Research & Development Highlights

Technical Series
90-227

Design and Construction of a Monocoque House

Introduction

Unstable soils such as peat, swelling clay or permafrost are a problem in many parts of Canada Houses built on these soils can suffer extensive and costly damage due to uneven ground movement which causes the foundation to shifL

Canada Mortgage and Housing Corporation has investigated a number of house designs intended for unstable soils which are not suitable for conventional foundations. One of these is the "monocoque" or "unified shell" structure.

Design Concept

The monocoque structure features a one-piece shell similar to the shell of an egg or the unibody of a car. This is composed of plywood sheathing unified with sheet metal plates.

An internal framing system carries loads down to the foundation bearing points.

The result is an extremely rigid structure which can support itself where a traditional foundation would fail. This technology may also be useful in remote locations where adequate foundations are difficult to construct, or in earthquake zones where unusual foundation forces may be encountered.

Construction

The house is designed to be stick built, using conventional spruce lumber and 19 mm (3/4") plywood sheathing. Galvanized sheet steel is used to reinforce connections and a large number of nails are used to transfer the shear stresses.

The monocoque shell is constructed of sheets of 19 mm (3/4") plywood which cover the roof, side walls and main floor. The main floor is hung from the side walls which then transfer loads to the "A" frames. These frames are required to provide torsional and lateral stability, to allow for openings in the front and rear walls, and to transfer all the loads from the monocoque shell down to the foundations. The front wall footings are located close together to minimize torsional stresses. Stresses in the

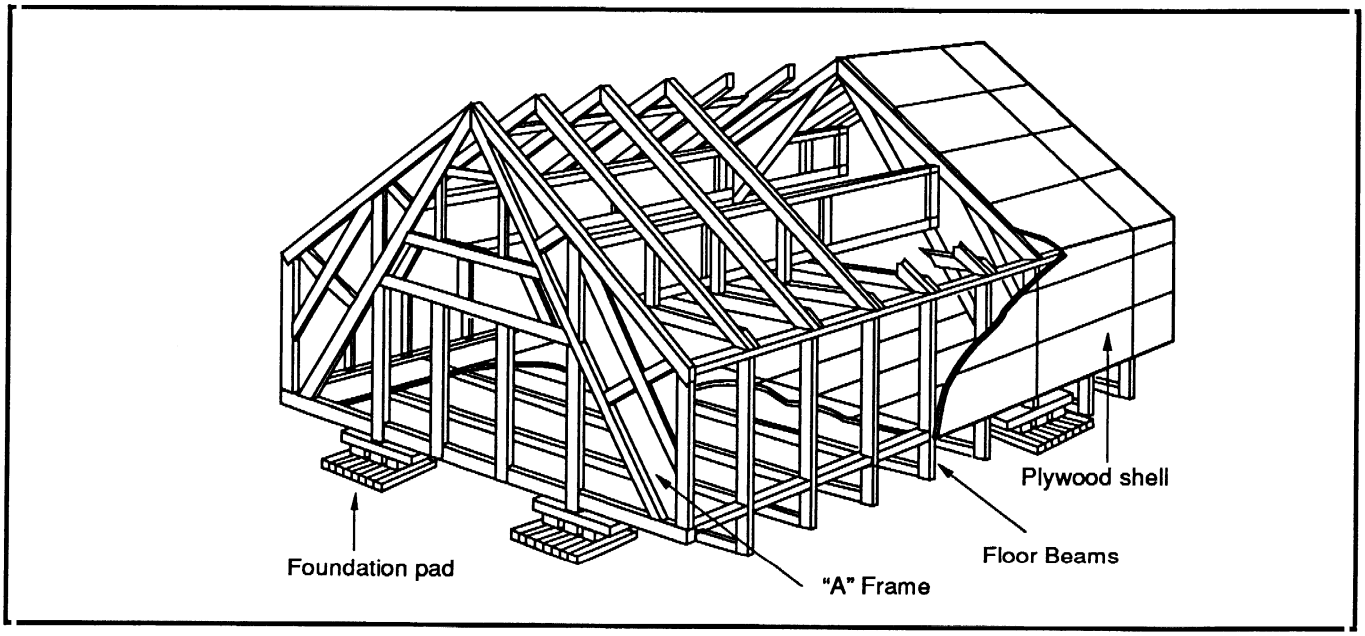

Figure 1: Monocoque structure

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walls are significant so openings are kept small in size and number. In the future, extra reinforcement may allow for larger openings. As in all engineered wood structures, the design of the connections was difficult; effective nailing of the plywood required much more than the conventional 9.5 mm (3/8") edge distance, so double framing material was required to back up the joints.

The prospect of supporting 45 tonnes (50 tons) of house on four spot foundations without using heavy duty support beams is fairly daunting. The floor is spanned 8.53 m (28') using built-up plywood web "I" sections rather than proprietary floor trusses. The "I" section for these built-up beams suggested the framing and connection system for the house which is basically a 19 mm (3/4") plywood tongue spliced between 5 cm x 15 cm (2" x 6") studs spaced 122 cm (48") apart. This double shear tongue connection detail is carried throughout the construction to connect floors, walls and roof framing members.

The building is 93 m^2 (1,000 sq. *ft.)* on the main floor and 46.5 m^2 (500 sq. ft.) on the second floor attic space. In terms of architecture, the present monocoque design limits the freedom of the designer. The size and shape of the building is limited and the location of openings is critical. The ground floor is virtually clear of partitions. The second floor is also clear, but head room is tight at the side walls. The need for external sheathing to transfer stresses requires that window and door openings be few in number and small in size. The end walls can have reasonably large openings; however they must be strategically placed to avoid structural framing members.

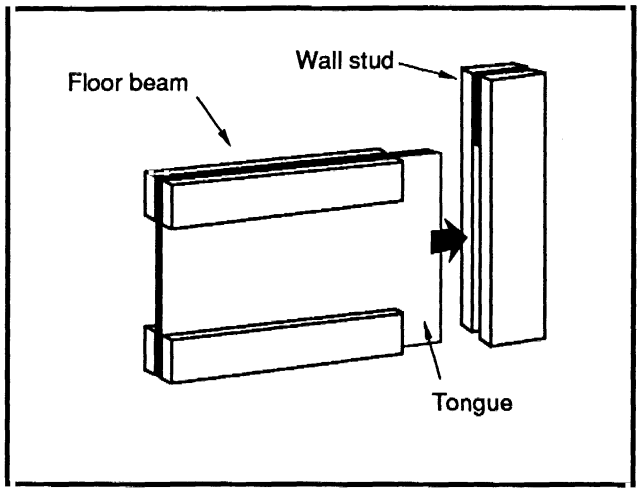

Figure 2: Plywood tongue connections

Research and development of the monocoque design continues. Test houses have been constructed in British Columbia and the Yukon, and their performance is being monitored.

Project Manager: Rob Duncan

Research Report: Design and Construction of a Monocoque House

Research Consultant: Gower Yeung and Associates Ltd.

A full report on this research project is available from the Canadian Housing Information Centre at the address below.

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