# DEVELOPMENT AND USE OF FARM BUILDING STANDARDS

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## INTRODUCTION

Farm buildings have been a very necessary part of most agricultural enterprises in Canada. Those constructed in the early days of settlement in Eastern Canada were built very sturdily. Timber had to be cleared to make way for field operations and there was, therefore, an abundance of large timbers which were used quite liberally for purlins, posts, beams and rafters. The foundations and stable walls of buildings in many areas were two or three feet in thickness of stone masonry. It was a good place to deposit the surface stones from the land as it was cleared. The barns were used primarily to house dairy and beef cattle with a few stalls for horses.

The buildings in the prairie areas of Western Canada were quite different from those built in Eastern Canada. They were much lighter in construction and there were very few with stone masonry walls. The barns were built primarily to house horses with a few stalls for dairy cows.

The advent of the farm tractor, mechanized machinery and equipment along with new management practices in livestock handling has made both types of buildings obsolete or difficult to remodel and adapt to modern practices. Since the Second World War a new era in farm building design and construction has developed in all areas of Canada. The general purpose barn for livestock has been replaced with special production buildings for each type of livestock or for the storage of different farm products. This has permitted more functional design and the adaptation of mechanized feeding and handling equipment. Construction practices have changed from the old traditional methods. New materials have come onto the market and prefabrication of many types of buildings has developed. Along with these changes has come the need by designers and prefabricators for building standards that might be specifically suitable for farm buildings.

Many farm areas adjacent to growing cities have come under municipal regulations which include a building code. Any new building or building addition in these areas has had to comply with the Public Building Code of the municipality which required an excessive cost for the building.

Building codes have developed and are in use in most countries in the world for public buildings and private housing design. However, at the present time none of these codes apply directly to farm buildings and, in fact, few make reference to them. One code has adopted the definition of farm buildings and a deflection limitation to be applied to such buildings. Another defines farm buildings and states a minimum live load as ten pounds per square foot. The National Building Code of Canada simply lists some types of farm buildings under their major occupancy classification in a group of commercial and industrial buildings. Therefore, since there are no guide lines for farm buildings in the different building code claissifications industrial specifications are being applied to farm structures.

Agricultural buildings serve a specialized and extremely varied range of functions. Therefore, any narrow or restrictive type of regulation is not consistent with modern-day functional design for such buildings. Most agricultural engineers designing buildings in Canada have used recommendations and allowable loads for structural members from different text books that have been developed primarily in the United States. The Canadian Farm Building Plan Service has attempted to use reasonably consistent design criteria based on text book information, some aspects of the National Building Code of Canada, the results of testing procedures on structural members and from experience gained in farm building construction practices by different members associated with the Plan Service. However, due to the wide variation in climatic conditions in Canada and the snow and wind problems it has been difficult to satisfy all conditions. An urgent need, therefore, has developed for a set of criteria for the functional design and construction of all types of buildings that would satisfactorily apply to all areas of Canada.

The National Building Code of Canada has been used since 1941 as an advisory publication and has been adopted in part or completely by most communities as a legal document. This code has been developed under an associated committee of 24 Canadian citizens consisting of engineers, architects, building officials, technical experts and others representing a cross-section of government, university, professional services and industry in Canada. This committee reports to the National Research Council. A recommendation was made to this committee through the National Committee of Agricultural Engineering to consider the development of a set of Farm Building Standards which could be a supplement to the National Building Code of Canada.

## FARM BUILDING STANDARDS

The Farm Building Standards Committee was established in 1962 by the Associate Committee on the National Building Code of Canada. This committee consists of 19 members representing a similar cross - section of Canadian personnel to that of the Associate Committee but dealing specifically with farm buildings. Farm Building Standards – Canada 1964, Supplement No. 6 to the National Building Code of Canada is the result of this committee's activities. It has been developed as a guide for those interested in the design, construction and the evaluation of a wide variety of farm buildings excluding the farm dwelling. It provides detailed recommendations to serve as references with the intent of obtaining safe and efficient performance and economy within such buildings. It is recognized that there are variations of good practice which may be equally satisfactory as those included and that they should be permitted also if properly evaluated for the purpose. It is not intended that the Farm Building Standards be a mandatory document. It does include all major functions in relation to the complete design of farm buildings.

*Use and Occupancy*

This relates to the functions of farm buildings with regard to fire hazards, safety and dimensional requirements and is divided primarily into two sections. The first section applies to the control of hazards in farm buildings for the purpose of minimizing losses of life and property. The second deals with space and facilities required for the animals and products. Fire is a major hazard in farm buildings accounting for a total loss in the province of Ontario in 1962 of over $7,000,000.00. The farm enterprise encompasses a life's work and usually a few generations have been involved in the establishment. Safety is therefore of utmost concern and the sacrifice of a herd of cattle, hogs, poultry, valuable crops and their storage should not be condoned by lack of good construction practices. Buildings have been classified, therefore, as high fire hazard buildings or as moderate fire hazard buildings. These classifications have been established simply to allow for the fire endurance ratings of materials and other fire control items as useful guides in design.

All measures possible should be used to permit the removal of certain types of livestock and the escape of people from buildings and to prevent the spread of the fire until it can be brought under control. There has been very little fire test work conducted that pertains to the many conditions that exist around farm buildings. No tests have been conducted in which the fire was above the area in which people or livestock were located and which would be necessary to vacate in event of fire. This is the condition in a two-storey barn where the flammable material is overhead and the livestock is in the stable beneath.

TABLE I. RECOMMENDED MINIMUM DISTANCES BETWEEN BUILDINGS TO PREVENT THE SPREAD OF FIRE DUE TO RADIATION

| Occupancy classification of burning building | Dimensions of burning building seen by adjacent building height to ridge (feet) x length (feet) | Recommended space separations of ordinary constructions with windows (feet) |
|---|---|---|
| | 10 x 14 | 40 |
| | 10 x 50 | 70 |
| | 10 x 100 | 95 |
| Division I | 12 x 20 | 50 |
| | 20 x 30 | 80 |
| | 20 x 50 | 100 |
| | 30 x 60 | 135 |
| | 10 x 14 | 30 |
| | 10 x 50 | 55 |
| | 10 x 100 | 75 |
| Division II | 12 x 20 | 45 |
| | 20 x 30 | 65 |
| | 20 x 50 | 80 |
| | 30 x 60 | 105 |

Table 1 outlines minimum distances between buildings to prevent the spread of fire due to radiation. Spacial separation is only one factor that affects the spread of fire between buildings on a farmstead. The control of fire is difficult to obtain due primarily to the inadequacy of fire-fighting facilities and water resources on the farm. There are limits to the distance that buildings may be separated as they affect management and efficiency of production. Thus, where it is not practical to provide the recommended spacial separation reasonable reductions may be made at the discretion of the designer and owner on the basis of a number of considerations. These would include suitable construction materials, proper orientation of buildings, fire-fighting facilities or alarm systems, and the characteristics of the buildings themselves. There is much need for research and testing in all of these areas, in order to establish more specific criteria for fire control and fire prevention.

A second important area of hazard control in which standards have been established has to do with egress from buildings for people as well as cattle and horses. Recommendations regarding suitable location and types of doors, stairways, ladders, and guard rails are included.

Space requirements and weights of various types of livestock and products are essential as a basis for determining live loads for design purposes. These space requirements are usually more than the bare minimum based on the physical dimension of the livestock and are more of an optimum based on efficient management practices and related to economics of construction. The storages for certain types of crops may be designed primarily from the physical qualities of the products while other factors must be considered within other storages. The cross-sectional dimension of a silo must be based on the usage rate of the product as well as the total quantity such that in a tower silo a minimum of two or three inches per day must be used to prevent deterioration and spoilage of the products. Such factors as this must be fully considered in the functional design of modern buildings.

*Design*

Since Farm Building Standards is a supplement to the National Building Code the design of farm buildings should be in accordance with various sections of this code unless stated otherwise in the Standards. This section deals primarily with the design of structural members of the various buildings and considers all climatic loads, loads due to the intended use of the building, loads that may be applied during the construction of the building, loads due to the materials of construction and loads due to earth and water pressure that may be applied below ground level.

TABLE II. FLOOR LOADS DUE TO USE

| Use of area of floor | Design Load psf |
|---|---|
| Cattle | |
| Tie stall barns | 70 |
| Loose housing (except bedded area) | 80 |
| Slotted floors | (1) |
| Milking Parlour | 70 |
| Milk room or milkhouse | 50 |
| Sheep | 30 |
| Swine—solid floors | 40 |
| —slotted floors | (1) |
| Horses | 100 |

(1) calculated by separate formula.

Table II is taken from Table XV of Farm Building Standards (1) and is the estimated floor loads due to use. The table indicates areas where it is not possible to give general loads. Climatic loads such as those due to snow and wind are fairly precise loads in most countries based on records obtained over various periods of time. However, it is considered that loads due to snow based on measured ground snow cover may be somewhat high for general farm building roofs. There is also reason to permit farm building design with a reduced overall safety factor in recognition of the low risk to human life and low value of contents or low risk to loss of contents in certain classes of building.

The method of satisfying these conditions has been met in the Standards by permitting increases in allowable stresses depending on the type of use and occupancy. For the structural design of low hazard farm buildings the allowable stresses in tension, compression, bending and shear may be increased by 20% in elements designed to support climatic loadings and for other than low hazard buildings these allowable stresses may be increased by 10%. These increases are applicable to the allowable stresses outlined in the National Building Code and listed in the Standards and may be applied in addition to other modification factors for applicable conditions that are contained therein. These increases are not applicable for assembly occupancies such as auctions or show arenas.

Low hazard farm buildings are intended to include any buildings other than those intended for high human occupancy. Buildings of high human occupancy include processing rooms, work or rest areas likely to be occupied by several persons over an extended period, particularly during the winter.

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predict the point of separation accurately in a manner that is not possible for fluid. The grain flow pattern must of course be governed by friction while the nearly ideal fluid flow pattern is governed by inertia which is not a consideration at all in the slow flow of grain.

The angles observed above and below the disc-like obstacle in figure 6 are important in the theory of grain flow, where the coefficient of internal friction is often assumed to be equal to the tangent of the angle of repose. The question of which angle is pertinent must be answered, unless indeed the assumption itself is rejected.

The observations that raised the most questions were those of the discharge from a central orifice. The gradual orientation of the grains and development of the flow pattern made it clear that no theory could be very useful if it contained the assumption that the grain behaved as an isotropic substance. In particular, if a region of shear failure were predicted by calculation based on this assumption, the actual shear region in the moving grain might be quite different.

It was noted by Barre (5) that the pressures at the bottom of a grain bin increased when emptying began. It seems clear that this change in pressure was caused by changes in the internal friction of the grain, but the internal friction itself must be modified by the orientation of the kernels.

In the case of the rough vertical wall, the shear occurs in a narrow zone inside the grain close to the wall. The shear consists almost entirely of a sliding action between orientated grains rather than a rolling action. This effect indicates that the friction between oriented kernels sliding against one another is lower than the friction for any other type of motion. Carrying this conclusion over to the case of outflow through an orifice it means that as the kernels become orientated, the active shear extends gradually into regions of lower shear stress. At the same time, the stress distribution itself must change throughout the bin.

## CONCLUSION

The strong influence of kernel orientation upon the flow patterns of wheat grain flowing under gravity makes it necessary to review the existing theories of grain flow, particularly for asymmetrical agricultural grains. The assumption of isotropy must be examined carefully after the magnitudes of the changes in internal friction with orientation have been determined.

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## USE OF FARM BUILDING . . .

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The snow load to be applied is estimated as 60% of the ground snow load with a minimum of 20 pounds per square foot to ensure safety during construction of the building.

*Building Services*

Building services are an essential part of a complete design of a modern production or processing and storage building. To a large extent the efficiency of production in livestock buildings and also in the storage life of various types of products is dependent on the conditions maintained in the structure. Therefore, the equipment required to maintain these conditions must satisfy the basic specifications as to operation and installation. With the increase in use of electrical energy on the farm, it is essential that standards be established not only from the safety aspect but also to ensure efficient operation of electrical equipment and to give adequate light with proper control where required. For example, a wire size should be based on a 1% voltage drop on maximum demand when it supplies poultry brooders, incubators, fluorescent lighting or other voltage-sensitive application. For other loads 2% voltage drop is satisfactory.

Water is an essential service in all livestock production buildings and therefore the types and quantities of water and the most efficient methods of distribution, heating where required, and control must be included in overall design procedures. It is also essential that all wastes on farms should be disposed of in a safe and sanitary manner, such that no possible pollution can occur, thus, basic standards must be based on quantities and types of wastes to be disposed.

*Health and Sanitation*

Buildings must be constructed and maitained such that conditions conducive to the good health of animals and suitable for quality production and storage of agricultural products can be maintained. In certain types of buildings the dimensional requirements for the livestock may be determined by the health and sanitation requirements rather than by other physical factors. In the same manner, certain types of materials may be required.

*Appendices*

This section has been drawn together to make available physical data on different types to help determine the different criteria or facilities in the overall design. These may be supplemented with other information as it becomes available.

## SUMMARY

Farm Building Standards has been developed as a supplement to the National Building Code of Canada such that it represents contemporary farm building practices in Canada. It outlines the necessary physical dimensions and criteria for efficient and economical design of buildings commensurate with optimum production and storage of agricultural products. It covers recommendations to reduce the hazard from fire and accidents in and around buildings and establishes environmental conditions and necessary services for modern-day production practices. They are for the most part, considered minimum standards by which safe and efficient buildings may be designed.

Further research and testing of procedures and components will help to fill some of the gaps and substantiate

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