STRUCTURAL EVALUATION OF FARM BUILDINGS

INTRODUCTION

The building codes were first developed after large fires damaged cities causing unnecessary loss of life and property. It was concluded that some of these devastating disasters could have been prevented if construction was regulated. Therefore, cities and other governing authorities started regulating construction.

Building codes were created to stop these disasters. Over time more and more requirements were added to the building codes as good practice. The modern building codes far exceed the initial intent to stop the disasters.

Agricultural buildings have never been required to comply with the building code requirements due to the historical inception of the codes and the progression of the codes. This has created a significant problem when trying to identify what would be a minimum standard to design, construct, or evaluate an agricultural (farm) building.

An inaccurate statement would be, “agricultural buildings can be built in any manner regardless of engineering principals.” A correct statement would be, “agricultural buildings should be safe for their intended purpose.”

This document contains guidelines that can be used to evaluate existing agricultural (farm) buildings that are not governed by a specific code or standard.

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1. DEFINITIONS

Standard of Practice – the process of having a building added to a property.

Design – The layout of the building, the dimensions and orientation, the placement on the property, the configuration of the spaces, the size of the rooms.

Structural Design – The process of sizing members to resist snow and wind loads.

Construction – the process of fabricating and erecting building materials to create a building.

2. CURRENT STANDARD OF PRACTICE

Historically, the Standard of Practice for constructing agricultural buildings has been for owners or builders to construct buildings that stand for moderate wind and snow loads giving it their best efforts. The standard of practice has not been to ignore loads and the load paths needed to resist external loads.

Today, reputable builders obtain or use structural designs to provide buildings to a certain location. The loads used for the structural designs are normally less than the levels specified in the building code, but the building are designed to some level of load. The standard of practice has been for reputable builders to handle the typical situations, and to seek out help from others (engineers) in areas beyond their understanding. There is no reason to structurally design a simple rectangular building over and over again.

Unfortunately, some buildings have been built by unqualified people who have not given their best effort to make sure the buildings stand for wind and snow. Significant errors have been made leading to predicable failure.

3. EXISTING BUILDINGS

The modern building codes recognize the need to distinguish between new and existing buildings. Agricultural buildings have the same issue. The only difference is that agricultural buildings are not regulated, and some are still using archaic ways doing things.

Existing building on many farms throughout the Midwest are at all sorts of level of risk. Some are hazardous while others are well built. Many of the existing buildings standing on farms are in disrepair and at a high risk of collapse from moderate loads.

4. RECOMMENDED STANDARD OF PRATICE

The standard for farm construction should be that the people who specify, erect, or modify buildings, should understand building loads, statics, and wood design.

The standard should be that the right people design a building and the right people erect a building.

The obvious solution is to have new or old buildings engineered and constructed by people who understand modern-day construction when things are difficult.

Simple repairs or simple modifications need not be engineered. Repeated simple structures need not be structurally design over and over again.

5. RECOMMENDED CODE / STANDARDS

Simple codes of construction are needed for the agricultural buildings. One for new construction and one for existing buildings.

To the surprise of some, agricultural buildings are included in the IBC under Miscellaneous Group U buildings. The problem is that much of the code does not apply to agricultural buildings.

The IBC is the recognized building standard for new construction. It has the following sections that describe in detail requires for modern construction using modern materials:

CHAPTER 16 STRUCTURAL DESIGN

CHAPTER 18 SOILS AND FOUNDATION

CHAPTER 19 CONCETE

CHAPTER 21 MASONRY

CHAPTER 22 STEEL

CHAPTER 23 WOOD

These code sections are written with the goal of providing information on modern construction methods for different aspects of all structures. Therefore, the information within each section is vast and changing as building construction has changed and continues to change.

Agricultural buildings are significantly less complex and less of a threat to human life than theaters, courtrooms, museums, libraries, hospitals, office buildings, malls, airports, schools, factories, prisons, apartment buildings, etc. Therefore, farm building requirements for design and construction should be simpler.

While not as complex, agricultural buildings use concrete, steel and wood. Those specifying the material or putting the materials together should have a working knowledge of the concepts.

The IBC generally references industry standard documents for loads and building materials. This industry standard should not be ignored when constructing or modifying a wood structure.

The standard for determining building loads is the *Minimum Design Loads and Associated Criteria for Buildings and Other Structures* (ASCE/SEI 7-16) which describes the means for determining snow, and wind loads, for general structural design.

A standard for wood design is the *National Design Specification (NDS) for Wood Construction* published by the American Wood Council's (AWC) Wood Design Standards Committee and has been approved by ANSI as an American National Standard. This document has all sorts of information on how to connect wood members.

6. RECOMMENDED PEOPLE

Engineers are not required on every building or every building modification. This would be impractical; however, people should not go beyond their knowledge.

Professional Structural Engineers (SE) are qualified to design buildings through education and training. Professional Engineers are held to a Professional Code of Ethics. The National Society of Professional Engineers (NSPE) publishes the Professional Code of Ethics.

The NSPE also regulated the engineering community issuing penalties and fine to individuals who violate the code of ethics. This include fining those who practice without a license. Through training, testing, and experience, Professional Engineers are able to evaluate systems using laws of physics and modern building science. Even if there is no building standard, engineers are bound by their code of ethics to safeguard the general public. The code of ethics includes the following rule:

> *"Engineers shall hold paramount the safety, health, and welfare of the public."*

For this reason, professional engineers may not be able to recommend a building for repair or continued use depending on exiting conditions. The owner may disagree.

Unsuspected farmers should not be sold into believing that a building is well constructed when the builders followed no standard.

BUILDING INSPECTIONS

7. BUILDING USE STATEMENT

A simple Building Use Statement should be formulated that describes what is the purpose of the building. An old dilapidated building with no purpose is different than a newly constructed building with vital purpose. Each building presents a different level of hazard to the general public or to those that may occupy the building.

Farm buildings are unique since the Use and Occupancy may change with time. The following are typical Building Use Statements:

1. The building was newly constructed and was being used for a vital purpose of the farm.
2. The building was re-purposed.
3. The building was dormant but had potential for future use.
4. The building was used for storage.
5. The building was obsolete but had aesthetic, historic, or sentimental value.
6. The building was obsolete and in ill-repair.
7. The building was under construction and not in use when the failure occurred.

The freestall barn collapsed while under construction.

8. BUILDING OCCUPANCY STATEMENT

A simple Building Occupancy Statement should be established that describes who uses the building currently or in the future under normal or unique conditions.

An unused locked building with no purpose is different than a newly constructed building where the general public is able enter. An owner should be able to choose to knowingly risk the loss of animals or material in the event of a building failure. However, an unexpectant person should never be exposed to a life safety issue. A person should never find themselves trapped within a hazardous building during a storm. A Building Occupancy Statement should answer the questions:

1. Who or what occupies the building on a regular basis?
2. Who would be able to enter the building unexpectantly or in the future?

The following are typical Building Occupancy Statements:

1. The general public is able to drive on the property and enter the building without limitation.
2. Delivery people are able to access the building.
3. Temporary employees have unobstructed access to the interior as part of daily work.
4. The property is family owned and operated. Only property owners are allowed within buildings. All others are considered trespassing.
5. The building is locked, and no one is allowed to enter the building.

9. MEAN OF EGRESS STATEMENT

Accidents can be sudden and accidental. Building failures can be unexpected or predictable. Loss of life and loss of property normally happens when collapse is progressive and unexpected.

Many failures happen slowly and the building shows signs of distress prior to catastrophic failure. People are able to get out, and the contents can be removed. Shoring and stabilizing efforts are able to be undertaken. A building with a weak system that creates a fast collapse event, or an entrapment situation should be avoided at all cost.

The following are typical Mean of Egress Statements:

1. The lower level had one exit. This created a hazardous situation in the case of the first floor collapsing.
2. The building had several exterior doors. Egress was not an anticipated issue.

10. BUILDING LOCATION STATEMENT

A Building Location Statement should identify the risk to the surrounding property. Aerial images are easily obtained that show proximity relationships.

A building in the woods with no purpose is different than a leaning building next to a narrow entrance driveway. Whether a building is self-standing or adjoining to other existing buildings makes a difference to the level of risk around the building.

The following are typical Building Location Statements:

1. The building was far from other buildings or access ways.
2. The building was rigidly attached to the older barn to the south. Both structures were at risk.
3. The building was next to a main entrance creating a hazardous condition to anyone entering the property.

11. BUILDING OBSERVATION STATEMENTS

As part of the inspection, the general configuration of the building materials should be identified. This is normally done with photos. The photos should document the part of the structure that that can be seen:

1) How was the building framed?
2) What was used to construct the roof and walls?

The beam above the door was deflecting.

12. BUILDING DETERIORATION STATEMENT

Within reason, if deterioration is found, it should be evaluated or brought to the attention of the building owner. Deterioration can play a big role in determining if a building can be repaired or not. When a building is damage, the damaged areas must be repaired or replaced. It is not the responsibility of the inspector to find all defects of the buildings and guarantee that it will be safe for the next event; however, there may be areas of obvious deterioration that create a high risk of failure during future moderate weather events. If the deterioration is determined to be hazardous, it should be addressed.

The following are typical Building Deterioration Statements:

1. The building appeared to be in good condition. Little to no discoloration was found on exposed wood members.
2. The truss members and truss plates were discolored. The amount of discoloration indicated that there must be some degree of weakening of the structure compared to initial construction.

13. LOAD PATH STATEMENTS

Not every building is designed by an engineer, but every building that will stand for an extended period of time must have adequate complete load paths to resist gravity and lateral loads.

The following are typical Load Path Statements:

1. The connection to the adjoining building was inadequate.
2. The lateral wind system was questionable.
3. The gravity system was inadequate.
4. The building had sound gravity and lateral systems.

Unbalance soil load caused the standard pole shed to lean

14. EXTENT OF LOSS SUMMARY

A building that is damaged by a covered loss may need to be repaired to a certain level. The repairs may need to only include replacing the damaged materials to a pre-loss condition. The material needing repair or replacement from the covered loss event should be itemized.

The truss failed at the top chord splice location.

15. EXTENT OF TOTAL DAMAGE SUMMARY

Weak or damaged material beyond the covered loss may need to be repaired or replaced. The materials needing repair or replacement that are observed from the inspection of the building that are not related to the damage event should be itemized if they are a concern.

In general, if a structural element or system is repaired, the repairs should be sound. This may mean the building cannot be brought back to a pre-loss condition, if the pre-loss condition was determined to be inadequate.

The final repaired structure must be brought back to a safe condition for continued use based on the occupancy, or a warning should be issued.

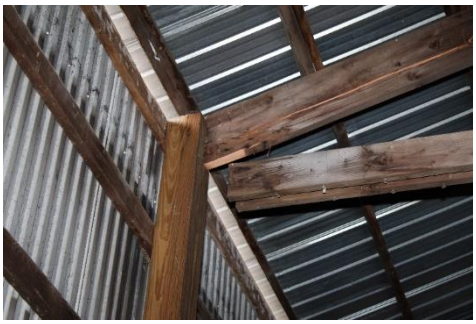
The barn had weak connections beyond the collapse.

16. HAZARD STATEMENT

After sufficient information on the building is gathered, a Hazard Statement should be issued if there is a threat to life or property. The level of hazard to life and property should reflect the building's use and occupancy, the mean of egress, and the previous discussed characteristics of the building and its surroundings.

The following are typical Hazard Statements:

1. The building was damaged by wind. The damaged materials can be repaired and replaced. There was no hazard to life or property identified beyond the damage area.
2. The building was damaged by snow. The extent of damage and the extent of deterioration made the building unsuitable for repair. The building was in a hazardous condition. No one should be allowed to enter the building.



The bottom chord of the truss came loose. Identically made trusses were a hazard.

17. REPAIR RECOMMENDATIONS

The ultimate goal of a structural inspection should be to determine if the building can be used or repaired.

Since agricultural buildings are not governed by any standard, the amount or level of repair is optional based on the level of risk that the owner wants to take. However, there should be a low level of risk of loss of life or loss of property.

2/3rd of the roof structure collapsed. The remaining roof structure was unreliable.

18. CONDEMNING A BUILDING

A building may be more difficult to repair than to tear down and rebuild based on all sorts of unique conditions.

Sometimes the extent of damage or previous modifications to the structure have so altered the structure that it is more expensive to make the structure safe than to tear down and start over. In these situations, the correct conclusion may be stating that the building has exceeded its useful service life.

The floor was removed which altered the lateral system. The barn was leaning and in danger of collapse.

19. DAMAGE ASSESSMENT OR CAUSATION

Given that agricultural buildings have not been required to follow the building code, it is difficult to point a finger at lack of design or poor construction as a cause.

However, farm buildings in the past have been designed and constructed with the intent that they remain standing when exposed to normal and expected wind and snow loads. This would be industry standard.

The problem becomes apparent when there is a failure. When an agricultural building falls down or fails, a cause must be determined. The following possible causes are typically reasonable conclusions that can be reached:

1) The gravity system or lateral was inadequate. The person responsible for the structural design was incompetent or chose to ignore engineering principles.
2) The building was not built correctly. A mistake was made when constructing the building. This would be a construction error.
3) The snow loads were excessive.
4) The wind loads were excessive.
5) The soil loads were excessive.
6) The building deteriorated over time making it weaker since construction.

There are other causes, but if the loads were not excessive, and the building was not weakened by deterioration, the fault remains with design or construction.

20. CONCLUSION

Agricultural buildings are at all sorts of level of risk. Some are on the brink of collapse, while others are built very well.

In today's society, the principles of engineering, the science of strength of materials, the knowledge of building loads, and the principles of soil mechanics have been better understood since codes were first developed.

There is no good reason to exclude agricultural buildings from being designed and constructed using modern minimal principles of structural engineering. Our society knows better. Our society knows anticipated wind and snow loads. Our society understand building components.

Even though there is no code enforcement that prescribes how agricultural buildings should be constructed, this does not give anyone the ability to put up a building in whatever way they want.

Untrained people that build agricultural buildings may knowingly ignore good construction practices that have made their way into paragraphs of building codes, but no one should ignore statics, gravity, soil mechanics, strength of materials, wood design principles, or wind loads. Contractors and owners should not ignore industry standards.

Ignoring the basic requirement for a building to remain standing when exposed to moderate lateral loads or failing to provide a clear lateral load system for a building is not the industry standard practice.

The building had not been used in a very long time. Collapse was a predictable event.

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