approach that moves away from the common trends of inefficient, energy-consuming, little-or-no-design and environment-disturbing building practices. As the result of a few human interventions, these works also outline the role of practice in a larger scope – a critical role played again and again, from historical master builders to the pioneers of the Modern Movement.

AIIA research team,
CUHK,
Dou Pavilion,
Venice,
Italy,
2016

A variant of the Checkered Playroom – 'Dou Pavilion', the China outdoor pavilion for the 15th Venice Biennale of Architecture.

AIIA research team,
CUHK, Spatial Panel System,
Checkered Playroom,
Chongqing,
China,
2017

There are now more than 80 Checkered Playrooms in China, located over eight provinces. This is the fourth generation in Chongqing, constructed by volunteer secondary-students and their parents.