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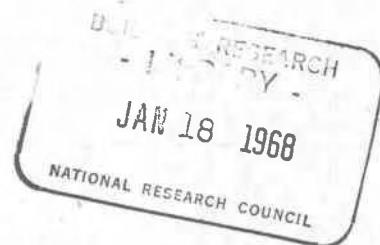
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DIVISION OF BUILDING RESEARCH

HOUSING NOTE NO. 29



THE MARK V PROJECT
PART I: A COST STUDY OF A TYPICAL BUNGALOW

by
A. T. HANSEN

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(This Housing Note presents a brief summary of the first part of this study; the second is summarized in Part II, Housing Note No. 30. Information on the complete study is contained in report # NRC 9590 of the Division of Building Research, NRC, Ottawa, and may be obtained for 50 cents by writing to the Publications Section of DBR.)

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HN 29





FIGURE 1: Floor plan.

THE MARK V PROJECT:

Part 1: A cost study of a typical bungalow

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In recent years industrial engineering methods have been increasingly used to analyse work content and methods in manufacturing industries,

to increase productivity and reduce costs. Industrial engineering has been chiefly confined to factory production although there has been a growing appreciation of the value of work study and methods analysis of on-site construction.

The Division of Building Research of the National Research Council decided in 1965 to apply these techniques to their analysis of wood frame house construction. The study formed part of the experimental house program of the National House Builders Association as Mark V of the series, and was carried out through the co-operation and assistance of Connelly Developments Ltd. at their Glen Cairn Subdivision near Ottawa. Central Mortgage and Housing Corporation also assisted by providing the services of two of their Building Compliance Inspectors.

Scope

The first phase of the study was to determine the material and labour content in a typical wood frame bungalow built in accordance with the builder's usual construction methods. Following completion of this phase, a second house was built, identical with the first but constructed according to the minimum requirements of the Residential Standards, to determine the savings that might be achieved by this means. No changes were made that would significantly reduce the quality or affect the appearance of the second house. This note summarizes the results of the study of the first house. A succeeding note will describe the effect of changes incorporated in the second house.

Procedure

For purposes of this study, the construction process was subdivided into various separate operations, from stakeout to final cleanup. All labour and materials directly connected with each operation were recorded.

Only on-site labour was recorded. Management personnel who contributed no physical labour towards the construction of the house were not included in the costs. To simplify calculations, labour was assumed to be \$3.50 per hr. This was the average wage of eight trades in the Ottawa area in 1965, with an allowance to cover contributions to holiday pay, workmen's compensation, unemployment insurance and other benefits.

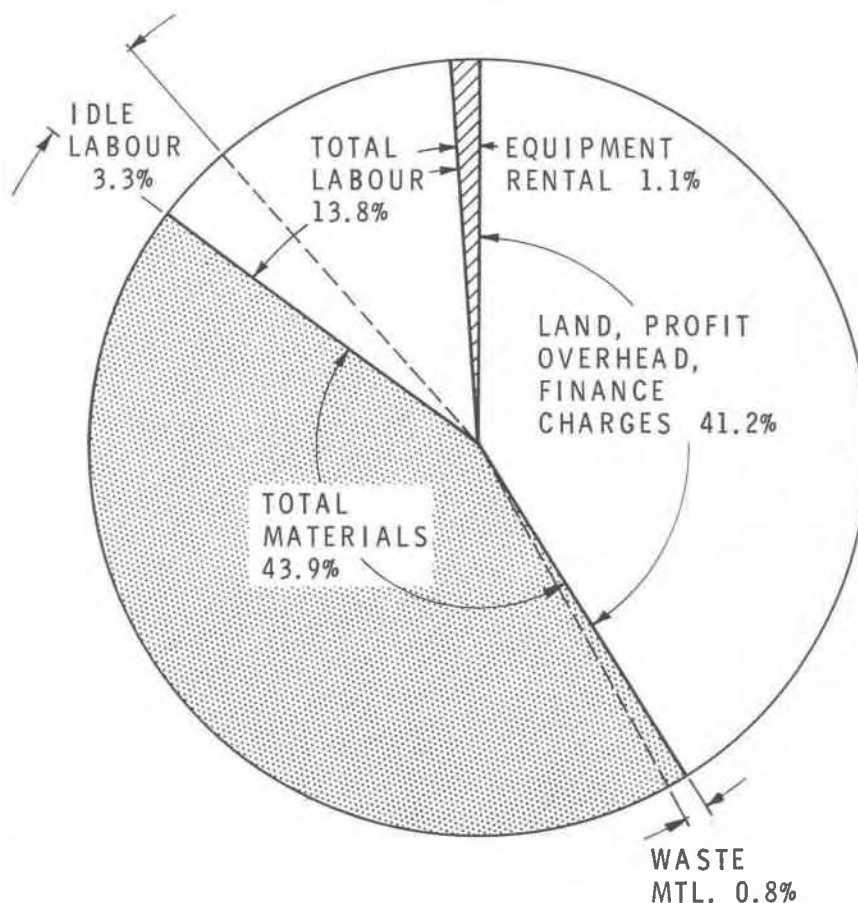


FIGURE 7: Cost components of selling price (\$18,000).

The quantity of materials installed and the amount of waste or scrap was also determined.

Description of House

The house was a three-bedroom wood frame bungalow with 1,150 sq ft of floor area (Figure 1). It was completely site built with the exception of prefabricated roof trusses and cabinets. Only the studs were delivered pre-cut. It had a carport, fireplace and full basement. Brick veneer and aluminum siding were used on the exterior walls and applied over gypsum sheathing. Aluminum fascia and soffits were used at the eaves and rakes. The carport ceiling and storage shed were covered with plywood.

Gypsum wall board was used as interior finish. Resilient flooring was used in the kitchen and foyers, ceramic tile in the bathroom and hardwood flooring in the remaining areas. Roof trusses and partition studs were spaced 24 in. o.c. while the remainder of the framing was at 16 in. o.c. Details of the first house are shown in Figures 1 and 2. Figures 3 to 5 are photographs showing a few of the construction stages, and Figure 6 is a photograph of the completed house.

On-Site Costs

The total measured on-site construction cost for this house was \$10,586. Of this amount, 74.6 per cent (\$7,895) was for materials, including \$141 for waste or scrap. Equipment rental costs for earth moving equipment was 1.9 per cent of the on-site cost. The remaining 23.5 per cent (\$2,489) was for labour. This does not include operator's time for rental equipment as this cost is accounted for in the equipment rental rates.

A summary of the equipment, labour and materials costs for each construction operation is shown in Table I. This table also lists the percentage of the total cost represented in each of the 22 operations.

Labour

The first house required a total of 714 man-hours, not including the man-hours required to operate rental equipment. There was a wide variation of labour cost content in the different operations. Labour cost for installing exterior doors and windows, for example, was only 8.3 per cent of the total cost of the operation, whereas the labour in painting repre-

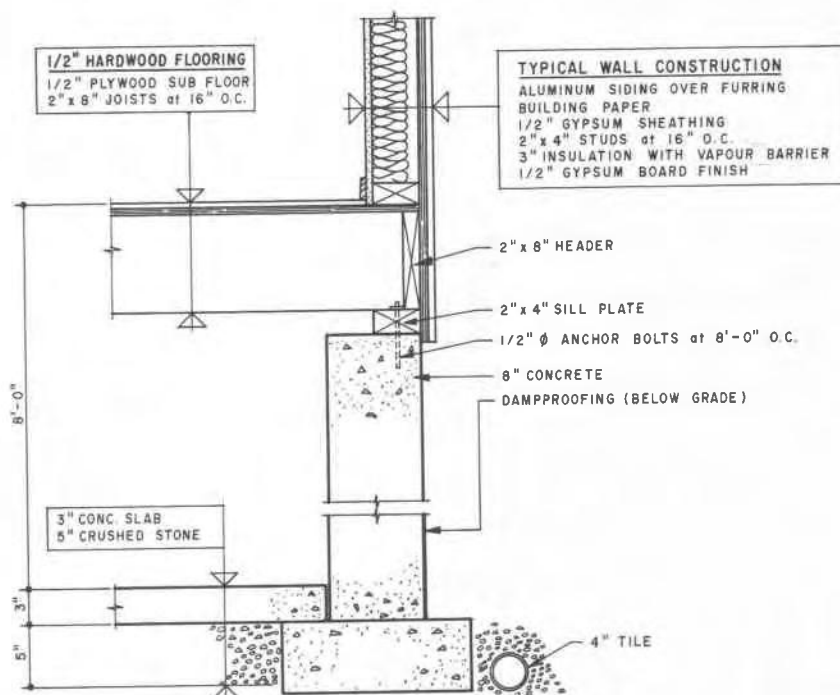


FIGURE 2: Typical wall detail of House No. 1.

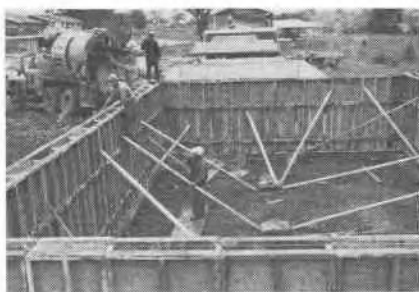


FIGURE 3: Placing concrete foundation walls — first house.



FIGURE 4: Delivery of framing and sheathing materials — first house.



FIGURE 6: First house completed ▲



FIGURE 5: Wall framing, first house ►

sented 76.7 per cent of the cost. Two of the most important operations—rough carpentry and finish carpentry together accounted for about 27 per cent of the total on-site cost; the la-

bour component for these two, however, was only 15 to 16 per cent of the cost.

The total labour cost was only 23.5 per cent of the on-site cost. This is

surprising since the house was site built, not prefabricated in the accepted meaning of the term. At one time it was common to assume that site labour accounted for 40 to 50 per cent of the total cost of construction. The low labour content shown in this study indicates that modern building materials such as prehung windows, sheet materials, roof trusses, cabinets, aluminum siding and soffits have a large built-in factory labour content and considerably reduced on-site construction time over the years. The introduction of modern equipment such as electric hand saws, power trowels and even paint rollers has also contributed to lower labour content.

Idle Time

Idle time accounted for approximately 23 per cent of the total on-site man-hours. In this study, idle time was defined as the time during which a worker stopped building activity. This included coffee breaks,

rests, time spent in awaiting or receiving instructions and delays caused by other trades or adverse weather conditions.

Idle time varied from 12 per cent for painting to about 40 per cent in the construction of the basement. Generally speaking, it was greater for heavier work.

Materials

The total quantity of framing lumber used in the first house was 6,770 board feet. The plywood used as sub-flooring, underlay, sheathing and exterior finish amounted to 3,824 sq ft. About 4,917 sq ft of gypsum wall board and gypsum sheathing were also used. Approximately 278 lb of nails and over 11,000 staples were used for all operations, for a total of over 52,000 fasteners.

The quantity of waste or scrap material was small, representing only 1.8 per cent of the total materials cost. The largest item of scrap was in the aluminum siding, which amounted to

13 per cent of the siding. About 7 per cent of the gypsum wallboard was either wasted or scrapped and was the second major item in terms of cost. The third major item was waste or scrap lumber (6 per cent of the 2 by 8 lumber, 5 per cent of the 2 by 4 lumber). These three items accounted for over half the total cost attributed to waste or scrap.

On-Site Cost and Selling Price

The selling price of the house was \$18,000. The measured on-site cost, therefore, represented approximately 59 per cent of the selling price. The remaining 41 per cent is made up of serviced land costs, profit, overhead, and various financial charges. When related to the selling price, the component costs due to labour, materials and equipment rental are approximately 14, 44 and 1 per cent, respectively (Figure 7).

Equipment

The equipment cost shown in Table I — (items 1 and 3) includes only equipment hired on an hourly basis. It does not include vehicle time such as that for delivery or pick-up; this is usually considered as part of materials suppliers' or subcontractors' overhead. The vehicle time, recorded but not included in the cost summary, amounted to 195 vehicle hours of which 97 per cent was idle time. This large proportion of idle time suggests the possibility for saving in this area. If realized, this saving should be reflected in lower materials costs or subcontract prices.

Conclusions

Although the records of this first phase of the study are for a particular house built by one builder, they should be indicative of a typical cost breakdown of the various operations in an average three-bedroom wood frame bungalow.

This study is the first of its type in Canada for a complete housebuilding operation. The results obtained from it will undoubtedly lead to further studies of this nature which will examine other aspects of house construction costs.

It is significant that the total on-site building costs represent less than 60 per cent of the final selling price. Items responsible for the remainder of the cost may also be useful areas for a future study.

TABLE I
SUMMARY OF ON-SITE CONSTRUCTION OPERATIONS

Operation	Per Cent of Total On-Site Cost (\$10,586)	Cost Components (per cent)		
		Labor	Equipment	Materials
Earthwork	2.13	11.0	89.0	0.0
Sod, final grade	0.94	43.5	...	56.5
Walks, drives, exterior steps	2.16	15.2	0.6	84.2
Foundation walls (including footings, drain tile)	7.15	29.2	...	70.8
Basement floor (including base)	2.78	35.6	...	64.4
Rough carpentry (including sill, beams, columns)	15.29	15.6	...	84.4
Roofing (including chimney saddle) ..	2.41	22.8	...	77.2
Insulation and vapour barrier	1.64	23.4	...	76.6
Exterior doors, windows (including storms, sash, frames)	7.81	8.3	...	91.7
Plumbing (including service to house) .	5.29	9.8	...	90.2
Electrical (including range)	4.78	18.3	...	81.7
Heating	4.29	13.8	...	86.2
Wallboard (including wall tile)	6.32	41.0	...	59.0
Interior finish carpentry and millwork .	11.82	14.6	...	85.4
Hardwood floors (including sanding, varnishing)	4.10	20.4	...	79.6
Resilient and ceramic flooring (including underlay or base)	1.18	31.1	...	68.9
Chimney and fireplace	5.30	34.7	...	65.3
Brick veneer	2.36	32.8	...	67.2
Aluminum siding, fascia and soffits (including strapping and sheathing paper)	6.10	18.7	...	81.3
Plywood siding and ceiling (carport) exterior wood trim	1.62	29.0	...	71.0
Exterior and interior painting	2.67	76.7	...	23.3
Miscellaneous (cleanup, repairs, deliveries)	1.86	92.3	...	7.7
TOTALS	100.00%	23.5	1.9	74.6