Part 6 – Steel Reinforcement for Walls

6.1 – Overview

Building any structure using Amvic ICFs requires the installer to have a good knowledge of the fundamentals of steel reinforcement. This part of the manual will discuss the basics of reinforcing steel requirements for Amvic ICF walls.

6.2 – Plan Requirements

The designer (Architect/Engineer) of any project should clearly indicate the following information on his plans:

1. Separate cross sections of all walls using Amvic ICF. Each cross section should clearly show the size of Amvic ICF block used (i.e. 4, 6, 8, 10 or 12 inch) for the building inspector and installer.
2. Each cross section should show the wall heights involved for every storey.
3. Vertical and horizontal reinforcing steel bar sizes, spacing and grade of steel should be clearly marked for every storey in each wall cross section or in a separate note on other sheets.
4. The placement of reinforcing steel, especially the vertical ones should be clearly marked (i.e. off center or towards interior/exterior or centered in the wall).
5. The designer should specify the lap splice type and lengths for every section of the wall where splicing is anticipated. (Please refer to Reinforcing Steel Splicing in **section 6.6** of this chapter.)

6.3 – The Purpose of Reinforcing Bars

Reinforced concrete structures are composed of two different materials;

a. Concrete

b. Steel

Plain concrete is a strong material in compression. Compressing a plain concrete cube or cylinder requires a relatively large amount of compressive force before reaching compression failure. However plain concrete is relatively weak in tension (typically can only carry one tenth ($^1/_{10}$) of its compression strength in tension).

Reinforcing steel has excellent strength in both compression and tension loads but is more expensive than concrete.

Therefore reinforced concrete structures are typically designed by engineers such that concrete is mainly utilized for most of the compressive forces and reinforcing steel is utilized for all of the tensile forces and in some cases some of the compressive forces.

The design of reinforced concrete structures have been streamlined particularly over the last century for safety as well as economic feasibility. Reinforced concrete structures have had a tremendous track record in some of the most complicated structures including dams, bridges and high rise buildings across the globe.

6.4 – Horizontal Reinforcement

Amvic polypropylene webs are specifically designed to accommodate and secure the horizontal reinforcing steel in place without the need to tie them.

Typically the first course of horizontal reinforcement is placed in the notches closer to the EPS panel.

The second course of horizontal reinforcement is staggered so that it is placed in the notch towards the center of the concrete wall.

The third course is placed in the same position as the first course. The fourth course is placed in the same position as the second.

This staggered pattern of horizontal reinforcement is necessary to allow for the vertical reinforcement to be placed from the top and weave in between the horizontal steel bars.

Figures 6.1 and 6.2 below show typical vertical and horizontal reinforcing patterns for below grade and above grade applications using 8” Amvic ICF block respectively.

6.5 – Vertical Reinforcement

Vertical reinforcement is placed after the Amvic ICF wall has been stacked and completely erected. In case of a multi-storey wall then the vertical reinforcement is placed after the erection of each individual storey. Vertical reinforcement bars are slid into place from the top and weaved into the horizontal reinforcement and secured into the proper place according to the project plans and specs.

Refer to figures 6.1 and 6.2 below.

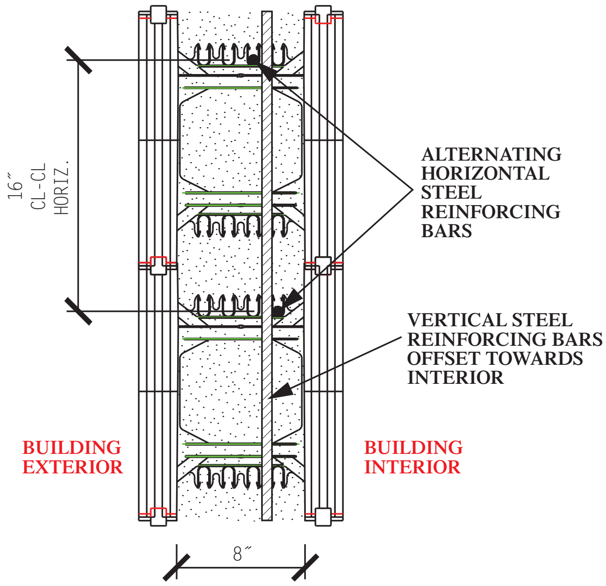

Figure 6.1 – Typical below grade reinforcing steel placement

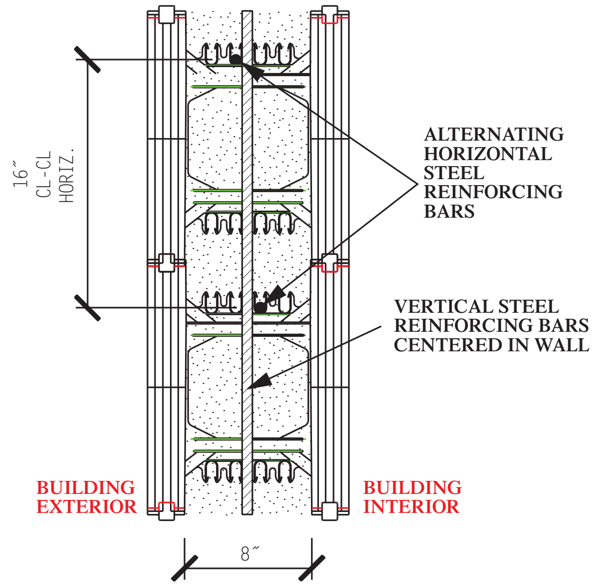

Figure 6.2 – Typical above grade reinforcing steel placement

6.6 - Reinforcement for Wall Openings

Most walls will have window or door openings or both. Creating a wall opening in a reinforced concrete wall creates extra stress around that opening especially at the corners. Window and door headers also known as lintels can be subjected to significant bending moment and shear forces depending on several factors.

Please refer to Appendix A for more details on how to handle reinforcement in wall openings.

6.7 – Reinforcement Splicing

Steel reinforcement typically comes in 20 foot (6 meter) lengths. In such cases where steel reinforcement is required to exceed this length, then a splice is required. The main purpose of the splice is to transform the stresses whether tensile or compression from one steel reinforcing bar or a group of bundled bars to another in a manner to satisfy the governing local building/engineering codes and/or requirements of engineering plans and specs.

6.7.1 – Types of Lap Splice

For the purpose and scope of this manual we will only discuss one type of splicing known as **lap splicing.**

Lap splicing is typically overlapping reinforcing steel over a certain length. The length of the splice should be calculated according to the local building codes or by a local engineer and specified on the project plans.

There are two main types of lap splices:

1. **Contact Lap Splice** – The lapped reinforcing bars MUST be in contact with each other and secured together.

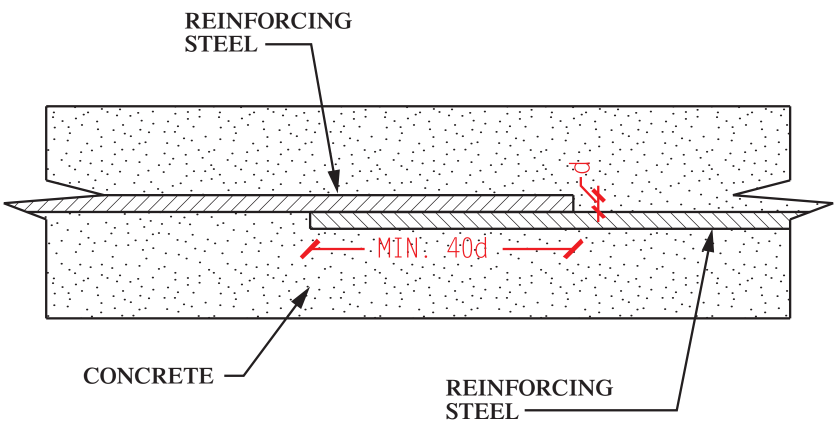

Figure 6.3 – Contact lap splice

2. **Non Contact Lap Splice** – The reinforcing bars are allowed to be spaced at a distance of one fifth (1/5) of the lapped length to a maximum of 150 mm or 6 inches.

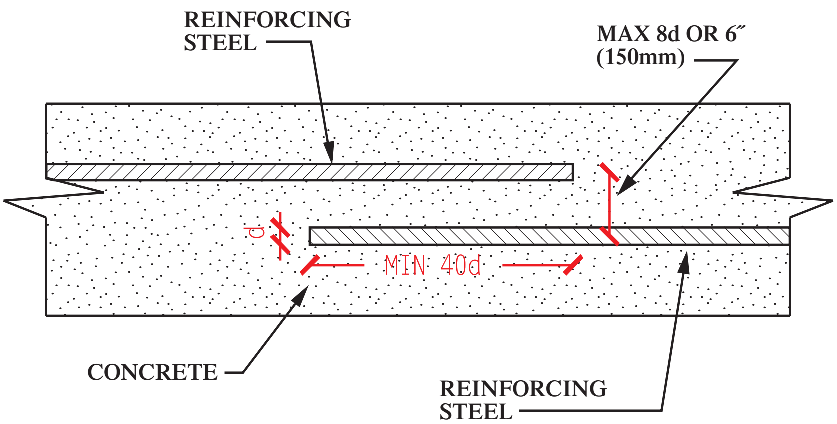

Figure 6.4 – Non-contact lap splice

6.7.2 – Minimum Requirement for Lap Splice Length

Both types of lap splices have a minimum splice length requirement as follows:

Tip

Minimum Lap Splice Length = 40 x Reinforcing Steel bar diameter (40d)

Example

Canadian Reinforcing Steel System

When splicing a 10M reinforcing steel bar which has a diameter of 11.3mm, the minimum lapped splice length is:

40 x 11.3mm = 452mm

Example

US Reinforcing Steel System

When splicing a #5 reinforcing steel bar which has a diameter of 0.625 inches, the minimum lapped splice length is:

40 x 0.625 inches = 25 inches

6.8 – Lapped Splices for Multiple Concrete Pours

When a project has more than one storey of Amvic ICF walls, it is necessary for the installer to understand how to perform vertical reinforcement lap splices between the different pours.

There are two options, both of which are satisfactory from an engineering/structural standpoint.

Option 1

Extend the vertical reinforcement steel bars beyond the top level of the lower storey. The length of the extension should be equal to the required splice length specified by the design engineer or a minimum length of 40d (where d = diameter of smaller steel bar being spliced). Please refer to figure 6.5 below for typical details.

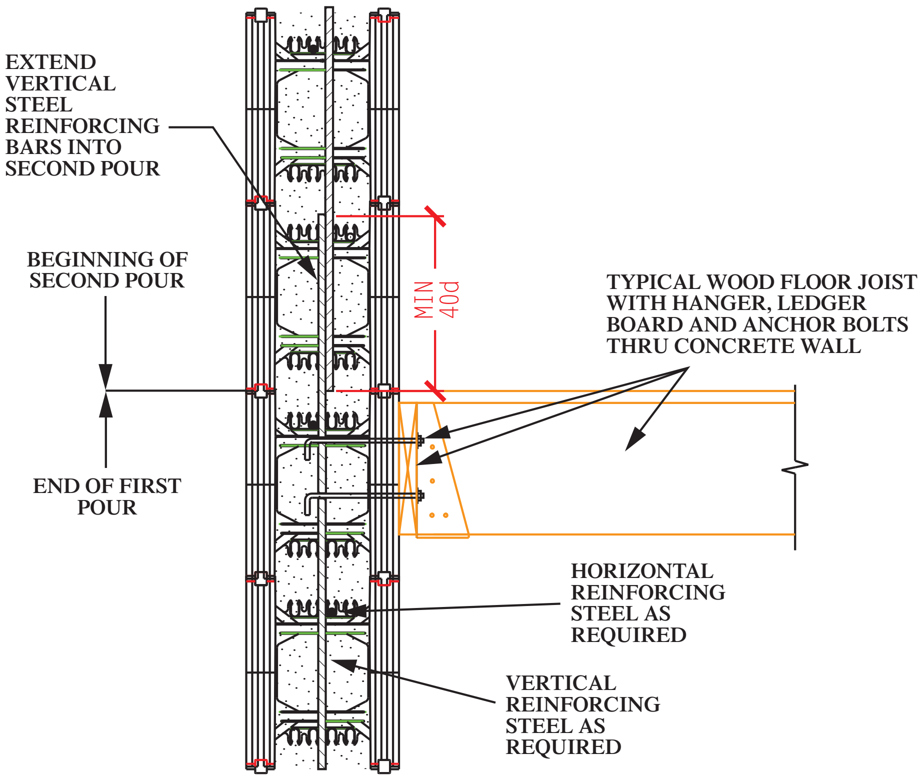

Figure 6.5 – Vertical lap splice

Option 2

Cut the vertical reinforcement steel bars for the lower storey so that they are flush with the top of that wall. Shortly after pouring the concrete, wet set additional vertical reinforcing bars also known as dowels into the concrete. These should extend into the freshly poured wall a length equal to the splice length specified by the design engineer or a minimum length of 40d (where d = diameter of smaller steel bar being spliced). The wet-set vertical splice reinforcing steel bars should ALSO protrude into the upper wall by the same splice length specified by the design engineer or 40d as a minimum. Please refer to figure 6.6 below for details.

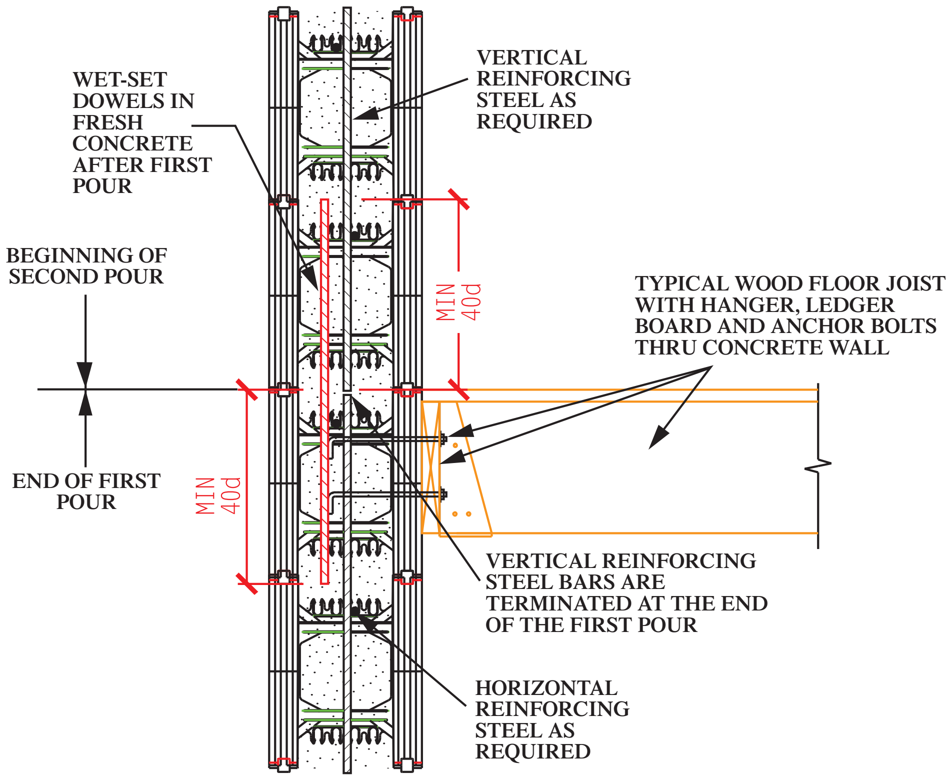

Figure 6.6 – Vertical lap splice using a dowel

6.9 – Designing Reinforcing Steel for Walls

Determining the reinforcing steel schedule whether vertical or horizontal is a structural engineering task which depends on many factors. This is beyond the scope of this technical manual, however, some tools are available for the residential construction market to assist in reinforcing steel design. The tools are explained below.

6.9.1 – Canada

CCMC report no.13043-R contains reinforcing steel tables for below grade and up to 2 storeys of above grade applications in residential projects. The report also contains some lintel tables for wall openings both in metric and imperial units.

There are applicability limits mentioned in the report which must be adhered to.

If the particular project at hand falls outside of these limits then a local licensed/registered engineer should be retained.

Code Requirements

A – Design of reinforced concrete shall be in accordance with CSA A23.3.

B – Reinforcing steel placement shall conform to CSA A23.1, CSA A23.4 and/or the local building code having jurisdiction.

C – Reinforcing steel bars shall conform to clause 7 of CSA A23.1 AND CSA G30.18.

D – Minimum Steel Yield Strength shall not be less than 300 MPA (40 ksi).

6.9.2 – United States

NAHB (National Association of Home Builders) in association with PCA (Portland Cement Association) have prepared the **"Prescriptive Method for Insulating Concrete Forms in Residential Construction"** specifically for the ICF industry [REF. 1].

This document contains reinforcing steel schedules for below grade and up to 2 storeys above grade applications. It also contains several lintel tables for wall openings in different applications. As expected, there are limitations which must be adhered to.

Code Requirements

A – Design of reinforced concrete and placement of reinforcing steel bars shall be in accordance to ACI 318 or ACI 332 and/or the local building code having jurisdiction.

B – Reinforcing steel bars shall conform to one of the following specifications;
1 – ASTM A615 – Specifications for Deformed and Plain Billet-Steel Bars

B – 2 – ASTM A706 – Specifications for Low-Alloy Steel Deformed and Plain Bars

B – 3 – ASTM A996 – Specifications for Rail-Steel and Axle Steel Deformed Bars

C – Minimum yield strength of reinforcing steel shall be Grade 40 (300 MPa) except for seismic design categories D1 & D2 the minimum yield strength of reinforcing steel shall be Grade 60 (400 MPa).

For applications that fall outside the scope of the **"Prescriptive Method"** a local licensed/registered engineer should be retained.

PCA (Portland Cement Association) has prepared another tool for engineers to assist in the design of ICF walls – "Structural Design of Insulating Concrete Form Walls in Residential Construction" [REF. 2]. This publication explains in more detail the engineering principles involved in design load bearing and non-load bearing ICF walls even for walls outside the scope of "The Prescriptive Method".

6.10 – Steel Reinforcing Bars and Jobsite Safety

Unguarded protruding steel reinforcing bars are hazardous and can result in injury or death.

The following measures greatly reduce the hazards of exposed reinforcing steel:

- Guard all protruding ends of reinforcing steel bars with caps or wooden troughs, or
- Bend reinforcing steel so exposed ends are no longer upright.
- When employees are working at any height above exposed rebar, fall protection/ prevention is the first line of defense against impalement.

Figure 6.7 – Plastic mushroom caps on protruding steel bars

Code Compliance

According to OSHA (Occupational Safey & Health Administration – USA) article 1926.701 (b), the following clause shall apply to the jobsite:

"All protruding reinforcing steel, onto and into which employees could fall, shall be guarded to eliminate the hazard of impalement."

A similar compliance clause present in OSHA (Occupational Health and Safety Act – Canada).