Some projects using the Frame restraint method

Fig. 5 is an image of the first building[2] constructed with cast-in-place fabric-formed walls. The two sky-lights shown are experimental passive (evaporative) cooing devices: the one on the right containing water, and the one on the left containing water-soaked char-coal (to increase the rate of evaporation).

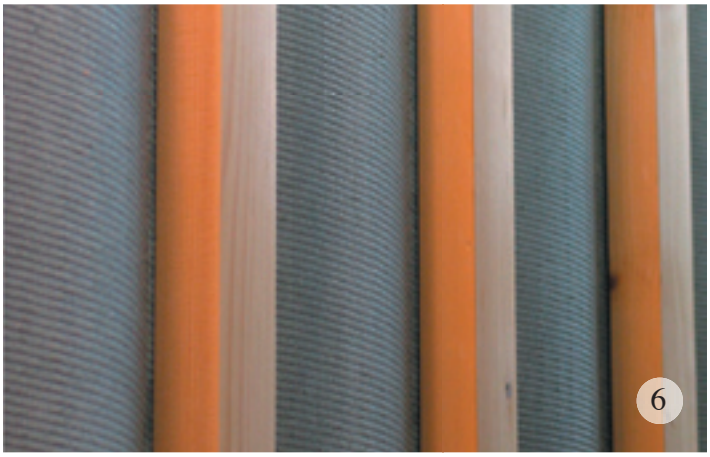

Fig. 6 shows a detail of an interior detail of a URC wall used in a commercial building by architect Shunji Kon-do. Unno also acts as a consultant for other architects and builders wishing to use his URC formwork methods

Fig. 7 shows the undulating surface texture produced by this technique on the exterior of wall of Shunji Kondo's building.

Fig. 8 shows the exterior concrete walls of Unno's "Stone renaissance" house, built in Funabashi City, Chiba for Susae Nakashima (2005). These walls are constructed using steel pipes restrained by standard form-ties running through holes drilled in the pipes. The (slightly diagonal) vertical impressions left by these pipes are freely composed as part of the wall's design.

Fig. 9 shows a close-up of the Nakashima "Stone Renaissance" house walls. The horizontal depression running along the length of the wall, just above mid-height, is given by the horizontal overlap of upper and lower sheets of netting (this netting comes in approximately. 2 metre-wide roles -- geotextile fabrics come in roles up to 17.5 ft. (5.3m) wide). The sheets are not fastened to each other along this joint, but are simply allowed to overlap as the pressure of the wet concrete presses one sheet firmly against the other. The form-ties also leave their own slight horizontal 'echoes' in the surface of the pressurized membrane.

A flexible formwork membrane produces architectural and sculptural forms and surface textures as a direct result of construction decisions and details. The mold surface subtly changes its shape in response to the forces it resists.

Fig. 10 shows the an interior view from inside the Nakashima "Stone Renaissance" house.

Some projects using the Quilt-Point restraint method

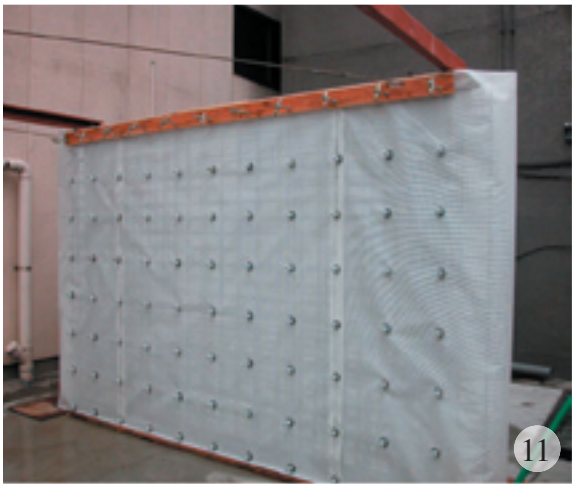

Fig. 11 shows formwork for a ‘quilt-point’ wall. In this application the wall’s reinforcing steel is used to hold up the formwork membrane, so no vertical framing members are needed. The only ‘framing’ required are the lateral support braces attached to the top of the wall form. A grided pattern of form-ties restrains the fabric formwork membrane. These ties are provided with large washers to distribute the stresses imposed on the fabric. It will be appreciated that while more form-ties are used than in a conventional wall of this size, this is an extraordinarily light wall-form consuming very little construction material.

Fig. 12 shows the walls formed by the Fig 11 formwork above providing support and ground level parking in a three-story private residence for client Katsunori Hiyoshi in Koutou-Ku, Tokyo (2002).

The connections between the fabric membrane and existing boundary conditions such as footings, floors, columns, overhead beams, etc. can be surprisingly simple. Although it seems counter-intuitive, the fabric does not need to be continuously connected along any of its edges (top, sides, or bottom). Instead, Figs. 13, 14 and 17 show how the fabric can be allowed to deflect freely between restraint points. This greatly simplifies installation of the fabric formwork.

Fig. 13 shows the free edges of the formwork and concrete along the side and top of a cast-in-place wall infilling a bay of steel framing. Also note the small colored stones placed in the form-tie points after casting.

Fig. 14 shows the base of a URC quilt-point wall cast on a steel beam. The pressure produced by the first few centimeters of concrete serves to pre-stress the membrane along its free edge between support points, thus increasing its stiffness to the point where it acts like a rigid mold surface. The fabric needs only to be held in place momentarily while the first concrete is being placed, Once the fabric is stressed into a rigid state the joint is entirely self sufficient.

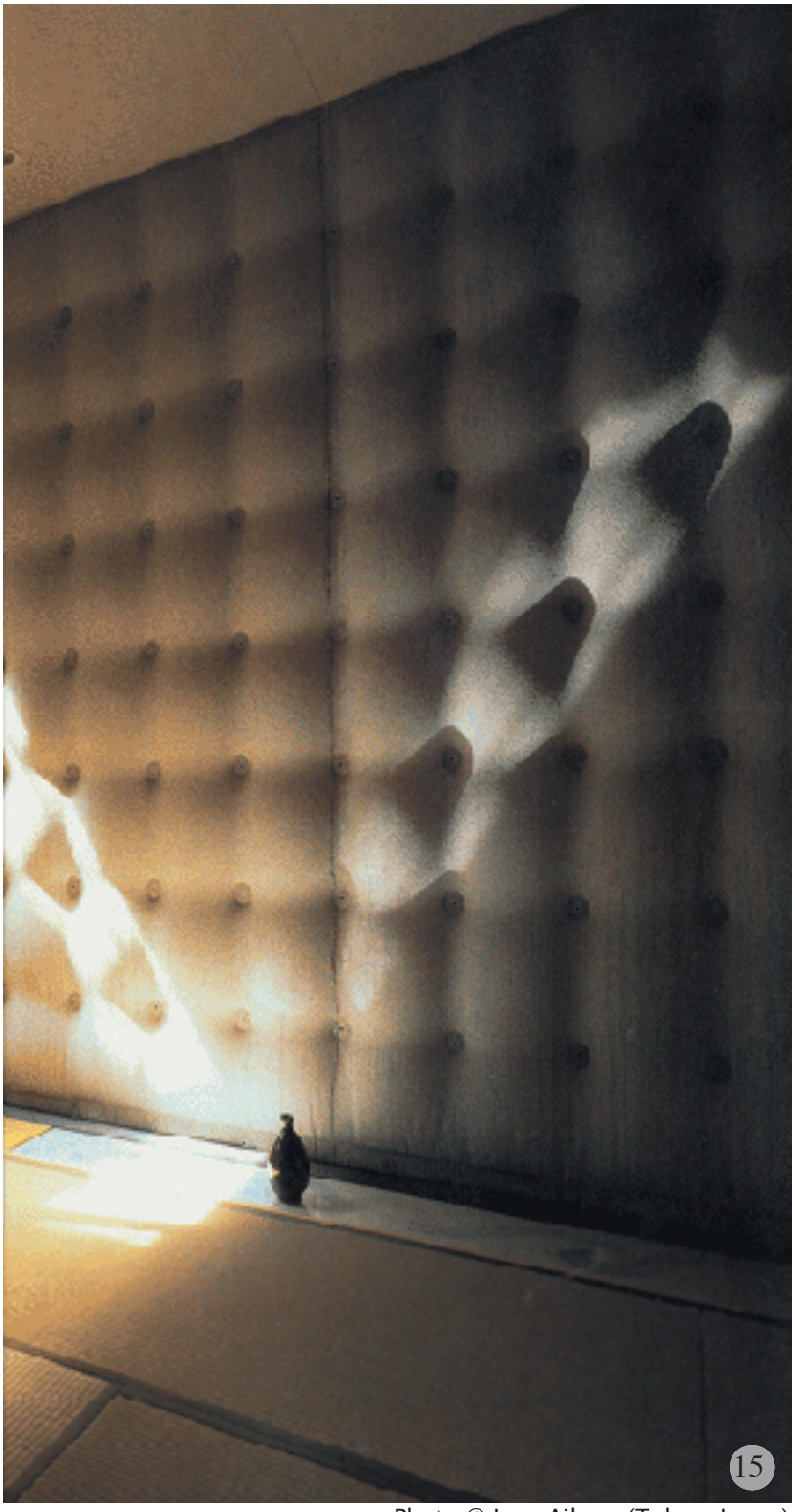

Photo © Isao Aihara (Tokyo, Japan)

Figs. 15, 16 and 17 are all taken from Unno's "URC house with grass", built for Eiji Hoshino in Edogawa-Ku, Tokyo (2003). Fig. 15 shows a URC quilt-point wall used in a traditional Japanese room. Note that the base of this wall used a continuous fixed connection to a rigid horizontal frame member, as opposed to the free edge details shown in Figs. 13, 14 and 17. Unno placed a narrow glass strip in the floor at the bottom of this wall to reflect incoming light across the wall. Fig. 16 shows the dining room of the "URC house with grass". Fig. 17 shows a close-up view of the dining room wall. Here Unno used a free-edge detail where the cast-in-place wall meets an exposed steel column.

Zero-Waste Formwork

In terms of sustainable construction and the reduction of construction waste, Kenzo Unno's most valuable contribution may be his "zero-waste" formwork system described below. Standard cast-in-place concrete construction requires the construction of two heavy walls of wood for molds. After casting, these molds are un-built, removed, and eventually, after only a few uses, transported to the landfill. Unno has brilliantly re-thought cast-in-place wall molds to produce a method where no virtually labor or material is wasted or discarded. Unlike ICF formwork systems that employ rigid insulation on both sides of the wall, Unno's method leaves beautifully finished exposed concrete, with its thermal mass benefits, on one side, and wood furring strips attached to the wall on the other.

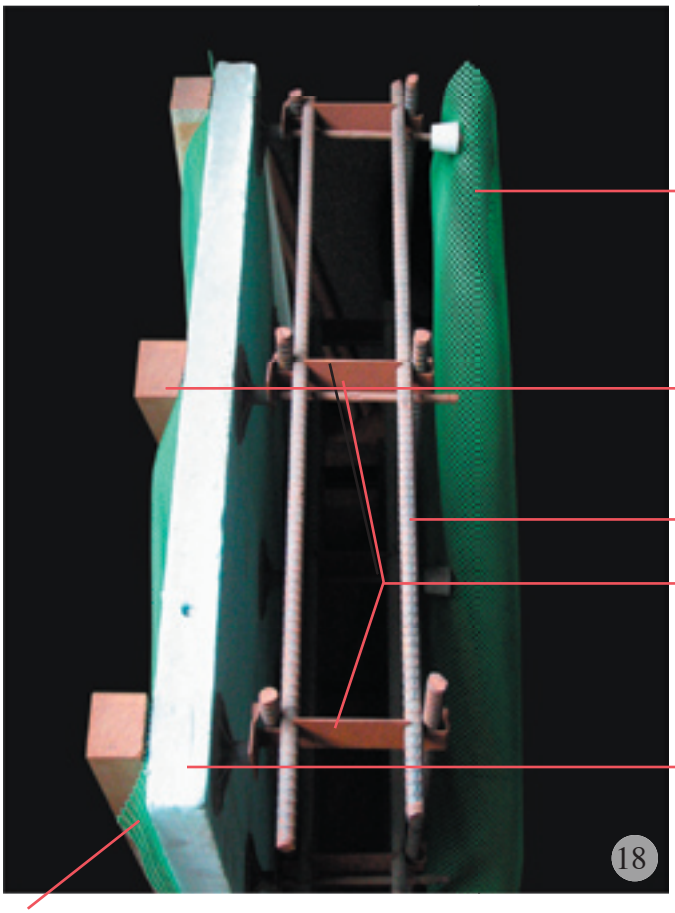

Fig. 18 illustrates Unno's Zero-Waste Formwork

Formwork Membrane (in this case scaffold netting): The membrane could also be a re-usable polyolefin geotextile. This Membrane would be restrained by either the "frame" or "quilt-point" methods (not shown in this image) as described earlier. Removal of this membrane leaves a beautiful exposed concrete surface providing thermal mass to the interior.

Studs/Furring: used to support rigid insulation while placing concrete, and remaining in place as furring for finished walls

Reinforcing Steel

Form-Ties

Rigid Polystyrene Insulation

This image shows a back-up layer of netting placed outside of the rigid insulation. Unno initially placed used netting in this location as a kind of structural back-up insurance in case the rigid insulation failed during concrete placing. Since he has never had a failure of the insulation he no longer uses this layer of netting.

If the Japanese netting shown here is replaced by a woven polyethylene or polypropylene geotextile, the membrane would be re-usable many times over (the upper limit is presently unknown). When it has served its useful life as concrete formwork it can still be used for its original purpose of earth stabilization. Zero Waste. The only labor required to remove the formwork is the snapping of the form ties and the removal of the light formwork fabric (neither Unno's netting nor polyolefin plastics adhere to concrete, so form-oils are not needed). Storage volumes for fabric forms are a tiny fraction of that required for plywood forms and whalers.

Detailing by Kenzo Unno includes a few tricks that are native to flexible formwork. These include the ability to tie objects or precast pieces into the formwork membrane, resulting in a seamless joint between the two. Fig. 19 shows this treatment using a field stone (Nakashima "Stone Renaissance" house).

Fig. 20 shows a glass wall meeting the end of a fabric-cast wall in a controlled recessed joint (Nakashima "Stone Renaissance" house). Blockouts can be placed inside a fabric formwork to form recesses, but a flexible membrane can also be allowed to simply deflect around frames or other building elements as required.

Figure 21 shows Unno's detailing at the base of a fabric-cast wall (Nakashima "Stone Renaissance" house). The sensual curves of fabric-cast concrete, which are determined by the dictates of natural law, produce inherently beautiful curves. Combining these with the machined edges and surfaces of industrial building components provides rich new possibilities for the language of architectural form.

NOTES:

1. This netting is commonly used to enclose scaffolding on construction sites in Japan. Unno adopted it as an inexpensive and readily available construction material. The open mesh, however, allows cement paste to pass through the membrane and it is not as re-usable as the woven polyolefin geotextiles used at CAST and elsewhere. Sourcing Polyolefin geotextile fabrics in the Japanese construction market, however, has proved to be difficult.

2. Beginning in the 1970s, the late Spanish architect Miquel Fisac designed and constructed a number of buildings using pre-cast concrete panels formed in flexible plastic sheets REF. Unno invented his flexible formwork for cast-in-place walls entirely independently from Fisac's work. It is worth noting that at more or less the same time as Unno was developing his methods, two other people were also independently developing methods of forming cast-in-place fabric formed concrete: a builder and businessman Rick Fearn (currently CEO of Fab-Form Industries in Surrey B.C. Canada - www.fab-form.com), and the author of this article.

CREDITS:

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