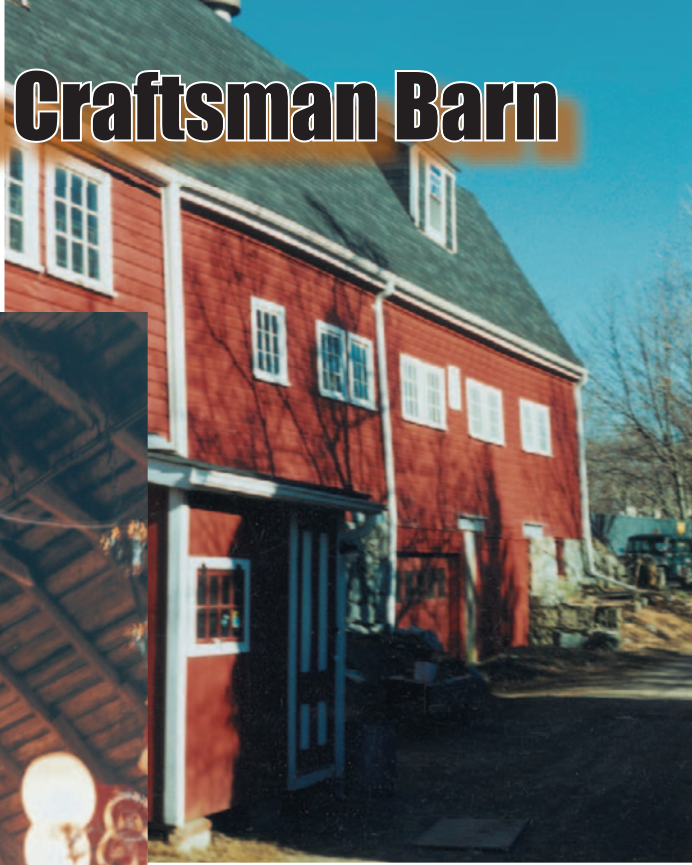
How to "Right" the Yankee Craftsman Barn

Cabled Tension System Returns Barn to Stable Vertical Position

By: Craig E. Barnes, PE, SE



Side of barn

Roof interior

The Yankee Craftsman barn, constructed in 1933 in Wayland, Massachusetts, was sheathed with horizontally arranged timber boards overlain by wood clapboards. The footprint of the structure is 38'-6" x 85'-0". Typical barn construction utilizing flagstone looselaid foundation, a first floor wood frame and a partial mezzanine at the front entry to the barn was utilized. The purpose of the barn in 1933 was for livestock and storage of hay.

In more recent years, the barn has been utilized as an antique display and sales shop for classic antiques. Circa 1994, the owner became very concerned because of the sidesway action that the barn was undergoing as it displaced to the east. Through the years, the rear wall of the barn lost its ability to act as a vertical diaphragm (shear wall) and, lacking any type of horizontal diaphragm within the barn structure, had displaced as much as 6-inches at the eave line.

Additionally, the barn had experienced water intrusions, which over time rotted away some portions of the eave and several roof rafters. The front wall of the barn, which contained the double slide door entry where farm equipment used to pass, has for years faced the farmhouse and street. For appearance reasons, this front wall received greater attention and maintenance than the rear wall. The rear wall appeared to have been totally neglected. Construction consisted of vertical studs, some of which extended 14-feet high, uninterrupted. Clapboards were applied directly to studs, and through the years had shrunk and deteriorated to the point where light freely passed through the entire wall system. With many years of weather exposure, whatever securement there had been between clapboards and studs had loosened to a point where the rear wall was laterally deflected almost as much as internal portions of the structure.

CBI Consulting became involved at the request of John Carmen, formerly of CBI Consulting Inc., who had a long standing relationship with the Sweeney family, the owner's of Yankee Craftsman. The Sweeney's came to John following a review of several engineering proposals intended to stabilize and/or reconstruct the building. From a stand-point of stabilization, original proposals called for buttressing and/or reinforcing, and had given no thought to re-establishing the alignment of the building. As a separate effort, previous engineering proposals had discussed a partial reconstruction as a possibility to establish the appropriate alignment of the building.

Following meetings at the site with the Sweeneys, John Carmen, and Craig Barnes, P.E., it was agreed to explore a process by which the barn could be returned to a stable vertical position by the use of a cabled tension system. The rationale for this was quite simple. Considering the barn had taken years to gradually sidesway logically then, through a process of gradual tensioning of a system of cables appropriately placed for maximum

Load distribution angle at first floor

Cables passing through floor

Front elevation at completion of "righting"

Stiffening channel at Eave 1

benefit, the barn could be returned to a vertical position, also over a number of years. Certainly the return of the barn to its original position could be accomplished in a more efficient fashion than it had taken Mother Nature to displace the barn initially. Thus the concept of controlled tensioning was born.

At the same time the tensioning concept would be implemented, a carpenter would be engaged to replace the rotted elements. The carpenter would also tighten and secure elements of construction that were questionable given practices of barn construction existing many years ago.

Considerations

1. How to develop a load system to move the structure at selected spots. Next; how to develop a system and procedure that would not disrupt the ongoing retail function. It was imperative that the barn continue to operate as a retail showroom.

2. How to distribute loads so that existing frail construction could either be reinforced or maintained without being excessively loaded. Could the building be pushed and/or pulled to be able to establish realignment? What would the reacting mechanism be for the imparted loads?

3. The barn, being of typical open roof construction and in this case with the hay storage mezzanine only partially through the building, would have a tendency to act like a giant thin shelled membrane being subjected to a concentrated load. How would a concentrated load effect the wall roof combination?

4. What kind of time frame would be necessary to return the barn to a tolerable position? Once the barn was returned to a near vertical position, what structural system would be necessary so that, with the restraining force removed, the barn would not return to its sidesway condition?

Solutions

1. It seemed reasonable to attempt the use of cables as the most efficient system to impart load to the structure. Cables by their very nature would impart load in one direction only. This could be done by bringing loads from the eave line diagonally back through the building. Cables were arranged to go from the eave line diagonally though the building to a line of stiffened elements of the first floor framing.

2. Loads from the cables would be distributed to the wood structure by the use of channels and angles.

3. With no accurate way to determine the force that would need to be applied to the cable to move the barn, creative solutions were in order. We estimated that, at a minimum, the magnitude of wind loading that had perhaps initiated the displacement through the years would be necessary to return it. Using this reasoning, cables were sized to take ¾ of the potential design wind load required under the current code. This calculation and the placement of the cables resulted in minimum ⅜-inch-diameter rope cable. Essentially, practical location and installation of the cables became the control rather than the actual loads that were to be applied. The stiffening elements of the structure needed to resist the load, however, were sized not for the cable capacity, but for the ¾ wind load.

4. Perhaps the most important aspect of reinforcement for distribution of concentrated tension loads was the creation of a first floor diaphragm. The diaphragm would distribute the horizontal cable loads to newly established vertical braces.

5. In order to track the movement of the structure through the periodic tensioning process, measurement points were established by dropping plumb bobs through various locations of the building, tied into the first floor level at the base. We were fairly confident that, once reinforced, the first floor framed structure would be relatively stable and could act as a baseline. Measurements were established to be able to track the building movements both in the north-south and in the east-west direction, and to be able to track the deformation of the roof structure. Additionally, inclinometers were placed on posts within the structure beneath the first floor level to track column tilt. The inclinometers would be helpful in determining whether or not the concept of the first floor base being a permanent benchmark was indeed accurate.

With everything in place, the tensioning started and the rest is history. Over a period of five years, the structure was "righted". Not unexpectedly, tensioning over time revealed the stiffness differences of the structure. This required slight adjustment to the sequence

Inclinometer on wood column

Stiffening channel at Eave 2

and the number of turns on a particular clevis. With deformation as a guide, and a system designed for ¾ wind load, there was no need to gauge the force level in the cables. Had the structure not moved when tensioned, we were prepared to install additional cabling.

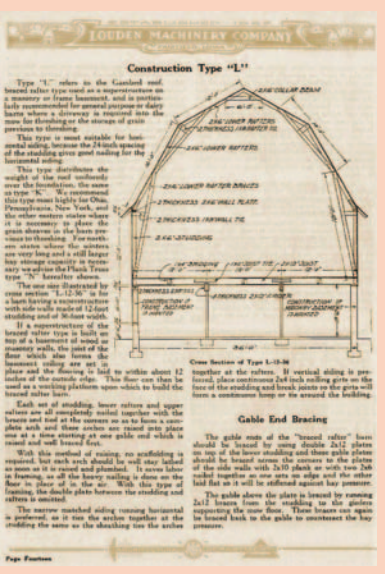
At the end of the five year period the rear wall was reconstructed to function as a shear wall. All things being equal, in 70 years another engineer may repeat our effort.■

Craig E. Barnes, PE, of CBI Consulting Inc., has over 38 years experience designing, coordinating, and managing structural and civil engineering projects throughout New England. Mr. Barnes has designed governmental, educational, industrial, and residential projects utilizing all types of construction and materials

Louden Barns

By: Ben Brungraber & Jim DeStefano

In 1867, William Louden formed the Louden Machinery Company in Fairfield, Iowa. He was an inventor and innovator in Dairy Farming whose contributions to agricultural technology rivaled those of Cyrus McCormack and John Deere. His company produced machinery, hardware and accessories for dairy farming, including his patented hay carrier that allowed hay to be efficiently stacked high in barns.



The hay carrier ran on a monorail track suspended below the ridge of a barn. This device had made the small, timber framed barns of its time obsolete. Many older barns were retrofitted with Louden's hay carriers. Since the timber tie beams were often in the way, they were routinely cut away, resulting in the premature demise of the structure.

In 1919, The Louden Machinery Company published a book of pre-engineered barn plans that could be built by farmers with limited carpentry skills. This turned out to be a brilliant marketing strategy. If farmers could be persuaded to build new and larger dairy barns, they would need to purchase products manufactured by the Louden Machinery Company to equip the barns. They provided a plan service to farmers, furnishing detailed blueprints, and on occasion they would actually build the barns. The standard barn plans came in widths from 24 feet to 40 feet and lengths up to 200 feet.

Louden Barns were framed entirely out of light dimensional lumber with simple lapped and nailed joints. The barns were designed to use standard lengths of lumber so that very little cutting would be needed to assemble the structure. This was a radical departure from timber framed barns, whose mortise and tenon joints required considerable skill to execute.

The barns typically had gambrel roofs that spanned over tall, column free hay lofts. The lower level of the barns housed the cow stalls and milking gallery. Louden developed an innovative system for ventilating foul air from the lower level up through the roof, since good light and ventilation were essential to a healthy dairy herd.

It is estimated that prior to Louden's death in 1931, over 25,000 Louden Barns were built around the world.

A CD of Loudon Barn Plans is available from
www.historybroker.com/cds/cd23.htm