to its place; but the drawing is transferred to a computer which cuts the marble for hundreds of square feet in hours; this material is epoxied to a mat which allows dozens of similar mats to be placed side by side in a mockup warehouse. Examining the pieces, the artist makes changes and adjustments that are inspired by his awareness of the whole and the way the whole is working. These corrections are made before the marble mats have left the shop where they are being made. The adjusted mats, with marble in place, are sent to the building site — which might be hundreds or thousands of miles away — and they can be installed in a matter of days.

What is so remarkable about all this is that the subtlety, humanity, and artistic refinement — which was commonplace in the 12th century, and which seemed completely out of the question in the 20th century — in the 21st century now comes once again within our grasp in a new form, never dreamed of by the ancients.

But what matters, what is most vital, is that these subtleties, in which living structure is created by living processes — albeit living processes of entirely new kinds — can be achieved and living structure attained on a massive scale.

10 / FABRICATION OF LUMINOUS GLASS CEILINGS

In the Athens project, the colored glass ceilings too were to have been fabricated by similar methods. Each ceiling was hand drawn, first in a very small pencil sketch. Using Photoshop this ceiling was then drawn and colored; a paper print of it was pasted in to our working 1:50 model, where it sat mounted on an acetate backing with real light shining through it (pages 563–65). Under these circumstances, a real physical simulation — the luminous quality of the ceiling and the effect of its color on the floors and space — could be observed directly, then assessed, modified, and perfected within a few rather rapid cycles.

Under these conditions the simulation (note: this was a real three-dimensional simulation, with real lights; the subtle light showing through the ceiling would not have been accurately simulated in any present-day computer program) allowed us to achieve very rapid closure to the adaptation process. A degree of harmonious adaptation that might, a thousand years ago, have taken years of trial and error, could here be successfully achieved in a matter of hours or days.

Once we decided on a particular ceiling, we then turned that design over to a process through which the small, sketchy drawing itself could then be turned directly into fabrication. At first the Photoshop drawing itself, on a file no bigger than 2 megabytes, was handed over to our fabricator who enlarged the drawing, and used a photo-mechanical technique to put the design photographically, onto a two-layer sheet of glass. The first layer of white glass, a few microns thick, had been fused to the glass surface. A second similar layer, in blue glass, was then generated on the glass surface with the design showing through. The whole sheet of glass, together with its white and blue layers, and showing every detail of the original rough sketch at the appropriate scale for the real ceiling, was then fired in a kiln and slumped over a stainless steel form to the right radius curve. In the same kiln it was then tempered, in sections. The process is fast and cheap, and is capable of representing all the subtlety and adaptation which the artists who made the drawing in the first place, and the model makers who made it right in the luminous model, could achieve . . . in no more than a few hours. Thus the final ceiling was made directly by a computer-model-mechanical-fabrication technique from the simplest hand-drawn sketch.

Experimental glass panel. A hand-drawn design for clouds, was first sketched, then transferred to Photoshop, then transformed by a photographic process onto glass, which was then fabricated to form panels for a curved, vaulted luminous ceiling about 25 meters by 50 meters. The complete ceiling is shown on page 563. Image and computer files, Christopher Alexander; fabrication of this sample panel, Larry Berk.

Once again, in this example something which would have taken months or years of painstaking craftsmanship a thousand years ago, could be made cheaply, and almost in a matter of hours — yet showing the hand-drawn quality and art which would have seemed impossible in the earlier industrial age of the 20th century.

11 / EXTENSION OF ULTRA-MODERN TECHNIQUES TO ALL FORMS OF INNOVATION AND CONSTRUCTION

I hope the examples of this chapter make it clear how, in our second modern era, even the most intricate adaptations that can be conceived in a building, and at scales of speed, size, number and intricacy which stagger the imagination, become possible through a combination of computer techniques, unusual technology that is linked to the computer, and forms of management which break projects up in unfamiliar ways.