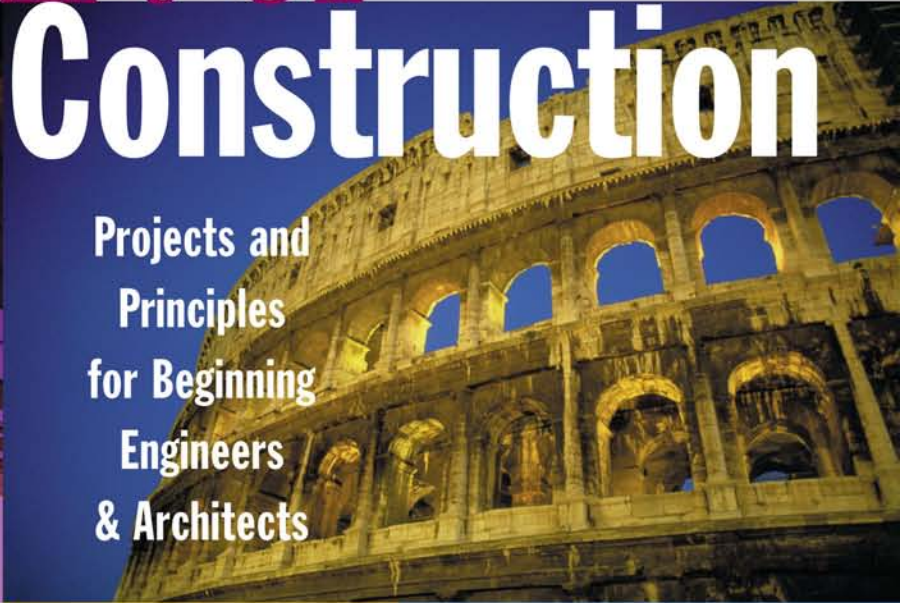


MARIO SALVADORI



The Art of Construction

Projects and
Principles
for Beginning
Engineers
& Architects



Winner of the New York
Academy of Sciences
Children's Science Book
Award and the
Boston Globe-Horn Book
Award for Nonfiction

THE ART OF CONSTRUCTION

Projects and Principles
for Beginning Engineers
and Architects

Mario Salvadori

Drawings by
Saralinda Hooker and Christopher Ragus



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*For Niccolò
and all my other young friends
who keep asking me
why buildings stand up*

Text © 1990 by Mario Salvadori

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PREFACE TO THE THIRD EDITION

THE LAWS GOVERNING the construction of structures do not change with the passing of years or centuries; they are basic laws of nature. Yet I find it necessary to add a preface to this third edition of my book because of the experience I have acquired over the last fifteen years in the schools of New York City and other parts of the United States.

After teaching architectural structures at Princeton and Columbia Universities for many years, I introduced in 1975 a special school program to excite greater interest in mathematics and science in young students. Many thousands of youngsters in junior high and high schools have been exposed to the program since then, and the study of architecture and structure has attracted them to subjects they previously considered obnoxious. Our program has stimulated them to stay in school and to perform well in a wide range of subjects. *The Art of Construction* is one of the tools we use to present our program to grade school students. I feel it is worthwhile for parents and teachers to realize that a simple book on architecture may help solve one of the problems that concerns educators all over the country.

Finally, I must add that although *The Art of Construction* was written for youngsters, it seems to be of great interest to older “youngsters” as well, among them some of the architects I serve as a professional structural engineer. The third edition of this book has been brought up to date on the few data that have changed with time and may be read as an original work.

Mario Salvadori
New York, New York
January 1990

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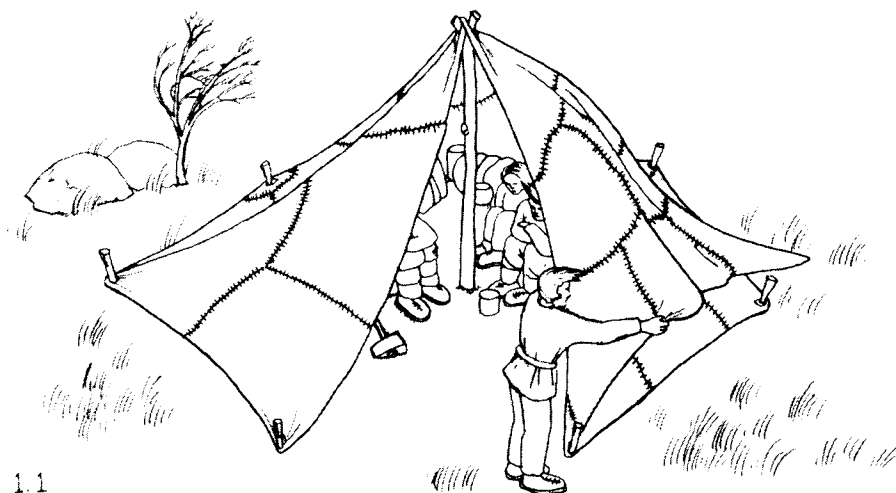
I wish to express my deep gratitude to the children of Harlem,
who joyfully started me on a new career
and
to Pearl Kaufman, who put the book together so many times
with love, patience and skill.

1 ■ From Cave to Skyscraper

THIRTY THOUSAND YEARS AGO, people roamed from place to place hunting animals for food and looking for wild plants to eat. As they were always moving, they did not build houses. They slept under the stars, got wet under the rain, sweated under the sun, and cooked their meals over open wood fires. Much later on, they began to put up shelters, tents made of animal skins, and tried to protect themselves from the weather. If they were lucky and roamed in mountainous areas, they might find caves where they could cook and sleep. Caves were better places to live in, but tents had the advantage of being easily moved. If the supply of animals or wild plants ran out, men and women could pull up stakes and set up housekeeping where there was more food. They literally “pulled up stakes” because they had found that, without ropes anchored to the ground, their tents could be blown away by the wind. So they fought the force

of the wind and stiffened the tent by means of fiber-ropes attached to stakes driven into the ground (Figure 1.1), just as we do today when we go camping.

Of course, for people to be able to live under the tent, a pole made out of a tree branch had to support the top at the center, and the taller the pole, the taller the tent. It would have been comfortable to use poles tall enough to allow men to stand up under the tent, but it was not easy to do this.



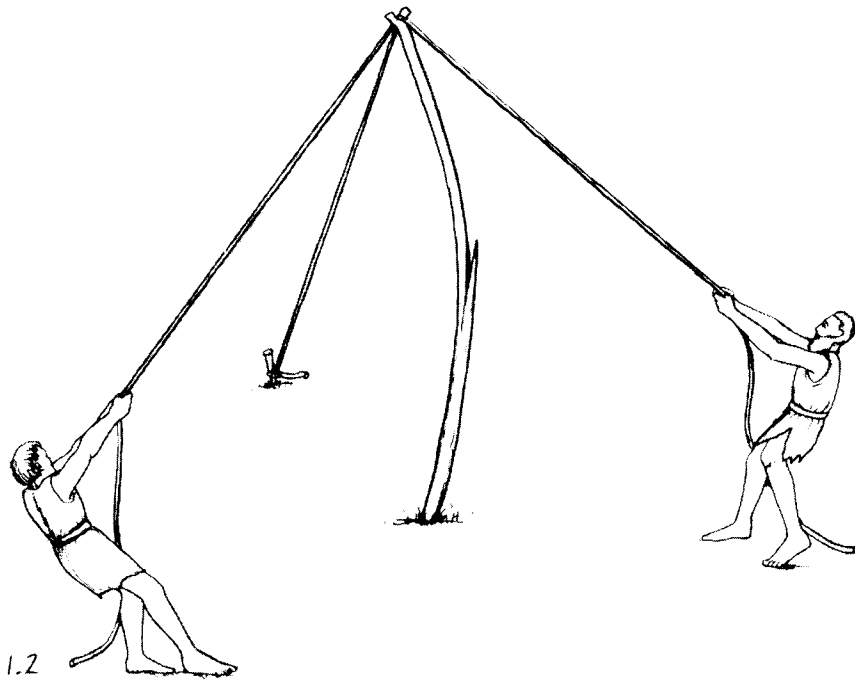
If the pole were tall and thin it might bend and collapse under a high wind pressure or when the ropes were pulled too hard (Figure 1.2). If the pole were thick, it would not collapse but would be heavy and hard to carry. The tent people had to be satisfied with thin, short sticks that were both light and stiff, so they could not stand up straight under their tents.

To make sure the wind would not pull out the stakes they also set heavy stones on the skin all around the bottom of the tent. The tent wouldn't blow away unless the wind could lift the weight of the stones and then pull out the stakes. The heavier the stones, the stronger the wind had to be to move them.

A few more thousands of years went by, and about ten thousand years ago people slowly began to learn a new way of getting food. Instead of eating wild plants, like rice that grew by itself in certain spots, they learned to plant vegetables, wheat, barley, millet and rye, to water them, to tend them, and to grow enough to feed their families without ever moving camp. At the same time they learned to catch wild animals and to feed and

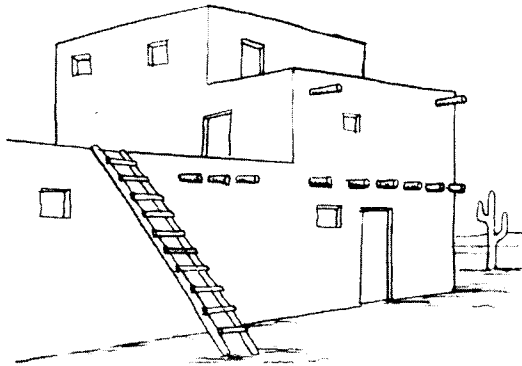
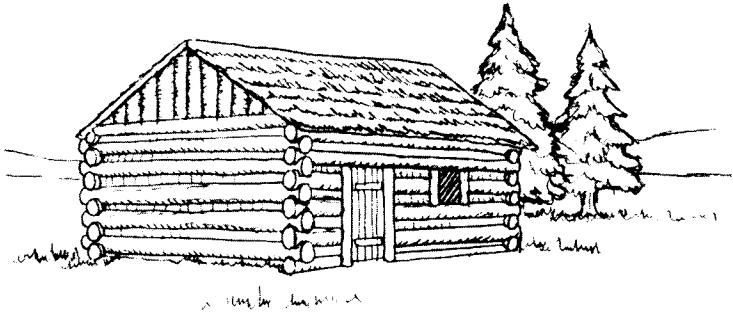
keep them in captivity. They domesticated dogs, asses, oxen, horses, and turkeys and thus provided meat as well as vegetables and grain for themselves and their families without having to be on the move all the time. Humankind had discovered agriculture.

When early men and women had to break camp often and carry tents on their backs, they could not have very comfortable homes. But once they had found ways of staying in one place, they started to think of building shelters that were larger, stronger, and more comfortable than tents. As they learned to farm, they slowly became builders and their houses became larger and taller.

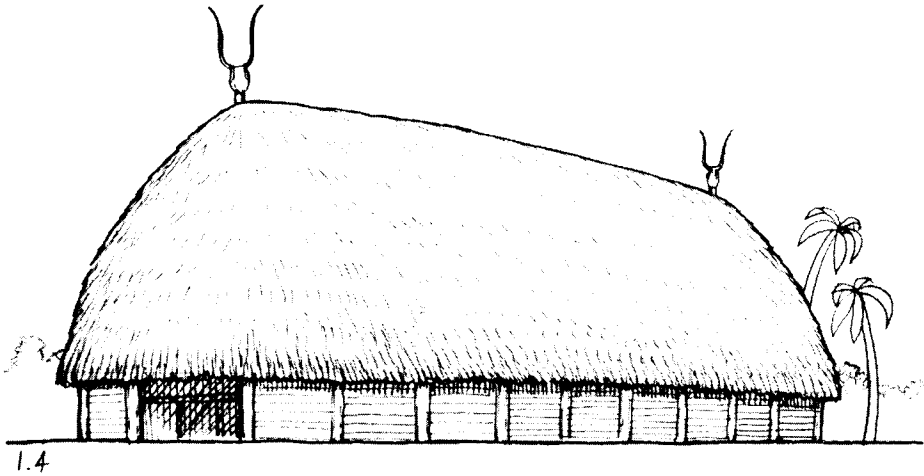


Each family had its own permanent home. In cold climates it was usually made out of logs or stones set one on top of the other. In moderate climates it was built of mud mixed with straw, a material called *adobe*, while in hot climates it was made out of wood poles and thatched roofs (Figure 1.3). When many families lived near one another, their houses made up a village. In order to meet together and discuss common problems, the village people built large buildings that served both as their

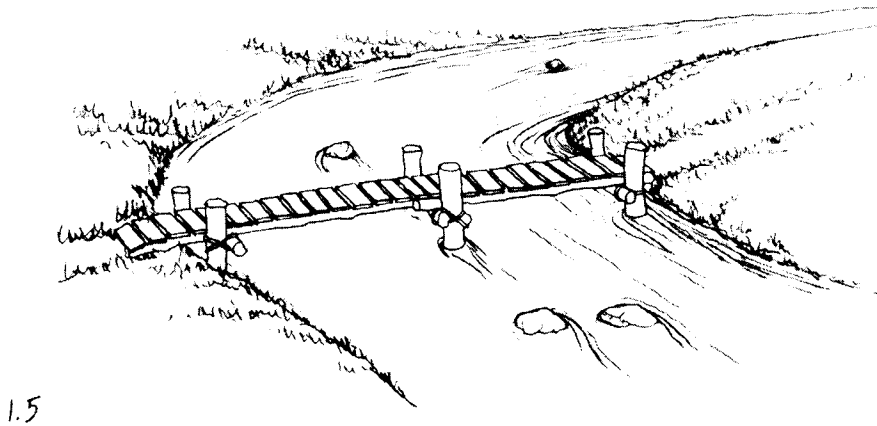
4 • The Art of Construction



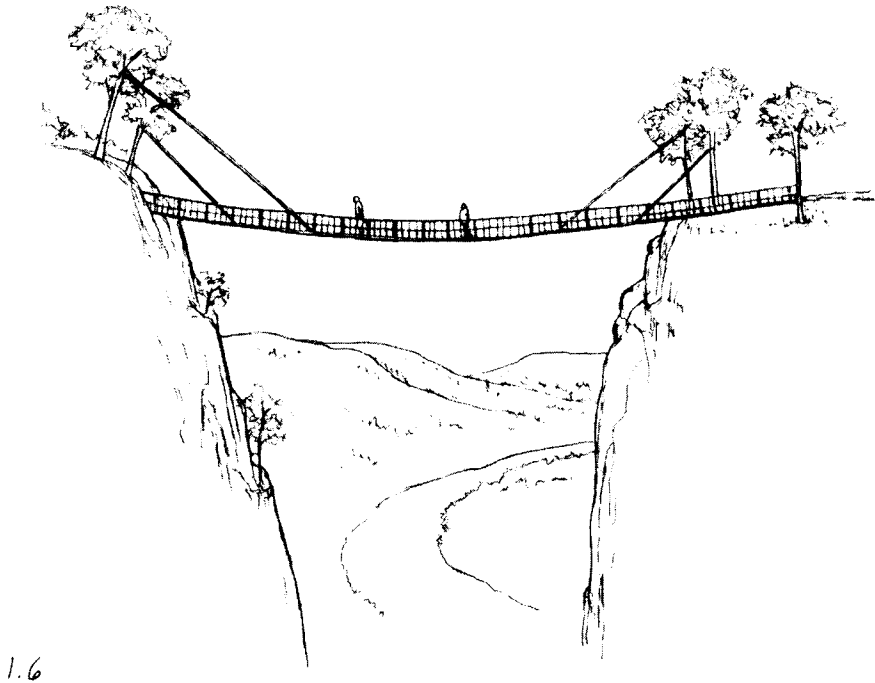
town halls and their churches (Figure 1.4). To get from one house to another, they maintained well-kept paths, and, eventually, to go from village to village, they built roads. Since the



roads often crossed deep rivers or rivers that flooded in the spring, bridges of tree trunks supported by wood poles had to be built (Figure 1.5). When the roads had to cross ravines in the



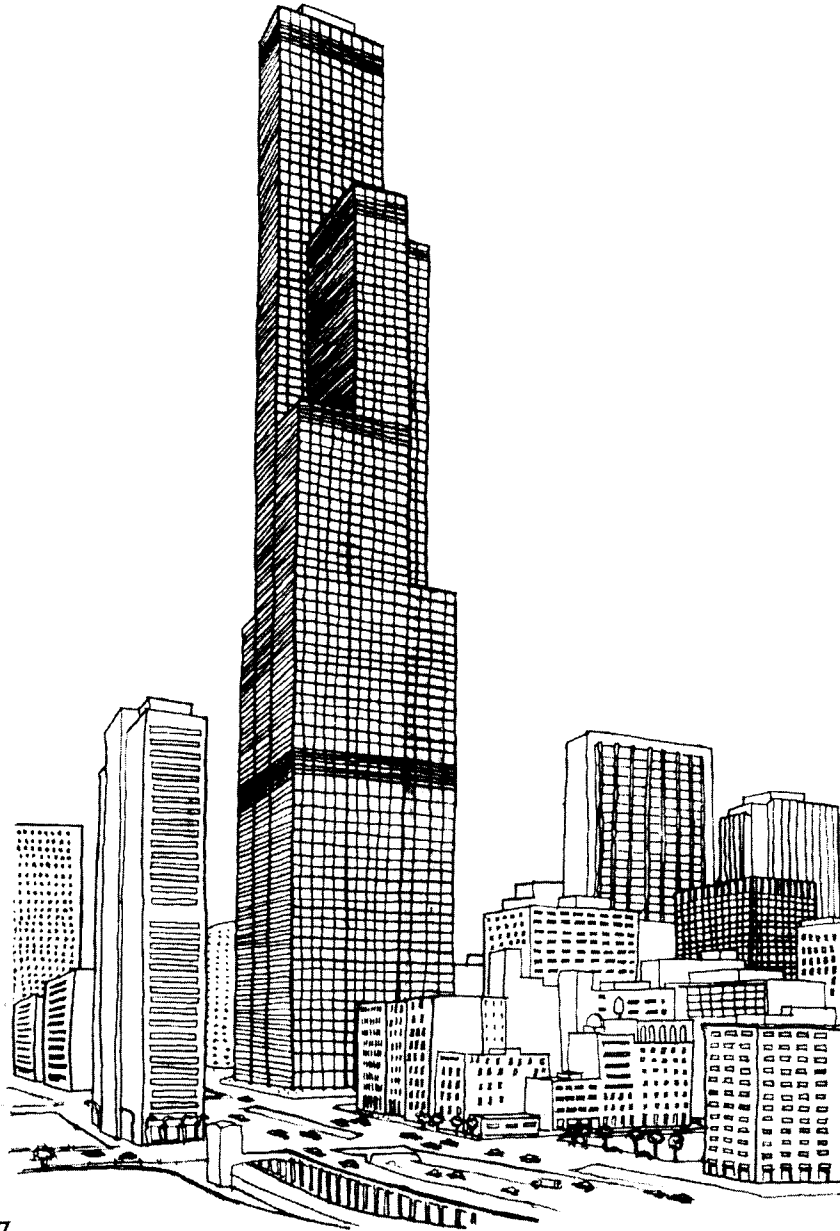
mountains, suspension bridges with cables of vegetable-fiber rope and walking decks of wooden planks had to be strung across (Figure 1.6). Gradually people learned how to use the materials they found in nature, such as stone, wood, and vegetable fibers.



Some of these structures, like the pyramids of Egypt, which were built over four thousand years ago to house the bodies of the Pharaohs when they died, were as high as 482 feet and used millions of heavy stone blocks. Others, like the cliff dwellings of the Indians of Arizona and New Mexico, built around 1,000 A.D., had as many as four floors. These houses were built on the rims of cliffs to make it difficult for the enemy to attack them once the ladders used to climb into them had been pulled up.

Now, thousands of years later, we still build houses; and although we do it often with man-made materials, like steel or bricks or concrete, we use the same skills our ancestors did to fight the same natural forces and to make sure that our buildings will not fall down.

We have learned to build high, but safely. There is a building in Chicago that is the tallest in the world. It is called the Sears Tower and is 1,454 feet tall. It has 110 floors, and yet it is perfectly safe (Figure 1.7). Modern men and women have also learned to build meeting halls, as their ancestors did, but they are so large that as many as 80,000 people can sit under the roof of one of them and watch a baseball or a football game (Figure 1.8). Their suspension bridges are made out of steel and can

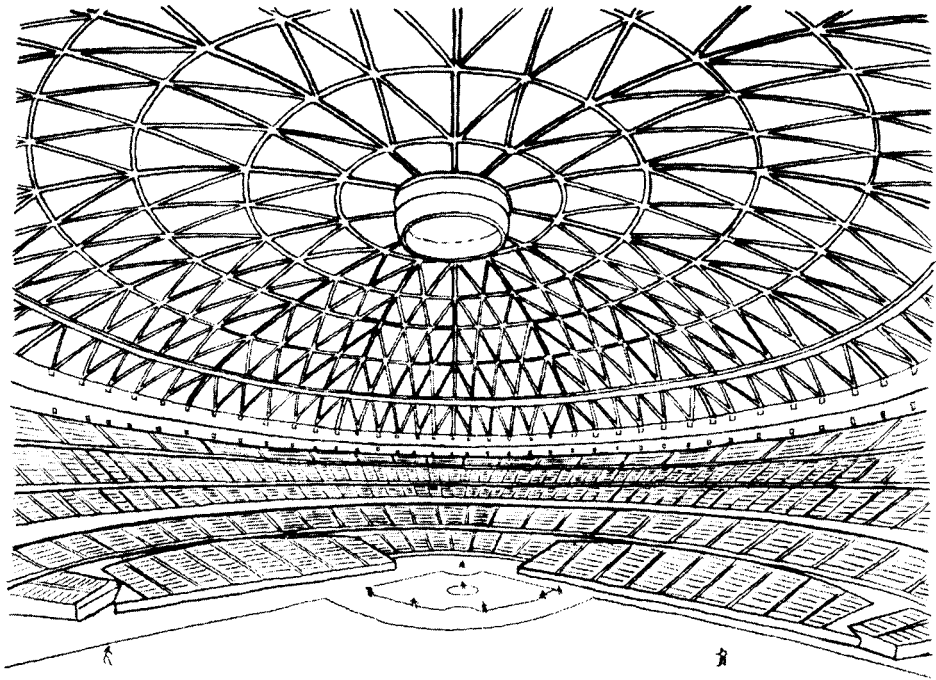


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cross rivers over 5,000 feet wide, but they are built on the same construction principles used in the fiber-rope bridges made by their ancestors (Figure 1.9).

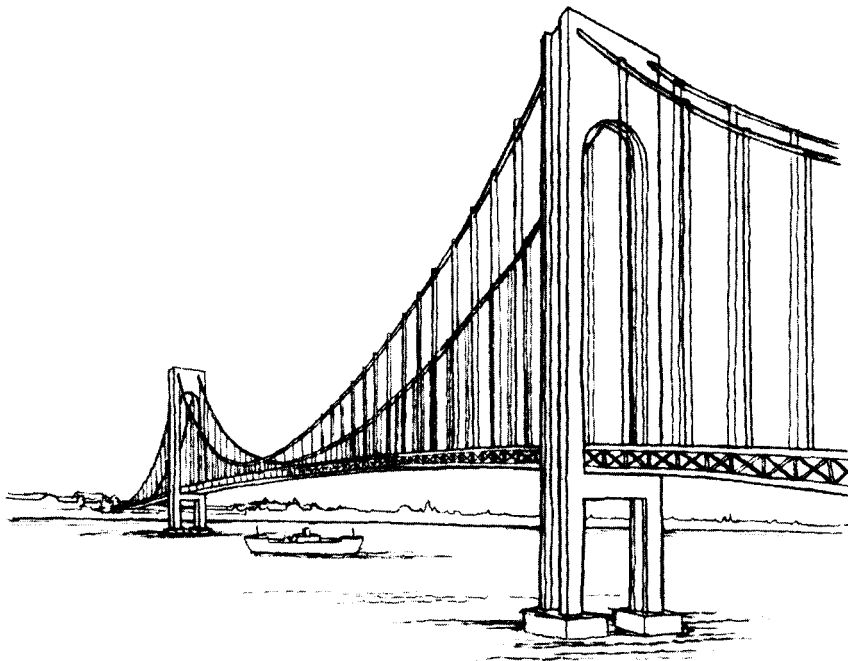
This book will show you how tents and houses and stadiums and bridges are built and how you can build some lovely small models of these structures by using nothing but paper, strings, ice-cream sticks or tongue depressors, glue, and pins.

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