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ASSESSMENT OF FAILURES OF POST-FRAME BUILDINGS IN NEW YORK STATE DUE TO SNOW LOAD

by

C.A. Gooch, P.E. and K.G. Gebremedhin
Senior Extension Associate and Professor, respectively, Dept. of Ag. & Bio. Eng.
Cornell University, Ithaca, NY 14850

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A series of winter storm events during early January, 1999 resulted in significant accumulations of precipitation in many areas of New York State. Several agricultural structures failed as a result of the excessive snow load. Many of these were post-frame buildings constructed to house dairy cattle. A field investigation was conducted with the objective of evaluating why the buildings failed. A total of seven buildings were evaluated and are presented in this paper. Most buildings failed because of insufficient bracing of truss members. In all instances, buildings that had been repaired or replaced exhibited insufficient bracing and/or inadequate structural connections.

Failures, Snow loading, Post-frame construction, Building code, Dairy housing

Assessment of Failures of Post-Frame Buildings in New York State Due to Snow Storm

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C.A. Gooch, P.E.[1] and K.G. Gebremedhin[2]

Introduction

The accumulation of snow and ice on roofs resulting from a series of winter storm events in New York State during January of 1999 caused several agricultural building failures. Winter storms started dumping significant levels of snow, sleet and freezing rain during the first full week of January. Precipitation continued to accumulate during the following week with continuous below freezing conditions. Building failure reports began to be received at Cornell University on January 14th. Many agricultural structures, some new and many older ones failed as a result of the accumulation. An exact number of building failures is impossible to ascertain but it is estimated that over 100 failures occurred in the region in and around Wyoming County (Western Central New York). One newspaper reporter reported an estimated loss approaching 50 farm buildings in Wyoming County alone (Vrooman, 1999). Also, a significant number of failures occurred North of the Finger Lakes region.

Approximately one week after the failures took place, we visited several farms in two different regions that had reported problems to their respective county extension offices. Five farms were visited in Wyoming County and two in Cayuga County. Both of these Counties are major dairy production areas in New York State.

Background Information

Failure of a dairy barn can be a major economic disaster for the dairy producer. The loss may not be limited to failure of the building but also potentially loss of some or all of the cows occupying the building. Without construction insurance coverage, such an advent may cause the producer to go out of business.

Most new dairy housing facilities constructed in New York State are of post–frame construction. The outer cladding is either corrugated steel or aluminum or a combination of both. Curtain sidewalls are readily used in many new facilities to facilitate ventilation. The sidewalls on the majority of the older facilities are either completely or partially covered with cladding. A significant number of dairy barns are not engineered or are only partially engineered (usually trusses only).

The older facilities typically have internal moisture problems as a result of inadequate ventilation. Historically, New York dairy farmers prefer buildings that minimize heat loss in the winter in order to keep the working environment more comfortable for the animal caretakers. This creates wet in-service conditions. More recently, mostly due to the invention of curtain sidewall systems, New York barns are better ventilated and seem to have less issues with biodeterioration of structural members.

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[1]Senior Extension Associate, Dept. of Ag. & Bio. Eng., Cornell Univ., Ithaca, NY 14850
[2]Professor, Dept. of Ag. and Bio. Eng., Cornell Univ., Ithaca, NY 14850

Dairy producers, like most other business managers, are interested in making purchases at the least cost. Obviously, there is nothing wrong with this philosophy. However, many producers loose site of the true cost of the facility over its anticipated life and focus on initial cost only. For perceived budgetary reasons, some producers cut back on some of the important details that go into a structure in order to keep it initially affordable. One such item is requiring a complete engineered structural system.

Performing a complete structural design of the building, to ensure that it will safely endure storm events of acceptable frequencies, is imperative. A prudent designer will follow the appropriate building code, ensuring that the design loads for the area are adequately supported. Loads are safely and effectively transferred to the ground through designed structural elements.

New York State Building Code

Unlike the other states in the country, New York and Wisconsin have their own building codes. The other 48 states either follow the Basic Building Code (BOCA), Uniform Building Code (UBC), or the Standard Building Code (SBC). The state codes are not necessarily equivalent to the current model codes used in the majority of the country (Carson, 1997). Bohnhoff (1999) reported that a new building code, the International Building Code, is in the final stages of development and will supersede the existing model codes in the near future.

The design snow load for New York State varies immensely by region. The ground snow loads for various regions in the State as required by the New York State Building Code (1999) is shown in Figure 1.

Building loads caused by snow accumulation are difficult to accurately predict. For instance, light, freshly fallen snow may have only one-twentieth the density of water, while wetter snow may have a density of one-third that of water (Carson, 1997). Based on this information, Table 1 was developed to give the reader an idea of the depth of snow required to achieve a design snow load value.

Additional difficulties result from the uneven distribution of snow on the roof of a building causing unbalanced loads. Two to four times the design load can occur where drifts, ice dams, or sliding snow build up (Carson, 1997). This can commonly occur:

- near projections above the general roof level
- at intersecting roofs
- at sheds below and beside a higher roof or silo, or
- on projecting eaves.

Equally difficult to take into account is the layering of various forms of winter precipitation. Layers of snow, ice, snow, ice, etc. are not addressed in the New York State building code. This is probably not a major reason for concern from a design standpoint. It could, however, become a significant issue if building owners are entering

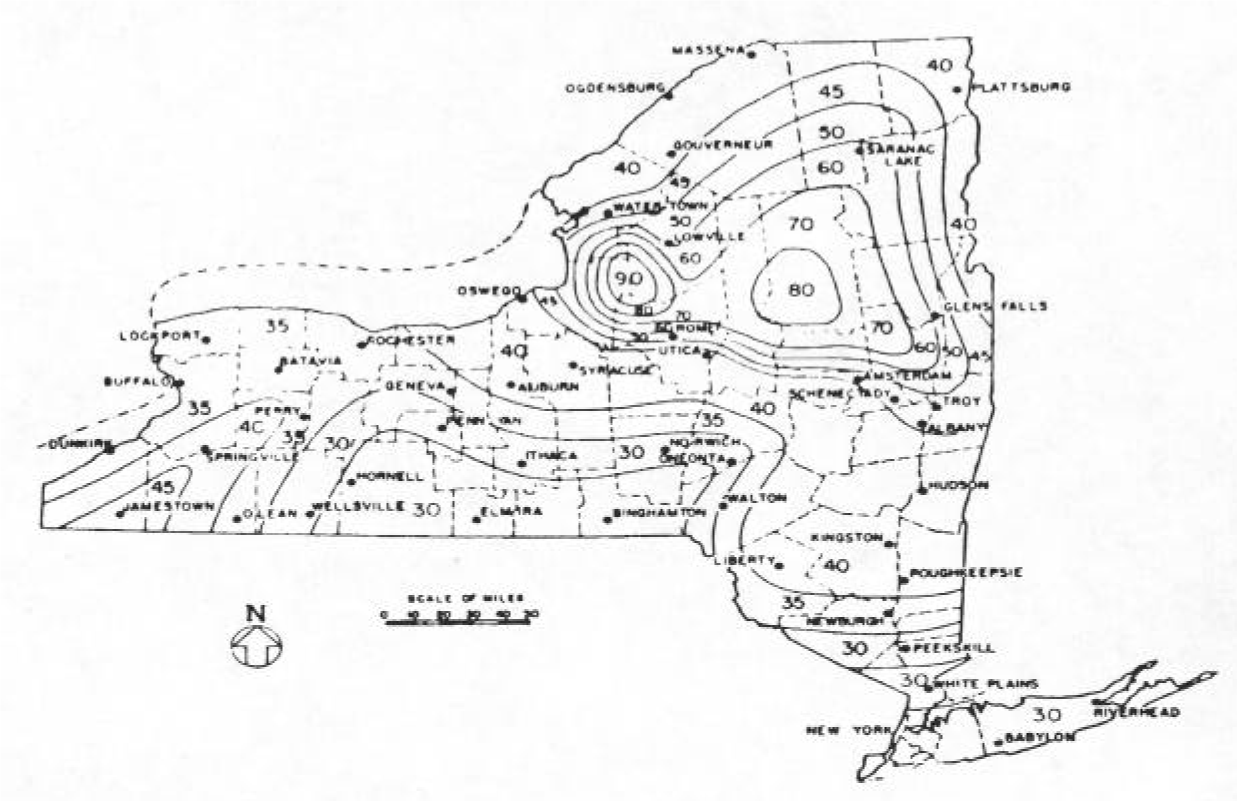

Figure 1. Basic ground snow design loads (NY State Building Code, 1999).

Table 1. Snow load based on accumulation depth.

Snow depth on roof (ft.)	"Dry snow" (lbs./sq. ft.)	"Average snow" (lbs./sq. ft.)	"Wet snow" (lbs./sq. ft.)
1	3	12	21
2	6.5	24	42
3	9.5	36	62
4	12.5	48	83
5	15.5	60	104

into litigation over a failed structure and the in-place ground snow load needs to be determined to check if it exceeded the design snow load for the area (i.e., did the storm exceed the 50 yr. design value?).

New York State Building Code (1999) Section 651.3 states:

> *"The requirements of this subchapter shall not apply to non-residential farm buildings including barns, sheds, poultry houses, and other buildings and equipment on the premises, used directly and solely for agriculture purposes."*

As a result, large (2,000 plus cows) dairy housing and associated milking facilities are constructed without code compliance. Major structural systems are not always engineered, electrical systems may not conform to the National Electric Code, and Life

Safety and fire codes are totally unheard of. Yet, significant capital investment is made in the facility, and large numbers of people and cows may occupy them 24 hours a day, 365 days a year. Under this scenario, protection of life and property is not adequately insured.

The need to follow a building code doesn't go unnoticed by the agricultural construction community. William Miller, Wyoming County, New York Code Enforcement Officer (1999), reports that at least one major post-frame contractor who regularly builds in the county, attempts to obtain approval of his agricultural building package for a non-agricultural applications. Mr. Miller indicated that he has found the company's design of agricultural buildings to be non-code complying from a structural standpoint. To receive approval, inadequate members must be increased in size or replaced with a higher stress-rated material.

Engineering of Dairy Facilities in New York

Dairy facilities in New York State vary immensely relative to the level of design and engineering incorporated in any one structure. There are many new and large dairy facilities recently built with little or no structural design. Additionally, there are facilities constructed, renovated, or repaired by construction crews unfamiliar with proper construction techniques needed to adequately carry or transfer loads.

There are also dairy facilities that exemplify sound engineering design and quality construction. Most of these facilities are pre-engineered and are built by major post-frame companies. A smaller number of dairy facilities are constructed by local builders, who have in-house engineering expertise or hire services from outside. Reportedly, a few dairy producers are hesitant in using some of the larger pre-engineered building firms because the firms are sometimes unwilling to make the desired changes to their standard building packages to meet specific needs of the farm (McMahon, 1996). This attitude has driven a few dairy producers to go with alternative building suppliers or contractors who may or may not be providing an engineered structure.

Only Trusses are Typically Engineered in Dairy Facilities

More times than not, the truss system is typically engineered by a truss manufacturer. Most truss manufactures have computer software to design trusses for a given application. A major problem lies in that rarely is truss design incorporated into the overall building design. Contractors who don't build fully engineered buildings, many times, procure engineered trusses for their buildings. However, the contractor may fail to provide adequate structural connections to secure the designed trusses to posts or headers in a manner to form a complete building system. Unknowledgeable contractors, for example, install knee bracing connecting the truss and the post incorrectly without the truss designer's knowledge. One common mistake is connecting knee bracing to the bottom chord of a truss thus creating secondary stresses on the bottom chords for which the bottom chord may not be designed to handle.

Communication Between Contractor and Truss Designer

In the case of a complete and comprehensive set of engineered drawings to build from, some communication may be needed between the engineer of record and the contractor. In the case when only the truss system is designed or engineered, contractors may not be knowledgeable as to how to properly install, secure, and brace trusses. Prudent truss manufacturers should provide a copy of HIB-98 Post Frame Summary Sheet, *Recommendations for Handling, Installing, & Temporary Bracing Metal Plate Connected Wood Trusses Used in Post-Frame Construction* (TPI, 1998) to their customers. Steve Youngs (1999), Plant Manager for P&R Truss Company, told us that they always provide copies of HIB-98 to building contractors who install their trusses. He also stated that, many times, the information is disregarded by the contractor when the building is being constructed for an agricultural application.

Structural Issues Related to High Moisture Environment

Traditionally, dairy facilities have been poorly ventilated. Poor ventilation results in high levels of gases and moisture accumulation in the building. Wood absorbs moisture until it reaches equilibrium with the surrounding barn air. When moisture levels are sufficiently high, microorganisms grow and consequently cause biodeterioration of structural members. The rate of structural deterioration depends on many variables: type of wood, treatment of wood, moisture level, temperature, and degree of exposure, to list a few. The structural characteristics of the members are compromised resulting in a reduced strength.

Collapse Insurance for Agricultural Structures

The subject of insurance as applied to agricultural facilities is of particular interest. Because the State of New York does not require agricultural facilities to follow a building code, one would think that the insurance industry would be cautious as to what type of buildings they would be willing to insure. Personal communication with two insurance industry representatives (Grover Ellwood, and Bruce Porter, 1999) revealed that the following are the major items that their companies consider when evaluating a potential building to be insured: age of structure, type of construction, condition of structure, occupancy of building, alterations to building, and history of farm relative to claims.

While these items help form an overall criteria for a decision, what is lacking is compliance with a building design code. Mr. Porter (1999) added that one item that his agency takes into consideration is whether or not the building was built by a contractor. As was discussed previously, at least one contractor in the area is knowingly constructing buildings for his clients that do not conform to design snow loads for the region.

Mr. Porter (1999) did mention that when a dairy producer wants to insure his new facility, his insurance company prefers to see professional engineer stamped drawings for the building(s). He further indicates that the field agents, who 90 plus percent of the time make the final decision as to whether to offer coverage or not, do not have the appropriate training to evaluate a structure relative to compliance with the intended design. Their judgement is based on general visual inspection. This is not to say that insurance companies do not realize what is going on in the field. It appears that they are able to overcome these shortcomings by offering collapse insurance to their customers at rates that are sufficiently inflated to cover the higher probability of future claims. Mr. Porter (1999) indicates that a dairy producer is offered a reduced insurance rate if the structure is designed by a professional engineer.

It generally appears that insurance companies are willing to offer insurance for major agricultural structures that are occupied by a large number of cows and a significant number of people. Yet, they are not in any way subjected to follow any building, electrical, fire, or life safety codes.

Case Study Objectives
The objectives of the case studies reported herein were:

1. To access the reasons for the failures based on an in-field observation. If failure did not occur, to evaluate the existing structure for structural problems observed by the owner.

2. To evaluate the repairs made to failed structures, if any.

3. To look for a common structural deficiency or pattern of failure of the buildings that failed.

The following pages provide a summary of seven dairy barns we visited that were significantly impacted by the snowstorms. The first five barns were located near Perry, New York. These barns were visited on January 23, 1999. The last two barns, located north of Auburn, New York, were visited on January 28, 1999. We did not choose which buildings to visit. Local Cornell Cooperative Extension Educators made the arrangements based on reports they had received from dairy producers in their respective counties.

Not all of the barns we visited collapsed as a result of the storms. Some partially failed while others were saved as a result of the snow being shoveled off the roof. Because of the timing of our visits relative to the time of failure, we did not have the opportunity to observe undisturbed failure scenes. However, we did see many of the repairs that were being put in place and commented on them as much as possible.

For each case study, information is provided that explains the general description of the building, information that was provided by the owner, and our own observations.

Case No. 1

General Building Description:
The building in Case No. 1 was constructed in two phases. The original part of the building was built by a local contractor in 1980 using post-frame construction. It was 56 ft. wide, 156 ft. long, and nominal 12 ft. high sidewalls. Solid 6x6 sidewall posts were

spaced 8 ft. on center. Attached to this building in the longitudinal plane was a 58 ft. wide, 140 ft. long, 14.5 ft. high post-frame addition built by a major pre-engineered post-frame company in 1996. This addition had 3-ply 2x6 laminated columns spaced 10 ft. on center. A small lien-to addition attached to the original building was located adjacent to the old building/new building interface. Both the original building and the new addition were used to house dairy cows.

Owner Observations and Comments:

Neither the original building nor the addition failed due to the 3 plus ft. of snow accumulation on the roof. The owner indicated that the accumulation was not homogeneous. It was a mixture of 2 to 4 in. of snow followed by a layer of ice, then some more snow and again a layer of ice, etc.

Based on significant visible lateral deflections of the compression web and bottom chord members of the trusses in the original building, the fire department was called in to shovel the roof. Twenty to thirty men worked for several hours to remove snow from the roof. A large volume of snow on the upper roof was transferred to the lien-to addition roof causing increased loading. A barn employee recalled hearing creaking and groaning in the area of the lien-to addition and reported this to the shoveling crew. Efforts were re-directed towards shoveling snow from the lien-to roof and it was saved.

The farm owner reported a significant accumulation of blown snow on the first three bays of the old roof immediately adjacent to the new addition (the addition had a higher peak than the original building). This resulted in an unbalanced snow load on the roof. The owner reported seeing no significant deformations in the new building.

Evaluation of the Truss Construction:

The truss configuration of the original building is shown in Figure 2. Top and bottom chords were 2x8's and web members were 2x4's. Trusses were spaced 4 ft. on center. The owner commented that the web members marked ① deflected approximately one foot out-of-plane and those members marked ② also deflected significantly. The calculated slenderness ratios for the web members marked ① and ② are 90 and 79, respectively. These values exceed the allowable limit of slenderness ratio of 50 (National Forest Products Association, 1991). Lateral bracing of these members would be appropriate to reduce the unsupported buckling length.

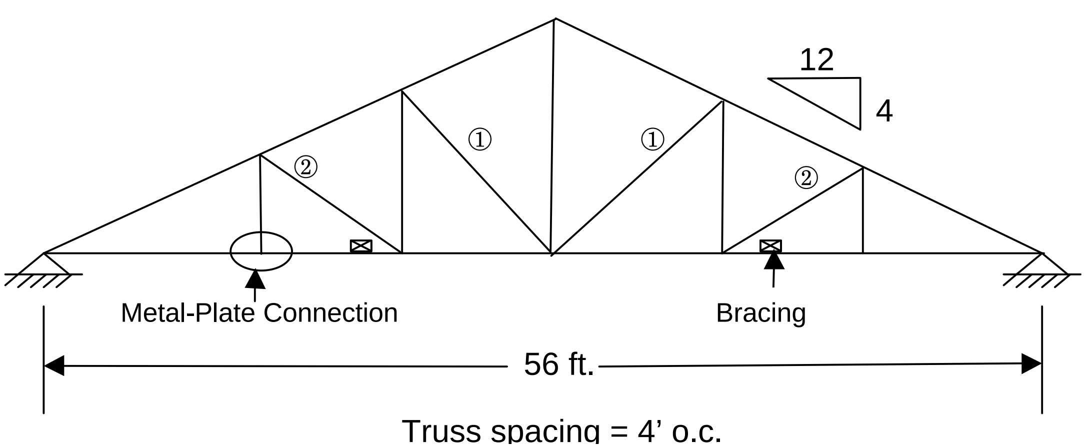

Figure 2. Truss configuration of the original truss for Case No. 1.

The truss configuration of the new addition is shown in Figure 3. Top chords are 2x12's, bottom chords are 2-2x6's stacked on edge, starred (*) web members are 2-2x6's and the rest are 2x4's. These trusses were spaced 10 ft. on center. Visual observation showed that the trusses lack bottom chord, web, and diagonal bracing members.

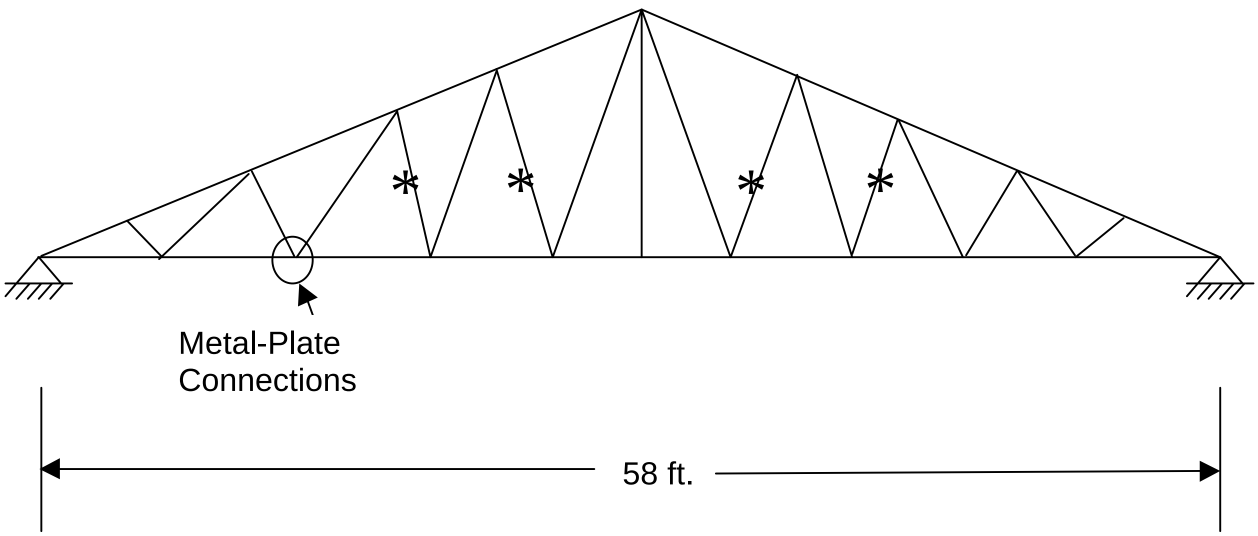

Figure 3. Truss configuration of new addition for Case No. 1.

Case No. 2

General Building Description:
This structure was originally built in 1966 for lactating-cow housing. More recently, it was renovated to heifer housing during a herd expansion. All original structural members were constructed from rough-cut Hemlock. Trusses were fabricated on-site based on a design provided by an extension agricultural engineer (Figure 4a). Rough-cut Hemlock gusset plates where nailed to truss members to form joints. Visual observation revealed that several of the gusset plates were split and also cupped. This may be because the wood was "green" during truss construction. The building had an east-west orientation.

Poor ventilation exists in the building due to the presence of low sidewalls that could only be partially opened. The owners reported significant deterioration of the nailed joints and they attributed it to the moist environment. Initial deterioration was probably higher then it is at present due to the higher moisture generated by lactating cows that originally occupied the building.

Owner Observations and Comments:
Snow accumulation was about 4 to 4-1/2 ft. on the North side of the building and approximately 1-1/2 ft. on the south side. This loading caused the center of the trusses to deflect about one foot downward at mid-span. Noticeable was the large gap that developed between the butted ends of the two members forming the truss bottom chords. The connection at the butted ends was a wooden gusset plate located at mid-span.

Failure of the trusses occurred in the 2nd through the 4th or 5th bays located in the northeast corner of the building. The owners jacked the bottom chord of the remaining standing trusses back to their approximate original position and supported the trusses by placing 2 - ply 4x6 posts at the mid-span of each truss. After this was completed, the roof was shoveled to remove the remaining snow. The remainder of the building was saved.

Evaluation of the Original Truss and The Repairs Made After Failure:
In the original truss configuration, under ideal vertical conditions of the truss, the center and the other two vertical web members are zero force members (Figure 4a). This means that no force is transferred by these members from the top chord to the bottom chord. Hence, the truss can be considered as one big triangle.

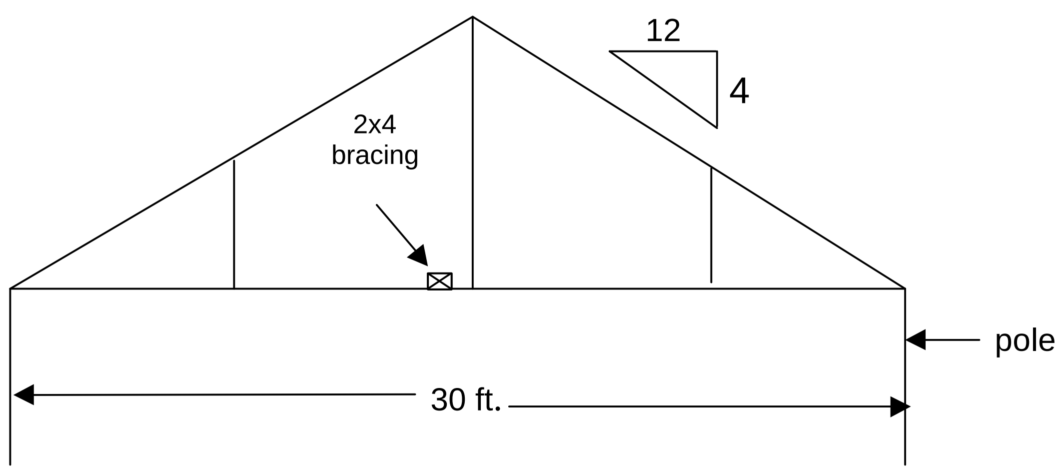

Figure 4a. Truss configuration for Case No. 2.

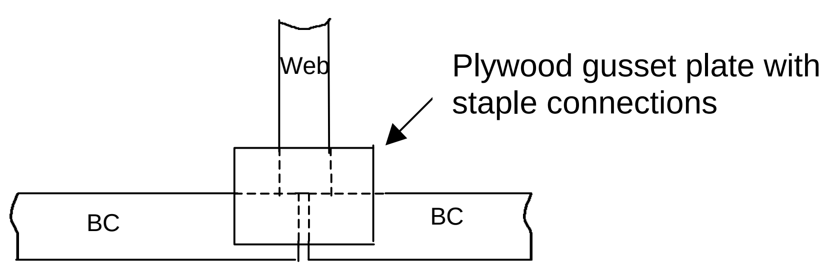

Figure 4b. Bottom chord connection for Case No. 2.

The remedy employed by the building owners changed the load transfer mechanism of the trusses. By placing the 2-ply posts directly under the center vertical web member, the center web member now carries the sum of the vertical components of the top chords at the ridge. This puts the center web member in compression, a load that it was not originally designed to carry.

The bottom chord lateral bracing was originally at mid-span only and was not moved after the center posts were put in place. No diagonal bracing existed on the roof.

The tension splice of the bottom chord was at mid-span of the truss. The strength of the connection was entirely dependent upon a few nails connecting the gusset plate to the bottom chord, and the strength of the nails was compromised by corrosion because of the moisture-laden environment.

Case No. 3

General Building Description:

Building No. 3 was a six-row freestall facility built using post-frame construction. The building was occupied by a large number of the 2,300 total lactating cows that were on the farm. The barn was constructed in three phases by the owner over multiple years. After completion of the final phase, the total length of the 104 ft. wide building was 400 ft. The 120 ft. long section built during the 1st phase was constructed in 1985 and was centrally located with respect to the two additions. One hundred feet of the original building collapsed due to the snow load. The roof cladding was aluminum and the building was oriented east-west.

The side wall columns were spaced 8 ft. o.c. and the trusses were spaced 4 ft. o.c. The trusses were not symmetrical. The roof slope was 4 on 12 on one side and 3.5 on 12 on the other. Truss joints were plywood gusset plates connected with glue and staples (not nails). Knee braces were nailed to truss bottom chords every fourth post. No diagonal bracing was present in the roof. Minimal lateral bracing existed for the bottom chords.

Evaluation of the Original Buildings and The Repairs Made After Failure:

We visited this site on the day when substantial clean-up operations were being performed and the new replacement trusses were being installed. Consequently, we were able to evaluate the damaged trusses and also observe the installation of the new trusses.

The collapse of the trusses seemed to have originated at the web members marked ①. These members failed by buckling under the heavy snow load. The connections marked ② on Figure 5 were also separated. The slenderness ratios of the compression web members marked ① were greater than 50. Installation of appropriate lateral bracing on these members would have reduced the buckling length to an acceptable value. The owner of the building indicated to us that they had constructed the original building with farm labor.

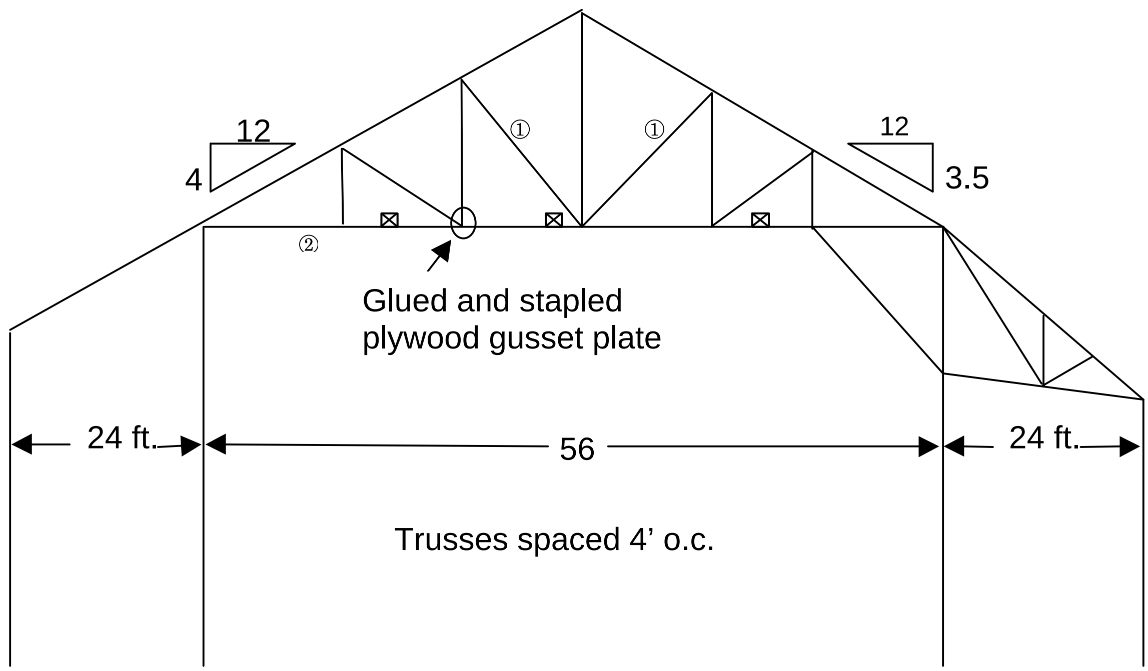

Figure 5. Truss configuration for Case No. 3.

The producer expressed his disappointment about the failed building, yet he failed to recognize the need to install lateral bracing in the new trusses despite the fact that he was provided instructions by the truss manufacturer describing how to do so. Again farm labor was used to set the trusses and make repairs.

The plant manager for the truss company was on-site during our visit. He expressed concern over the corrosion potential of metal-plates in dairy housing applications. He suggested that some guidelines need to be developed to address corrosion prevention. Additionally, he noted that, in his experience, embossed aluminum roofing retards snow sliding more so than smooth metal roofs. Embossed aluminum roofing material is commonly used on buildings for animal housing. Perhaps, this needs to be further investigated and if substantiated, may call for some design adjustment to account for this characteristic.

Case No. 4

General Building Description:

This building was a pre-engineered steel structure built in 1970 and was used as a freestall cow barn (Figure 6a). The barn had a north-south orientation. Although it was a steel frame building, 2x8 wood purlins, spaced 38 in. o.c., were installed on edge in lieu of steel purlins. The wood purlins clear spanned 16 ft. The measured sidewall height was 9 ft.

This building lacked any meaningful ventilation system. Consequently, a high-moisture environment existed in the barn. The purlins were visibly wet. Reportedly, the original galvanized roof had been replaced in 1987 due to advanced rusting.

Owner Observations and Comments:
The owner was not available to directly comment on the condition of the structure as a result of the snow load. However, reliable information was provided by the Cornell Cooperative Extension county representative who accompanied us to the site.

The snowstorm resulted in an unbalanced snow load on the structure. There was heavy snow accumulation on the east-facing roof. Failure was avoided by shoveling snow off the roof. The owner noticed visible deflections of the purlins and consequently decided to remove the snow.

Evaluation of the Existing System:
A mechanical or natural ventilation system should be installed in the barn to improve air ventilation. The orientation of the barn provides the opportunity to take advantage of the prevailing westerly winds but the relatively low sidewall height may not allow sufficient air to enter the building. A mechanical ventilation system would be more effective in this building. Plans should also be made to either replace the existing wood purlins with engineered metal purlins or install new intermediate wood purlins. The existing purlins (Figure 6b) given their size (2x8), span (16 ft.), spacing (38 in. o.c.) and in service condition (wet) are far from being adequate for the design load.

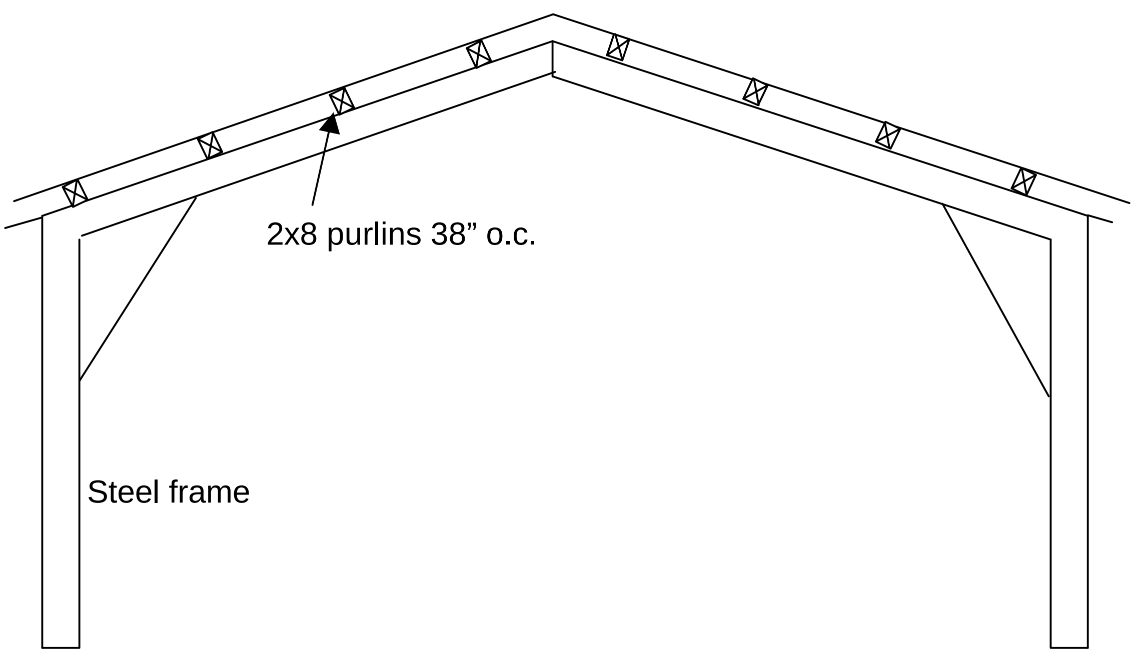

Figure 6a. Building cross-section for Case No. 4.

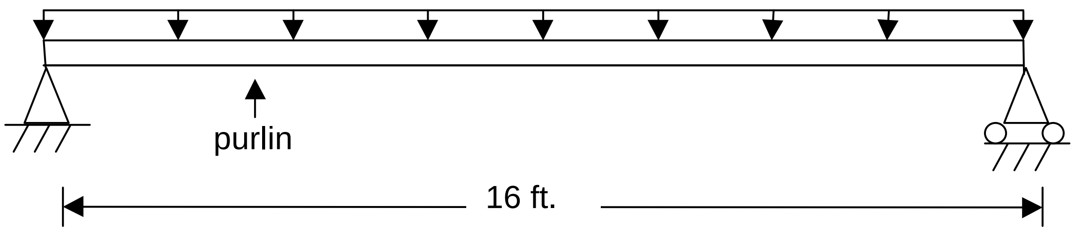

Figure 6b. Span of the 2x8 purlin.

Case No. 5

General Building Description:

Case No. 5 was a pre-engineered 6-row freestall building that was approximately 400 ft. long with 14 ft. high curtain sidewalls. The building was built in 1998. The roof support system consisted of trusses in the center 61 ft. and 24 ft. long rafters on adjacent sides. The building appeared to be well designed and constructed and was orientated north-south. At approximately the midpoint of the building on the north side failure occurred that caused the collapsed of two bays (one truss) only. The remainder of the building appeared undamaged and seemed in serviceable condition. Approximately one-half of the required repairs to the building had been performed at the time of our visit.

Owner Observations and Comments:

The owner reported that he had just passed under the area that collapsed with feed delivery equipment when failure took place. Additionally, the owner's son was in the building tending to a sick cow when failure occurred. The owner indicated that the building was designed for a snow load of 35 to 40 pounds per sq. ft. which is appropriate for the region. He estimated the evenly distributed snow depth on the roof to be between 3 to 4 ft. deep. Using values from Table 1 for "average snow load", the load on the roof would have been between 36 and 48 psf.

Evaluation of the Existing System:

The building was well braced as shown in Figure 7. The bottom chords had sufficient lateral bracing members, and all long compression web members were adequately braced laterally. One end of each knee brace was connected to an intermediate post and the other end extended up to the truss top chord where it was properly connected.

Careful investigation of the remains of the failed laminated post showed that the center ply had a large knot located at the location of apparent failure. The posts were not laterally braced along the weak axis. Because of the visible buckling observed by the owner during the snowstorm, he braced the interior posts laterally subsequent to the failure of the one post. It seems that the post with the large knot failed and pulled down on the truss that was connected to it. A split across the holes of the truss-to-post connectors (bolts) was visible perhaps due to racking effect. Nevertheless, the building appeared to be well designed as was exhibited by the fact that the failure was contained within one post/truss assembly.

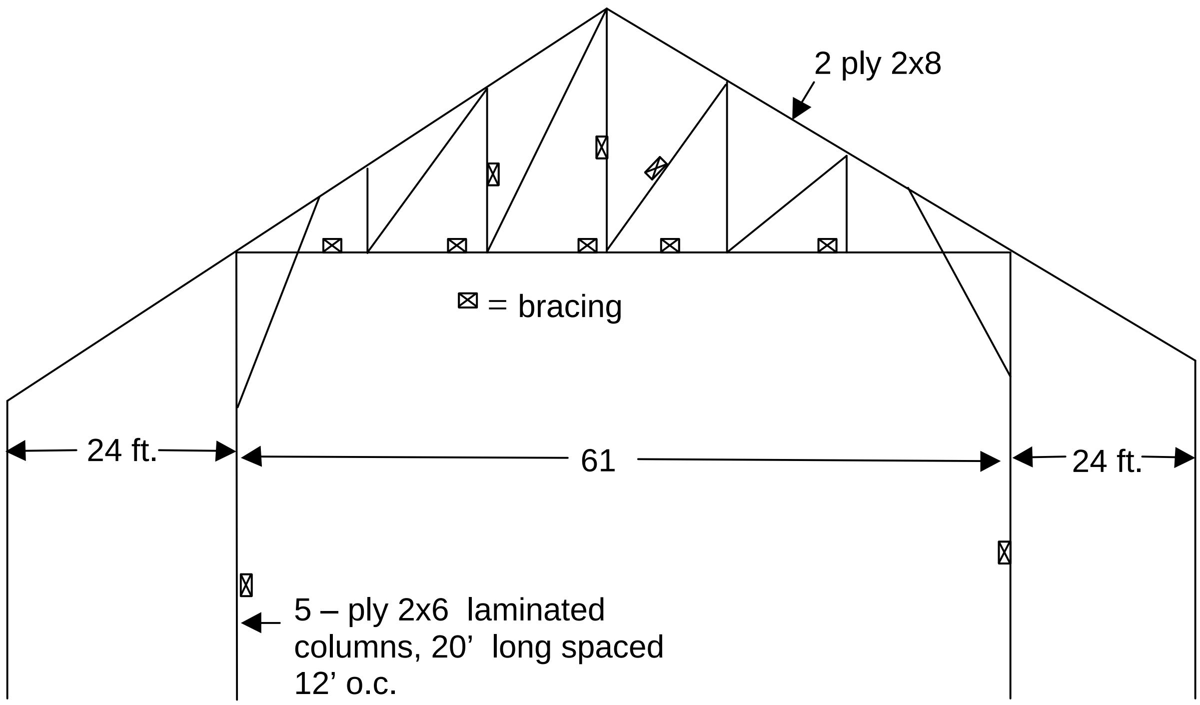

Figure 7. Typical cross-section of Case No. 5.

Case No. 6

General Building Description:

Case No. 6 was a 6-row tunnel ventilated freestall barn that was about 3 years old. The orientation of the building was north-south. The building was insulated with approximately 1-1/2" of faced polyisocyanurate foam-core insulation fastened to the underside of the truss bottom chord. The building was 110 ft. wide and 400 ft. long with 12 ft. high curtain sidewalls. The center 57 ft. was clear span. Inverted trusses with an extended bottom chord were used to span from the sidewall post to the intermediate post. The extended bottom chord provided a smooth transition from the inverted truss to the upright truss for the foam-core insulation ceiling. It was reported that only the trusses were engineered in this building.

During our visit, the building was under repair. All debris generated as a result of the collapse of about two-thirds of the building had been removed.

Owner Observations and Comments:

No information was available from the owners of the facility.

Evaluation of the Existing System:

During the visit, an unobstructed view of some of the remaining original trusses that withstood the snowstorm and also the new trusses that were installed was possible. Some of the original bottom chord insulation boards were torn off during the collapse and the recently installed trusses were not covered with insulation.

The configuration of the original center truss is shown in Figure 8. The truss spacing was 4 ft. o.c. The bottom chords were adequately braced laterally, but the compression web members were not.

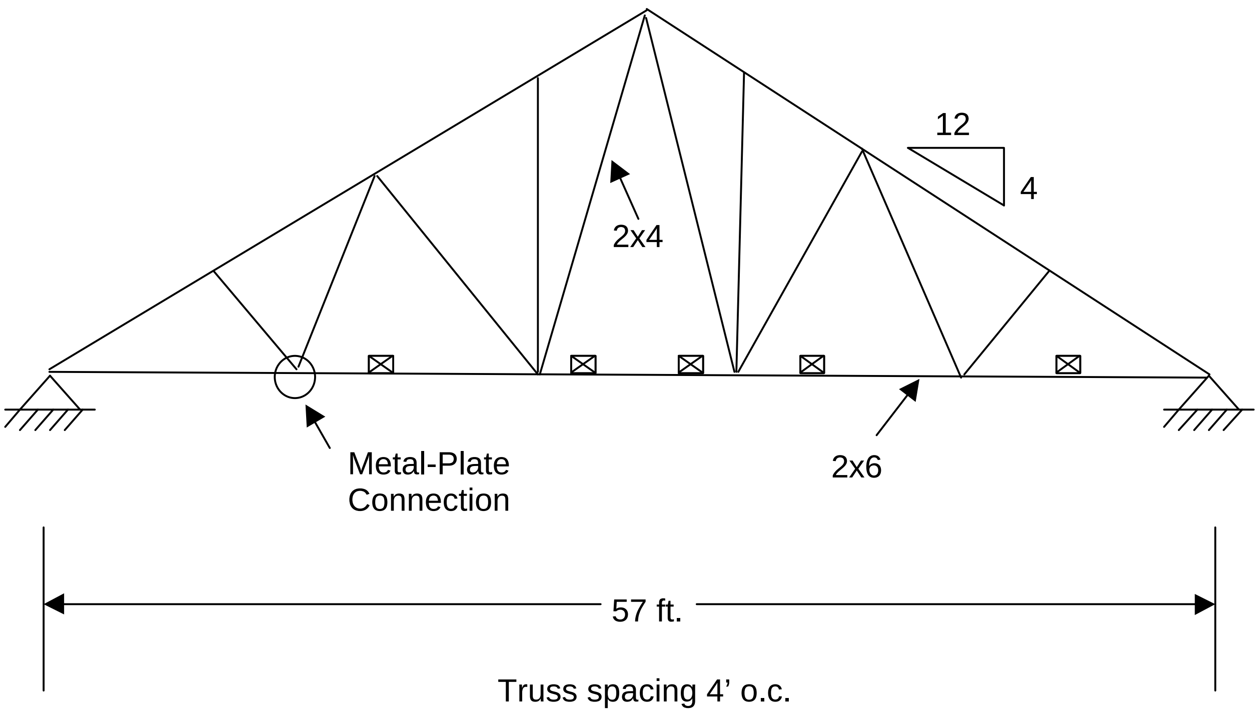

Figure 8. Original center truss configuration for Case No. 6.

The configuration of the replacement trusses are shown in Figure 9. The new trusses were spaced 2.67 ft. on center (3 trusses per 8 ft.). Bottom chord, top chord, and web members were 2x6's, 2x8's, and 2x4's, respectively. Many of the new trusses were only toe-nailed to the horizontal header running between the posts. This type of connection may prove to be inadequate to withstand uplift forces caused by wind. Also, gaps between insulation boards (because of improper installation) will allow moisture migration to the attic space and become trapped within. As previously mentioned, this situation may be detrimental to the strength of the wood and the integrity of the connection as well as the deterioration of the insulation.

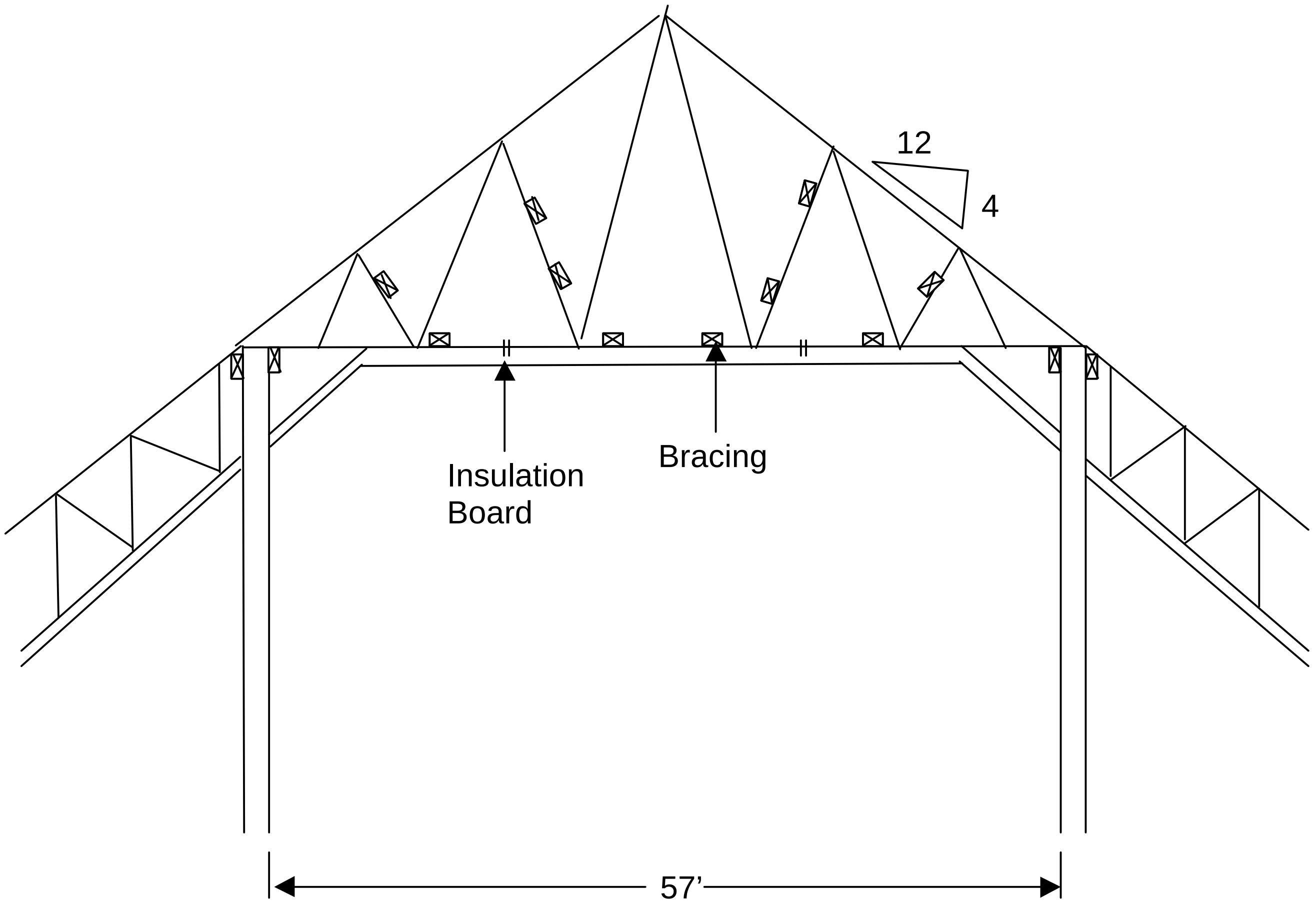

Figure 9. Replacement truss configuration for Case No. 6.

Case No.7

General Building Description:
The last building observed was a two-row freestall barn with a center feed bunk built in 1970. The building was 43 ft. wide and 8 ft. high. The building was constructed as an addition to a much older stanchion barn, which was located on the south side. The peak height of the stanchion barn was much higher than that of the freestall barn.

At the time of the visit, the remains of the collapsed building had been removed and a replacement building was almost completely constructed. The side wall height for the new building was increased to 14 ft. to improve natural ventilation by extending the original post by another 6 ft. The details of this connection are shown in Figure 10.

Owner Observations and Comments:

The owner mentioned that all but three trusses collapsed during the night. The three trusses were subsequently replaced with new trusses when the new building was built. All repair work was performed by a local building contractor.

The New Structure:

As stated previously, the original 8 ft. high posts were extended to 14 ft. To increase the sidewall height by 6 ft., a new 6x6 post was placed on top of the original 6x6 post and held in place by two - 2x6 scab boards nailed sparingly to the post with common nails. The method of connection and the materials used is marginal at best.

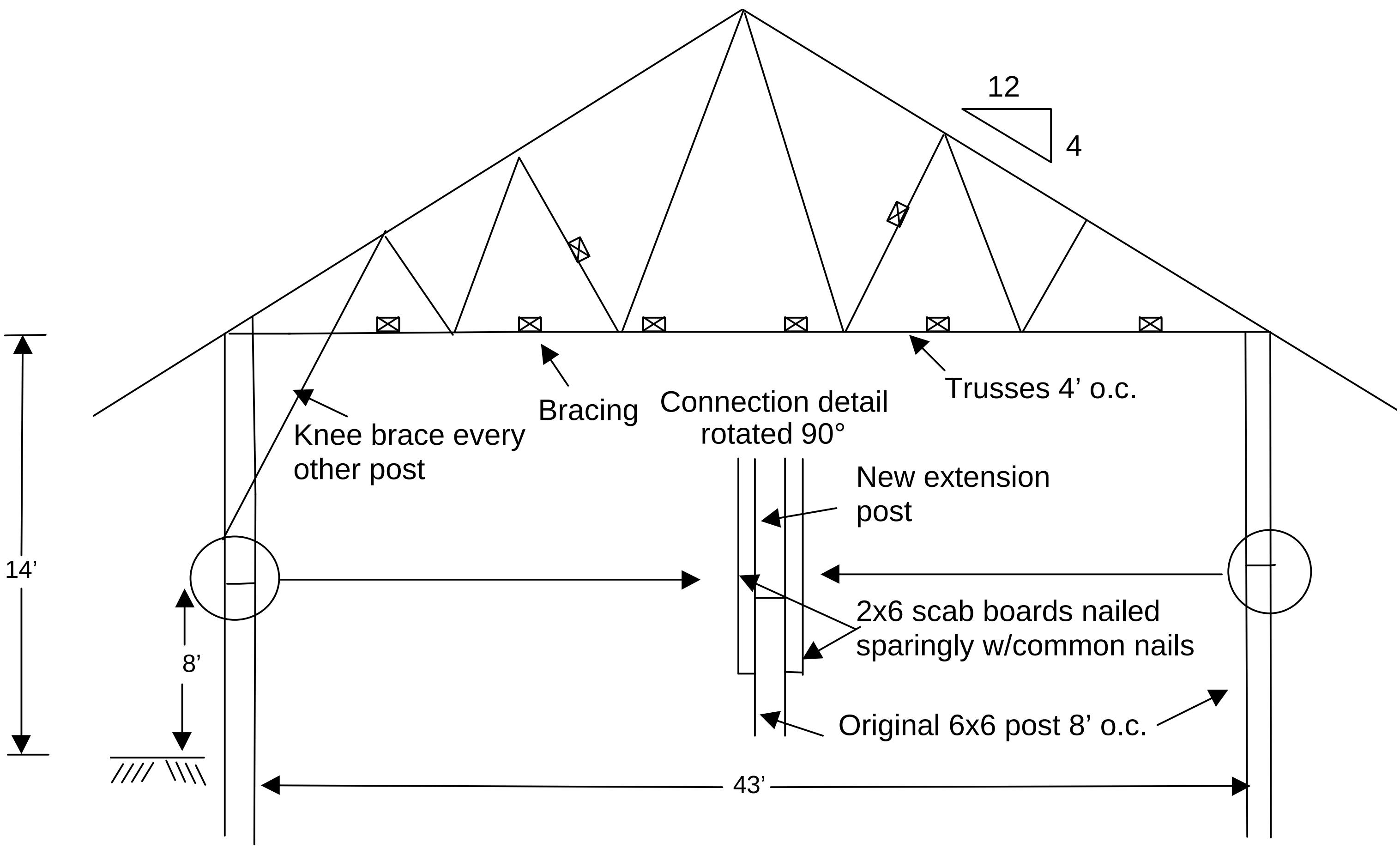

Figure 10. Cross-section of rebuilt barn for Case No. 7.

The new posts used on the left wall of the building extended all the way to the top chord and the trusses were face nailed to the posts. The posts on the right wall however, were not extended to the top chords. The trusses on this side of the building are toe nailed to the header. From casual observation, the latter connection seems to be inadequate to resist uplift forces.

The connection of the intermediate trusses on the left wall consisted of face nailing the truss to an intermediate stub block. The stub block was securely fastened to the header

with multiple nails. On the right wall, however, trusses were merely toe nailed to the header as no stub blocking was installed.
The truss lower chords and compression web members were adequately braced laterally, and knee braces were properly fastened to top chords.

Summary

A series of winter storm events during January, 1999 resulted in significant accumulations of precipitation in many areas of New York State. Several agricultural buildings failed as a result of the snow load, many of which were built using post-frame construction. A field observation was conducted with the objective of evaluating why the buildings failed. For buildings that had been partially or fully repaired or replaced, an evaluation of the new building was made. A total of seven buildings were evaluated and the findings are presented herein. Most of the trusses that failed and their replacements seem to have inadequate bottom chord lateral bracing and/or lateral bracing of compression web members. Also, they appeared to have in adequate diagonal bracing as well as adequate truss-to-header connections. Agricultural buildings constructed in New York State are exempt from the New York State Building Code. Comparatively few industrial, commercial, or residential buildings failed during this same time frame. Results from a survey of local insurance agencies revealed that insurance companies generally don't require agricultural structures to be built to any design standard.

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