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Canadian Practice in Wood Frame Construction

by

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By R. A. Orr (Canada)

A typical and traditional home in Canada is of wood frame construction. The wood frame home could best be described as a structure with a wood floor platform on horizontal wood joists; a wall structure of vertical members called "studs" with a sheathing skin; a roof of horizontal joists and sloping rafters with a sheathing skin; all of which are assembled on a perimeter foundation of masonry or concrete.

Buildings of wood frame construction are successfully used in every part of Canada, where climatic conditions are most extreme. Temperatures range from −40° F to 100° F with variations in excess of 60° in 24 hours; snow loadings range from 10 to 60 lbs. psf; winds reach a velocity of up to 105 miles per hour; and annual rainfalls range from almost none up to 60 ins. per year. Wood frame construction is used economically in both single and multiple family units, in densities of from 1 to 25 units per acre, with height limitations of 3 storeys, or approximately 28 ft. Performance and practice codes employed today in wood frame construction have been developed primarily from a continuing study of acceptable practices and experience. Building techniques of wood frame construction utilize the versatile qualities of timber, and the uniform standards of timber production in Canada, to meet the market demands.

Since the 1940's wood frame construction has been adapted to large scale production and prefabrication. Prefabrication of wood frame construction has been used extensively to produce residential and commercial buildings to meet markets over a wide geographic area. This type of prefabrication lends itself effectively to economical production for small as well as the large markets and to the control of design standards. Mechanisation is not extensive or elaborate in the "prefab" factories. Rather, prefabrication leads to greatly increased productivity through improved materials handling, job layout, and supervision in the plant, and by imposing order at the job site.

The operations of 'Engineered Homes' are typical of this type of operation, and the company's finished products are typical of contemporary wood frame homes. Engineered Homes is an integrated home building operation involved in construction, prefabrication and land development. Prefabrication of wood frame components is centralized, for the entire Western Canadian market, in the Calgary factory. The 54,000 sq. ft. factory building is located on a 6 acre site which provides full yard storage for all materials. Geographic market areas of this factory are Saskatchewan, Alberta and British Columbia with an economical delivery radius up to 800 miles.

Production of the Calgary factory varies from 800 to 1,200 housing units per year. Additional production could be achieved with existing plant facilities. Sales are made throughout the market area from a selection of approximately 60 basic plans with many architectural variations available for each individual plan.

The design function

The design of the company's basic housing plans is premised on these four primary considerations:

- market demand for variety of non-repetitive home production;
- code limitations and inspections over a broad geographic area;
- transportation;
- availability of skilled on-site labour.

Standard component system

Engineered Homes has adapted a standard component system to meet these requirements. This component system is co-ordinated through the practice of grouping together of structural members (or parts) that will remain constant throughout various architectural designs, structural designs, costing and production. This grouping of components constitutes the essential basis of all design and serves as the key to efficiently and economically producing a quality product while offering the wide scope of variations demanded by the consumer market.

Component assembly. In the assembly of the finished component the size of each of its individual parts is restricted in all dimensions. The component itself is restricted in at least two of its dimensions with the variable dimension being the length in plan. Generally, all finished components are designed and sized to work from (or be accommodated within) 4 ft. bearing or take-off points, i.e. a 4 ft. modular grid is used. By way of example, the plan shown in Fig. 1 is designed through the assembly of 15 standard factory-produced components. Included in these standard components are:

- standard floor joist component, varied in 16 in. multiples;
- stairwell component, fixed in plan;
- standard exterior wall component, varied in 16 in. multiples;
- standard interior wall component, varied in 16 in. multiples;
- window components, five types varying only in elevation, fixed in plan;
- standard roof component, varied in 16 in. multiples;

The exterior wall component (elevation 8′0″; thickness 4″; length in 16″ multiples) serves as an example to illustrate material use: parts are 2″ × 4″ vertical studs, 7′8″ long, at 16″ centres; 3/8″ plywood exterior sheathing; 2″ × 4″ horizontal plates at top and bottom. A standard exterior wall of 8 ft. length is considered as 5 standard 16 in. increments, plus two half increments of 8 in. at each end.

Design Plans. Complete production, erection and finishing of the homes is achieved using four plans, namely: basic set of architectural and detail plans; floor joist plan; stud plan; and roof plan.

The success of an individual plan, in terms of economical and efficient production, lies in the effective architectural design application of basic components, supplementing these with the required number of variable components. The plan "template" is first established by determining the fixed components (i.e., windows, doors, stairwells and flues). Basic components are then laid out on even or part multiples of 4 ft. length. Variable components fill between fixed components to complete the plan.

A standard cross-section is used in all designs with fixed vertical height and varying house width. Finishing details and schedules are applied to the basic plan. The joist plan, stud plan and roof plan are simple line drawings, each showing the code number of all parts for production purposes. Dimensions are shown to locate the fixed components such as stairwells and fireplaces on the joist plan, and doors and windows on the stud plan.

The factory production function

Deliveries of components from factory to site are scheduled to assure a continuity of site work from foundation to final finish with no loss of man hours. Components and all materials are generally shipped in four packages,

(1) Floor package.
(2) Framing package (walls and roof).
(3) Internal finishing package.
(4) Exterior and site improvement package.

Systematic delivery of factory-built prefabricated components facilitates the accurate scheduling of site work and a greater degree of site supervision. The progress of one hypothetical home, from purchase to completion, through the four shipments scheduled, would follow this pattern:

Floor package – Components of the beams used to support the floor joists are cut to exact required length, carefully coded for the guidance of site assemblers and strapped in bundles for ease of handling. Floor joists are precut and coded in accordance with assembly blueprints. These components, together with the sub-floor material as required for the plan, complete the first shipment to the site. The first shipment is scheduled to arrive on completion of the perimeter foundation.

Superstructure package – wall and roof material – Interior wall studs and plates are precut to required length in the factory. Studs and plates are assembled on jig tables using a prepared

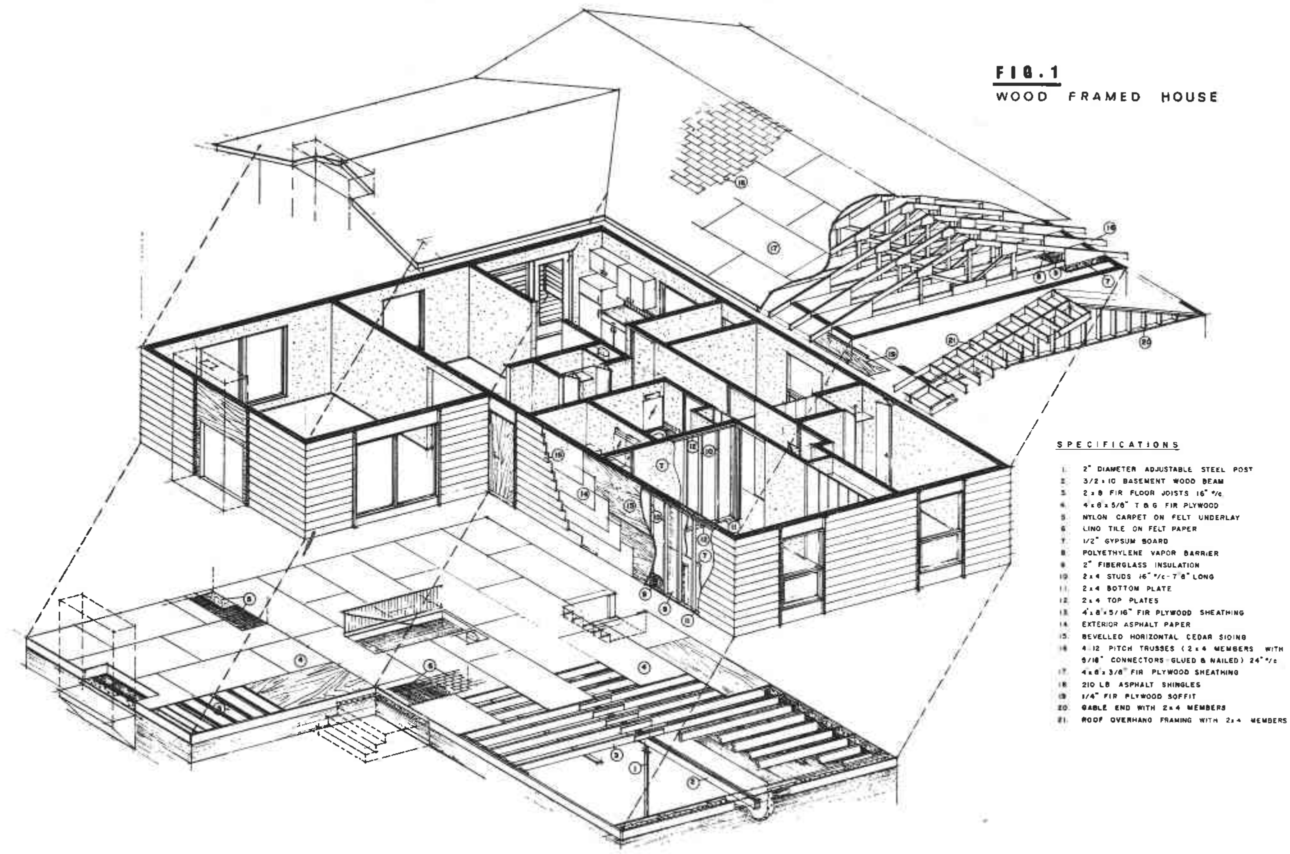

FIG. 1
WOOD FRAMED HOUSE

template to assure speed and accuracy. Fixture backing plates, provision for plumbing, heating, etc. (as dictated by the home plan) are built-in to wall sections. Exterior wall studs and plates are precut and assembled on a jig table template in the factory and exterior plywood sheathing is nailed to the stud wall.

Windows, sashes and frames are purchased in complete sets, which are then completely assembled in the window section of the plant. Hinges, fasteners and weatherstripping are affixed to all movable window units. Completed units are then framed as required with jacks and studs to form a "window wall" which in turn is integrated into the complete wall section.

Doors are completed, according to blueprint specification, in hte door section which carries out all necessary work, including glazing where required. All provision for locksets, hinges, weatherstripping, and decorative glass are completed prior to shipping. Exterior door units are finished in the factory for nailing into wall sections at the site. Protective primer coats are applied to both exterior and interior doors in the factory.

Roof trusses, prefabricated completely within the factory, are ready to be set on wall sections at the site. Method of manufacture, employing accurate patterns for each truss design, makes it possible to hold members rigid while gussets are glued and stapled into position. Gussets are attached to both faces. Where plans and specifications require rafters and ceiling joists in lieu of roof trusses the following procedure pertains: rafters and ceiling joists are precut, coded and bundled, in the same manner as floor joists, to ensure simplicity of erection at the site.

Roof decking is bundled at the factory in accordance with requirements of the individual plan. Gable ends are completed in the factory in the same way as exterior wall sections. Precut studs and joists are framed on a jig table then sheathing is applied to one side. Soffits, manufactured in a separate section of the factory, are precut to size and prime coated to protect against the weather.

Vapour barrier paper, insulation and interior wall finishing material are installed at the site following erection of all wall sections. Roofing material is installed following completion of roof decking.

Interior finishing package – Counter tops, as required for kitchen cabinets and bathroom vanities, are produced in the factory's finishing shop which prepares all interior finishing items called for in the plan. Prefabricated kitchen cabinets, available in a variety of sizes and finishes are included in the Interior Finishing Package. Site workers need only position the cabinets and secure them to the wall. Interior stairs are cut and assembled.

Interior doors, together with frames, are shipped in a knock-down package for site installation in interior stud wall openings.

Exterior finishing package – Exterior finishing items such as plywood panels and fencing are included in the final shipment.

Supplementary plumbing and heating packages – Various other finishing packages are available, such as plumbing, electrical and heating, all custom designed to suit individual floor plans.

Labour Content in manufacture of packages – The direct production time for the packages required to construct the home shown in Fig. 1 is:

Package 1 –	6 man hours
Package 2 –	100 man hours
Package 3 –	30 man hours
Package 4 –	7 man hours
Total	– 143 man hours

This manufacturing plant employs approximately 80 men in direct labour.

The site assembly function

The following abridged description of site labour indicates the direct man hours required to complete the home shown in Fig. 1:

Preliminary site work – Excavation, forming and placing of concrete footings; and setting wall forms.

Package 1 – Placing floor joist components; applying floor sheathing components; pouring concrete wall and backfilling. Direct labour to complete the above—4 man crew, 185 man hours.

Packages 2 and 4 – Are delivered to the front of the backfilled foundation aboard a detachable flat deck trailer unit (40′ × 8′ wide). Components are loaded at the factory in order that they will be erected on the site. Erection commences with hand placement of components and application of materials in the following sequence: three exterior walls; all interior walls; front exterior wall; roof trusses; roof sheathing; and exterior finish. Direct labour—6 man crew, 160 man hours.

Interior finishing – The interior of the home is completed by applying 1/2 in. gypsum board to the stud walls (horizontally), using sheets varying in size from 4′ × 8′ to 4′ × 16′, depending on most economical cut for room dimensions. Gypsum panel joints are mechanically taped in a three coat application. Direct labour—4 man crew (2 boarding and 2 taping), 90 man hours.

Mechanical installations (plumbing, heating, and electrical) are done at this time—102 man hours.

Package 3 – Is delivered and installed in the interior of the home. Direct labour—2 man crew, 60 man hours. The home is decorated and floor covering installed–130 man hours.

The complete construction schedule outlined above can be done in approximately 20 working days but in practice the actual scheduling is done on a 60 day to 120 day basis for economical reasons. This type of scheduling allows a distribution of the work force over a series of homes so that the total labour force is kept to a minimum of crews. A 60 home project is quite reasonably scheduled for completion in 120 days with the completion of the homes coming one per day, after 60 days.

Conclusion. Wood frame construction does not lend itself to highly mechanized production. The productivity gains of the component manufacturing system are primarily achieved through the orderly provision of materials, jobs and supervision to the worker both in the factory and on the site.

The percentage of factory prefabricated components in the frame structure itself has remained quite constant in Canadian prefabrication for the past ten years. Gains in efficiency have been made largely by reducing the number of parts; by the simplification of components and by the manufacturing of individual items in the home (i.e., cabinets, doors, windows and mechanical items). Where lumber supplies are not economically available there is an application of the research that has been done to replace standard frame parts with factory manufactured structural parts, e.g., laminated beams, plywood box beams, stress skin panels and foam core panels. The discipline required to design using a standard component system has certainly never inflicted a limitation on the architectural results of manufactured homes. Rather it has enhanced the results as evidenced by the significant number of design awards won by Engineered Homes. It is the writer's opinion that increased productivity in both design and indirect labour could be achieved through the introduction of a standard module into the designing of the wood frame house. Ideally this module would be based on the metric system. Adoption of 40 or 50 centimeter stud spacing would require primarily that sheathing manufacturers produce products in dimensions appropriate to the metric system. Application of such a system would mean that any given home model could then be conceived, drawn, componentized and priced, right from the plan, without time consuming conversions in feet, inches, square feet and board feet.

With the technical knowledge and public awareness in the housing field there are many innovations and processes being attempted which are designed to increase productivity and lower costs of home manufacturing but wood frame construction remains difficult to equal for structural adequacy, versatility and low cost production.