Patents in Structural Engineering

By Christopher A. Rothe, Esq.

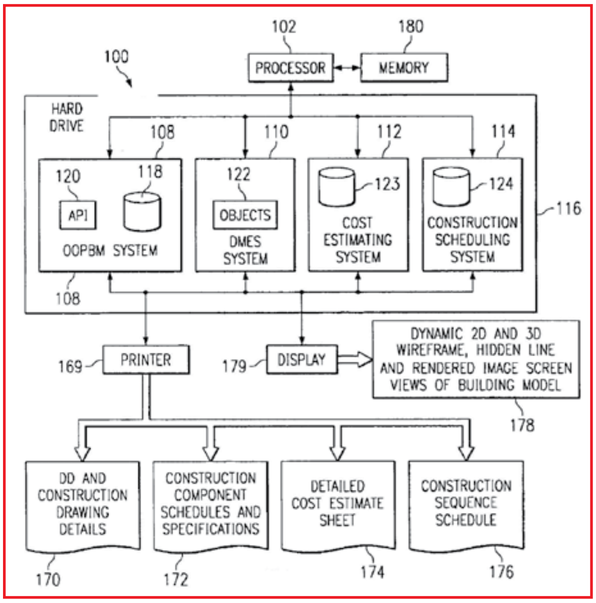
Engineers have obtained U.S. patents on important innovations for over two centuries. Some of the first engineers to obtain patents were structural engineers, many of whom did so between the late nineteenth and early twentieth centuries. Early U.S. patents reflect a time when engineers were busy designing and building America's infrastructure. This is evident in several early patents directed to trusses, bridges, dams and other public works.

Today, structural engineers concentrate their efforts not only on building new infrastructure, but also on maintaining, repairing and replacing the country's existing infrastructure. In addition, structural engineers are adapting to new technology, particularly computers and automated processes that reduce costs and increase efficiency. Moreover, structural engineers are focusing attention on projects related to energy, environmental concerns, natural disasters, antiterrorism and other issues that have received increased publicity in the last decade.

Building Information Modeling

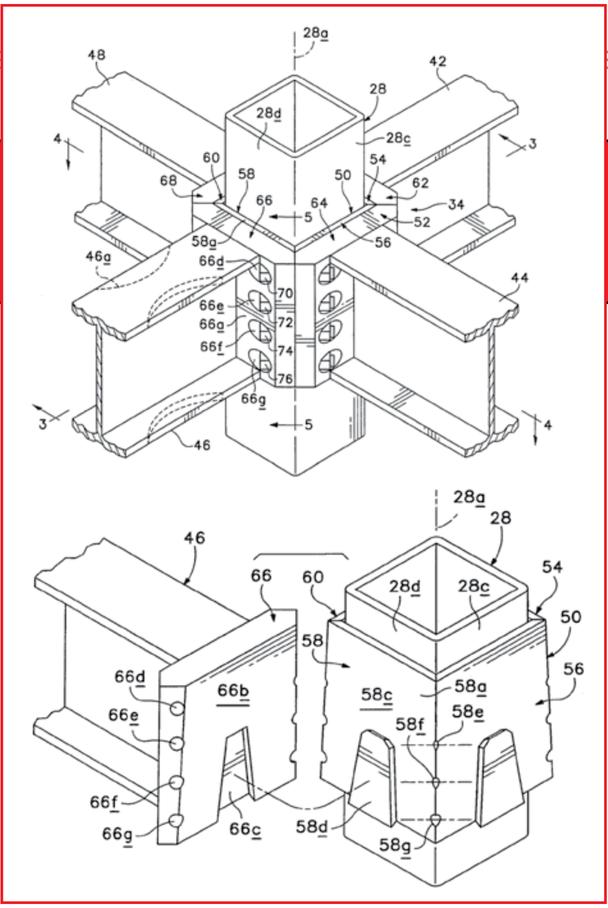
Engineers consistently look for ways to increase efficiency and reduce project costs. Computer-aided modeling is one means by which engineers have increased their efficiency. Systems have now evolved that integrate information from the architect, engineer and building contractor into a single system available to all parties on a design team. A number of modeling systems have been introduced, each with different features and functions. One example is described in U.S. Patent No. 6,859,768, which is directed to a "Computer-Implemented Automated Building Design and Modeling and Project Cost Estimation and Scheduling System." The inventor summarizes the system as a central source for all of the design and construction information for a construction project. The information is structured in a database that can be freely accessible to all members of an interdisciplinary construction project team. Examples of what can be stored in the system include design criteria, engineering formulas, manufacturer's specifications, sub-contractors' and suppliers' information, city codes and regulations, material specifications and client requirements.

In one version, the system includes computer software that is programmed to implement a number of systems, including an object-oriented parametric building ("OOPBM") modeler system; a design, modeling, estimation and scheduling ("DMES") system; a cost estimating system and a scheduling system. A block diagram of the basic system components is provided in *Patent Example 1*.



Patent Example 1: Figure 1 of U.S. Patent No. 6,859,768.

The OOPBM system is described as a system that enables graphical and non-graphical parametric objects to be defined and placed into a database. Elements, which are defined using a programmer's interface, are placed at accurate three-dimensional locations and orientations in a spatial database to assemble the building model.

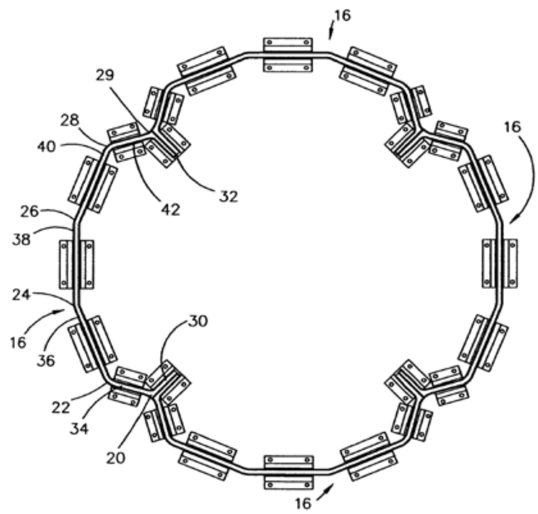


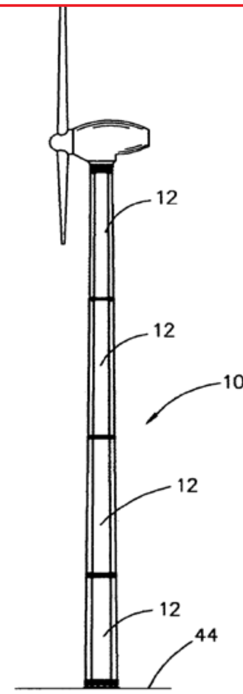
Patent Example 2: Figures 2 & 6 of U.S. Patent No. 7,021,020.

The DMES system includes elements created by the programmer's interface. Each element includes a set of internal functions and variables that contain formulas and values. Formulas and values encapsulate data from designers, engineers, specialists, manufacturers, city building codes and regulations. Elements are classified into different tiers, creating an assembly hierarchy that forms a logical sequence for assembly. Once elements are placed in the database, they pass and receive data from other elements in different tiers of the hierarchy until a complete building model is assembled.

The cost estimating system includes a database with local and regional unit cost information to be associated with materials, quantities, and other data contained in the elements. Cost data is compiled and turned into a cost estimate report for the entire project.

The scheduling system is a graphical scheduling database that creates graphs or charts to summarize the construction activities of a project. The graphs or charts may contain information such as dates, labor requirements, sequencing for construction, assembly and installation of the components and equipment of the building. The scheduling system identifies "critical path" activities to minimize overall project duration.





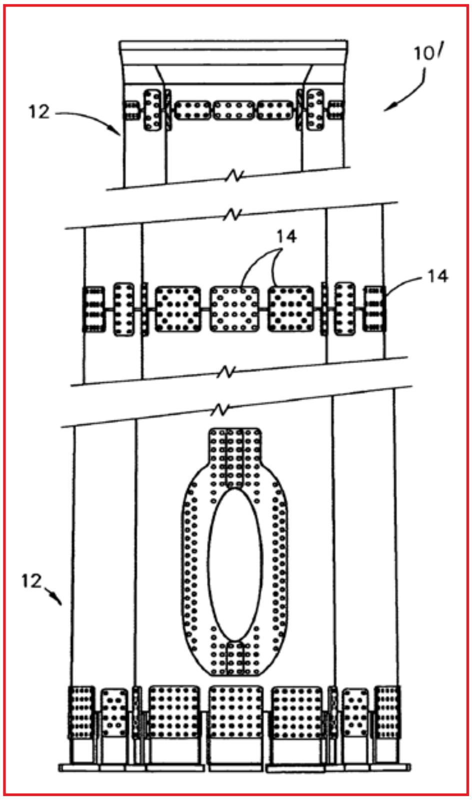
Patent Example 3: Figures 1 & 6 from U.S. Patent No. 7,360,340.

The various systems work together to generate a building design model and design documents. Because various sources of information are integrated, and data is functionally related, any changes made to a design parameter will result in additional computations and a redesign of the building model, down to the size, spacing and location of reinforcing steel. According to the inventor, the coordination of information increases the quality of design documents and the speed at which documents are produced. This coordination of information avoids on-site redesign issues that arise during construction due to poorly coordinated information. The relatively short time required to produce accurately coordinated design documents results in major cost reductions for the project.

Building Frame Construction

While some inventors seek to make the design process more efficient, others are developing ways to improve the construction process. U.S. Patent No. 7,021,020, titled "Moment-Resistant Building Frame Structure Componentry and Method", describes a frame interconnect structure intended to reduce the cost of steel erection. An example of the invention is described and shown as a collar assembly that joins ends of beams to columns at nodes of intersection. *Patent Example 2* illustrates one example of the collar assembly.

The collar assembly includes an inner collar structure that attaches around the perimeter of a column, and one or more outer collar structures, each of which is attached to the end of a beam. The inner collar structure has four sides facing outwardly, with each side having a wedge-shaped cleat. Each outer collar structure includes a complementary wedge-shaped socket that receives the cleat on one side of the inner collar structure. Beams are lowered into place, with the sockets of the outer collar structures being lowered onto the cleats projecting from the inner collar structures on the columns. The sockets and cleats nest with one another, forming a stabilized connection assisted by gravity. The bearing surfaces in the inner and outer collar structures are self-positioning and distribute moment loads to adjacent columns.



Patent Example 4: Figure 4 from '340 Patent.

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In a preferred version of the invention, the inner and outer collar structures are precision manufactured and pre-assembled with the columns and beams, respectively. According to the inventor, the preferred components can be manufactured economically under automated control processes. Because beams and columns are pre-assembled with the collar structures, construction is simplified.

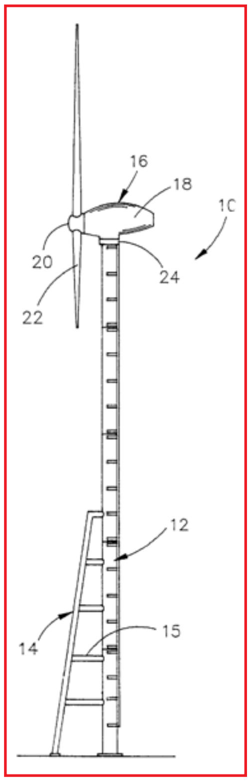
Renewable Energy Facilities

Structural engineers play a role in constructing renewable energy facilities, as shown in a series of patents directed to wind turbine tower construction. U.S. Patent No. 7,360,340 describes a wind turbine tower made up of tubular pole sections secured in an end to end relationship.

While a number of designs are suggested, the illustrated tower includes pole sections, with each section having four peripheral sections joined together. The peripheral sections are made from flat sheets that are bent or broken, resulting in a non-circular cross-sectional shape for the pole.

As shown in the cross-section of Figure 6 (*Patent Example 3, page 65)*, each pole section has 4 peripheral sections. Each peripheral section includes two end sections that join to end sections of adjacent peripheral sections, resulting in four inwardly extending portions with doubled wall thicknesses. The patent notes that the non-circular shape of the pole and the inwardly extending wall portions make it somewhat difficult to anchor the pole to a foundation. This issue is addressed with T-shaped connection members that connect the lower end of the lowermost pole section to a foundation. The T-shaped connection members are initially anchored to the foundation in a configuration matching the lower end of the lowermost pole section. Once the connection members are in place, the lowermost pole section is lowered onto the connection members and secured with splice plates. Once the lowermost pole section is attached to the foundation, the upper end of the pole section is connected with another pole section using additional splice plates (*Patent Example 4, Page 65*).

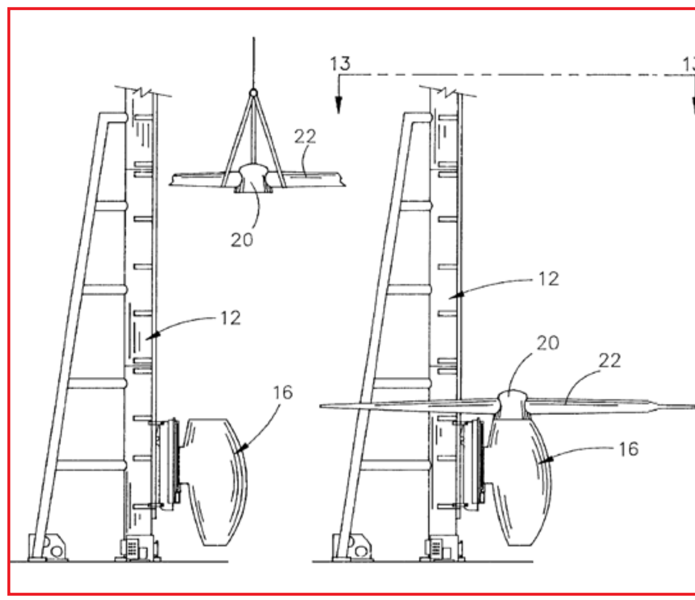
U.S. Patent Nos. 6,278,198 and 6,614,125 claim apparatuses and methods for mounting a wind turbine to the upper end of a tower. Wind turbine towers can reach as high as 70 meters (230 feet), requiring extremely large cranes to place the turbines. According to the patents, the costs of using such large cranes and operating them on site can be very expensive. Therefore, one of the objectives noted in the patents is to provide an alternative method for mounting wind turbines that does not require the use of large cranes.



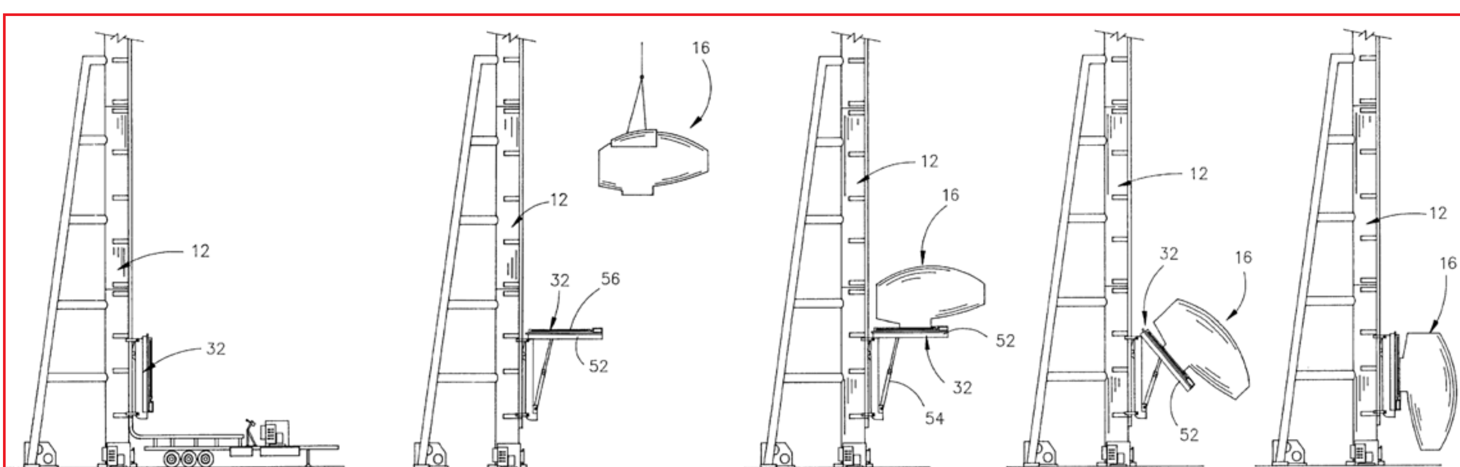
Patent Example 5: Figure 1 from U.S. Patent No. 6,278,198.

These patents describe a system that utilizes a carriage and guide rail system to mount wind turbines. A tower is erected with a support structure at the base that includes a pair of battered legs on one side of the structure. Braces secure the battered legs to the tower, which includes a pair of vertically disposed guide rails that extend from the lower end of the tower to the upper end of the tower (*Patent Example 5*).

In one method described in the patent, a carriage having a platform is placed onto the rails to travel up and down the tower. The platform pivots through an angle of 90 degrees between an approximately horizontal orientation and an approximately vertical orientation. Once the carriage is connected onto the rails at the lower end of the tower, the platform is moved to the horizontal position. A small crane then loads a wind turbine onto the platform. The platform is pivoted back to an approximately vertical position, after which a spinner/hub and rotor blades are assembled onto the turbine on the platform. (*See Patent Example 6 & 7*)



Patent Example 7: Figures 11 & 12 from '198 Patent in sequence.

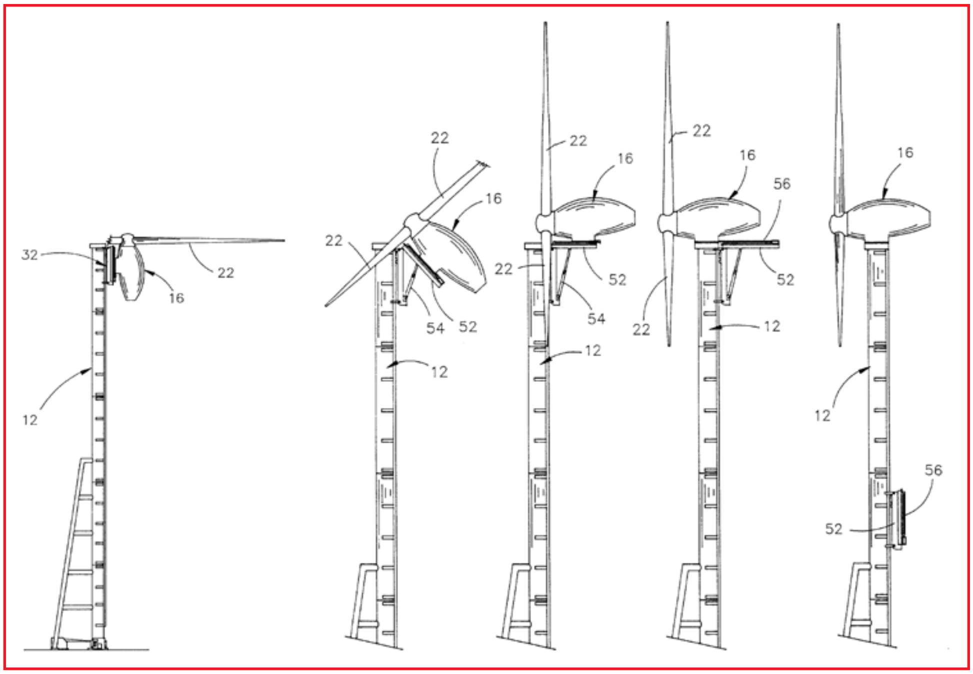


Patent Example 6: Figures 5, 7, 8, 9, 10 from '198 Patent in sequence.

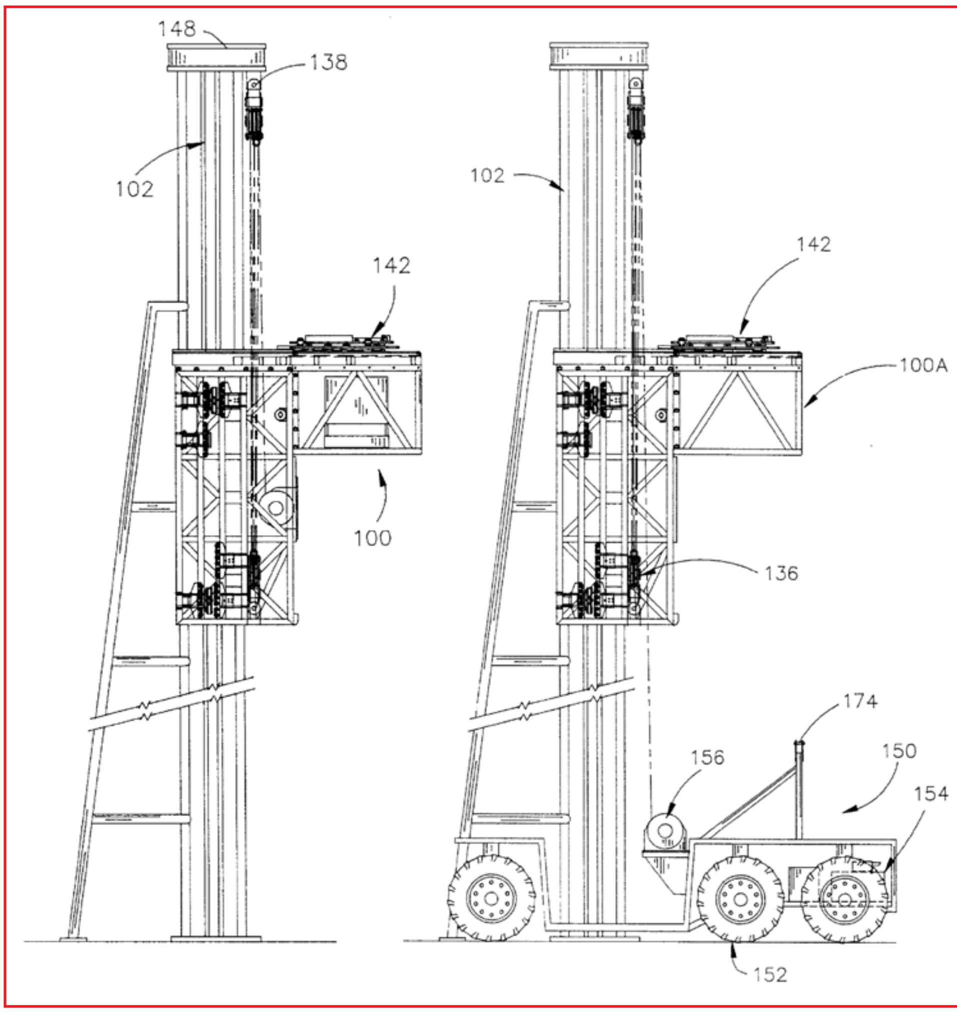
The platform supporting the assembled wind turbine is lifted along the rail system to the upper end of the tower by a winch located at the lower end of the tower. Once the platform reaches the upper end, the platform is pivoted ninety degrees back to the approximately horizontal position. The wind turbine is then advanced onto the upper end of the tower by a slide mechanism associated with the platform, and finally secured to the upper end of the tower. Once the wind turbine is secured, the platform is pivoted to an approximately vertical position, lowered to the lower end of the tower, and removed from the rails. (*See Patent Example 8*)

These patents belong to a family of related patents, each directed to different aspects of a system for mounting wind turbines on tower structures. U.S. Patent No. 6,888,264 is directed to the tower structure itself. In one example, the tower has a support structure at the base with a battered leg structure at one side of the tower, opposite the side on which the carriage and rail system is attached. The battered legs are connected to one another and to the tower by braces.

U.S. Patent Nos. 6,505,785 and 6,522,025 describe alternative methods for mounting wind turbines that utilize a sled to transport the wind turbine to the upper end of the tower. In one version, the sled is self-contained, with an on-board power source and a winch system that controls movement of the sled up and down the tower. In another version, the power source and winch system are located on a transport vehicle at the base of the tower that operates the sled, and transports it from one tower to another when there are multiple installations. (*See Patent Example 9*)



Patent Example 8: Figures 14, 15, 16, 17, 19 from '198 Patent in sequence.



Patent Example 9: Figures 31 & 37 from U.S. Patent No. 6,505,785.

For More Information

For more information on the patents discussed in this article, and other structural engineering patents, the reader can visit the U.S. Patent and Trademark Office's website (**www.uspto.gov**), which provides a searchable data-base of issued patents and instructions for viewing patent documents.▪

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