LIMIT STATES DESIGN

Manitoba Building Code Requirements for the Design of Deep Foundations for Housing & Small Buildings

Norman A. Garcia, P.Eng., LEED AP BD+C
Building & Fire Safety Engineer
Office of the Fire Commissioner
Norman.Garcia@gov.mb.ca

Manitoba

Goals

You will learn:

1. Manitoba Building Code (MBC) requirements pertaining to design of deep foundations of housing and small (Part 9) buildings.

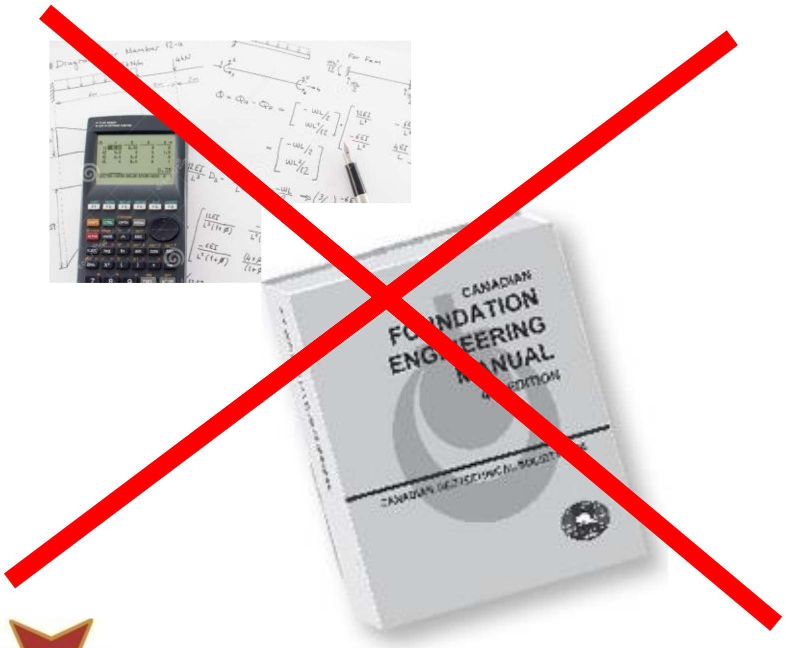
2. How to identify compliant or non-compliant construction drawings.

Outline

1. Overview of foundation design process
2. Shallow foundations
3. Deep foundations
4. Previous design methods
5. History of Limit States Design in the NBC
6. Limit States
7. Limit States Design Philosophy
8. Sample Construction Notes

This is NOT about:

X Teach limit states design calculations, structural analysis and structural design.



… but Limit States Design from the perspective of building code official.

Building Department

Manitoba

Foundation Design Process

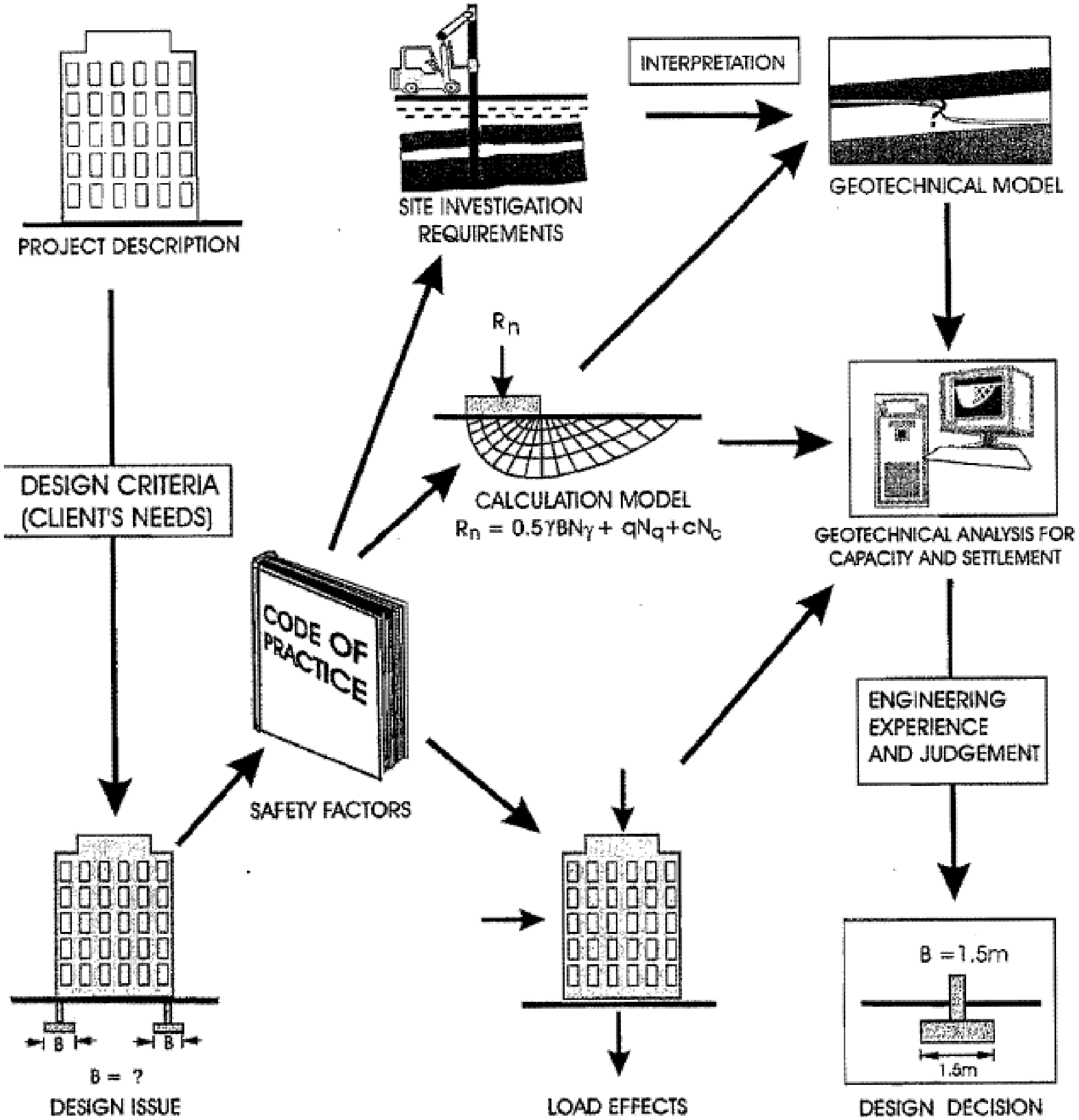
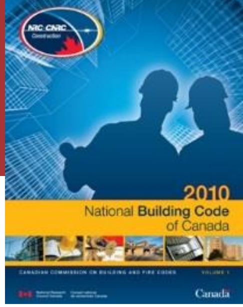


FIGURE 7.1 *Components of foundation design and role of codes of practice (after Ovesen 1981, 1993 and Becker 1996a).*

Manitoba

Foundation Types



Division A. 1.4.1.2.(1) Defined Terms

Foundation means a system or arrangement of *foundation units* through which the loads from a *building* are transferred to supporting *soil* or *rock*.

Foundation unit means one of the structural members of the *foundation* of a *building* such as a footing, raft or *pile*.

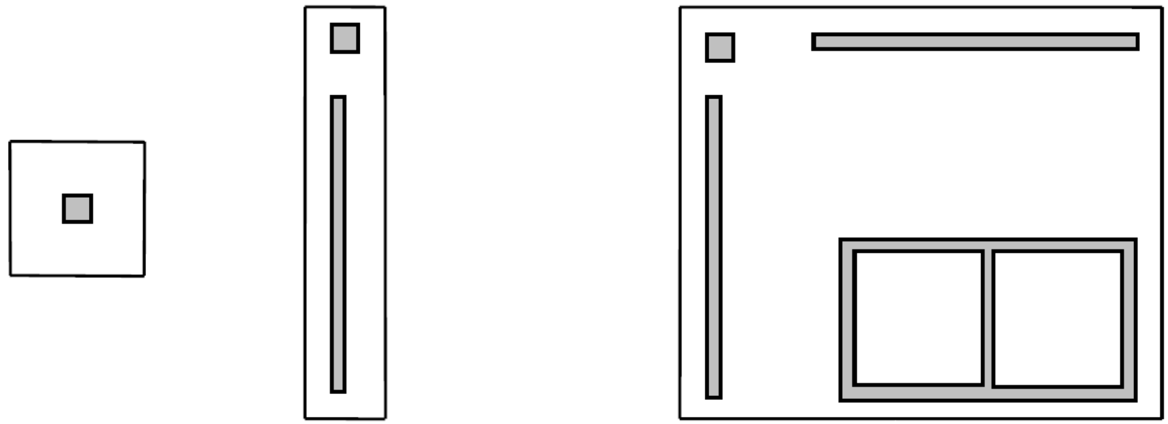
Shallow foundation means a *foundation unit* that derives its support from *soil* or *rock* located close to the lowest part of the *building* that it supports.

Deep foundation means a *foundation unit* that provides support for a *building* by transferring loads either by end-bearing to *soil* or *rock* at considerable depth below the *building*, or by adhesion or friction, or both, in the *soil* or *rock* in which it is placed. *Piles* are the most common type of *deep foundation*.

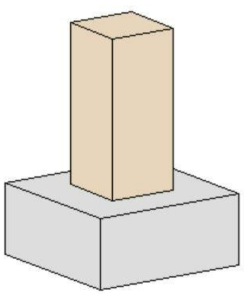
Pile means a slender *deep foundation unit* made of materials such as wood, steel or concrete or a combination thereof, that is either premanufactured and placed by driving, jacking, jetting or screwing, or cast-in-place in a hole formed by driving, excavating or boring. (Cast-in-place bored *piles* are often referred to as *caissons* in Canada.)

Manitoba

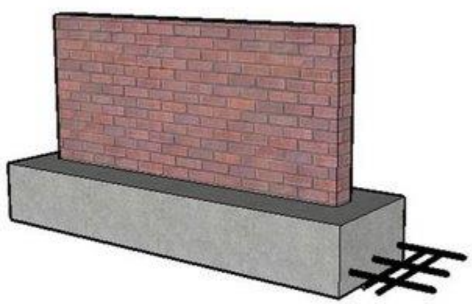
Shallow Foundations



(a) Pad Footing (b) Strip Footing (c) Raft Footing



column pad footing



Shallow Foundations

As per **Section 9.15. Footings and Foundations**

Manitoba Amendments:

2(55) **Sentence 9.15.1.1.(1) is replaced with the following:**

1) This section applies to *foundations* designed and constructed for a single-family dwelling, a two-family dwelling or row housing. (See Section 9.35. for small garages and carports, and Part 4 for other *buildings*.)

2(56) **The following is added after Article 9.15.2.4.:**

9.15.2.5. **Design Requirements**

1) Footings, *foundations*, *foundation* walls or *basement* walls shall conform to Table 9.15.2.5. and this section.

Shallow Foundations

Table 9.15.2.5.
Footings, Foundations, Foundation Walls and Basement Walls
Forming Part of Sentence 9.15.2.5.(1)

Type of Soil	Type of Construction Materials	Design Requirements	
		Footings and Foundations	Foundation Walls and Basement Walls
Coarse Grain[1] (e.g. sand, gravel, cobbles, boulders)	Concrete	Table 9.15.3.4	Table 9.15.4.2.A. Table 9.15.4.2.B.
	Masonry	Not Permitted	Table 9.15.4.2.A. Table 9.15.4.2.B.
	Precast Concrete, Steel	Section 4.2.	Section 4.3.
	Wood	Article 9.15.2.4.	Article 9.15.2.4.
Fine Grain (e.g. clays, silt, shale)	Concrete (cast in place)	Fig. 9.15.2.5.A. Laterally supported walls – One *Storey* Fig. 9.15.2.5.B. Laterally supported walls – Two *Storey* Fig. 9.15.2.5.C. Laterally unsupported walls Fig. 9.15.2.5.D. Piers @ 2.5 metres O.C. Maximum Fig. 9.15.2.5.E. Piers @ 3 metres O.C. Maximum Fig. 9.15.2.5.F. Attached garage *foundation*	
	Masonry	Not permitted	Appropriate Section of Part 4 of this Code [2]
	All other materials	Section 4.2. of Part 4 of this Code	
Organic (muskeg, top soil) filled ground	All materials	Designed by a *professional engineer*	
Permafrost (known or suspected areas)	All materials		

Notes to Table 9.15.2.5.

1 *Soils* with an allowable bearing of 75 kPa or greater.
2 Installation of *foundation* walls, other than case-in-place concrete in regions with fine grain *soils*, subject to approval of the *authority having jurisdiction*.

Shallow Foundations

9.4.4. Foundation Conditions

9.4.4.1. Allowable Bearing Pressures

1) Footing sizes for *shallow foundations* shall be
a) determined in accordance with Section 9.15., or
b) designed in accordance with Section 4.2. using
  i) the maximum allowable bearing pressures in Table 9.4.4.1., or
  ii) allowable bearing pressures determined from *subsurface investigation*.

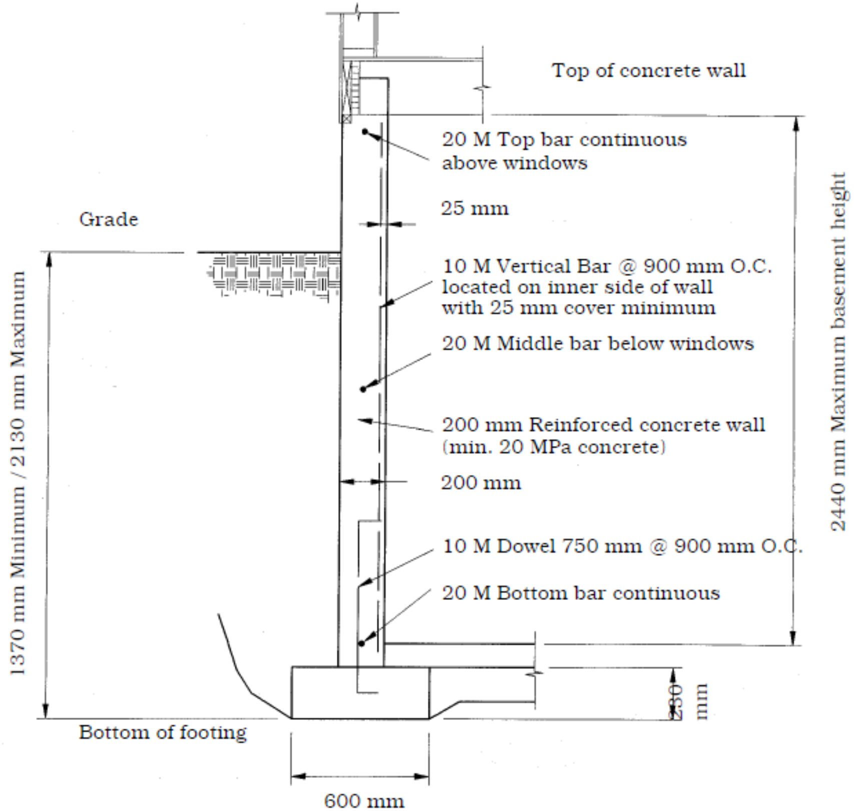
Table 9.4.4.1.
Allowable Bearing Pressure for Soil or Rock
Forming Part of Sentence 9.4.4.1.(1)

Type and Condition of *Soil* or *Rock*	Maximum Allowable Bearing Pressure, kPa
Dense or compact sand or gravel(1)	150
Loose sand or gravel(1)	50
Dense or compact silt(1)	100
Stiff clay(1)	150
Firm clay(1)	75
Soft clay(1)	40
Till	200
Clay shale	300
Sound *rock*	500

Shallow Foundations

Figure 9.15.2.5.A.
Forming part of subsection 9.15.2.5.(1)

MINIMUM REINFORCEMENT FOR
LATERALLY SUPPORTED FOUNDATION WALLS
Up to 12 metres in length and in fine-grain soils



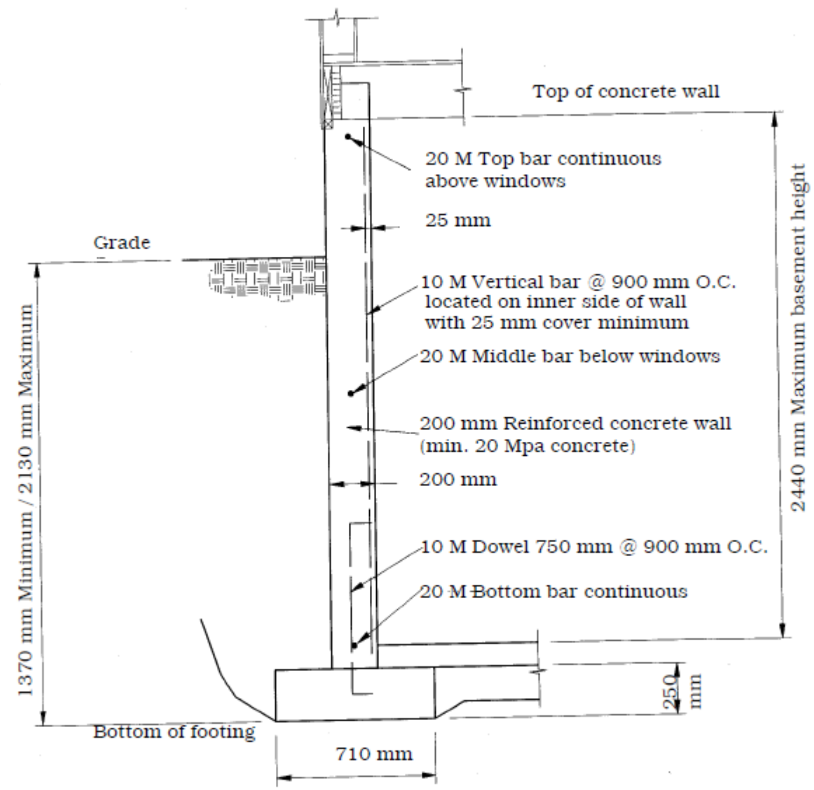
ONE STOREY

NOTES:
1) Walls over 12 metres in length shall be designed by a *professional engineer*.
2) Minimum interior column footing size 750 mm × 750 mm × 250 mm.
3) "M" means Metric bar.

Figure 9.15.2.5.B.
Forming part of subsection 9.15.2.5.(1)

MINIMUM REINFORCEMENT FOR
LATERALLY SUPPORTED FOUNDATION WALLS

Up to 12 metres in length and in fine-grain soils



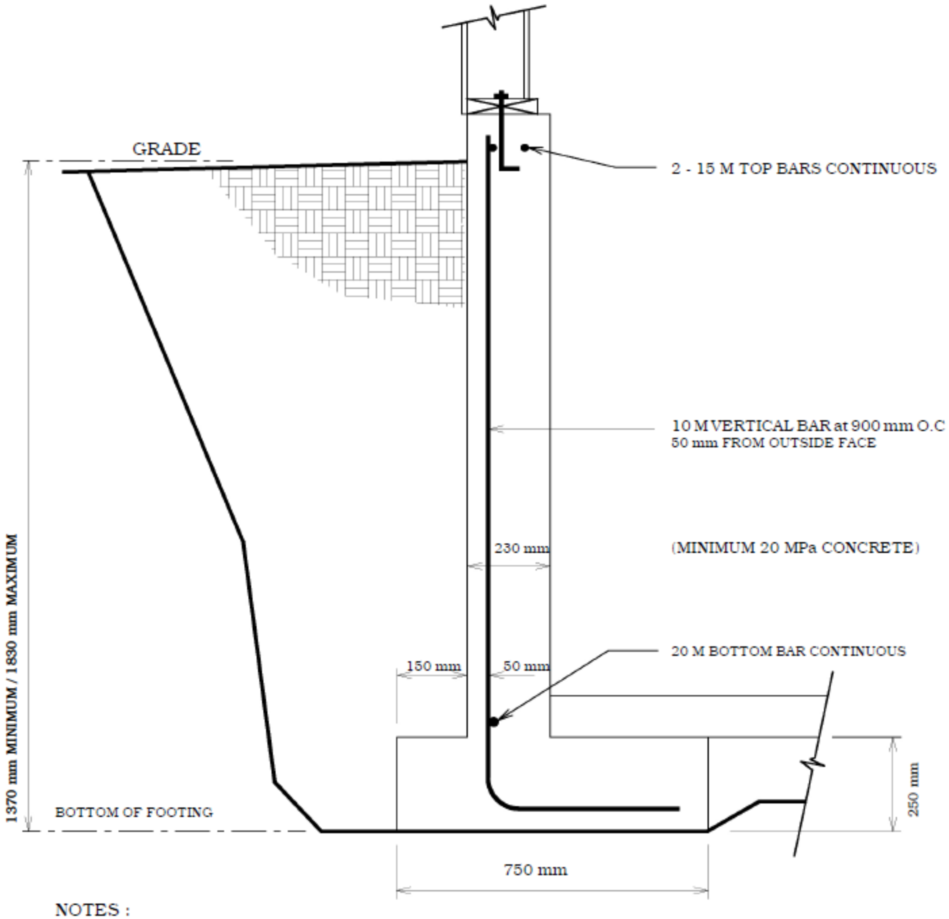
TWO STOREY

NOTES:
1) Walls over 12 metres in length shall be designed by a *professional engineer*.
2) Minimum interior column footing size 900 mm × 900 mm × 300 mm.
3) "M" means Metric bar.

Manitoba

Shallow Foundations

Figure 9.15.2.5.C.
Forming part of subsection 9.15.2.5(1)
MINIMUM REINFORCEMENT FOR
LATERALLY UNSUPPORTED FOUNDATION WALLS
UP TO 12 METRES IN LENGTH AND IN FINE–GRAINED SOILS

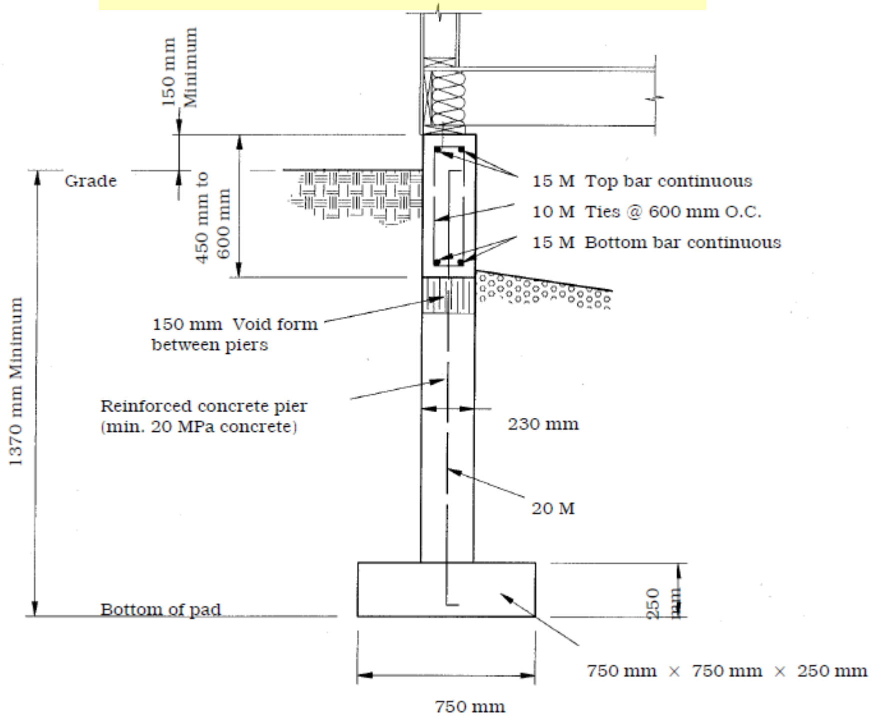


NOTES :
1) walls over 12 metres in length shall be designed by a *professional engineer*.
2) "M" means Metric bar

Shallow Foundations

Figure 9.15.2.5.D.
Forming part of subsection 9.15.2.5.(1)

MINIMUM REINFORCEMENT FOR
PIERS AND PERIMETER GRADE BEAMS IN FINE-GRAIN SOILS
FOR ONE STOREY FRAME DWELLINGS

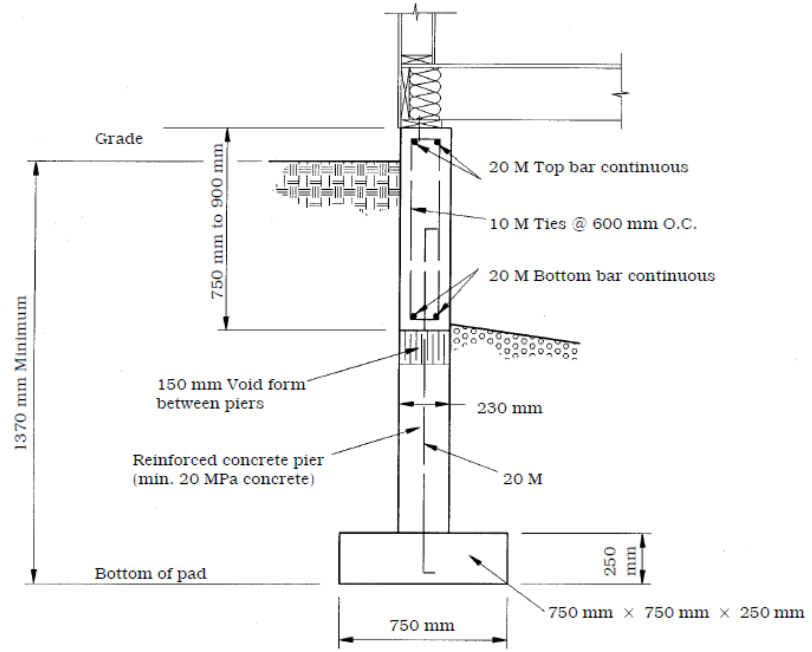


PIERS @ 2.5 metres O.C. MAXIMUM

NOTES:
1) Maximum supported joist length of 2.44 metres.
2) "M" means Metric bar.

Figure 9.15.2.5.E.
Forming part of subsection 9.15.2.5.(1)

MINIMUM REINFORCEMENT FOR
PIERS AND PERIMETER GRADE BEAMS IN FINE-GRAIN SOILS
FOR ONE STOREY FRAME DWELLINGS



PIERS @ 3.0 metres O.C. MAXIMUM

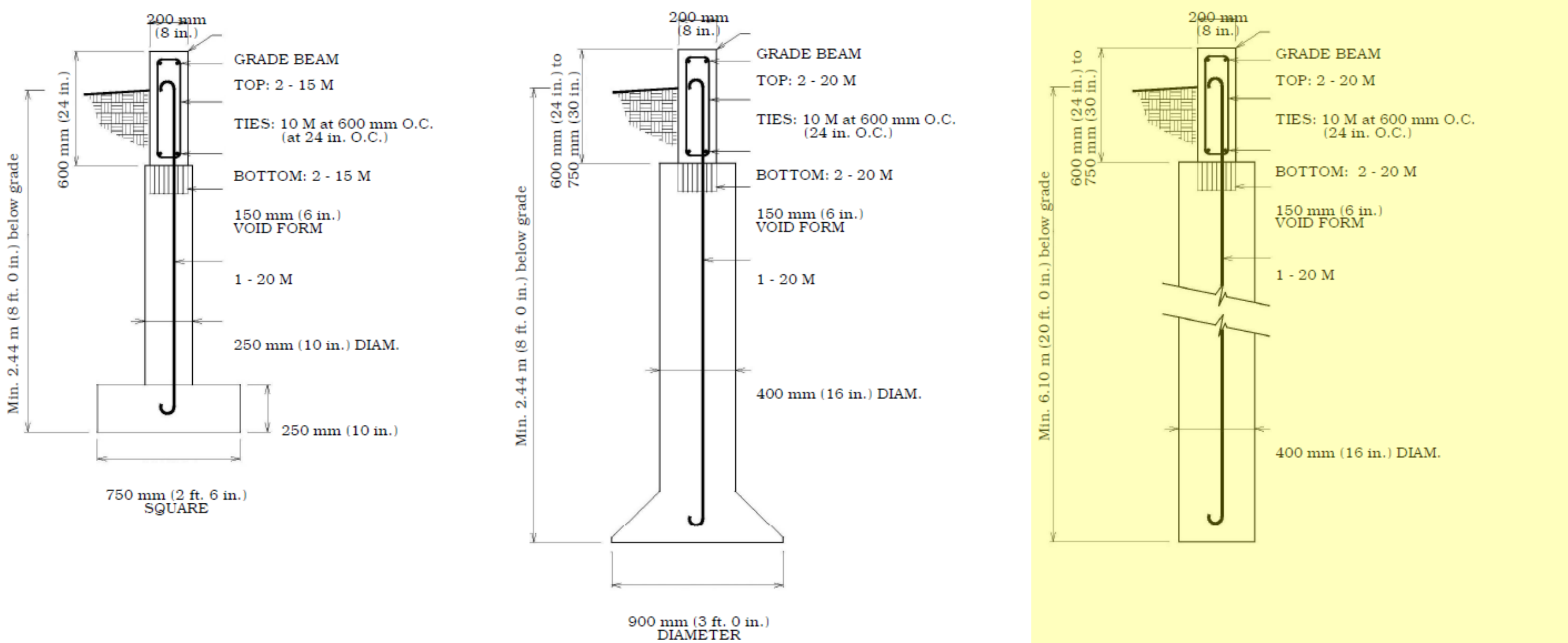
NOTES:
1) Maximum supported joist length of 3.05 metres.
2) "M" means Metric bar.

Manitoba

Garage Foundations

Figure 9.15.2.5.F.
Forming part of subsection 9.15.2.5.(1)

MINIMUM REINFORCEMENT FOR
ONE STOREY ATTACHED GARAGE GRADE BEAMS
IN FINE-GRAINED SOILS



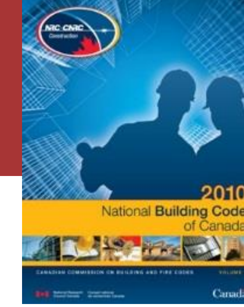
PIER and PAD
Maximum spacing: 2.44 m O.C. (8 ft. 0 in. O.C.)

BELLED PILE
Maximum spacing: 3.66 m O.C. (12 ft. 0 in. O.C.)

FRICTION PILE
Maximum spacing: 3.66 m O.C. (12 ft. 0 in. O.C.)

"***reverse engineering***" – not allowed to design for other types of buildings

MBC Provisions



9.4.1. Structural Design Requirements and Application Limitations

9.4.1.1. General

(See Note A-9.4.1.1.)

1) Subject to the application limitations defined elsewhere in this Part, structural members and their connections shall

a) conform to requirements provided elsewhere in this Part,

b) be designed according to good engineering practice such as that provided in CWC 2014, "Engineering Guide for Wood Frame Construction," or

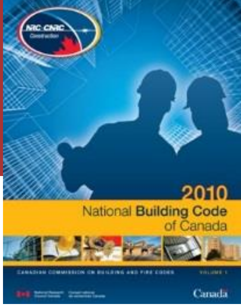
c) be designed according to Part 4 using the loads and deflection and vibration limits specified in

i) Part 9, or

ii) Part 4.

No "*prescriptive requirements*" for deep foundations. Only for single-family dwelling, a two-family dwelling or row housing.

MBC Provisions



What is "*prescriptive-based*"

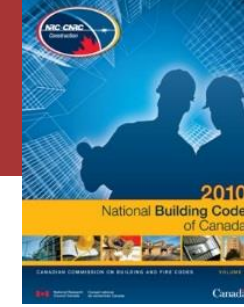
Describes in detail

- the types of materials that can be used, and
- how they must be used.

What is "*performance-based*"

- describes
  - Acceptable level of performance that an assembly, material, or system must meet without stating how the item is assembled

MBC Provisions

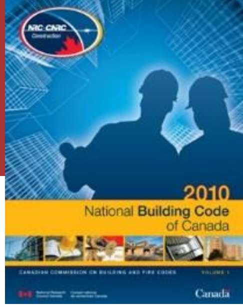


What is "*prescriptive*"

1. Based on past experiences
2. Not applicable to all building types
3. With limitations that restrict application
4. When limits are exceeded →go to Part 4
5. If all conditions are met, professional design is not required.

Manitoba

MBC Provisions



4.2.7.2. Design of Deep Foundations

1) *Deep foundations* shall be designed in conformance with Subsection 4.2.4. and this Subsection.

4.2.4. Design Requirements

4.2.4.1. Design Basis

1) The design of *foundations*, *excavations* and *soil*- and *rock*-retaining structures shall be based on a *subsurface investigation* carried out in conformance with the requirements of this Section, and on any of the following, as appropriate:

a) application of generally accepted geotechnical and civil engineering principles by a professional engineer especially qualified in this field of work, as provided in this Section and other Sections of Part 4,

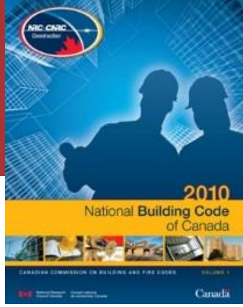
b) established local practice, where such practice includes successful experience both with *soils* and *rocks* of similar type and condition and with a *foundation* or *excavation* of similar type, construction method, size and depth, or

c) in situ testing of *foundation units*, such as the load testing of *piles*, anchors or footings, carried out by a person competent in this field of work.

(See Note A-4.2.4.1.(1).)

2) The *foundations* of a *building* shall be capable of resisting all the loads stipulated in Section 4.1., in accordance with limit states design in Subsection 4.1.3.

MBC Provisions



4.2.4. Design Requirements

4.2.4.1. Design Basis

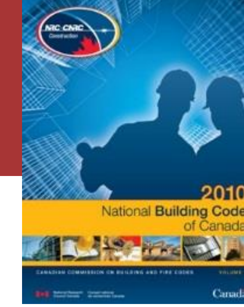
3) For the purpose of the application of the load combinations given in Table 4.1.3.2.-A, the geotechnical components of loads and the factored geotechnical resistances at ULS shall be determined by a suitably qualified and experienced professional engineer. (See Note A-4.2.4.1.(3).)

4) Geotechnical components of service loads and geotechnical reactions for SLS shall be determined by a suitably qualified and experienced professional engineer.

5) The *foundation* of a *building* shall be designed to satisfy SLS requirements within the limits that the *building* is designed to accommodate, including total settlement and differential settlement, heave, lateral movement, tilt or rotation. (See Note A-4.2.4.1.(5).)

6) Communication, interaction and coordination between the *designer* and the professional engineer responsible for the geotechnical aspects of the project shall take place to a degree commensurate with the complexity and requirements of the project.

MBC Provisions

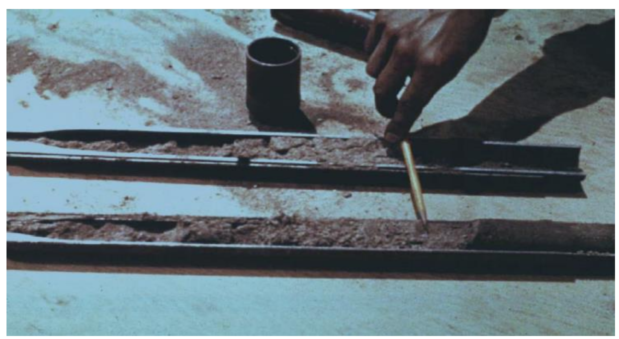


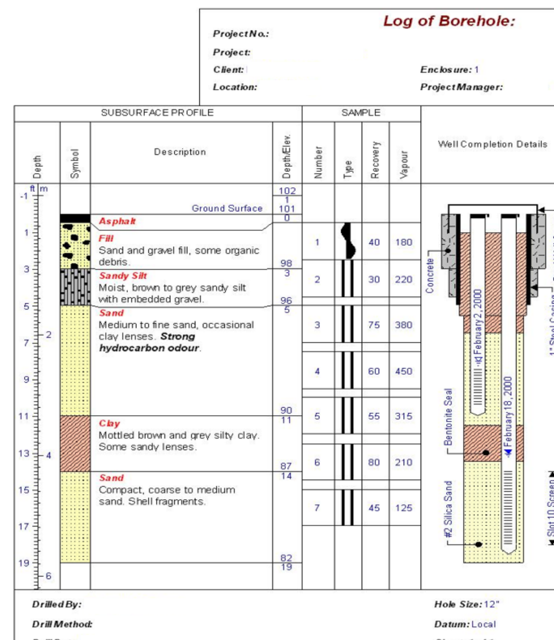
Subsurface investigation means the appraisal of the general subsurface conditions at a *building* site by analysis of information gained by such methods as geological surveys, in situ testing, sampling, visual inspection, laboratory testing of samples of the subsurface materials and *groundwater* observations and measurements.

4.2.2.1. Subsurface Investigation

1) A *subsurface investigation*, including *groundwater* conditions, shall be carried out by or under the direction of a professional engineer having knowledge and experience in planning and executing such investigations to a degree appropriate for the *building* and its use, the ground and the surrounding site conditions. (See Appendix A.)

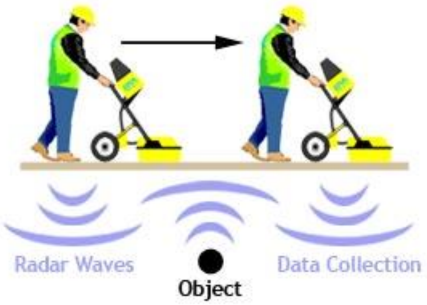
A-4.2.2.1.(1) Subsurface Investigation. Where acceptable information on subsurface conditions already exists, the investigation may not require further physical subsurface exploration or testing.

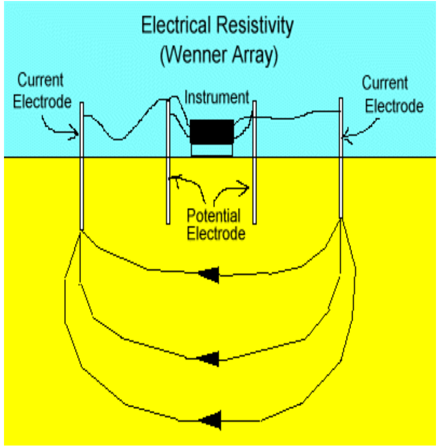




Common In-Situ Tests

1. Standard Penetration Test (SPT)
2. Dynamic Cone Penetration Test (DCPT)
3. Cone Penetration Test (CPT)
4. Becker Penetration Test (BPI)
5. Field Value Test (FVT)
6. Pressure-meter Test (PMT)
7. Flat Dilatometer Test (DMT)
8. Plate Bearing Test and Screw Plate Test
9. Permeability Test



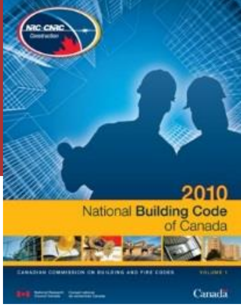


Geotechnical Report

Good Engineering Practice:

1. Terms of reference of the investigation
2. Scope of the investigation
3. Procedures and equipment used in the investigation
4. Proposed-structure/s
5. Geological setting
6. Topography, vegetation, and other surface features
7. Soil profile and properties
8. Groundwater observations
9. Existing adjacent structures
10. Foundation studies, including alternatives
11. Recommended field instrumentation and monitoring
12. Recommended construction procedures, if appropriate
13. Recommended field services
14. Conclusions and recommendations

MBC Provisions



4.2.2.3.
Field Review

MB Amendment:
"qualified person responsible to the designer"

1) A field review shall be carried out by the *designer* or by another ~~suitably qualified person~~ to ascertain that the subsurface conditions are consistent with the design and that construction is carried out in accordance with the design and good engineering practice. (See Note A-4.2.2.3.(1).)

2) The review required by Sentence (1) shall be carried out

a) on a continuous basis
  i) during the construction of all *deep foundation units* with all pertinent information recorded for each *foundation unit*,
  ii) during the installation and removal of retaining structures and related backfilling operations, and
  iii) during the placement of engineered *fills* that are to be used to support the *foundation units*, and

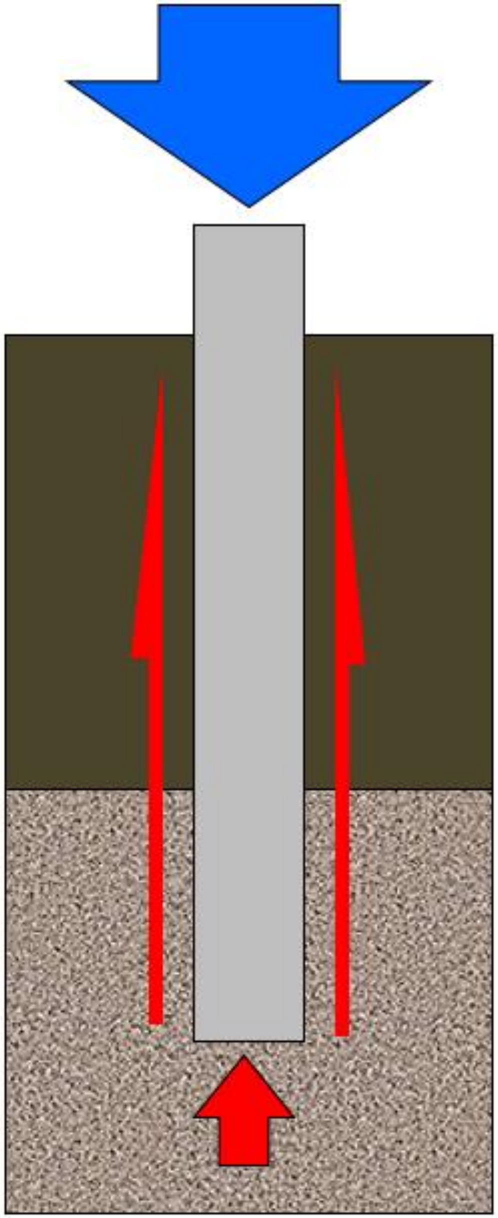
b) as required, unless otherwise directed by the *authority having jurisdiction*,
  i) in the construction of all *shallow foundation units*, and
  ii) in excavating, dewatering and other related works.

Manitoba

Deep Foundations

When to use deep foundations?

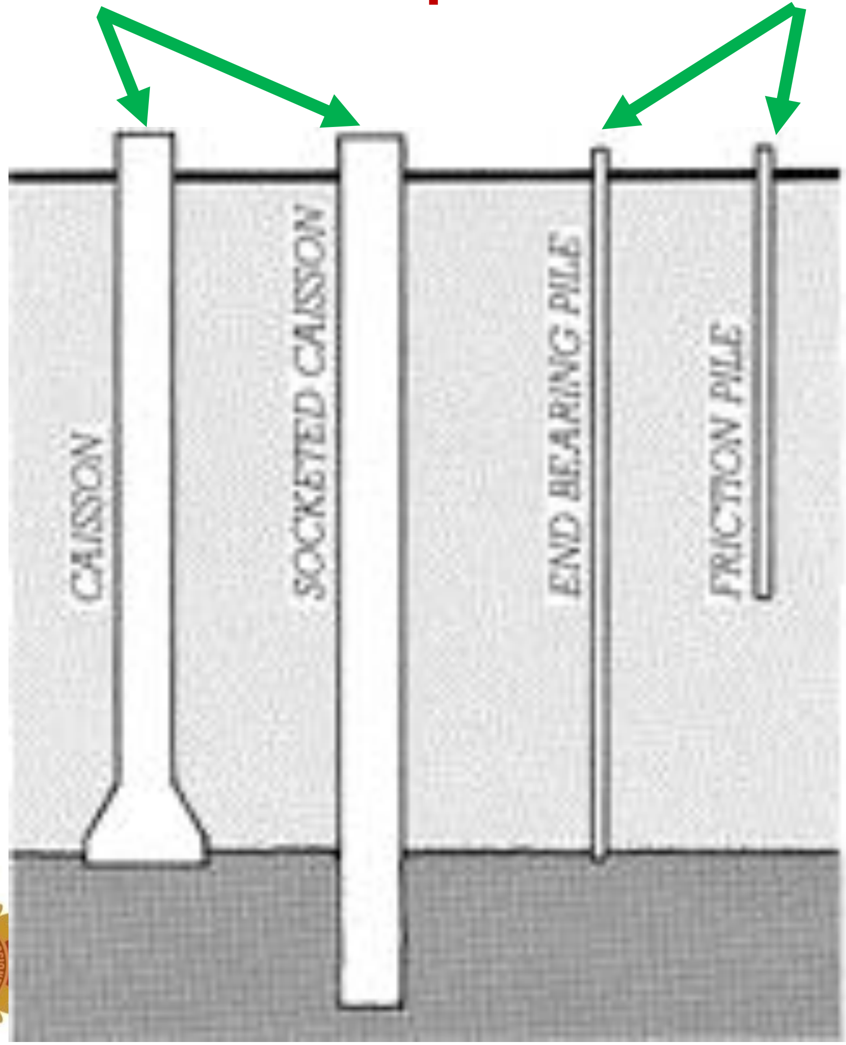
- ➢ When large concentrated loads applied by the structure or when the soil near the ground surface is **unsuitable** for shallow foundations.
- ➢ Adequate resistance from a combination of:
  - shaft friction along the length, and
  - end-bearing at the base of the piles.



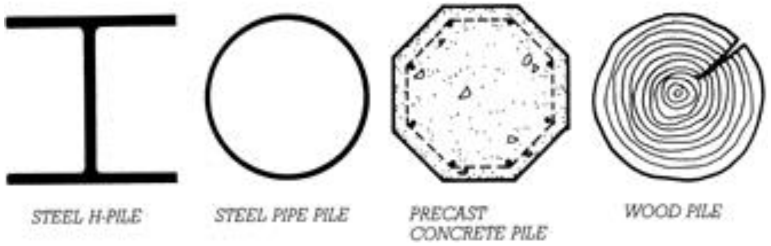
Deep Foundations

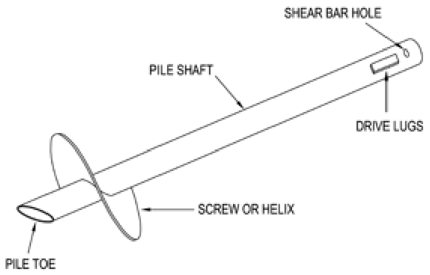
Drilled and cast-in-place

Driven

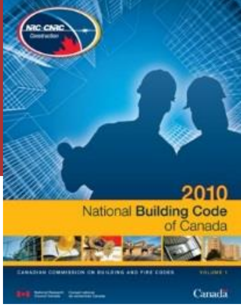


Material





Deep Foundations



2010 NBC:

4.2.7. Deep Foundations

4.2.7.1. General
4.2.7.2. Design of Deep Foundations
4.2.7.3. Tolerance in Alignment and Location
4.2.7.4. Incorrect Alignment and Location
4.2.7.5. Installation of Deep Foundations
4.2.7.6. Damaged Deep Foundation Units

Previous Design Methods

- **Plastic Design**
- **Ultimate Strength Design**
- **Working Stress Design**

a.k.a. Allowable or Permissible Stress Design

- **Limit States Design**

a.k.a. Load and Resistance Factor Design (LRFD)

Emphasize only one limit state, usually associated with a limiting stress or member strength

Working Stress Design (WSD)

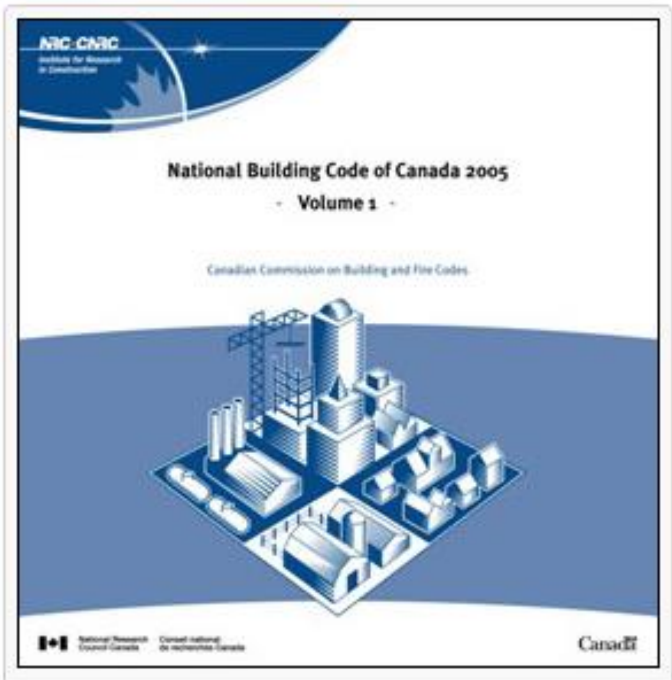
- First introduced in the early 1800’s
- Quicker, less on-site engineering
- Single global factor of safety is used
- No soil samples needed to determine soil bearing capacity.
- No Geotechnical Report needed.

$$FS = R_u/S_a \quad \text{or} \quad S_a = R_u/FS$$

Manitoba

History of LSD in the NBC

- 1975 – introduced in NBCC, for the steel structures, concrete structures, wood, cold-formed steel, and masonry,
- 1983 – aluminum structures
- 1995 – foundations
- 2005 – made LSD mandatory for all structural design including deep (pile) foundations

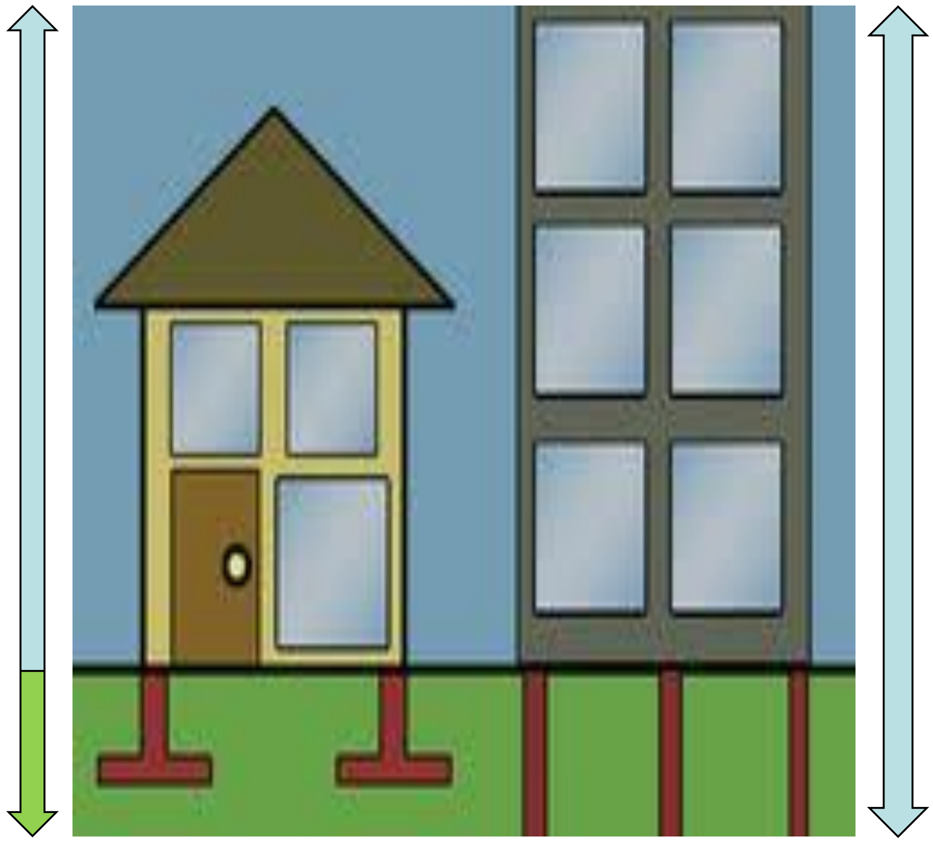


History of LSD in the NBC

Before 2005:
Above-grade → LSD
Below-grade → WSD

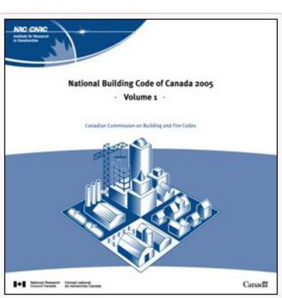
LSD

WSD



2005-onwards:
Above-grade → LSD
Below-grade → LSD

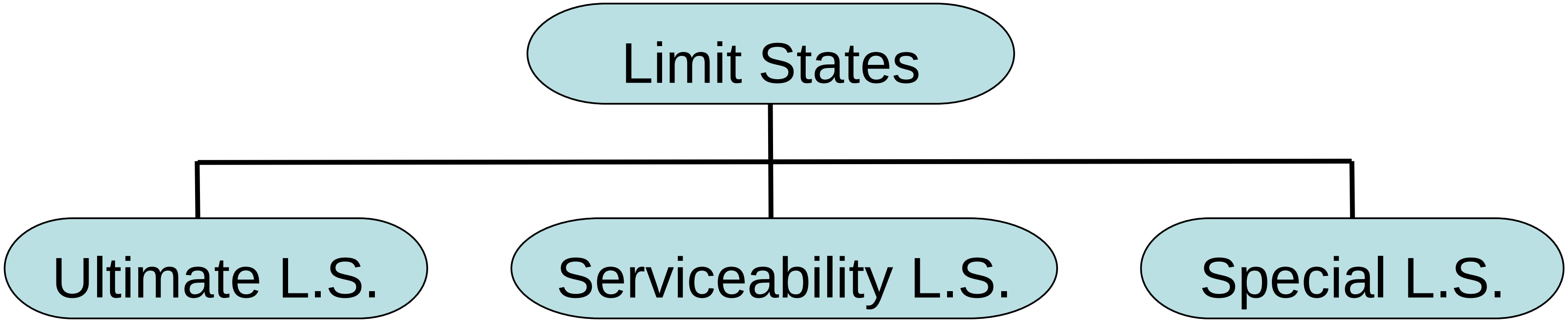
LSD



Manitoba

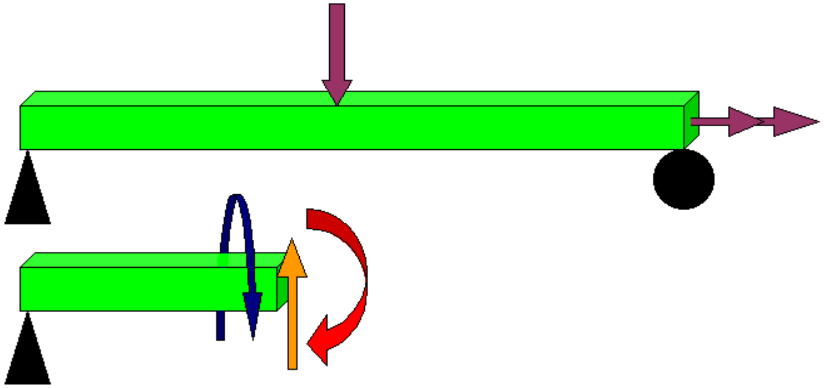
What are "Limit States"

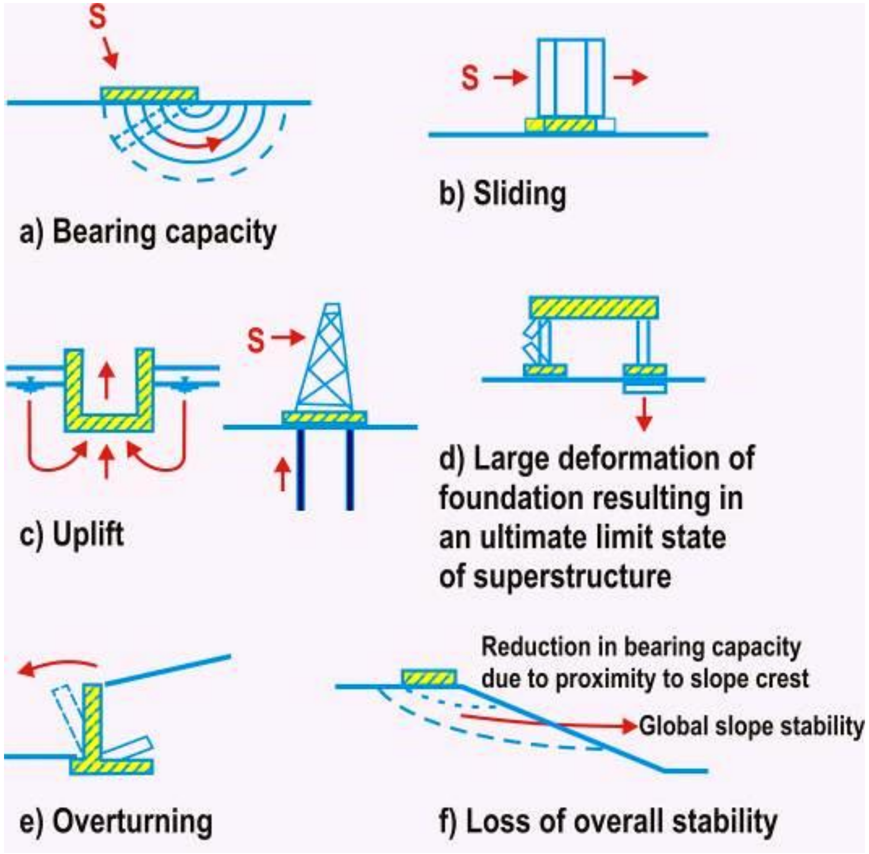
- Conditions under which a structure or its component members no longer perform its intended function or purpose
- Based on things that go wrong and do not perform satisfactorily
- Whenever a structure or part of a structure fails to satisfy one of its intended performance criteria, it has reached a "limit state"



Ultimate Limit States (ULS)

- Collapse or rupture
  e.g. bearing capacity of footings
- Safety concerns
- Things that are dangerous





Ultimate Limit States (ULS)

Example of ULS failure:

Failure of Transcona Grain Elevator

Manitoba Fre

WINNIPEG, MONDAY, OCTOBER 20, 1913.

ERY ABOUT DEATH

Pinned on Tree Tells
Body Was to be Found.

N VICTIM'S WRITING.

dams Had Been Missing Two
from His Vancouver Home.

SIDENT HUERTA
EMAINS AT HELM

Not Resign Nor Run Away,
Declares—Has Plenty of
ey For His Projects.

BIG ELEVATOR ANNEX
SWAYS UNDER STRAIN

Foundation Gives Way Under
C. P. R. Grain Warehouse
At North Transcona

BUILDING IS IN RUINS

Contained Almost Million Bushels
of Wheat---Machinery Is
Wrecked

The annex of the huge C.P.R. internal terminal elevator at Transcona sank steadily for 12 hours on Saturday until it had subsided into the ground for 20 feet, at the same time tilting over to an angle of between 30 and 35 degrees. At midnight, when it was feared that the whole structure must collapse, owing to the tremendous strain placed on the concrete of which it was constructed, by the angle at which the building had canted to, the heavy cupola on top collapsed and, by relieving the strain on the foundation, brought the slipping to a stop. The huge storage bins in the annex were filled almost to their capacity of a million bushels of wheat, and, when the cupola fell, it destroyed the whole of the complicated apparatus for removing the grain from the bins to the work-house, so that the C.P.R. is now confronted with the problem of getting almost a million bushels of wheat out of a building tilted to an angle at which it appears as though it must collapse every moment, in time to have is shipped to the great lakes before the

AIR LINE TO WINNIPEG

Aviator Intends Flying from Minneapolis in New Machine.

HAD SUCCESSFUL FLIGHT.

Young Man Wishes to Prove to His Parents that His Biplane Is All Right.

(Free Press Special.)

Minneapolis, Minn., Oct. 19. — An aeroplane trip from Minneapolis to Winnipeg as a climax to months of industry is now the aim of A. T. Heine, aviator, who Friday afternoon made a successful flight at Fort Snelling with his biplane, built along Curtis lines. After a few more trips he plans to be off for Winnipeg this week. He says he is going to show his father and mother that he succeeded in the face of their disapproval and opposition. Heine Jr. says he knows no better way to demonstrate it than to land in an aeroplane just as far from his father's home as possible.

"The plane's behavior in Friday's flight convinced me I have as good a machine as I have ever ridden in" said Heine "and I have added features that add to its safety. I can easily make 75 miles an hour and if I fly at that rate only two hours a day, I can make Winnipeg easily."

Heine took a course in aviation from Glen Curtis. Immediately after he received his license he came to Minneapolis and set out to build his aeroplane. He plans to start a school of aviation here later.

TWENTY SOLDIERS
KILLED IN WRECK

Troops Train Plunges Through Trestle Near State Line, Miss.
—One Hundred Injured.

CANADIAN
TROUBLE

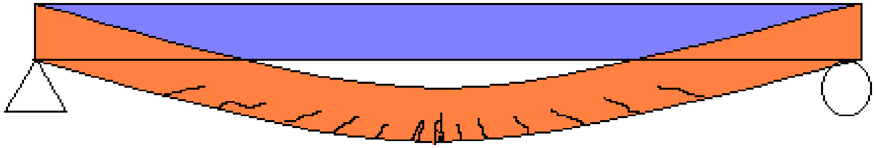
Head Office
Branches
By Au

MAY ANNUL

Alleged that Emi
gled Across Fr
Disguised as W

Serviceability Limit States (SLS)

- Things that affect function of structure under expected service loads
- Safety of structure not an issue
- Consists of:
  - Excessive movements (e.g. settlement, heave, lateral movement, cracking, tilt)
  - Unacceptable vibrations
  - Local damage and deterioration
- Things that make life difficult, but are not necessarily dangerous.



Manitoba

Serviceability Limit States (SLS)

Example of SLS failure:

Palace of Fine Arts in Mexico City has settled more than 3 m than the surrounding streets for a period of 50 years and still settling

Serviceability Limit States (SLS)

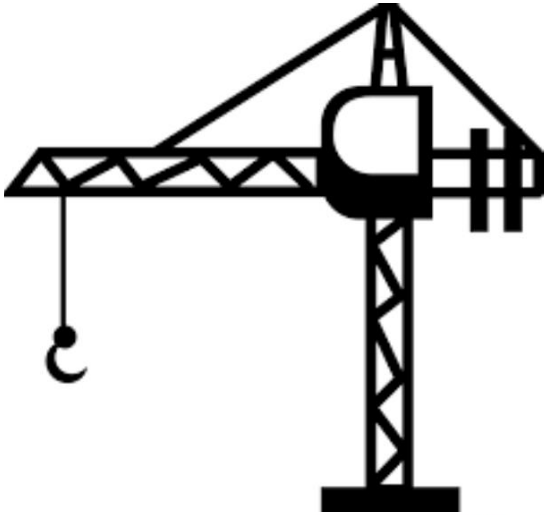
Example of SLS failure:

Tower of Pisa, Italy

Special Limit States

"Other" Limit States:

- Damage or collapse in extreme earthquakes.
- Structural effects of fire, explosions, or vehicular collisions.
- Fatigue Limit States (FLS) resulting from many load repetitions (e.g. crane-supporting structures)

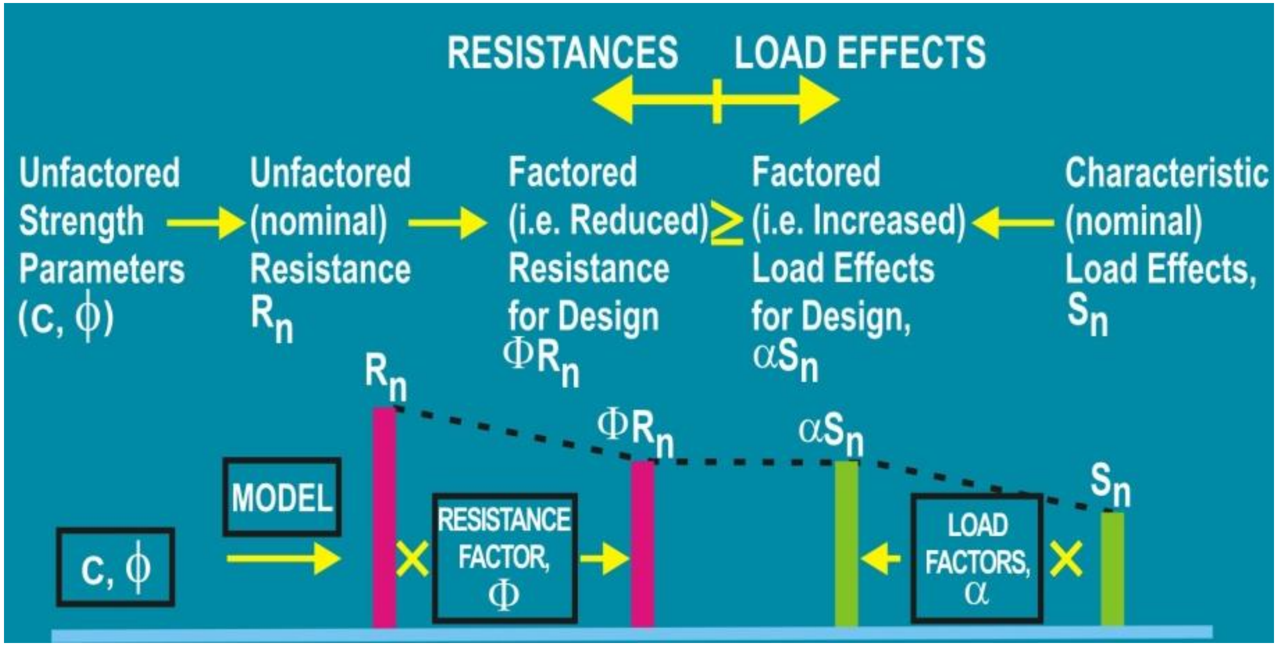


Manitoba

Limit States Design (LSD)

Basic Design Equation:

$$\phi R_n \geq \Sigma \alpha_i S_{ni}$$



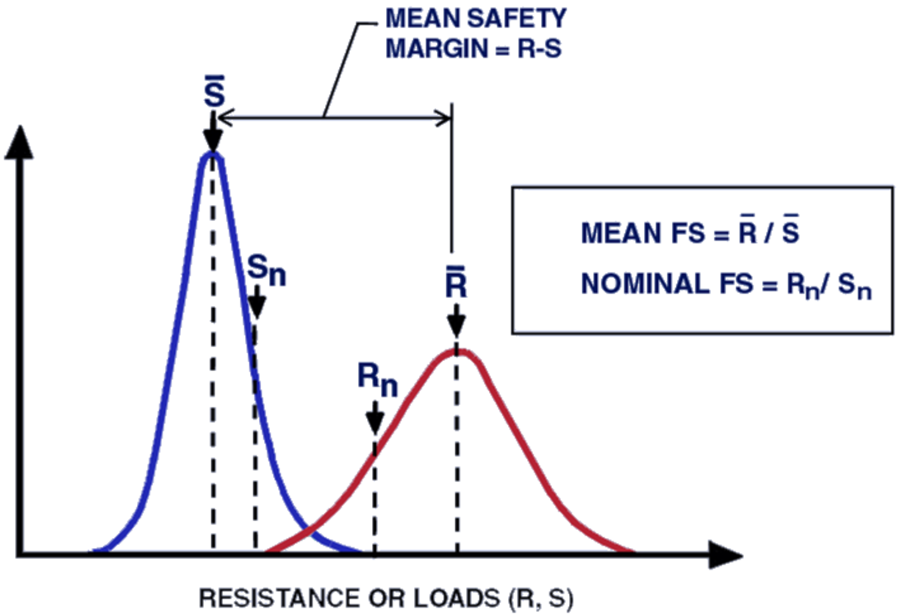
Limit States Design (LSD)

$$\phi R_n \geq \Sigma \alpha_i S_{ni}$$

$\phi < 0$

$\alpha \geq 1$ (usually but not always)

Values are specified in Part 4 NBC



Φ and α factors are to account for:

- ✓ Uncertainty in loads
- ✓ Probability of occurrence
- ✓ Variability

Limit States Design (LSD)

Table K-1 of 2010 NBC Structural Commentaries:

	Description	Resistance Factor, Φ
1.	**Shallow foundation**	
(a)	Vertical bearing resistance from semi-empirical analysis using laboratory and in-situ test data	0.5
(b)	Sliding	
	(i) based on friction ($c = 0$)	0.8
	(ii) based on cohesion/adhesion ($\tan \phi = 0$)	0.6
2.	**Deep foundation**	
(a)	Resistance to axial load	
	(i) semi-empirical analysis using laboratory and in-situ test data	0.4
	(ii) analysis using static loading test results	0.6
	(iii) analysis using dynamic monitoring results	0.5
	(iv) uplift resistance by semi-empirical analysis	0.3
	(v) uplift resistance using loading test results	0.4
(b)	Horizontal load resistance	0.5

Calculation Example:

R_n = 2,500 kN, ultimate axial capacity from static pile load test

ϕ = 0.6

ϕR_n = 0.6 x 2,500 kN

= **1,500 kN,**

factored axial geotechnical resistance at ULS

Manitoba

Limit States Design (LSD)

Why use Limit States Design?

- Achieve consistent design approach between geotechnical (traditionally WSD) and structural engineers (LSD)
- Economic advantages
  - Probability of a Limit State being reached is within “acceptable limits”;
  - Complete elimination of probability of a Limit State being achieved in the service life of a structure is impractical
  - Uneconomical designs
- Technical aspects

WSD or LSD?

How do we know which calculation method was used by the engineer?

Manitoba

Working Stress Design (WSD)

<u>Probably</u> WSD, so investigate further.

CAST-IN-PLACE CONCRETE PILE NOTES

- CONCRETE SHALL BE A (TYPE 50) CONCRETE IN ACCORDANCE WITH AMERICAN CONCRETE INSTITUTE (ACI) 301, AND 318

-CAST-IN-PLACE PILES ARE DESIGNED FOR AN ASSUMED SKIN FRICTION OF 300 PSF

- CONCRETE SHALL BE NORMAL WEIGHT UNLESS OTHERWISE SPECIFIED AND SHALL OBTAIN 28 DAY COMPRESSIVE STRENGTHS AS FOLLOWS

  - CONC. PILE -------------------- 35MPA
  - AGGREGATE SIZE ----------- 1" MAX.
  - CONC. SLUMP ----------------- 3" MAX.
  - AIR ENTRAINMENT ----------- 4-6%
  - VIBERATION -------------------- TO A DEPTH OF 10' (FT)

- PILES SHALL BE NO MORE THAN 2% OUT OF PLUMB AND NOT MORE THAN 2" (INCH) OUT OF ALIGNMENT

- PILE REINFORCING TO BE 2 LENGTHS OF 15M REBAR AND SHALL EXTEND FROM THE BOTTOM OF THE PILE TO A MIN OF 2" (FT) INTO THE GRADE BEAM / WALL

- ALL REINFORCING STEEL USED SHALL BE CLEAN BILLET FREE OF LOOSE RUST, DIRT , OR OTHER CONTAMINANTS THAT WOULD REDUCE BONDING STRENGTH AND SHALL BE AS FOLLOWS

  -15M ----------------------- G30.18-09 400MPA

Manitoba

Working Stress Design (WSD)

Probably WSD, so investigate further.

FOUNDATION NOTES:

ALL STRAIGHT SHAFT CONCRETE PILES ARE DESIGNED AS CAST-IN-PLACE FRICTION ELEMENTS IN FIRM UNDISTURBED MATERIAL WITH AN ALLOWWBLE FRICTION APACITY OF 300 PSF. FOOTINGS SHALL BE FOUNDED ON FIRM DRY UNDISTURBED SOIL (EXCLUDING SILT) CAPABLE OF PROVIDING AN ALLOWABLE BEARING CAPACITY OF 1500 PSF. ALL BELLED PILES ARE DESIGNED AS END BEARING ELEMENTS FOUNDED ON FIRM DRY UNDISTURBED SOIL (EXCLUDING SILT) CAPABLE OF PROVIDING AN ALLOWABLE BEARING CAPACITY OF 2500 PSF. THE OWNER / CONTRACTOR IS RESPONSIBLE FOR VERIFYING THESE ASSUMPTIONS WITH A SOILS INVESTIGATION. STEINER DRAFTING & DESIGN, ACCEPTS NO LIABILITY FOR THESE ASSUMTIONS OR FOR ANY REDESIGN OF THE FOUNDATION RESULTING FROM THE CONTRARY SOILS CONDITIONS.

Working Stress Design (WSD)

Probably WSD, so investigate further.

FOUNDATION

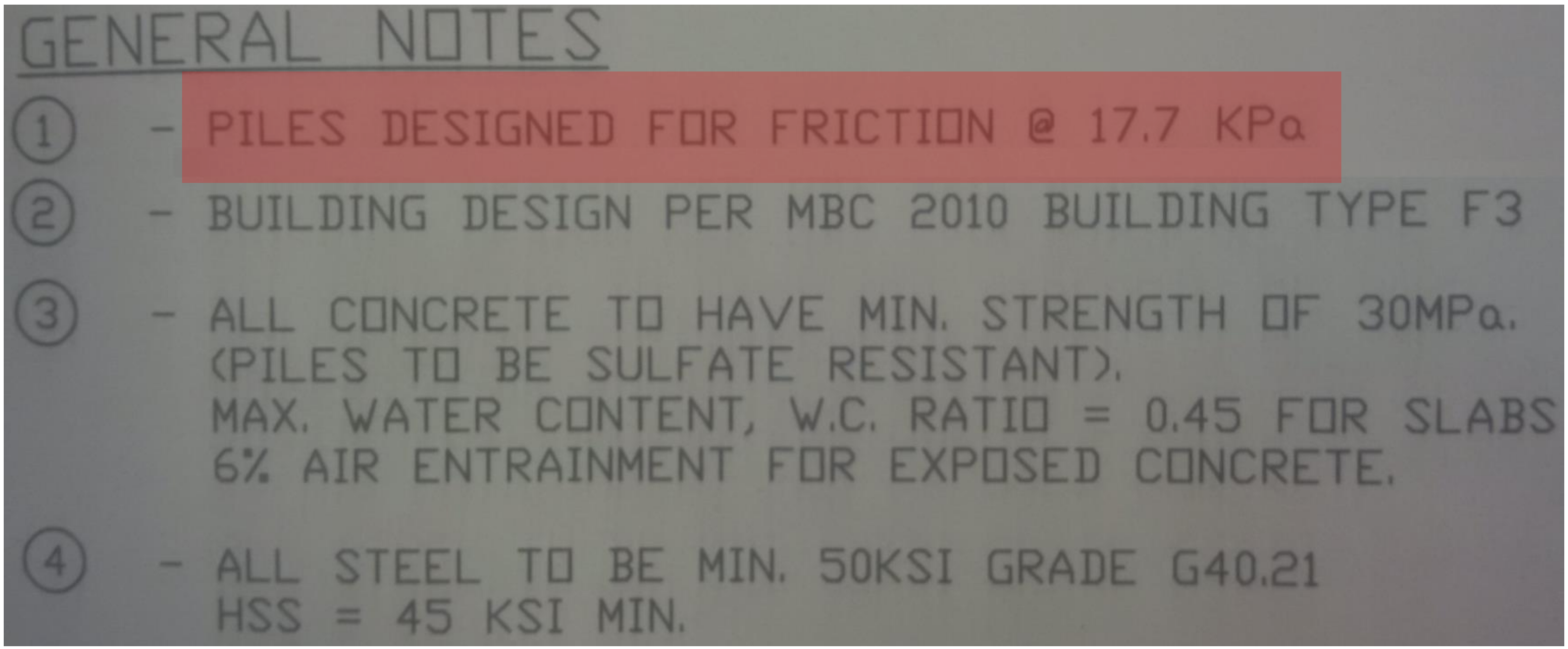
1. Foundation has been designed as bearing end cast in place piles
2. Piles working capacities as follows:
450 mm/18" - 400 kips / 1800 kN,
400 mm/16" - 265 kips / 1200 kN
3. All piles shall be made with sulphate resistant cement type 50 with a concrete strength of 35 MPa.
4. Piles shall be no more than 2% out of the plum and 2" / 50mm out of alignment.
5. Defective or piles which are damaged in construction will not be accepted. Additional piles shall be substituted by the piling contractor at no extra cost to the owner.

OFFICE OF THE FIRE COMMISSIONER MANITOBA

Manitoba

Working Stress Design (WSD)

Probably WSD, so investigate further.



GENERAL NOTES

1 - PILES DESIGNED FOR FRICTION @ 17.7 KPa

2 - BUILDING DESIGN PER MBC 2010 BUILDING TYPE F3

3 - ALL CONCRETE TO HAVE MIN. STRENGTH OF 30MPa.
(PILES TO BE SULFATE RESISTANT).
MAX. WATER CONTENT, W.C. RATIO = 0.45 FOR SLABS
6% AIR ENTRAINMENT FOR EXPOSED CONCRETE.

4 - ALL STEEL TO BE MIN. 50KSI GRADE G40.21
HSS = 45 KSI MIN.

Working Stress Design (WSD)

<u>Probably</u> WSD, so investigate further.

CONCRETE FOR C.I.P. PILES SHALL BE:

32 MPa (4,600 psi) @ 28 DAYS
SULPHATE RESISTANT CEMENT
AGG. SIZE = 40mm (1-1/2")MAX
SLUMP = 75mm (3")
AIR = 3 - 6%

- THE DESIGN CAPACITIES FOR ALL CAST-IN-PLACE FRICTION PILES SHALL BE 300psf UNLESS INDICATED BY A GEOTECHNICAL REPORT FOR THE SITE.

- NEGLECT FIRST 6'-0" FROM GRADE FOR INTERIOR PILES

- NEGLECT FIRST 8'-0" FROM GRADE FOR EXTERIOR PILES

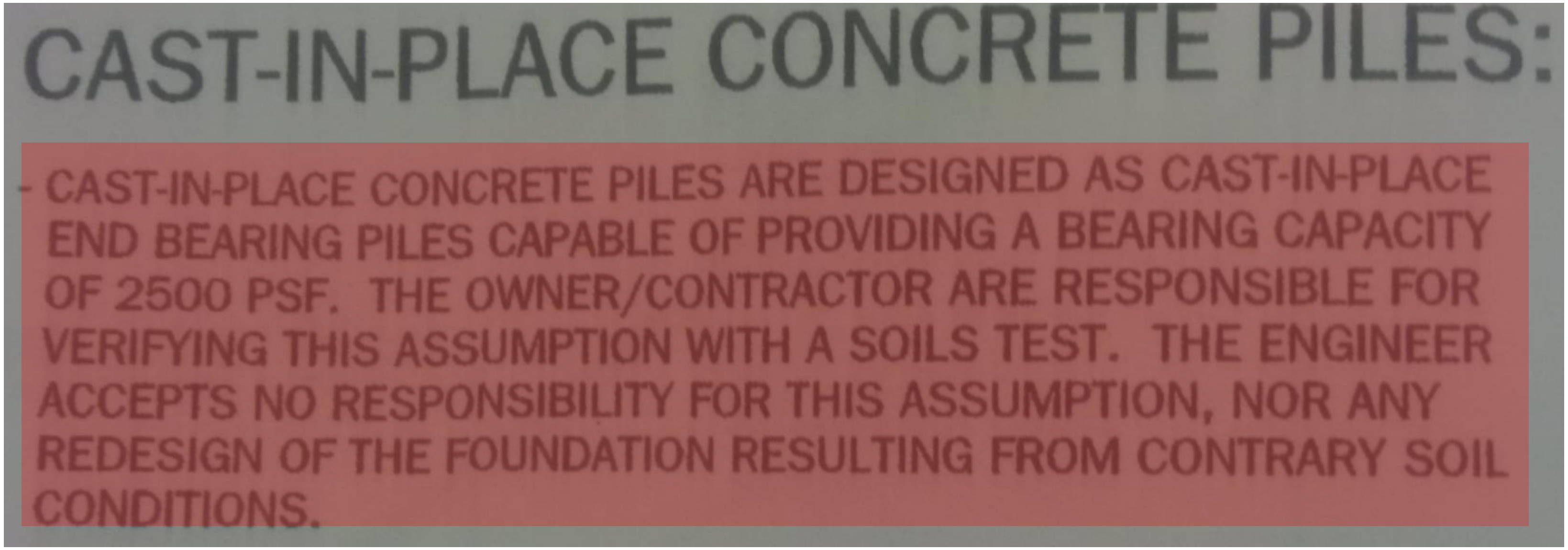
- EACH PILE SHALL BE PLACED NOT MORE THAN 2% OF ITS LENGTH OUT OF PLUMB AND SHALL BE POSITIONED NOT MORE THAN 50mm (2") FROM THE LOCATION SHOWN ON THE PLAN. PILES NOT MEETING THESE REQUIREMENTS WILL BE REPLACED AT NO COST TO THE OWNER.

OFFICE OF THE FIRE COMMISSIONER MANITOBA

Manitoba

Working Stress Design (WSD)

Probably WSD, so investigate further.



CAST-IN-PLACE CONCRETE PILES:

- CAST-IN-PLACE CONCRETE PILES ARE DESIGNED AS CAST-IN-PLACE END BEARING PILES CAPABLE OF PROVIDING A BEARING CAPACITY OF 2500 PSF. THE OWNER/CONTRACTOR ARE RESPONSIBLE FOR VERIFYING THIS ASSUMPTION WITH A SOILS TEST. THE ENGINEER ACCEPTS NO RESPONSIBILITY FOR THIS ASSUMPTION, NOR ANY REDESIGN OF THE FOUNDATION RESULTING FROM CONTRARY SOIL CONDITIONS.

Manitoba

Working Stress Design (WSD)

Probably WSD, so investigate further.

Pile installation shall be provided under the full time inspection of a qualified professional geotechnical engineer selected by the structural consultant.

7. Maintain accurate record of each pile. Submit a copy of this record to the structural consultant.

8. Foundation design based on data found on existing building drawings.

9. Full-length steel sleeves should be maintained on site and utilized as required during construction to maintain pile holes in a clean dry state.

10. All friction piles are designed on the basis of 14.3KPa skin friction. Effective length of friction piles is total length as shown on plan minus 3000mm for exterior piles and minus 15000 mm for interior piles.

Working Stress Design (WSD)

Probably WSD, so investigate further.

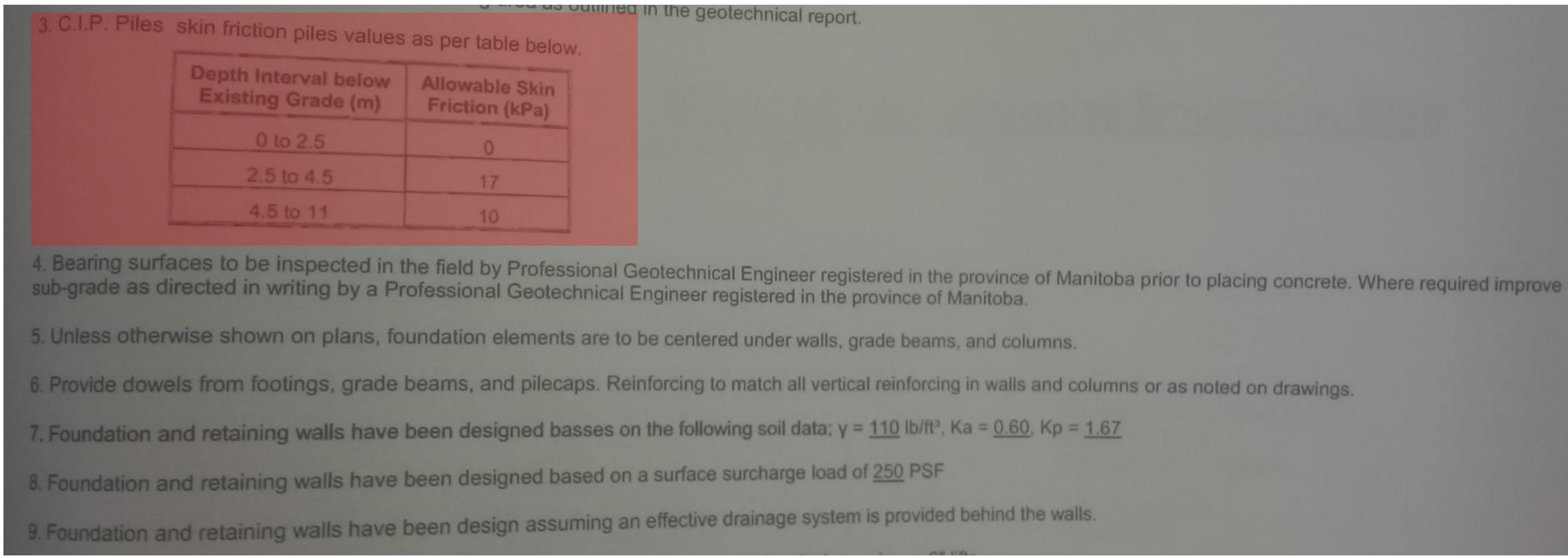
All END BEARING PIERS shall be founded on compacted granular OR UNDISTURBED SOIL providing a bearing capacity of 2500 psf. The owner/ contractor is responsible for verifing this assumption with a soil test. [redacted]. accepts no liabillity for this assumption, nor for any redesign of the foundation resulting from contrary soil conditions.

Any wet or otherwise unsuitable material encountered shall be totally removed and filled with lean mix concrete or crushed rock compacted to 100 percent proctor density.
Compact granular to 95% std. proctor in 6" Max. lifts.

Manitoba

Working Stress Design (WSD)

__Probably__ WSD, so investigate further.



... in the geotechnical report.

3. C.I.P. Piles skin friction piles values as per table below.

Depth Interval below Existing Grade (m)	Allowable Skin Friction (kPa)
0 to 2.5	0
2.5 to 4.5	17
4.5 to 11	10

4. Bearing surfaces to be inspected in the field by Professional Geotechnical Engineer registered in the province of Manitoba prior to placing concrete. Where required improve sub-grade as directed in writing by a Professional Geotechnical Engineer registered in the province of Manitoba.

5. Unless otherwise shown on plans, foundation elements are to be centered under walls, grade beams, and columns.

6. Provide dowels from footings, grade beams, and pilecaps. Reinforcing to match all vertical reinforcing in walls and columns or as noted on drawings.

7. Foundation and retaining walls have been designed basses on the following soil data; γ = 110 lb/ft³, Ka = 0.60, Kp = 1.67

8. Foundation and retaining walls have been designed based on a surface surcharge load of 250 PSF

9. Foundation and retaining walls have been design assuming an effective drainage system is provided behind the walls.

Working Stress Design (WSD)

<u>Probably</u> WSD, so investigate further.

GENERAL NOTES

1. ALL PILES ARE DESIGNED AS CAST-IN-PLACE FRICTION ELEMENTS IN FIRM MATERIAL WITH AN ALLOWABLE FRICTION CAPACITY OF 300 PSF. FOOTINGS SHALL BE FOUNDED ON DRY UNDISTURBED SOIL CAPABLE OF PROVIDING A BEARING CAPACITY OF 1500 PSF. THE OWNER/CONTRACTOR IS RESPONSIBLE FOR VERIFYING THE ASSUMPTION WITH A SOILS TEST. [redacted] ACCEPTS NO LIABILITY FOR THE ASSUMPTION NOR FOR ANY REDESIGN OF THE FOUNDATION RESULTING FROM CONTRARY SOIL CONDITIONS.
2. ANY WET OR UNSUITABLE MATERIAL SHALL BE REMOVED AND THE CAVITY FILLED WITH LEAN MIX CONCRETE OR CRUSHED ROCK COMPACTED TO 100 PERCENT STANDARD PROCTOR DENSITY. STANDARD PROCTOR DENSITY FOR THE EXISTING SUB-GRADE UNDERFLOOR FILL AND SUB-BASE GRANULAR FILL SHALL BE A MINIMUM OF 95 PERCENT.
3. THE CONTRACTOR AND SUB-TRADES SHALL VERIFY ALL DIMENSIONS AND SHALL REPORT ANY DISCREPANCIES BEFORE COMMENCING THE WORK.
4. THE CONTRACTOR SHALL PROVIDE ADEQUATE SHORING FOR THE EXCAVATION TO PREVENT CAVING.
5. EXTERIOR BACKFILL SHALL BE PLACED ONLY AFTER MAIN FLOOR SYSTEMS AND BASEMENT FLOOR SLABS

Working Stress Design (WSD)

<u>Probably</u> WSD, so investigate further.

GENERAL NOTES

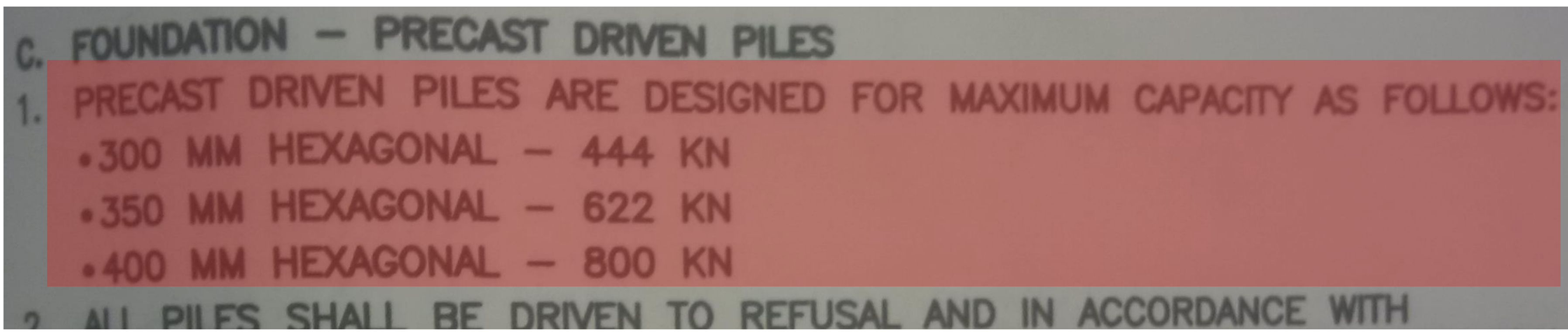
1. ALL RELEVANT CSA STANDARDS, PROVICIAL AND FEDERAL BUILDING CODES, WORKMAN'S COMPENSATION BOARD, AND LOCAL BY-LAWS SHOULD APPLY TO THIS PROJECT.

2. THE FOUNDATION DESIGN ASSUMES A SAFE ALLOWABLE SOIL BEARING VALUE OF 5000 PSF ON BEDROCK. THE OWNER/CONTRACTOR IS RESPONSIBLE TO OBTAIN A SOILS INVESTIGATION REPORT TO VERIFY THIS ASUMPTION AND TO ASSESS WHETHER INTOLERABLE SOIL SWELLING/CONTRACTION WILL BE PREVALENT AT THE BUILDING LOCATION. SHOULD THE ACTUAL SITE SOIL CONDITIONS VARY FROM THE ASSUMED CRITERIA, THE OWNER/CONTRACTOR SHALL NOTIFY THE ENGINEER IMMEDIATELY FOR A FOUNDATION RE-DESIGN BEFORE PROCEEDING WITH CONSTRUCTION.

3. ALL PILES ARE DESIGNED AS CAST-IN-PLACE FRICTION ELEMENTS ASSUMING AN ALLOWABLE SKIN FRICTION CAPACITY OF 300 PSF. ALL HOLES SHALL BE DRILLED TO THE DEPTHS AND DIMENSIONS NOTED ON THE DRAWINGS. THE CONTRACTOR SHALL NOTIFY THE ENGINEER IMMEDIATELY IF THE DEPTHS INDICATED CANNOT BE ATTAINED. DURING EXCAVATION FOR THE FOUNDATION OR DURING INSTALLATION OF THE PILES, IF UNSTABLE OR GROUND WATER IS ENCOUNTERED, NOTIFY THE ENGINEER IMMEDIATELY BEFORE PROCEEDING WITH CONSTRUCTION.

Working Stress Design (WSD)

<u>Probably</u> WSD, so investigate further.



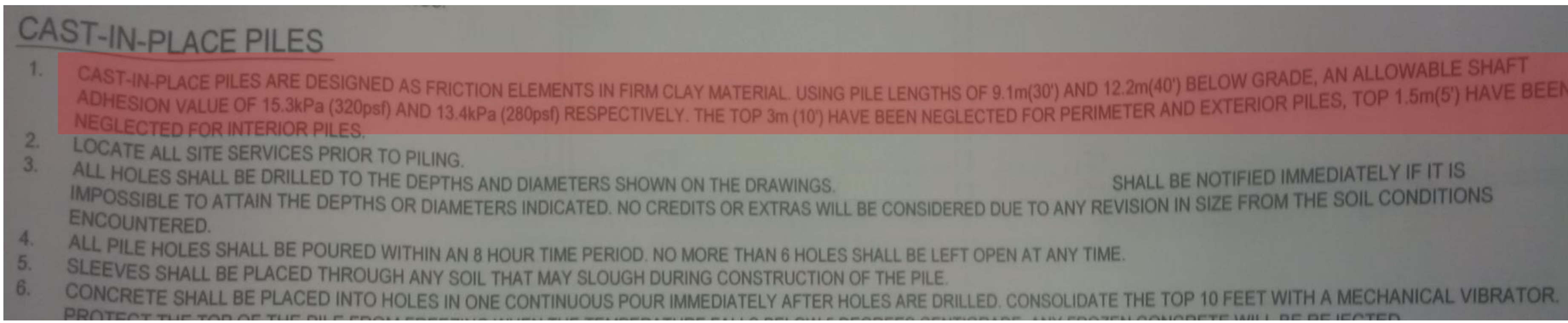
C. FOUNDATION – PRECAST DRIVEN PILES

1. PRECAST DRIVEN PILES ARE DESIGNED FOR MAXIMUM CAPACITY AS FOLLOWS:
   - 300 MM HEXAGONAL – 444 KN
   - 350 MM HEXAGONAL – 622 KN
   - 400 MM HEXAGONAL – 800 KN

2. ALL PILES SHALL BE DRIVEN TO REFUSAL AND IN ACCORDANCE WITH

Working Stress Design (WSD)

<u>Probably</u> WSD, so investigate further.



CAST-IN-PLACE PILES

1. CAST-IN-PLACE PILES ARE DESIGNED AS FRICTION ELEMENTS IN FIRM CLAY MATERIAL. USING PILE LENGTHS OF 9.1m(30') AND 12.2m(40') BELOW GRADE, AN ALLOWABLE SHAFT ADHESION VALUE OF 15.3kPa (320psf) AND 13.4kPa (280psf) RESPECTIVELY. THE TOP 3m (10') HAVE BEEN NEGLECTED FOR PERIMETER AND EXTERIOR PILES, TOP 1.5m(5') HAVE BEEN NEGLECTED FOR INTERIOR PILES.
2. LOCATE ALL SITE SERVICES PRIOR TO PILING.
3. ALL HOLES SHALL BE DRILLED TO THE DEPTHS AND DIAMETERS SHOWN ON THE DRAWINGS. SHALL BE NOTIFIED IMMEDIATELY IF IT IS IMPOSSIBLE TO ATTAIN THE DEPTHS OR DIAMETERS INDICATED. NO CREDITS OR EXTRAS WILL BE CONSIDERED DUE TO ANY REVISION IN SIZE FROM THE SOIL CONDITIONS ENCOUNTERED.
4. ALL PILE HOLES SHALL BE POURED WITHIN AN 8 HOUR TIME PERIOD. NO MORE THAN 6 HOLES SHALL BE LEFT OPEN AT ANY TIME.
5. SLEEVES SHALL BE PLACED THROUGH ANY SOIL THAT MAY SLOUGH DURING CONSTRUCTION OF THE PILE.
6. CONCRETE SHALL BE PLACED INTO HOLES IN ONE CONTINUOUS POUR IMMEDIATELY AFTER HOLES ARE DRILLED. CONSOLIDATE THE TOP 10 FEET WITH A MECHANICAL VIBRATOR.

OFFICE OF THE FIRE COMMISSIONER MANITOBA

Manitoba

Limit States Design (LSD)

Example:

PRECAST CONCRETE DRIVEN PILES

1. THE CONTRACTOR SHALL CONFIRM THE LOCATION OF SUB-GRADE SERVICES PRIOR TO COMMENCING DRILLING FOR PILES.
2. PRECAST CONCRETE PILES SHOULD BE PRE-DRILLED AND DRIVEN TO PRACTICAL REFUSAL IN ACCORDANCE WITH GEOTECHNICAL REPORT.
3. FOUNDATION CONTRACTOR SHALL VERIFY THE LENGTH OF PRECAST PILES REQUIRED AT THIS SITE.
4. PILES DRIVEN WITHIN FIVE PILE DIAMETERS ON CENTER SHALL BE MONITORED FOR HEAVE AND WHERE IT IS OBSERVED, THE PILES SHALL BE RE-DRIVEN TO THE AFOREMENTIONED REFUSAL CRITERIA.
5. ALL FOUNDATIONS SHALL BE INSTALLED IN ACCORDANCE WITH THE GEOTECHNICAL REPORT THAT HAS BEEN PREPARED FOR THIS PROJECT. PILE INSTALLATION SHALL BE PROVIDED UNDER FULL TIME INSPECTION OF A QUALIFIED PROFESSIONAL GEOTECHNICAL ENGINEER REGISTERED IN THE PROVINCE OF MANITOBA, AND HOLDS A CURRENT CERTIFICATE OF AUTHORIZATION OF APEGM.
6. MAINTAIN AN ACCURATE RECORD OF EACH PILE. SUBMIT A COPY OF THIS RECORD TO THE DESIGN ENGINEER.
7. ALL PRECAST DRIVEN PILES DRIVEN TO REFUSAL ARE DESIGNED FOR THE CAPACITIES SHOWN:
   - 356mm DIAMETER HEXAGONAL: SLS = 625kN, FACTORED ULS = 780kN
   - 406mm DIAMETER HEXAGONAL: SLS = 800kN, FACTORED ULS = 1000kN
8. UNFACTORED DOWN DRAG LOADS ON PRECAST DRIVEN PILES:
   - 356mm DIAMETER HEXAGONAL: 600kN
   - 406mm DIAMETER HEXAGONAL: 690kN

   A LOAD FACTOR OF 1.25 IS USED FOR DOWN DRAG LOADS WHEN EVALUATING THE STRUCTURAL CAPACITY OF THE PILES.

(Deep)

Limit States Design (LSD)

Example:

PRECAST CONCRETE DRIVEN PILES

1. THE CONTRACTOR SHALL CONFIRM THE LOCATION OF SUB-GRADE SERVICES PRIOR TO COMMENCING DRILLING FOR PILES.
2. PRECAST CONCRETE PILES SHOULD BE PRE-DRILLED AND DRIVEN TO PRACTICAL REFUSAL IN ACCORDANCE WITH GEOTECHNICAL REPORT.

FOUNDATION CONTRACTOR SHALL VERIFY THE LENGTH OF PRECAST PILES REQUIRED AT THIS SITE.

4. PILES DRIVEN WITHIN FIVE PILE DIAMETERS ON CENTER SHALL BE MONITORED FOR HEAVE AND WHERE IT IS OBSERVED, THE PILES SHALL BE RE-DRIVEN TO THE AFOREMENTIONED REFUSAL CRITERIA.
5. ALL FOUNDATIONS SHALL BE INSTALLED IN ACCORDANCE WITH THE GEOTECHNICAL REPORT THAT HAS BEEN PREPARED FOR THIS PROJECT. PILE INSTALLATION SHALL BE PROVIDED UNDER FULL TIME INSPECTION OF A QUALIFIED PROFESSIONAL GEOTECHNICAL ENGINEER.
6. MAINTAIN AN ACCURATE RECORD OF EACH PILE. SUBMIT A COPY OF THIS RECORD TO THE DESIGN ENGINEER.
7. ALL PRECAST DRIVEN PILES DRIVEN TO REFUSAL ARE DESIGNED FOR THE CAPACITIES SHOWN:

- 12" (300MM) DIAMETER HEXAGONAL	SLS = 445KN, FACTORED ULS = 660KN
- 14" (350MM) DIAMETER HEXAGONAL - 625 KN (140 KIPS)	SLS = 625KN, FACTORED ULS = 936KN
- 16" (400MM) DIAMETER HEXAGONAL - 800 KN (180 KIPS)	SLS = 800KN, FACTORED ULS = 1200KN

(Deep)

Manitoba

Limit States Design (LSD)

Example:

ULS & SLS CAPACITIES FOR STATIC VERTICAL DRIVEN PRE-STRESSED PRE-CAST CONCRETE PILES

PILE DIAMETER (mm)	SLS CAPACITY	FACTORED ULS CAPACITY
300 (12")	443 kN (50 TONS)	532 kN (60 TONS)
350 (14")	620 kN (70 TONS)	744 kN (84 TONS)
400 (16")	797 kN (90 TONS)	956 kN (108 TONS)

(Deep)

Limit States Design (LSD)

Example:

FOUNDATIONS

1. A COPY OF THE GEOTECHNICAL REPORT COMMISSIONED BY THE OWNER IS AVAILABLE FOR REVIEW AT THE OFFICES OF THE ARCHITECT.
2. NOTWITHSTANDING THE INFORMATION PROVIDED IN THE GEOTECHNICAL REPORT THE FOUNDATION AND GENERAL CONTRACTORS SHALL SATISFY THEMSELVES AS TO THE PREVAILING CONDITIONS AT THE SITE AS NO EXTRAS SHALL BE GRANTED SHOULD CONDITIONS DIFFER FROM THOSE INDICATED.
3. ALL FRICTION PILES ARE DESIGNED ON AN SLS ADHESION VALUE OF 315 PSF AND AN ULTIMATE SKIN FRICTION OF 375 PSF, WITH AN END BEARING ULS CAPACITY OF 3000 PSF.. EFFECTIVE LENGTH OF FRICTION PILES IS TOTAL LENGTH AS SHOWN ON PLAN MINUS 8'–0".
4. FRICTION PILE REINFORCING TO BE 20'–0" LONG UNLESS NOTED IN PLANS; 10M RINGS AT 48 IN. ON–CENTRE AND 3–10M RINGS AT 6" ON–CENTRE AT TOP. EXTEND VERTICAL PILE REINFORCING 1'–6" INTO BEAMS OR WALLS. PILE REINFORCING TO BE 5–10M FOR 16 IN. DIAMETER PILES, 6–10M FOR 18 IN., 5–15M FOR 20 IN., 5–15M FOR 22 IN., 6–15M FOR 24 IN..
5. PROVIDE 10 MIL POLYETHYLENE WRAPPED SONOTUBE, GREASED COMPLETELY ON INSIDE FOR TOP 5'–0" OF PILES INDICATED ON PLAN.

PRECAST CONCRETE PILES TO BE DRIVEN TO LOAD CAPACITY AS SHOWN BELOW:

A) 12 IN. HEX. – 100 KIPS (SLS); 248 KIPS (ULS)
B) 14 IN. HEX. – 140 KIPS (SLS); 351 KIPS (ULS)
C) 16 IN. HEX. – 180 KIPS (SLS); 450 KIPS (ULS)

0.40 GEOTECHNICAL RESISTANCE FACTOR

(Deep)

Manitoba

Limit States Design (LSD)

Example:

CAST-IN-PLACE PILES

1. CAST-IN-PLACE PILES ARE DESIGNED AS FRICTION ELEMENTS IN FIRM CLAY MATERIAL WITH AN ALLOWABLE FRICTIONAL CAPACITY SHOWN BELOW;

Pile Length (m)	SLS (kPa)	Factored ULS (kPa)
3m to 9.1m	16.5	19.5
1.5m to 3m (interior)	19.1	22.9

2. THE TOP 3m (10') HAVE BEEN NEGLECTED FOR PERIMETER AND EXTERIOR PILES, TOP 1.5m(5') HAVE BEEN NEGLECTED FOR INTERIOR PILES.
3. LOCATE ALL SITE SERVICES PRIOR TO PILING.
4. ALL HOLES SHALL BE DRILLED TO THE DEPTHS AND DIAMETERS SHOWN ON THE DRAWINGS. BEACH ROCKE ENGINEERING LTD. SHALL BE NOTIFIED IMMEDIATELY IF IT IS IMPOSSIBLE TO ATTAIN THE DEPTHS OR DIAMETERS INDICATED. NO CREDITS OR EXTRAS WILL BE CONSIDERED DUE TO ANY REVISION IN SIZE FROM THE SOIL CONDITIONS ENCOUNTERED.
5. ALL PILE HOLES SHALL BE POURED WITHIN AN 8 HOUR TIME PERIOD. NO MORE THAN 6 HOLES SHALL BE LEFT OPEN AT ANY TIME.
6. SLEEVES SHALL BE PLACED THROUGH ANY SOIL THAT MAY SLOUGH DURING CONSTRUCTION OF THE PILE.
7. CONCRETE SHALL BE PLACED INTO HOLES IN ONE CONTINUOUS POUR IMMEDIATELY AFTER HOLES ARE DRILLED. CONSOLIDATE THE TOP 10 FEET WITH A MECHANICAL VIBRATOR. PROTECT THE TOP OF THE PILE FROM FREEZING WHEN THE TEMPERATURE FALLS BELOW 5 DEGREES CENTIGRADE. ANY FROZEN CONCRETE WILL BE REJECTED.
8. PROVIDE FULL LENGTH REINFORCING FOR PILES IN UNHEATED AREAS.
9. A COPY OF THE GEOTECHINCAL REPORT IS AVAILABLE AT THE OFFICES OF THE ARCHITECT.
10. CENTER ALL PILES UNDER GRADE BEAMS OR WALLS UNLESS OTHERWISE NOTED.

(Deep)

Limit States Design (LSD)

Example:

FOUNDATION NOTES:

ALL STRAIGHT SHAFT CONCRETE PILES ARE DESIGNED AS CAST-IN-PLACE FRICTION ELEMENTS IN FIRM UNDISTURBED MATERIAL WITH AN ALLOWWBLE FRICTION APACITY OF 300 PSF. . ULS VALUES FOR TELEPOSTS ON PILES = 450 PSF AND ALL OTHER PILES ULS = 450 PSF. THE DESIGN OF THE FRICTION PILES IS NOT HIGHLY TECHNICAL. THE CONTRACTOR SHALL PROVIDE A FIELD REVIEW TO ASCERTAIN THAT THE SUBSURFACE CONDITIONS ARE CONSISTANT WITH THE DESIGN AND THAT CONSTRUCTION IS CARRIED OUT IN ACCORDANCE WITH THE DESIGN AND GOOD ENGINEERING PRACTICE. DURING THE CONSTRUCTION AND FIELD REVIEW OF THE CAST-IN-PLACE FRICTION PILES THE CONTRACTOR SHALL RECORD ALL PERTANENT INFORMATION FOR EACH PILE. NOTE: ALLOWABLE LOADS GOVERN THE DESIGN.

(Deep)

Limit States Design (LSD)

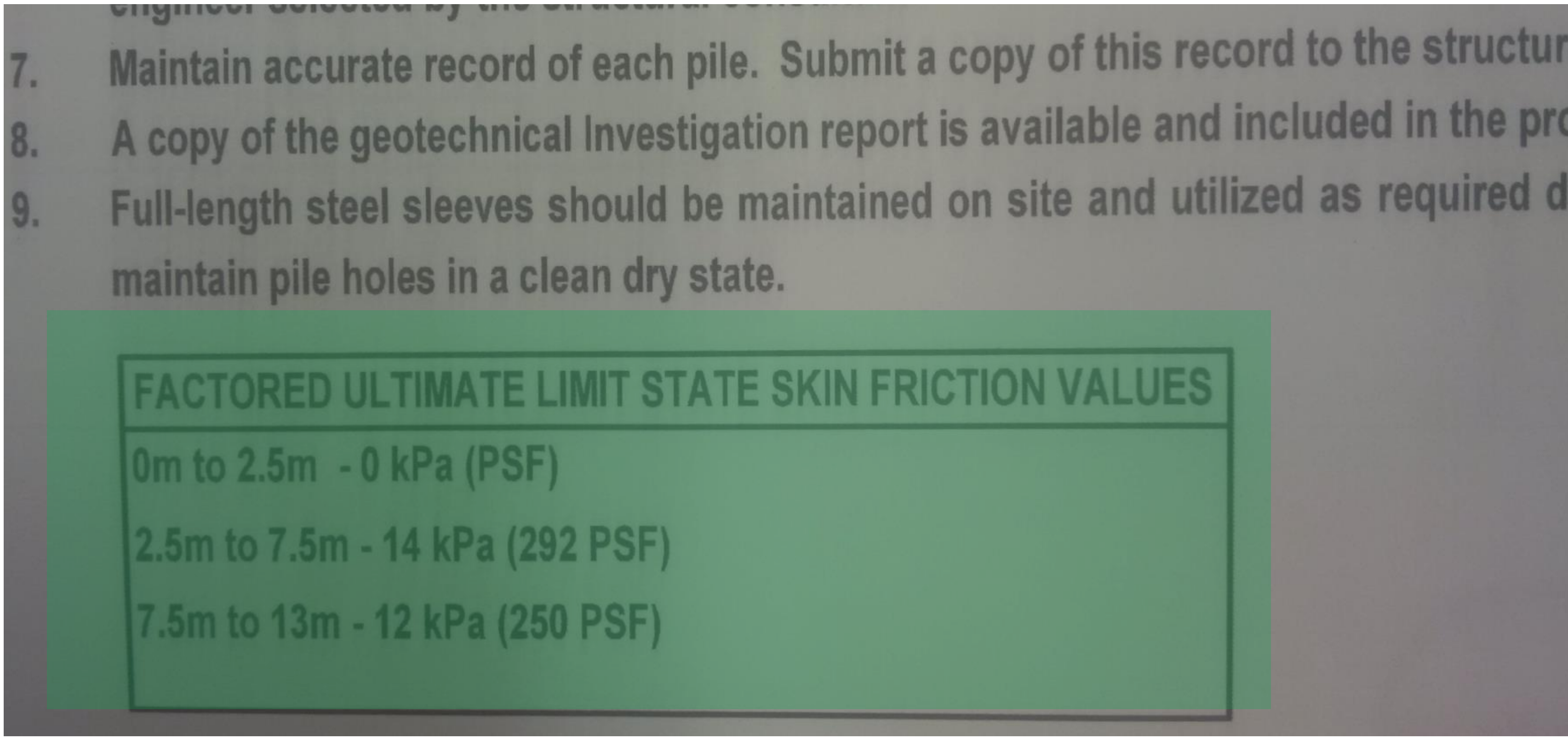
Example:

5. All foundations shall be installed in accordance with the geotechnical report that has been prepared for this project. A copy of the report is attached to the specifications.
6. Pile installation shall be provided under full time inspection of a qualified professional geotechnical engineer selected by the structural consultant.
7. Maintain an accurate record of each pile. Submit a copy of this record to the structural consultant.
8. All precast driven piles driven to refusal are designed for the factored limit state capacities as shown (A 0.4 geotechnical resistance factor has been applied.):
   - 12" (300mm) diameter hexagonal - 560 kN
   - 14" (350mm) diameter hexagonal - 760 kN
   - 16" (400mm) diameter hexagonal - 1000 kN

(Deep)

Limit States Design (LSD)

Example:



7. Maintain accurate record of each pile. Submit a copy of this record to the structura
8. A copy of the geotechnical Investigation report is available and included in the pro
9. Full-length steel sleeves should be maintained on site and utilized as required du maintain pile holes in a clean dry state.

FACTORED ULTIMATE LIMIT STATE SKIN FRICTION VALUES
0m to 2.5m - 0 kPa (PSF)
2.5m to 7.5m - 14 kPa (292 PSF)
7.5m to 13m - 12 kPa (250 PSF)

(Deep)

Limit States Design (LSD)

Example:

ULS & SLS CAPACITIES FOR STATIC VERTICAL DRIVEN PRE–STRESSED PRE–CAST CONCRETE PILES

PILE DIAMETER (mm)	SLS CAPACITY	FACTORED ULS CAPACITY
300 (12")	443 kN (50 TONS)	532 kN (60 TONS)
350 (14")	620 kN (70 TONS)	744 kN (84 TONS)
400 (16")	797 kN (90 TONS)	956 kN (108 TONS)

(Deep)

OFFICE OF THE FIRE COMMISSIONER MANITOBA

Manitoba

Limit States Design (LSD)

Example:

GENERAL NOTES

1. ALL PILES ARE DESIGNED AS CAST–IN–PLACE END BEARING PILES CAPABLE OF PROVIDING A ULS BEARING CAPACITY OF 246 KPA (5.14 KSF) BASED ON THE SOILS REPORT

2. ALL CAST–IN–PLACE PILES SHALL BE DRILLED TO THE DEPTHS SHOWN ON THE DRAWINGS. THE CONTRACTOR SHALL NOTIFY THE ENGINEER IMMEDIATELY IF IT IS IMPOSSIBLE TO ATTAIN THE DEPTHS INDICATED.

3. CONCRETE FOR PILES SHALL BE 30 MPA @ 28 DAYS AND SHALL BE SULPHATE RESISTANT (TYPE 50) CEMENT WITH A SLUMP NOT EXCEEDING 5".

4. REINFORCING STEEL SHALL BE NEW BILLET DEFORMED BARS IN ACCORDANCE WITH CSA G30.12 STANDARDS.

   *10M BARS = 300 MPA
   *15M BARS & LARGER = 400 MPA

   A) ALL REINFORCING SHALL BE FREE FROM LOOSE RUST, MUD, OIL OR OTHER COATS WHICH WOU

(Deep)

Limit States Design (LSD)

Example:

March 5, 2018

Office of the Fire Commissioner
Building & Fire Safety Engineer,
508-401 York Ave Winnipeg, MB R3C 0P8

Attention: Norman A. Garcia, P.Eng.,

Dear Mr. Garcia:

Re:
Permit #:

---

1. The contractor shall locate all site services prior to piling.
2. Sleeves shall be placed through any soil that may slough during construction of the pile.
3. Center all piles under beams or walls unless otherwise noted.
4. All steel pipe piles are designed as end bearing elements on sounds bedrock with an assumed ULS capacity 0.33Fy and an assumed SLS capacity of 0.3Fy.

Trusting that this is satisfactory,

(Deep)

Limit States Design (LSD)

Example:

FOUNDATIONS

1. A COPY OF THE GEOTECHNICAL REPORT COMMISSIONED BY THE OWNER IS AVAILABLE FOR REVIEW AT THE OFFICES OF THE ARCHITECT.
2. NOTWITHSTANDING THE INFORMATION PROVIDED IN THE GEOTECHNICAL REPORT THE FOUNDATION AND GENERAL CONTRACTORS SHALL SATISFY THEMSELVES AS TO THE PREVAILING CONDITIONS AT THE SITE AS NO EXTRAS SHALL BE GRANTED SHOULD CONDITIONS DIFFER FROM THOSE INDICATED.
3. ALL FRICTION PILES ARE DESIGNED ON AN SLS ADHESION VALUE OF 315 PSF AND AN ULTIMATE SKIN FRICTION OF 375 PSF, WITH AN END BEARING ULS CAPACITY OF 3000 PSF.. EFFECTIVE LENGTH OF FRICTION PILES IS TOTAL LENGTH AS SHOWN ON PLAN MINUS 8'–0".
4. FRICTION PILE REINFORCING TO BE 20'–0" LONG UNLESS NOTED IN PLANS; 10M RINGS AT 48 IN. ON–CENTRE AND 3–10M RINGS AT 6" ON–CENTRE AT TOP. EXTEND VERTICAL PILE REINFORCING 1'–6" INTO BEAMS OR WALLS. PILE REINFORCING TO BE 5–10M FOR 16 IN. DIAMETER PILES, 6–10M FOR 18 IN., 5–15M FOR 20 IN., 5–15M FOR 22 IN., 6–15M FOR 24 IN..
5. PROVIDE 10 MIL POLYETHYLENE WRAPPED SONOTUBE, GREASED COMPLETELY ON INSIDE FOR TOP 5'–0" OF PILES INDICATED ON PLAN.

(Deep)

Limit States Design (LSD)

Example:

CAST-IN-PLACE FRICTION PILES

1. CAST-IN-PLACE PILES ARE DESIGNED AS FRICTION ELEMENTS IN FIRM CLAY MATERIAL WITH A FACTORED GEOTECHNICAL SHAFT RESISTANCE AT ULS OF 23kPa FROM 2.5m(8.2') TO 4.5m(14.76'), AND 20kPa FROM 4.5m(14.76') TO 8.0m(26.25') FROM PRESENT GRADE LEVEL. THE TOP 2.5m(8.2') HAVE BEEN NEGLECTED FOR PILES.
2. LOCATE ALL SITE SERVICES PRIOR TO PILING.
3. ALL HOLES SHALL BE DRILLED TO THE DEPTHS AND DIAMETERS SHOWN ON THE DRAWINGS. THE ENGINEER SHALL BE NOTIFIED IMMEDIATELY IF IT IS IMPOSSIBLE TO ATTAIN THE DEPTHS OR DIAMETERS INDICATED. NO CREDITS OR EXTRA WILL BE CONSIDERED DUE TO ANY REVISION IN SIZE FROM THE SOIL CONDITIONS ENCOUNTERED.
4. THE GEOTECHNICAL ENGINEER SHALL PROVIDE SITE VISITS DURING CONSTRUCTION TO CONFIRM SOILS REPORT DESIGN VALUES.
5. ALL PILE HOLES SHALL BE POURED WITHIN AN 8 HOUR TIME PERIOD. NO MORE THAN 6 HOLES SHALL BE LEFT OPEN AT ANY TIME.

(Deep)

Manitoba

Limit States Design (LSD)

Example:

CAST-IN-PLACE FRICTION PILES

1. CAST-IN-PLACE PILES ARE DESIGNED AS FRICTION ELEMENTS IN FIRM CLAY MATERIAL WITH A FACTORED GEOTECHNICAL SHAFT RESISTANCE AT ULS OF 23kPa FROM 2.5m(8.2') TO 4.5m(14.76'), AND 20kPa FROM 4.5m(14.76') TO 8.0m(26.25') FROM PRESENT GRADE LEVEL. THE TOP 2.5m(8.2') HAVE BEEN NEGLECTED FOR PILES.
2. LOCATE ALL SITE SERVICES PRIOR TO PILING.
3. ALL HOLES SHALL BE DRILLED TO THE DEPTHS AND DIAMETERS SHOWN ON THE DRAWINGS. THE ENGINEER SHALL BE NOTIFIED IMMEDIATELY IF IT IS IMPOSSIBLE TO ATTAIN THE DEPTHS OR DIAMETERS INDICATED. NO CREDITS OR EXTRA WILL BE CONSIDERED DUE TO ANY REVISION IN SIZE FROM THE SOIL CONDITIONS ENCOUNTERED.
4. THE GEOTECHNICAL ENGINEER SHALL PROVIDE SITE VISITS DURING CONSTRUCTION TO CONFIRM SOILS REPORT DESIGN VALUES.

(Deep)

Manitoba

Limit States Design (LSD)

Example:

FOUNDATIONS

1. A COPY OF THE GEOTECHNICAL REPORT COMMISSIONED BY THE OWNER IS AVAILABLE FOR REVIEW AT THE OFFICES OF THE ARCHITECT.
2. NOTWITHSTANDING THE INFORMATION PROVIDED IN THE GEOTECHNICAL REPORT THE FOUNDATION AND GENERAL CONTRACTORS SHALL SATISFY THEMSELVES AS TO THE PREVAILING CONDITIONS AT THE SITE AS NO EXTRAS SHALL BE GRANTED SHOULD CONDITIONS DIFFER FROM THOSE INDICATED.
3. ALL FRICTION PILES ARE DESIGNED ON A FACTORED ULS RESISTANCE FRICTION OF 397 kPa TO 8'–0" TO 65'–0". EFFECTIVE LENGTH OF FRICTION PILES IS TOTAL LENGTH AS SHOWN ON PLAN MINUS 8'–0" BELOW GRADE OR MINMUM 3–0' BELOW TOP OF PILE.
4. FRICTION PILE REINFORCING TO BE 20'–0" LONG UNLESS NOTED IN PLANS; 10M RINGS AT 48 IN. ON–CENTRE AND 3–10M RINGS AT 6" ON–CENTRE AT TOP. EXTEND VERTICAL PILE REINFORCING 1'–6" INTO BEAMS OR WALLS. PILE REINFORCING TO BE 5–10M FOR 16 IN. DIAMETER PILES, 6–10M FOR 18 IN. DIAMETER PILES.

(Deep)

Manitoba

Limit States Design (LSD)

Example:

FOUNDATIONS

1. A COPY OF THE GEOTECHNICAL REPORT COMMISSIONED BY THE OWNER IS AVAILABLE FOR REVIEW AT THE OFFICES OF THE ARCHITECT.
2. NOTWITHSTANDING THE INFORMATION PROVIDED IN THE GEOTECHNICAL REPORT THE FOUNDATION AND GENERAL CONTRACTORS SHALL SATISFY THEMSELVES AS TO THE PREVAILING CONDITIONS AT THE SITE AS NO EXTRAS SHALL BE GRANTED SHOULD CONDITIONS DIFFER FROM THOSE INDICATED.
3. ALL FOOTINGS ARE DESIGNED BASED ON CAPACITIES AS FOLLOWS:
   A) ULS BEARING CAPACITY OF 125 KPA
   B) SLS BEARING CAPACITY OF 75 KPA
   C) FOOTINGS SHALL BE POURED ON UNDISTURBED NATIVE SOIL.
   D) REFER TO FULL GEOTECHNICAL REPORT FOR SUBGRADE PREPARATION REQUIREMENTS

(Shallow, just to illustrate Limit States Design)

Limit States Design (LSD)

Example:

B. FOUNDATION - CONCRETE FOOTINGS

1. Place footings on clean, unfrozen, undisturbed soil capable of sustaining 120 kPa ULS, 85 kPa SLS bearing pressure at depths shown on the drawings. Where bearing material is disturbed or soft, remove unsuitable material and back-fill with low strength concrete fill to the approval of the consultant.
2. n/a
3. Footings shall not be more than, 2" out of position shown on the foundation plan, no more than 2% out of level.
4. Refer to "Concrete" and "Reinforcing Steel" notes for material specifications and requirements.

(Shallow, just to illustrate Limit States Design)

Limit States Design (LSD)

Example:

FOUNDATIONS

1. A COPY OF THE GEOTECHNICAL REPORT COMMISSIONED BY THE OWNER IS AVAILABLE FOR REVIEW AT THE OFFICES OF THE ARCHITECT.
2. NOTWITHSTANDING THE INFORMATION PROVIDED IN THE GEOTECHNICAL REPORT THE FOUNDATION AND GENERAL CONTRACTORS SHALL SATISFY THEMSELVES AS TO THE PREVAILING CONDITIONS AT THE SITE AS NO EXTRAS SHALL BE GRANTED SHOULD CONDITIONS DIFFER FROM THOSE INDICATED.
3. ALL FOOTINGS ARE DESIGNED ON A FACTORED GEOTECHNICAL BEARING RESISTANCE AT ULS= 100 kPa AND AT SLS=125kPa. FOOTINGS SHALL BE POURED ON UNDISTURBED NATIVE SOIL.

(Shallow, just to illustrate Limit States Design)

Limit States Design (LSD)

Example:

TABLE '2'		
FOOTING BEARING SOIL	SLS, kPa	FACTORED ULS, kPa
COMPACTED IN-SITU SAND	86	103.4

(Shallow, just to illustrate Limit States Design)

Manitoba

Limit States Design (LSD)

4. FOUNDATION DESIGNED TO BEAR ON NATIVE COMPACT UNDISTURBED SILT. RECTANGULAR SPREAD FOOTINGS ARE DESIGNED FOR SLS BEARING PRESSURE OF 145 kPa AND ULS BEARING PRESSURE OF 200 kPa. CONTINUOUS STRIP FOOTINGS ARE DESIGNED FOR SLS BEARING PRESSURE OF 120 kPa AND ULS BEARING PRESSURE OF 175 kPa. DESIGN MAY NEED TO BE REVISED TO MEET ACTUAL SOIL CONDITIONS FOUND DURING CONSTRUCTION.

5. AFTER EXCAVATION, BUT BEFORE BACKFILLING, ENSURE THAT THE GEOTECHNICAL ENGINEER INSPECTS THE BEARING SOILS AND CONFIRMS THE LOAD CARRYING CAPACITY.

6. FOOTING ELEVATIONS, IF SHOWN, ARE NOT FINAL AND MAY VARY ACCORDING TO SITE CONDITIONS. EXTEND ALL FOOTINGS TO A BEARING LAYER APPROVED BY THE GEOTECHNICAL ENGINEER.

OFC Bulletin

OFFICE *of the* FIRE COMMISSIONER

January 5, 2017

Dear Stakeholder:

On December 20, 2017, the Office of the Fire Commissioner released bulletin OFC 17-002 "Limit States Design for Housing and Small Buildings". A PDF copy of the bulletin is attached to this e-mail, and is available for viewing and download at:
http://www.firecomm.gov.mb.ca/docs/ofc_17_002_limits_states_design.pdf

The purpose of the bulletin is to provide information about the Manitoba Building Code requirements pertaining to housing and small buildings that require the construction of deep foundations.

If you have any questions about the bulletin, please contact the Building and Fire Safety Section at 204-945-3322 (Toll Free at 1-800-282-8069) or via e-mail at firecomm@gov.mb.ca.

Sincerely,

Candace Russell Summers
Chief Building Official

508 Norquay Building • 401 York Avenue • Winnipeg, Manitoba • Canada • R3C 0P8
Telephone: 204-945-3322 • Fax: 204-948-2089 • Website: www.firecomm.gov.mb.ca

Manitoba

OFC Bulletin

Office *of the* Fire Commissioner

Building and Fire Safety

Date Issued: December 20, 2017
OFC 17-002

Limit States Design for Housing and Small Buildings

The purpose of this bulletin is to provide information about the Manitoba Building Code requirements pertaining to housing and small buildings that require the construction of deep foundations.

Limit States Design

Limit States Design (LSD) is a structural design method used for the design of steel, concrete, wood, masonry, and foundation structures under the Manitoba Building Code (MBC). LSD must be used for the design of deep foundations. The MBC requires that:

9.4.1.1. General
1) Subject to the application limitations defined elsewhere in this Part, structural members and their connections shall
a) conform to the requirements provided elsewhere in this Part,
b) be designed according to good engineering practice such as that provided in CWC 2009, "Engineering Guide for Wood Frame Construction," or
c) be designed according to Part 4 using the loads and deflection and vibration limits specified in
i) Part 9, or
ii) Part 4,

4.2.4.1. Design Basis
1) The foundations of a building shall be capable of resisting all the loads stipulated in Section 4.1., in accordance with limit states design in Subsection 4.1.3.

Deep Foundation

Deep foundation means a *foundation unit* that provides support for a *building* by transferring loads either by end-bearing to *soil* or *rock* at considerable depth below the *building*, or by adhesion or friction, or both, in the *soil* or *rock* in which it is placed.

Piles are the most common type of *deep foundation*. *Pile* means a slender *deep foundation unit* made of materials such as wood, steel or concrete or a combination thereof, that is either pre-manufactured and placed by driving, jacking, jetting or screwing, or cast-in-place in a hole formed by driving, excavating or boring. Cast-in-place bored *piles* are often referred to as *caissons* in Canada.

Design

The design of deep foundations must meet the objectives of Part 4 of the MBC and be based on the site subsurface conditions. The design must be carried out by a professional engineer licensed to practice in the Province of Manitoba and skilled in the area of work concerned.

Subsurface Investigation

Subsurface conditions must be taken into consideration by the professional engineer completing a deep foundation design under Part 4 of the MBC. The MBC requires that:

4.2.2.1. Subsurface Investigation
1) A *subsurface investigation*, including *groundwater* conditions shall be carried out by or under the direction of a professional engineer having knowledge and experience in planning and executing such investigations to a degree appropriate for the *building* and its use, the ground and the surrounding site conditions. (See Appendix A)

A-4.2.2.1.(1) Subsurface Investigation. Where acceptable information on subsurface conditions already exists, the investigation may not require further physical subsurface exploration or testing.

Field Review

A field review must be undertaken to confirm that the design is consistent with the subsurface conditions. Part 4 provides clear direction about the field review process as follows:

4.2.2.3. Field Review
1) A field review shall be carried out by the designer or by another qualified person responsible to the designer to ascertain that the subsurface conditions are consistent with the design and that construction is carried out in accordance with the design and good engineering practice. (see Appendix A.).

2) The review required in Sentence (1) shall be carried out
a) on a continuous basis
i) during the construction of all deep foundation units with all pertinent information recorded for each unit,
ii) during the installation and removal of retaining structures and related backfilling operations, and
b) as required, unless otherwise directed by the authority having jurisdiction,
i) in the construction of all shallow foundation units, and
ii) in excavating, dewatering and other related works.

4.2.2.4 Altered Subsurface Condition
1) If, during construction, the soil, rock or groundwater is found not to be of the type or in the condition used in design and as indicated on the drawings, the design shall be reassessed by the designer.

2) If, during construction, climatic or any other conditions change the properties of the soil, rock or groundwater, the design shall be reassessed by the designer.

Loads that may be applied to a deep foundation depend not only on the properties of the foundation as a structural unit, but also on the properties of the foundation soil (or rock) and of the soil/foundation system. Geotechnical criteria are determined on the basis of site investigations and geotechnical analyses.

Further information Please contact the Building and Fire Safety Section at 204-945-3322 with any questions or for clarifications.

508 - 401 York Avenue
Winnipeg Manitoba R3C 0P8
T: 204 945-3322
F: 204 948-2089
Toll Free: 1-800-282-8069 (in Manitoba only)
Website: www.firecomm.gov.mb.ca

Manitoba

EGM Practice Notes

FOR PROFESSIONALS > PRACTICE NOTES

ENGINEERS
GEOSCIENTISTS
MANITOBA

FOR PROFESSIONALS

Practice Notes

You should be aware of the following information, and use it in your practice:

April 26, 2018

Limit States Design - Foundations

It has come to the attention of the Engineers Geoscientists Manitoba's Investigation Committee that some members have attempted to design foundations for buildings using a methodology that falls below the acceptable standard of professional engineering. The methodology in question relies on analyzing the prescriptive aspects of the Manitoba Building Code (MBC) found in section 9.15.2.5, which includes a prescriptive description of piles acceptable for single-storey attached garages. The methodology, which the IC does not condone, involves the calculation and prediction of soil capacities based on reverse-engineering these prescriptive details.

All of Engineers Geoscientists Manitoba's practitioners must employ Limit States Design (LSD) methodology for the design of foundations of buildings that fall under the MBC. The prescriptive details illustrated in the figures presented in 9.15.2.5 are only appropriate for the specific use described in each detail. Therefore, the design of piles other than those for single-storey attached garages must include an appropriate establishment of soil capacities for the site in question.

Some Authorities Having Jurisdiction (AHJ) may have established soil capacity values that can be used for ULS and SLS foundation designs for specific Part 9 structures in their jurisdiction. These AHJ's may be consulted in the absence of site specific geotechnical information.

Engineers Geoscientists Manitoba's Investigation Committee wishes to further provide direction regarding sentence 9.4.1.1.b of the MBC. This sentence allows for "structural members and their connections" to "be designed according to good engineering practice such as that provided in CWC 2009, *Engineering Guide for Wood Frame Construction*". It is not 'good engineering practice' to rely on this sentence as justification to use Working Stress Design methodology for the design of foundations.

The Investigation Committee encourages all of Engineers Geoscientists Manitoba's practitioners to embrace *Limit States Design* as the only acceptable methodology for the engineered design of all building structural elements (including foundations).

References

- Prof. Marolo Alfaro, Phd., P.Eng., Dept of Civil Eng'g, University of Manitoba
- Structural Commentaries, User's Guide – NBC 2010
- Canadian Foundation Engineering Manual, 4th Ed, 2006
- CSA-S472-2004 - Foundations
- Concrete Design Handbook, 4th Ed, 2016
- Fire Inspection and Code Enforcement, 8th Ed, 2016

Manitoba

Office of the Fire Commissioner