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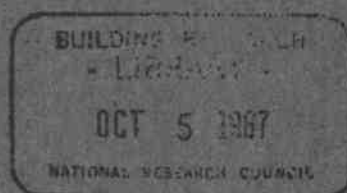
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A COST STUDY OF TWO WOOD-FRAME BUNGALOWS

by A. T. Hansen

ANALYZED



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Ottawa

June 1967

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A. T. HANSEN

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The cooperation provided by Connelly Developments Limited which permitted unlimited access to their building sites (Glen Cairn, near Ottawa) and the assistance provided by Mr. J. W. Ritchie, Assistant General Manager of this company, who contributed much of his time in collecting material cost data, must be particularly mentioned. The cooperation of the subtrades and the individual workers was most freely given.

Central Mortgage and Housing Corporation provided the services of two of their experienced building compliance inspectors for a large part of the study to assist in the collection of the information recorded in this paper. Without this assistance it would not have been possible to undertake the study at this time.

The collection of the records and reducing them into a meaningful form was naturally the major part of this project and the credit for this effort should rightfully be given to those who did this work—Messrs. E. Wagner (CMHC), W. H. Williamson, R. T. Sumi, and F. Eidsforth (DRB/NRC), T. H. Birtch (formerly CMHC now DBR), and Dr. I. Höglund, visiting scientist with DBR from the Royal Institute of Technology in Sweden.

It is hoped that the results obtained from this study will provide a useful contribution to the house building industry and in so doing provide a measure of satisfaction to all those who participated in the project.

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A COST STUDY OF TWO WOOD-FRAME BUNGALOWS

by
A. T. Hansen

In recent years, industrial engineering methods have been used more and more to analyze work content and methods in manufacturing industries.

The ultimate goal is to increase productivity, thereby reducing costs. Industrial engineering used to be chiefly confined to factory production. In more recent years, however, there has been an increasing appreciation of the value of the industrial engineers' tools of work study and methods analysis in on-site construction.

In 1947, the Small Homes Council of the University of Illinois in cooperation with the U.S. Department of Commerce undertook a study of several wood-frame and masonry houses to determine the assembly methods that involve the lowest cost.¹ This was followed by other studies of house construction by the Small Homes Council that were aimed at reducing costs.²⁻⁴

In 1961 and 1962, the Stanley Tool Works in cooperation with the U.S. National Association of Home Builders undertook a study of two wood-frame houses. This study, known as TAMAP (Time and Methods Analysis Program⁵) received a great deal of publicity, and was followed by other specific studies by the NAHB⁶⁻⁹ and by Michigan State University.¹⁰

Since its inception, the Division of Building Research of the National Research Council of Canada has had a continuing interest in the cost of construction. In 1963, the Division published the results of a pilot study conducted by Professor David C. Aird of the University of British Columbia regarding manpower utilization in Canadian construction.¹¹ The wide acclaim of this report indicates the general interest of the construction industry in this type of information.

In 1965, DBR/NRC began a limited study on wood-frame house construction. Two Building Compliance Inspectors from Central Mortgage and Housing Corporation assisted in the project, which was carried out in cooperation with the National House Builders Association. This study, known as Mark V in the series, formed part of the experimental house program of the Research Committee of NHBA. The program was carried out at Glen Cairn Subdivision (near Ottawa) through the cooperation and assistance of Connelly Developments Limited.

SCOPE

The immediate objective of this study was to determine how much the cost of a wood-frame house could be reduced if it was built to the minimum requirements achieved in a typical wood frame house by taking advantage of the minimum requirements in Residential Standards.¹² The study was primarily concerned with those things which would not significantly alter the appearance or quality of the house.

The study was divided into two stages. The first stage consisted of an examination of a typical three bedroom bungalow built in accordance with the builders usual construction methods. Labour and materials observations were taken for all building operations—from the stake out to the final clean up. Observations on this house provided information on the general labour and materials cost distribution of all the various building operations in the construction of a typical house. This house was built during the latter part of 1965. The results were analysed, and on the basis of this analysis, a number of changes in construction practice were suggested. These changes were incorporated in a second house, or stage 2, which was built in the summer of 1966. Records were again taken of labour and materials for all phases of construction.

The study was confined only to the on-site activity of the construction process. Items such as land cost, overhead, profit, finance charges, and mortgage insurance were not investigated since these were outside the scope of the study.

PROCEDURE

In the analysis, construction was divided into various separate operations. All labour and materials connected with each operation were recorded to determine the total cost of each operation.

Labour activity was recorded for each worker at one-minute intervals throughout the entire job. Only on-site labour was recorded and no attempt was made to account for a workman's time after he had left the building site. In each operation, the worker's time was subdivided into activities such as sawing, nailing, measuring, carrying materials and idle time.

"Idle time" is a category that requires special explanation. For the purpose of this study, idle time was defined as the time during which a worker stopped building activity. When a workman stopped for a coffee break, to talk to a fellow worker, to rest, to await or to receive instruction, or if he was held up by another trade or by the weather, he would be classed as idle. No attempt was made to differentiate between avoidable delays and unavoidable delays nor to differentiate between productive and non-productive time. Furthermore, no attempt was made to rate the effort of workmen to convert the "observed time" measurements to "standard time" equivalents, as is sometimes done in such studies. It was thought that this would introduce subjective judgments that might distort the results. It is difficult to establish such ratings with sufficient accuracy unless the person assigning the rating has considerable knowledge of the particular trade he is assessing and sufficient experience with effort rating.

In computing the cost of labour, a value of \$3.50 an hour was assumed. This was the average cost of eight trades in the Ottawa area in 1965 with an allowance to cover costs such as contributions to holiday pay, workmen's compensation, unemployment insurance and other benefits. To simplify calculations, an average labour cost was used for all operations. The cost of labour computed for the various operations must therefore be examined in the light of this wage rate if meaningful comparisons are to be made with other builders' operations.

The delivery of all material and the return of left over material after the completion of each operation was recorded. In addition, the exact amount of material installed was recorded for each operation. From these observations the values of waste or scrap were determined.

DESCRIPTION OF HOUSE NO. 1

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

Gypsum wallboard was used as the interior finish, with ceramic wall tile in the bathroom. Resilient flooring was used in the kitchen and foyers, ceramic tile in the bathroom, and hardwood strip flooring throughout the remainder of the house. Roof trusses and partition studs were spaced at 24 in. o.c. and exterior wall studs at 16 in. o.c. Details of house No. 1 are shown in Figures 1 to 3. This house was one of a number of similar houses built in the same development (Glen Cairn near Ottawa). It was altered in no way from the builder's usual construction. Figures 4 to 7 show a few of the construction stages.

DESCRIPTION OF HOUSE NO. 2

The floor plan of house No. 2 is identical with that of house No. 1; the over-all appearance of the two houses is the same (Figures 8 and 9). A number of changes in construction details were introduced, however, to improve efficiency in the use of materials and labour, while still meeting the requirements of Residential Standards.¹² In addition, because of a change in suppliers, some of the materials in the second house, such as windows and cabinets, are not identical with those in the first. These changes, however, did not form part of the study and will not be discussed in detail.

When house No. 2 was built, mortgages were so scarce that it was the only house under construction in the development at that time. This had a considerable influence on the labour time; more will be said about this later.

The changes that were incorporated in house No. 2 to reduce costs are listed and illustrated in Appendix A to this report.

OBSERVATIONS

Tables I and II provide a brief summary of the labour and materials costs of the various operations. In these tables the cost of labour and materials are tabulated for each of the 62 operations so that the contribution of labour and materials cost toward the total cost can be compared in each case. In these tables, the cost of labour has been assumed to be \$3.50 per hour; the quantities of material are for those in place with no allowance made for waste or scrap.

The breakdown of the construction into 62 operations made it practically impossible to determine the waste or scrap to be assigned to each operation. Some of the waste or scrap from framing the exterior walls, for example, was used in

the construction of the partitions. In addition, it proved difficult to determine whether material removed from the site after the completion of an operation would be re-used or destroyed. When the first house was studied, the continued transfer of material by tradesmen from one house to another made accurate accounting for material most difficult. In spite of these limitations, measurements of scrap were determined in most cases.

Figures 10 to 21 are bar charts that provide a graphical breakdown of the various operations. For simplicity, some operations that are listed separately in Table I have been combined. These charts show the component costs that make up each category. They differentiate between idle time and working time as well as between material used and material scrapped or wasted.

Finally, Figure 22 shows the sequence of work for the eleven major groups of operations that comprise the total construction of the second house. The bars on this chart are drawn approximately to a time scale to show the sequence of work.

(Other details of labour and materials costs gathered during this survey are available in a supplement to this paper. Copies can be obtained, free of charge, by writing to the Publications Section, Division of Building Research, National Research Council of Canada, Ottawa.)

DISCUSSION

The first house observed in this study was one of a number of similar houses in a housing development. As it was not altered in any way from the builder's usual construction, the labour and materials observations for this house should represent typical costs for this builder's operations.

House No. 2, however, involved different conditions. In 1966, when this house was built, mortgage money was so scarce that it was the only house under construction in the development at that time. This seems to have had an important effect on the construction operations. Tradesmen were not able to proceed in an orderly fashion from one house to another and develop a regular rhythm of work, as was the case in the first house. There was not the same sense of urgency to complete operations that there was during the construction of house No. 1. This may have been due partly to the general drop in house construction activity in the Ottawa area, and partly to the fact that some of the recommended changes constituted changes in the tradesmen's usual work procedures. This latter effect was more pro-

nounced in operations such as carpentry in which a number of changes were incorporated. In some cases, tradesmen were naturally reluctant to adopt methods that departed substantially from traditional practice.

Out of the total of 62 operations, only 23 should have been significantly affected in labour content. Of these 62 operations, however, 42 showed a higher labour content in the second house even though only 15 of these should have been affected by the changes. Of the remaining 20 operations that had lower labour content, only 8 should have been significantly affected by the changes.

Labour

The second house required a total of 872 on-site man-hours compared with 714 in the first house, not including those required to operate rental equipment such as shovels, front end loaders, and earth-moving trucks. The operator time for this equipment is covered by the equipment rental rate. If this time is included, the total man-hours would be 734 for the first house and 889 for the second. This represents 155 additional man-hours for house No. 2. (21 per cent more labour) as compared with house No. 1, even though the amount of materials in the house was less.

The labour cost of supervisors who contributed no physical labour to the construction is not included in the tabulated costs. Records of on-site visits made by supervisory staff, however, were kept. The total time spent on site by such supervisory staff was about 15 man-hours for the first house and about 46 for the second house. Although charges for this time have not been included in this paper, the labour for staff, such as working foremen, who contributed physical labour toward the construction is included.

Idle Time

Idle time, as previously defined, constituted approximately 23 per cent of the total on-site labour in the first house and 28 per cent in the second house.

Idle time varied considerably. The various proportions are shown graphically in Figure 21. In house No. 1, the proportion of idle time varied from 12 per cent for painting operations to 40 per cent for basement construction. In house No. 2, the proportion of idle time was generally greater, reflecting a general slow-down in construction. For the second house, idle time was

again lowest for painting (21 per cent) and highest for the basement construction (40 per cent).

The greatest increase in idle time was for the installation of the services (from 18 to 29 per cent) followed by rough carpentry (from 17 to 26 per cent) and the exterior wall finish and fireplace (also from 17 to 26 per cent). The total increase in idle time in the second house represented about 80 man-hours. In general, idle time was greater in heavier work, as may be expected, since idle time included time for rests. About one-half of the additional labour recorded in the second house was due to increased idle time.

Ratio of Labour to Materials

The ratio of labour cost to materials cost in the two houses varied from operation to operation as can be seen in Figures 10 to 21. In some cases, this ratio varied significantly from one house to the other for the same operation.

The over-all proportion of labour cost to the total on-site cost of the first house was 24 per cent, with the remainder being made up of materials costs (74 per cent) and equipment rental charges (2 per cent). The average proportion of labour in the total cost of installing *insulation, roofing, exterior doors, and windows* was only 13 per cent. As can be seen in Figures 10 to 21, other operations that had relatively low labour costs included: *services* (14 per cent); *finish carpentry* (15 per cent); *rough carpentry* (16 per cent); and *earthwork and site improvement* (19 per cent). Operations that entailed relatively high labour content included the miscellaneous group; *corrections, clean-up, and delivery* (95 per cent); *basement construction* (31 per cent); *wallboard and walltile* (42 per cent); and *painting* (77 per cent). The remaining operations—*finish flooring and exterior finish and fireplace*—were within 4 per cent of the over-all average.

In house No. 2, the situation was somewhat different: labour accounted for about 28 per cent of the total on-site cost, while materials accounted for almost 70 per cent. In the second house, the groups that exhibited low labour cost content were similar to those in the first house (*rough carpentry; finish carpentry; services; and roofing, insulating, exterior doors and windows*) which ranged from 16 to 20 per cent of the cost. Those containing significantly higher than average labour cost included *installation of wallboard and tile; exterior finish and fireplace; painting; and the miscellaneous group*. These contained 33 to 90 per cent labour. The remaining operations were within 4 per cent of the over-all average.

Materials

The proportion of total cost represented by materials was 74 per cent in house No. 1 and 70 per cent in house No. 2, or about \$7,754 and \$7,340 respectively, not including waste or scrap. If waste or scrap material is included, the totals are \$7,894 and \$7,507 respectively.

The total amount of framing lumber used in the first house was 6,770 fbm; in the second house this was reduced to 6,085 fbm. These figures include the lumber in the prefabricated roof trusses. This decrease represents a reduction of approximately 10 per cent in the quantity of lumber used. In addition, the total amount of plywood was 3,824 sq ft in the first house and 3,764 sq ft in the second.

Wood trim increased from 592 lineal ft in the first house to 740 lineal ft in the second. This was largely due to a change in window design. In house No. 1 the wallboard edges at windows and exterior door frames were finished with a corner bead. In house No. 2, since no provision was made in the frames for this detail, additional trim had to be used in these locations.

The total amount of gypsum wallboard and gypsum sheathing was 4,917 sq ft in the first house and 4,658 sq ft in the second. This reduction resulted from the omission of gypsum sheathing on the wall adjacent to the carport in the second house. A total of 278 lb of nails and over 11,400 staples were used in the first house for all operations for a total of over 51,000 fasteners. In the second house there were about 238 lb of nails and 13,000 staples for a total of about 48,000 fasteners.

In assessing the results of this study one should keep in mind that the houses were site built with the only prefabricated components being the roof trusses and cabinets. All other material was assembled on the site and only the wall studs were precut.

Waste and Scrap

Generally, the amount of waste and scrap material was small and represented only about 1.8 per cent of the cost of materials in the first house and 2.3 per cent in the second. It is interesting to note, however, that the largest item of waste or scrap was in the aluminum siding. This amounted to 13 per cent of the siding in the first house and 19 per cent in the second. The second major item of waste or scrap was gypsum wallboard, which amounted to 7 per cent of the wallboard in the first house and 8 per cent in the second. Lumber

was the third major item. In house No. 1 about 6 per cent of the 2 by 8 lumber and 5 per cent of the 2 by 4 lumber was waste or scrap; in the second house there was practically no scrap 2 by 8's but there was 5 per cent waste or scrap 2 by 4's. These three items accounted for over half the total waste or scrap in both houses.

The excessive waste or scrap aluminum was due in part to the fact that 10-ft-long sheets were used, whereas the longest required lengths were less than 9 ft, thus requiring that over a foot of material be cut from each sheet. Although it was possible to use some short lengths at doors and windows, many of the short pieces could not be used.

Equipment

Equipment costs shown in Tables I and II and in Figure 10 include only the cost of equipment that was hired on an hourly basis by the contractor or subcontractor. It does not include the operating time of equipment, such as delivery trucks or personal automobiles, usually considered as part of a subcontractor's or supplier's overhead. This vehicle time, except for private cars, was recorded as a matter of interest. The cost for the delivery truck times is reflected in the materials cost and is, therefore, not included as an additional expense in computing the costs.

In total, the non-rental on-site vehicle time observed for the first house amounted to about 195 hr of which about 97 per cent was idle time. This appears to represent an area where potential savings could be made through more efficient utilization of vehicles.

Selling Price Versus On-site Costs

The total measured on-site cost of house No. 1 exclusive of land but including waste and scrap, was \$10,585 (Figure 21). This house had a selling price of approximately \$18,000 so that the on-site construction costs represented only 58 per cent of the final selling price. The remaining 42 per cent is attributed to land cost, mortgage insurance, finance charges, profit, overhead and other costs that were incurred off site. It must be remembered also that the on-site labour time may differ from payroll time since there was no way of knowing how the tradesmen utilized their paid time when not on the building site.

The total on-site costs of house No. 2 was \$10,781, which was \$195 more than the first house and was due to the reasons previously described.

Effect of Construction Changes

The potential savings arising from the changes incorporated in the second house were calculated to be almost \$400. These savings were not always realized, so the measured costs for the second house did not fully reflect the savings that had been anticipated. What was demonstrated, however, is the considerable effect on productivity of job organization and of the conditions under which construction is carried out.

Even though the measured cost of the second house was almost \$200 more than the first, it is thought that this difference would have been considerably more had the changes not been introduced, because of the peculiar circumstances prevailing at the time of construction of the second house.

As most of the innovations had been used by different builders in other areas, none of the suggested changes were unique or experimental. Some of the changes have a more general application than others. For example, a wider spacing of wall studs is generally applicable, while the rearrangement of the floor and roof framing may be applicable only to this house design.

In evaluating the changes all dollar values have been based on 1965 prices for direct comparison with the first house. Prices of materials were supplied by the general contractor and the labour rate was again assumed to be \$3.50 per hr. This rate should be kept in mind when relating the potential savings to a particular area.

The calculated saving was almost 4 per cent of the entire on-site cost. The changes did not affect the quality or appearance of the house and all changes met the requirements of Residential Standards.¹²

Substituting polyethylene film for crushed rock fill beneath the basement slab saved approximately \$28 in materials. After allowing for the extra labour to excavate the footing trenches and pipe trenches, level the base for the slab, and lay the plastic film, there was still a \$6 saving in labour compared with that required to spread the crushed rock. The total potential saving of \$34 was not realized, however, because insufficient care was taken in levelling the base. This led to a substantial increase in the amount of concrete required for the floor slab.

Placing the footings without forms saved almost \$19 in labour in forming and stripping, not to mention the cost of wear and tear on the forms. More concrete was used when forms were not used, however, partly offsetting the potential savings.

Placing the sill plate on edge inside the formwork before the concrete was placed saved almost \$4 in material and about \$6.50 in labour. About \$3 of this saving was attributed to concrete as the total volume of concrete displaced by the sill was about $\frac{1}{5}$ of a cu yd.

Reducing the header joist from 2 by 8 to 1 by 8 saved about \$7 in materials. Moving the supporting basement beam a few inches to one side enabled the use of more efficient lengths of joists. This saved about \$12 worth of joist lumber. Four additional joists were saved in replanning the floor framing. In all, about \$27 was saved in floor framing material. Had the labour content followed the same course as that in the first house an additional labour saving of \$4 would have made a total saving of \$31.

Placing the exterior wall studs at 24 in. o.c. rather than 16 in. o.c., using a single top plate on the end walls and 3 rather than 4 studs at wall intersections, saved about \$25 in materials. The use of a single top wall plate in partition framing, together with single framing around partition doorways, the elimination of cripples over such doorways and the use of 3 rather than 4 studs at partition intersections, saved \$16 in materials. Again, had the proportion of labour to materials cost been the same as that in the first house, an additional labour saving of about \$12 would have made a total saving of \$54 on exterior wall and partition framing.

Eliminating the sheathing from the wall adjacent to the carport saved \$11 in materials. The labour to install the extra layer of paper required when sheathing is omitted was about equal to the labour of installing the sheathing. Omission of the sheathing has certain drawbacks, particularly with winter construction, when it is desirable to enclose the building rapidly. It is debatable if the omission of sheathing is advantageous in the long run, particularly if there is insufficient care to prevent damage to the paper.

Eliminating ridge blocking and using metal H clips instead to support the plywood edges saved 30 pieces of blocking and reduced the cost by about \$5.

Eliminating the 2 by 4 stringers to align the bottom truss chords and substituting 1 by 4 strapping only in those areas where the partitions did not keep the trusses aligned saved about \$14 in labour and materials.

The use of 4 nails per roof shingle rather than 6 led to a saving of \$4 in nails and \$7 in labour, a total saving of \$11.

An additional \$14 was saved by substituting spruce for pine in the basement stairs. The use of 5/16-in. select sheathing plywood for the carport ceiling instead of sanded 3/8-in. plywood saved \$27. By making the same substitutions in the carport storage shed, an additional \$16 was saved.

Relocating the attic access hatch in the carport ceiling rather than inside the house saved approximately \$5. When located inside the house the hatch must be insulated, trimmed, and painted, all of which breaks up the normal continuity of the ceiling construction. By locating it in the carport, the trim was eliminated, insulation was no longer required, and the painting operation was uninterrupted.

Substituting $\frac{3}{8}$ -in. oak for $\frac{1}{2}$ -in. oak flooring and using $\frac{1}{4}$ -in. poplar plywood beneath resilient flooring rather than $\frac{3}{8}$ -in. Douglas fir saved \$23 in materials cost for the flooring and \$11 in underlay. In addition, \$3 less labour was used to lay the thinner flooring. This brought the total saving to \$37.

Installing ceramic floor tile with an adhesive rather than on a mortar base saved about \$5 in labour and materials primarily due to the fact that the subfloor did not have to be installed below the tops of the floor joists. One disadvantage with the adhesive application is that the adhesive should be allowed to set before the joints are filled. The tile setter therefore must make two trips instead of one to complete the floor.

Reducing the cold air return inlets from four (in house No. 1) to one, and heating the basement with registers installed directly on the main duct rather than by branch ducts should have led to a saving of \$28 in labour and materials. This saving, however, was not realized, due mostly to extra labour. A new apprentice was employed during this operation and this had an important effect on the increased labour content.

Eliminating the discharge pipe on the hot water tank, pressure relief valve saved approximately \$1 in materials. Changing from copper to plastic for the waste and vent piping above the basement floor led to materials savings of about \$4 in terms of 1965 prices, but in terms of 1966 prices the plastic cost about \$21 less. Increased labour all but eliminated the saving, however. The increased labour was due largely to the plumber's inexperience in the use of plastic. Since this study, the installation time is reported to have significantly decreased.

Building the fireplace and chimney with the minimum required masonry around each flue and reducing the height by 8 in. to the minimum permitted height plus other minor changes should have led to savings in material of \$42 and a saving in labour of \$22, a total of \$64. This saving was not realized in practice. In the second house the proportion of concrete block used as back-up was less than in the first house and a considerable amount of face brick was used as back-up brick. In addition, the labour content was considerably higher even though there were substantially fewer masonry units used.

One large cost increase in house No. 2 was in painting; this required \$28 additional material and \$119 extra labour. A change in the type of windows and cabinets was responsible for a substantial part of this. The additional time required to paint the wood window sash accounts for a large part of the extra labour costs. In addition, wooden window and exterior door trim was used in the second house, whereas metal corner bead was used in the first house. The interiors of kitchen cabinets and bathroom vanity had to be painted on the site, whereas in house No. 1 they were factory painted. Increased idle time was also an important factor, accounting for about \$44 of the increased cost. The use of unsanded plywood for the carport ceiling and storage shed is thought to account for some of the increase in paint used in the exterior painting.

Unit Costs

Unit costs have been calculated for various operations listed in Table I. A list of these unit costs is included in the Supplement to this paper.

The total cost for the basements, including footings, foundation walls, floor slab, drainage tile, dampproofing and earth moving was only \$0.12 per cu ft of basement or \$0.85 per sq ft of floor area (based on exterior foundation dimensions). The cost of the entire superstructure, exclusive of services, earth moving, site improvement, carport and fireplace averaged \$0.59 per cu ft (excluding attic volume), or almost \$4.72 per sq ft of floor area. This superstructure cost represented about 60 per cent of the entire on-site cost. The cost per square foot of window was over four times that of aluminum-clad walls in the first house and three times that in the second house. This was due mostly to the difference in cost of the windows used in the two houses. *

The total cost of the basement, the first floor, the exterior walls and the roof-ceiling construction

were approximately the same, each about 10 per cent of the total on-site costs.

Work Sequence

As can be seen in Figure 22, there are a great many stops and starts involved in completing the operations necessary to build a house. It was not practicable, unfortunately, to provide a more detailed breakdown of the major groups of operations, since this is difficult to show on a chart of this size. Even when broken down into more detail, however, the construction process follows this same general pattern. In order to complete any one major operation, a number of stops and starts are necessary, making it most difficult to schedule trades to provide the most rapid construction sequence.

In installing the gypsum wallboard, for example, at least nine separate visits to the house are required by the tradesmen. On the first visit, the house is measured, on the second, the wallboard is delivered, and then it must be nailed in place, given three separate joint treatments, the ceiling spray coat applied, joints sanded, and given one or sometimes two touch-up treatments. As one trade may interfere with another, the problem of efficient subtrade organization can be readily appreciated.

CONCLUDING REMARKS

This project was to a large extent a pilot study and constituted the first venture by the Division into this field of research. It has provided an opportunity to develop a work study team and has revealed a number of areas that deserve further investigation. Job organization and materials handling methods, for example, are two important aspects that were not specifically studied in this project and they are thought to be worthy of separate investigations.

This study has determined the labour and materials content of a wide variety of operations in a typical house. It has shown that the over-all on-site cost in the first house was 24 per cent labour and 74 per cent materials. This would appear to indicate that savings in material seem to offer the greatest potential for cost savings. The fact that house No. 2 cost almost \$200 more than the first house, however, even though the total cost of materials was over \$400 less, shows that efficiency of labour should not be ignored.

The study showed that for this builder's operations the potential savings from individual changes were relatively small, but when all these changes were totaled, the potential savings were significant.

The changes incorporated in house No. 2 should have resulted in a saving amounting to approximately 4 per cent of the on-site cost. They did not significantly affect appearance of quality, and conformed to the requirements in Residential Standards. Although a significant saving, a 4 per cent reduction is not by any means spectacular and it probably indicates that the wood-frame construction practice in this builder's operation was basically efficient. It is also true, however, that this study did not concern itself with a study of job organization, materials handling techniques, and methods analysis and that it is quite conceivable that further savings could be achieved through refinements in these areas.

The fact that the total on-site building cost in house No. 1 represents less than 60 per cent of the final selling price leads one to speculate whether the items responsible for the remainder of the cost might not be a useful area for some future study.

As a concluding statement it must be emphasized that the results described in this paper apply to only two houses and to the operation of only one builder.

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- ¹² Residential Standards, Canada 1965. Supplement No. 5, National Building Code (NRC 8251).

TABLE I. SUMMARY OF TOTAL COST

Operation	Material		Labour		Total Cost	
	House No. 1	House No. 2	House No. 1	House No. 2	House No. 1	House No. 2
1. Stake out lot	—	—	3.97	6.83	3.97	6.83
2. Excavation	—	—	63.23 ⁽¹⁾	115.12 ⁽²⁾	63.23	115.12
3. Backfill	—	—	28.90 ⁽³⁾	21.45 ⁽⁴⁾	28.90	21.45
4. Dirt fill and rough grade	—	—	75.75 ⁽⁵⁾	23.72 ⁽⁶⁾	75.75	23.72
5. Top soil and grade	—	—	53.62 ⁽⁷⁾	98.68 ⁽⁸⁾	53.62	98.68
6. Lay sod, final grading	56.07	77.61	43.23	70.06	99.30	147.67
7. Lay walkways	23.16	22.60	5.66	19.48	28.82	42.08
8. Driveway	86.29	93.41	25.34 ⁽⁹⁾	61.02	111.63	154.43
9. Exterior steps	83.25	76.13	5.02	11.03	88.27	87.18
10. Stake out footings	—	—	4.26	4.32	4.26	4.32
11. Form, strip and place footings	58.08	68.18	24.90	36.81	82.98	104.99
12. Erect foundation wall forms	17.99	15.20	58.68	53.55	76.67	68.75
13. Place foundation wall	381.72	371.02	26.83	36.52	408.55	407.54
14. Strip foundation wall forms	—	—	36.63	29.63	36.63	29.63
15. Install drainage tile	32.45	29.91	20.13	20.94	52.58	50.85
16. Parge tie rod holes and dampproof walls	18.20	18.44	9.16	6.30	27.36	24.74
17. Carport piers and columns	16.67	18.42	13.18	17.38	29.85	35.80
18. Parge foundation wall (top)	2.96	2.28	26.95	27.07	29.91	29.35
19. Basement slab fill or dampproofing	46.87	19.08	48.83	14.23	95.70	33.31
20. Place and finish basement floor slab	142.70	176.95	55.82	54.89	198.52	231.84
21. Basement beam	56.76	56.87	6.18	7.88	62.94	64.75
22. Sill plates	9.84	8.55	17.56	10.97	27.40	19.52
23. Basement columns	27.40	21.65	2.57	2.28	29.97	23.93
24. Floor framing and strapping	197.04	182.84	31.15	51.69	228.19	234.53
25. Subfloor	151.32	150.65	15.35	20.24	166.67	170.89
26. Frame exterior walls	123.59	97.92	37.33	56.17	160.92	182.91
27. Frame storage shed and carport beams	29.98	28.50	10.86	21.35	40.84	49.85
28. Sheath exterior walls and gable	59.36	46.57	21.75	23.80	81.11	70.37
29. Frame and erect partitions	120.54	104.10	37.10	45.21	157.64	149.31
30. Roof and ceiling framing	356.02	333.08	36.40	37.92	392.42	371.00
31. Sheath roof	199.11	199.84	32.99	27.77	222.11	227.61
32. Miscellaneous rough carpentry	—	—	13.07	10.38	13.07	10.38
33. Shingles and eave protection	176.46	171.95	41.94	34.94	218.40	206.89
34. Flash chimney saddle	20.30	22.94	16.33	15.63	36.63	38.58
35. Insulation	132.60	143.05	40.60	60.14	173.20	203.19
36. Window frames, sliding sash and fixed glazing	582.55	432.98	39.55	44.27	622.10	477.25
37. Front and rear doors, and frames (including carport and storm door)	175.06	171.85	29.46	30.79	204.51	202.64
38. Plumbing (including service to house)	505.43	499.43	54.83	107.67	560.26	608.11
39. Electrical	413.16	416.62	92.52	110.71	505.68	527.33
40. Heating	391.30	379.63	62.88	94.09	454.18	473.72
41. Wallboard and corner bead application	276.35	265.90	93.98	74.32	370.33	340.22
42. Joint taping and finishing (including sanding and touchup and ceiling spray coat)	41.66	48.56	165.13	139.89	206.79	188.45
43. Bathroom wall tile	55.37	55.95	14.94	15.34	70.42	71.29
44. Kitchen cabinets, vanity, mirror and wall fixtures	688.27	576.22	42.24	57.52	730.51	633.74
45. Interior doors, frames and door trim	271.19	271.68	66.32	61.43	337.51	333.11
46. Base trim	27.83	27.96	29.75	27.53	57.58	55.49
47. Basement stairs and handrail	28.96	15.54	14.29	17.44	43.25	32.98
48. Miscellaneous interior woodwork	40.12	52.62	29.59	39.21	69.71	91.83
49. Hardwood floors (lay, sand, varnish)	339.06	309.91	88.68	82.72	427.74	392.63
50. Resilient floors (including underlay and waxing)	64.81	54.85	22.98	26.31	87.79	81.16
51. Ceramic tile floor (including base)	18.33	19.86	15.87	15.05	34.20	34.91
52. Install brick veneer	167.62	173.07	81.84	128.74	249.46	301.81
53. Chimney and fireplace	358.21	339.90	194.41	219.10	552.62	559.00
54. Storage shed siding and battens, and carport ceiling and beam cover	118.01	68.69	40.02	58.79	158.03	127.48
55. Aluminum siding	294.65	295.88	98.93	83.59	393.58	379.47
56. Aluminum soffits and fascia	189.04	188.46	22.05	25.67	211.09	214.13
57. Miscellaneous exterior trim	3.98	5.80	9.80	13.47	13.78	19.27
58. Interior painting and varnishing (exc. floors)	56.52	78.63	189.40	254.87	245.92	333.50
59. Exterior painting	9.55	15.61	27.53	80.79	37.08	96.40
60. Cleanup	—	—	92.94	106.46	92.94	106.46
61. Corrections and repairs	10.19	17.37	77.35	178.29 ⁽¹⁰⁾	87.54	195.64
62. Major deliveries	—	—	12.38	24.33	12.38	24.33

NOTES (1) Includes \$51.73 in equipment rental.
(2) Includes \$96.80 in equipment rental.
(3) Includes \$28.90 in equipment rental.
(4) Includes \$21.45 in equipment rental.

(5) Includes \$75.75 in equipment rental.
(6) Includes \$23.19 in equipment rental.
(7) Includes \$44.34 in equipment rental.
(8) Includes \$60.47 in equipment rental.

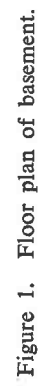
(9) Includes \$ 1.30 in equipment rental.
(10) Includes \$15.60 in equipment rental.

TABLE II
GENERAL SUMMARY OF TOTAL COST

Operations	Material		Labour		Total cost	
	House No. 1	House No. 2	House No. 1	House No. 2	House No. 1	House No. 2
1. Earthwork—site improvement	248.77	269.77	304.72 ⁽¹⁾	427.39 ⁽²⁾	553.49	697.16
2. Basement	717.64	719.48	325.37	301.64	1,043.01	1,021.12
3. Rough carpentry	1,330.97	1,230.57	252.31	315.67	1,583.28	1,546.24
4. Insulation—roofing—exterior	1,086.97	942.78	167.88	185.77	1,254.85	1,128.55
doors—windows	1,309.89	1,296.69	210.23	312.47	1,520.12	1,609.16
5. Services—electrical, plumbing, heating	373.49	370.41	274.05	229.55	647.54	599.96
6. Gypsum drywall, wall tile						
7. Interior finish carpentry	1,056.37	944.02	182.19	203.13	1,238.56	1,147.15
8. Finish flooring	422.20	384.62	127.52	124.08	549.72	508.70
9. Exterior finish and fireplace	1,131.51	1,071.82	447.05	529.36	1,578.56	1,601.18
10. Painting	66.07	94.24	216.93	335.66	283.00	429.90
11. Miscellaneous operations	10.19	17.35	182.67	309.08 ⁽³⁾	192.86	326.43
GRAND TOTALS	7,754.07 ⁽⁶⁾	7,339.83 ⁽⁶⁾	2,690.92 ⁽⁴⁾	3,273.80 ⁽⁵⁾	10,444.99	10,613.63

NOTES (1) Includes \$202.02 in equipment rental.
(2) Includes \$201.91 in equipment rental.
(3) Includes \$ 15.60 in equipment rental.

(4) Includes \$202.02 in equipment rental.
(5) Includes \$217.51 in equipment rental.
(6) Material costs do not include allowance for waste or scrap.



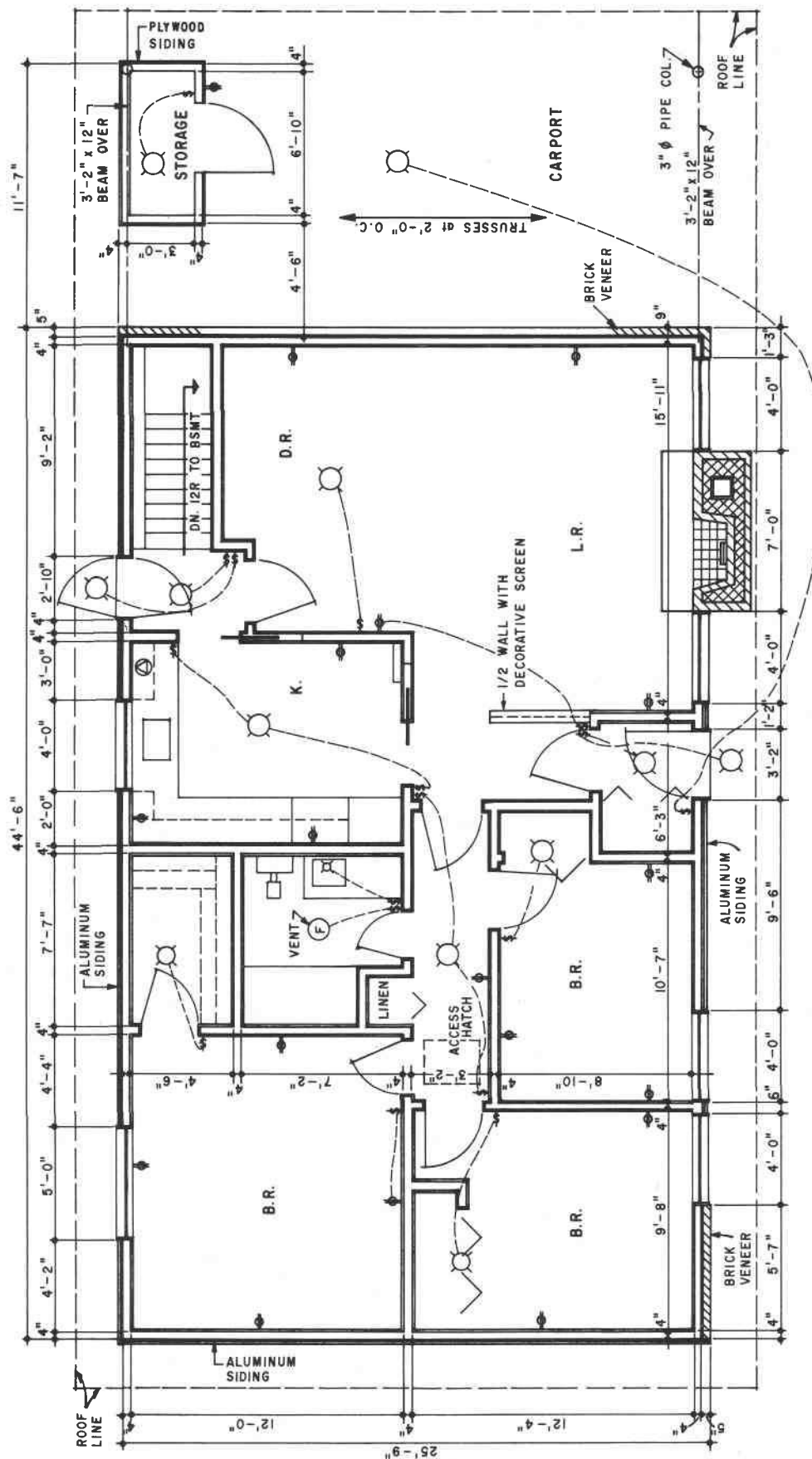


Figure 2. Floor plan of first floor.

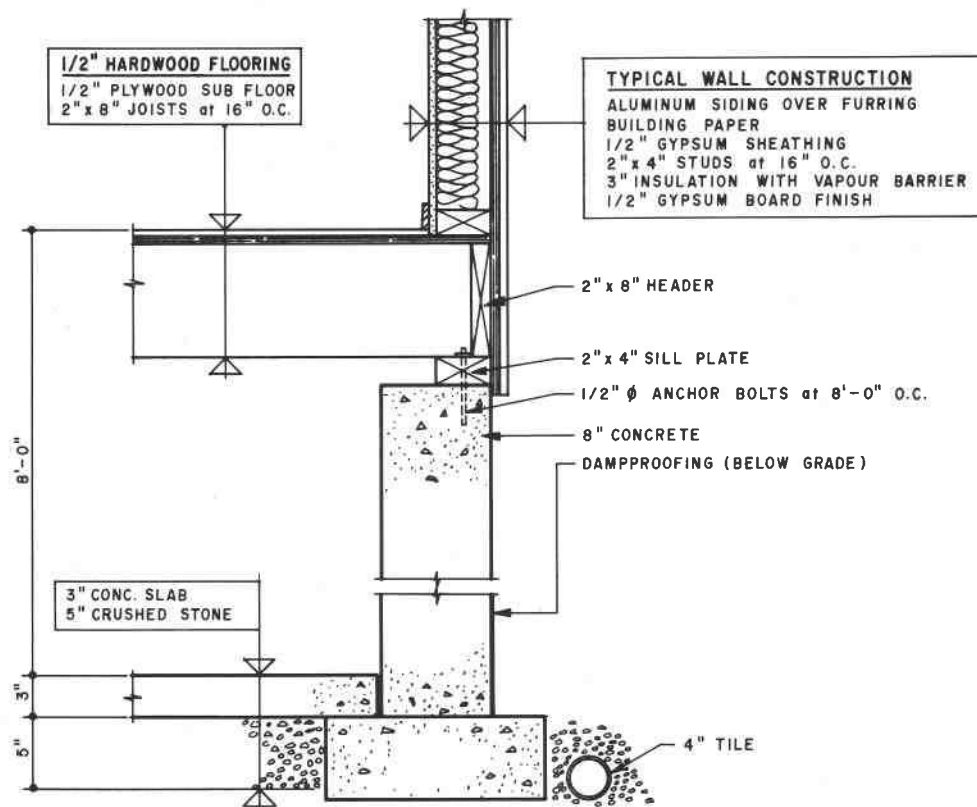


Figure 3. Typical wall detail of house No. 1.

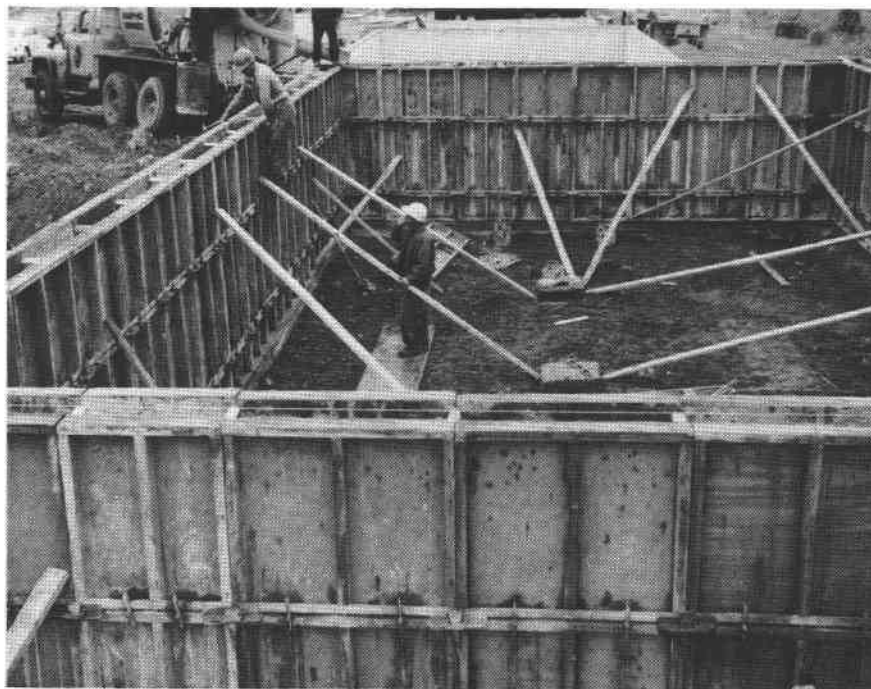


Figure 4. Placing concrete foundation walls (house No. 1).



Figure 5. Delivery of framing and sheathing materials (house No. 1).

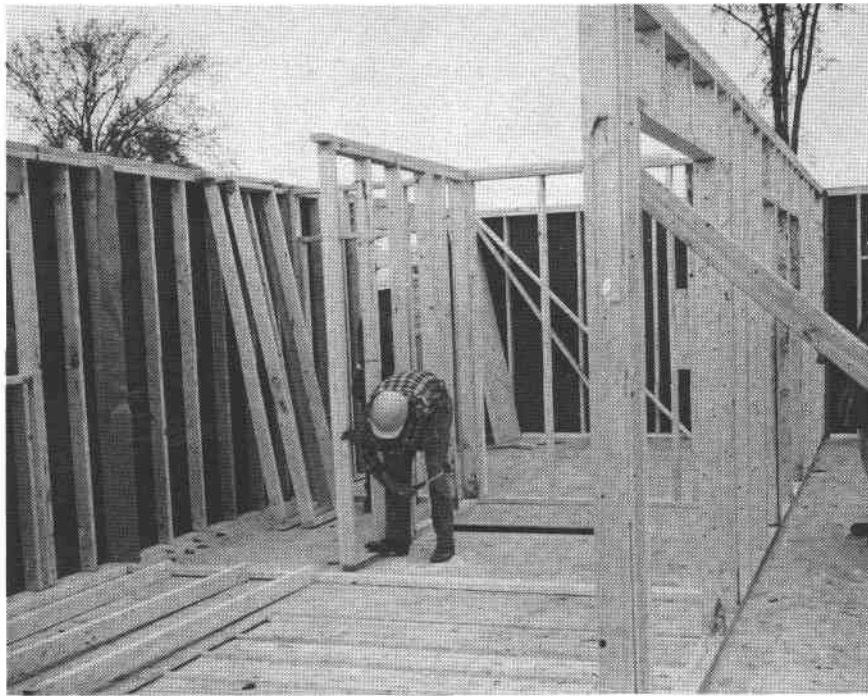


Figure 6. Wall framing (house No. 1).



Figure 7. Roof framing (house No. 1).



Figure 8. House No. 1—completed.

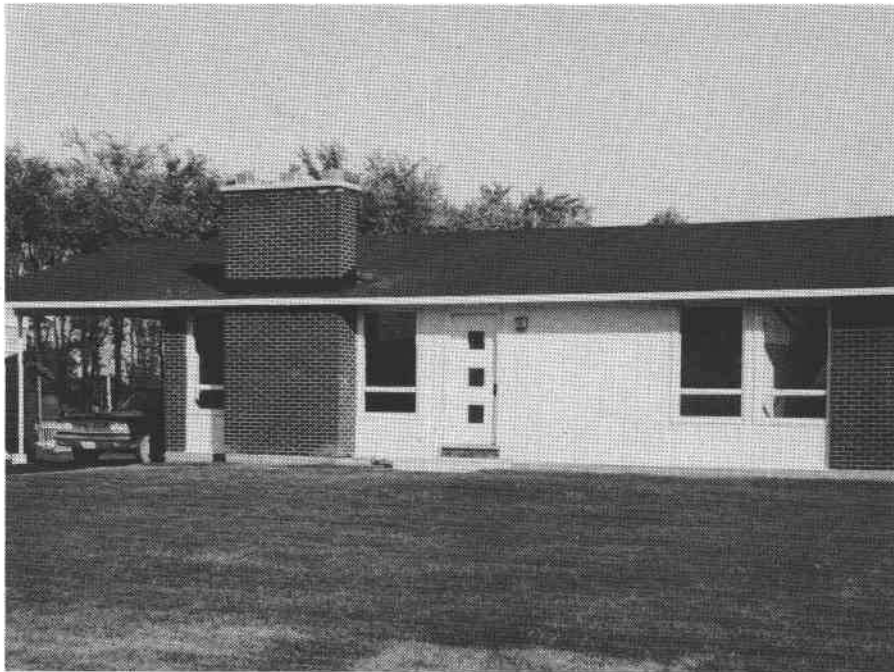


Figure 9. House No. 2—completed.

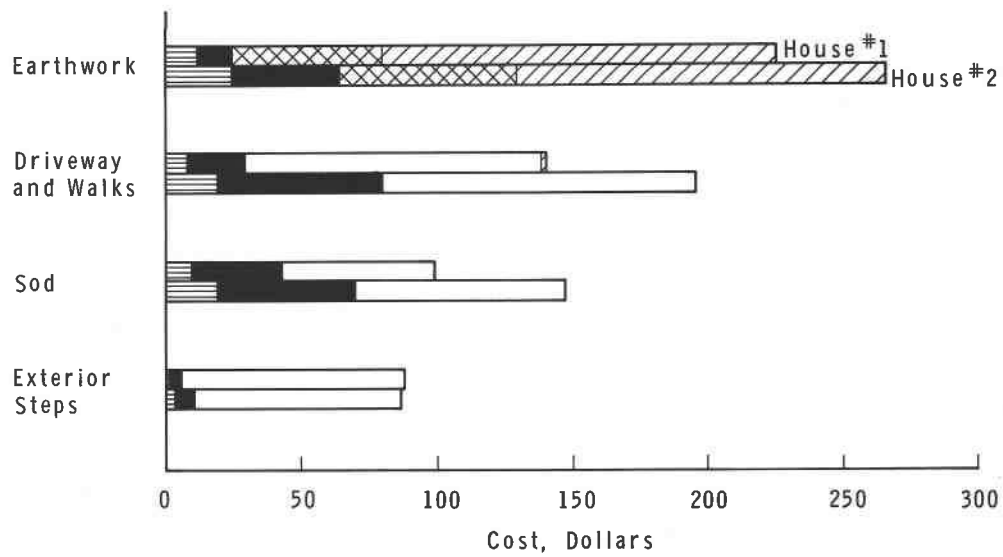


Figure 10. Earthwork and site improvement costs

House No.	Cost	% total cost	% labour	% materials	% equipment rental
1	\$553.	5.2	18.6	44.9	36.5
2	\$697.	6.5	32.3	38.7	29.0

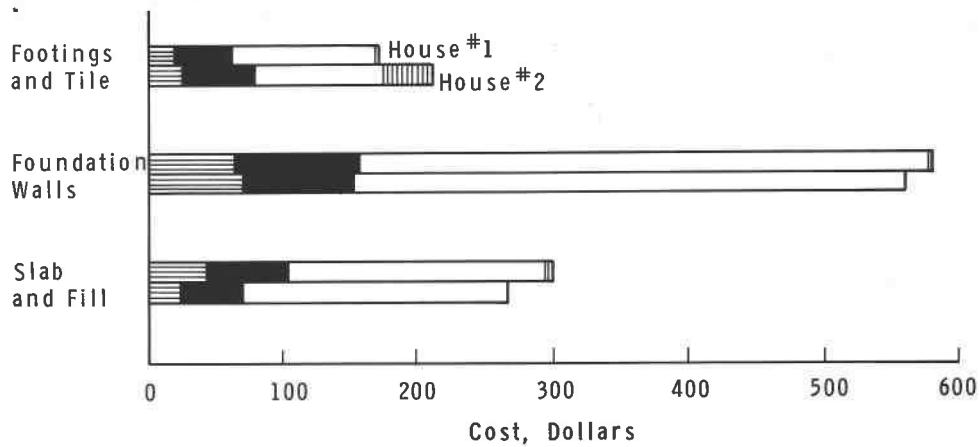


Figure 11. Basement costs

House No.	Cost	% total cost	% labour	% materials
1	\$1051.	9.9	31.2	68.8
2	\$1035.	9.6	29.5	70.5



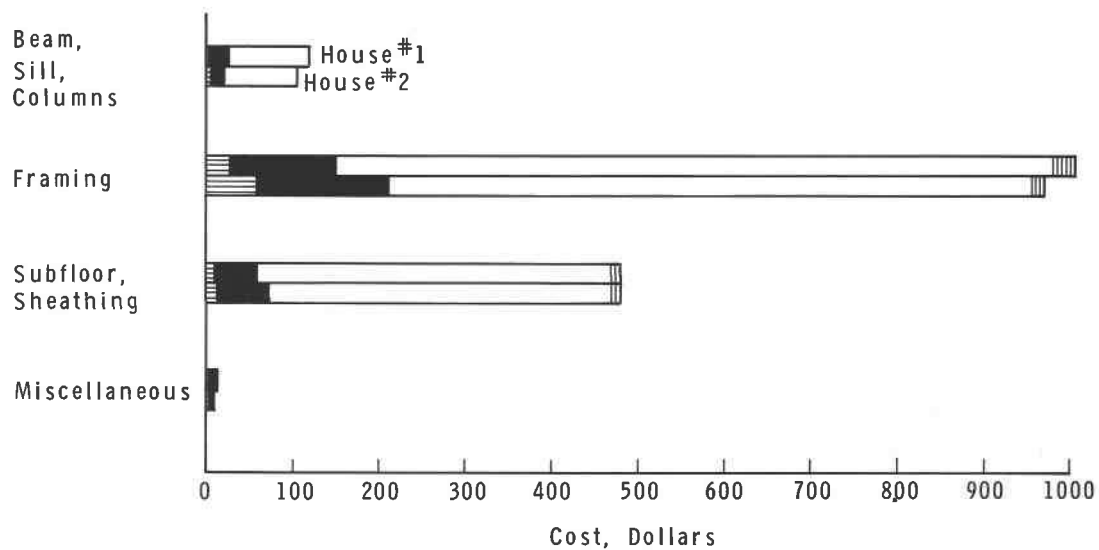


Figure 12. Rough carpentry costs

House No.	Cost	% total cost	% labour	% materials
1	\$1619.	15.3	15.9	84.1
2	\$1569.	14.6	20.4	79.6

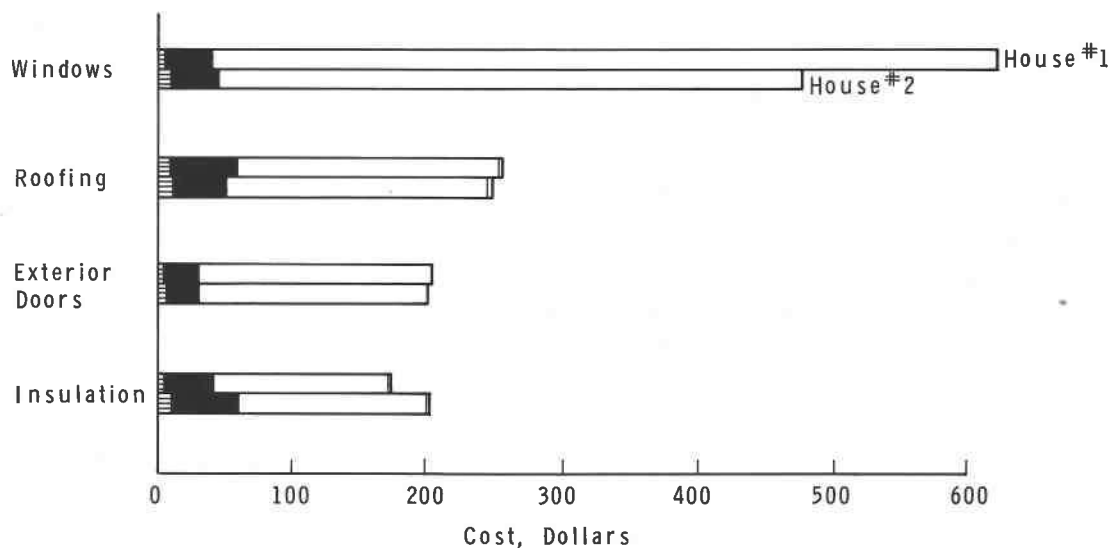


Figure 13. Roofing, insulation, exterior doors, windows costs

House No.	Cost	% total cost	% labour	% materials
1	\$1256.	11.9	13.4	86.6
2	\$1131.	10.5	16.5	83.5

■ Labour □ Materials
 ▨ Men Idle ▤ Waste or Scrap

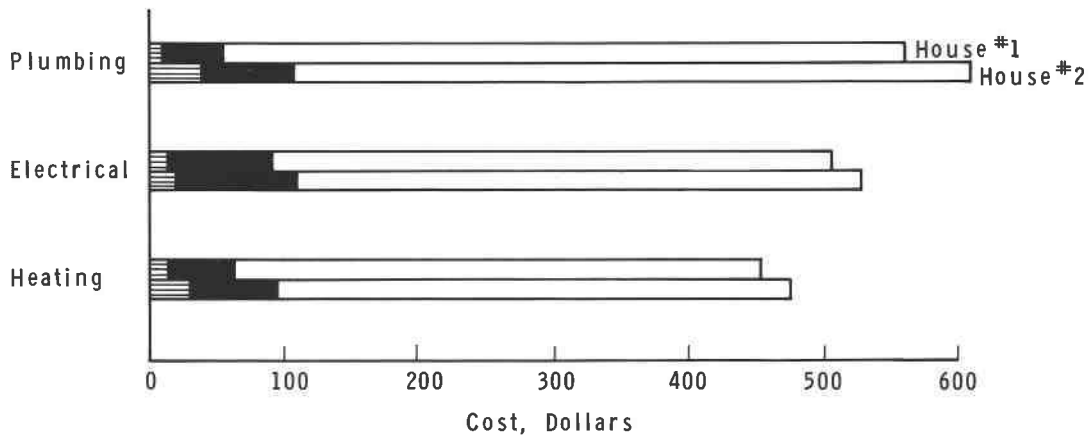


Figure 14. Services costs

House No.	Cost	% total cost	% labour	% materials
1	\$1520.	14.4	13.8	86.2
2	\$1609.	14.9	19.4	80.6

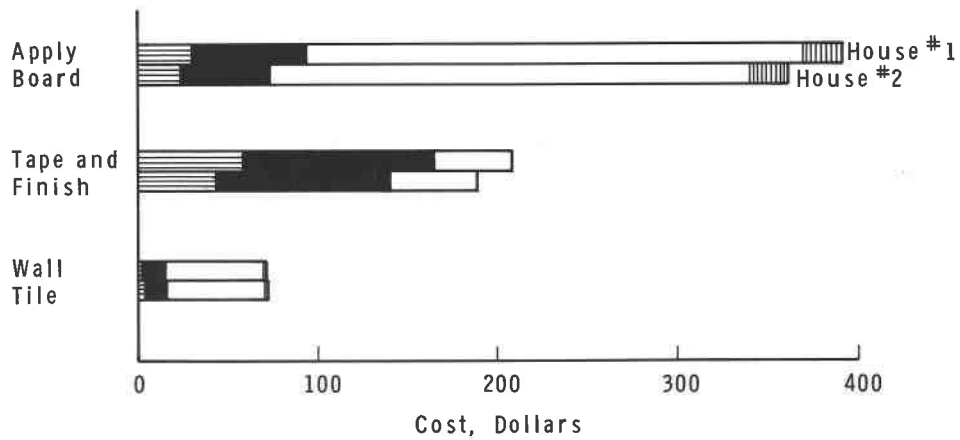


Figure 15. Wallboard and tile costs

House No.	Cost	% total cost	% labour	% materials
1	\$669.	6.3	42.3	57.7
2	\$621.	5.8	38.3	61.7

■ Labour
 ■ Men Idle
 □ Materials
 ▨ Waste or Scrap

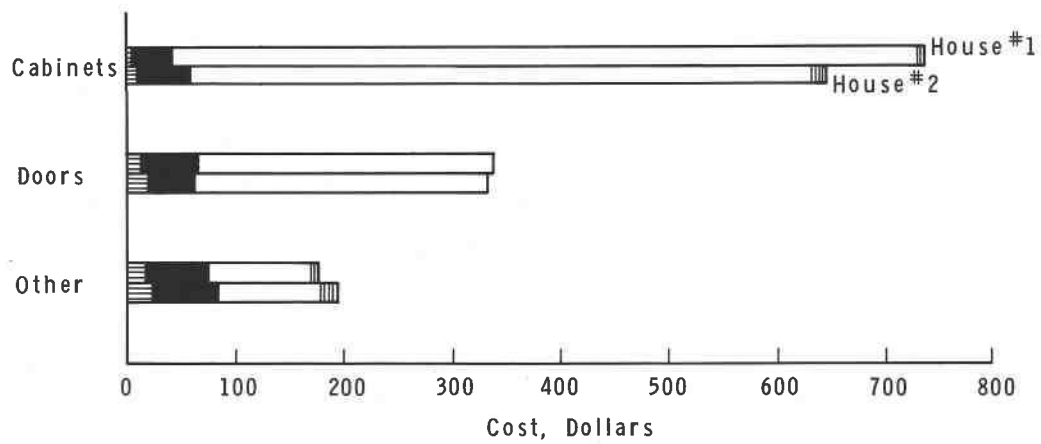


Figure 16. Interior finish carpentry costs

House No.	Cost	% total cost	% labour	% materials
1	\$1251.	11.8	14.7	85.3
2	\$1174.	10.9	17.7	82.3

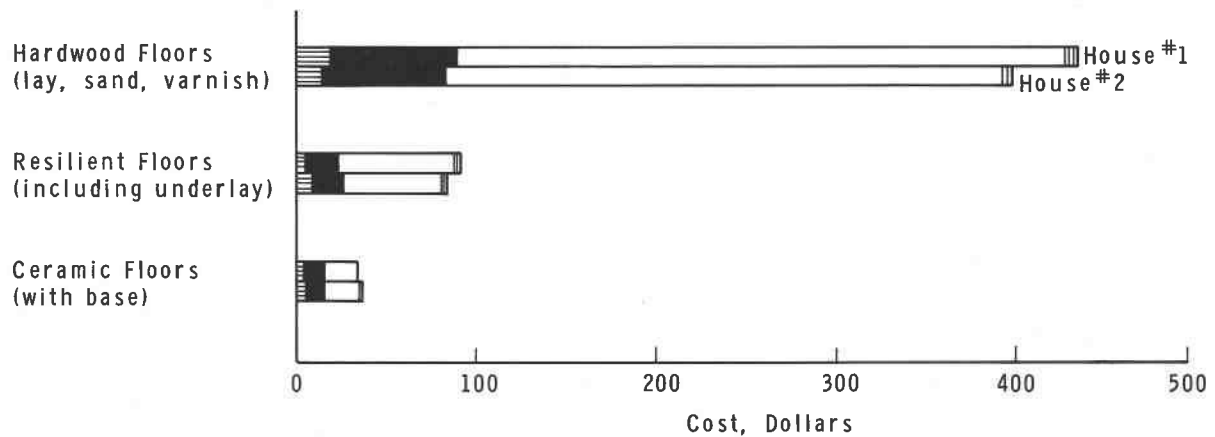


Figure 17. Finish flooring costs

House No.	Cost	% total cost	% labour	% materials
1	\$559.	5.3	23.2	76.8
2	\$518.	4.8	24.4	75.6

■ Labour
 ▨ Men Idle
 □ Materials
 ▤ Waste or Scrap

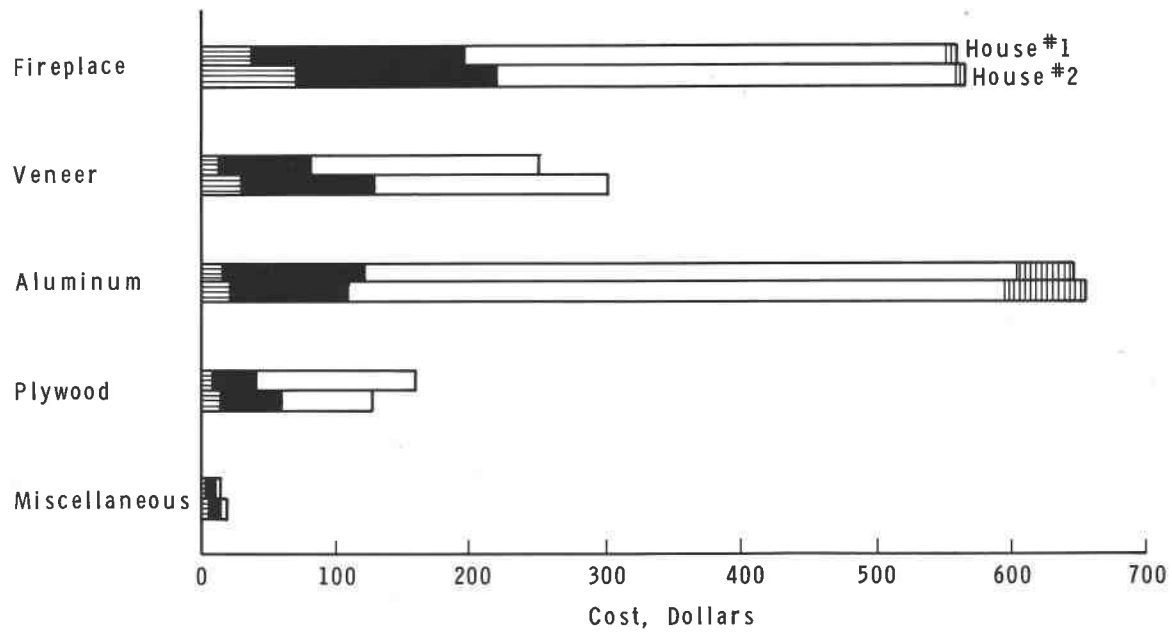


Figure 18. Exterior finish, fireplace costs

House No.	Cost	% total cost	% labour	% materials
1	\$1627.	15.4	28.3	71.7
2	\$1667.	15.5	33.1	66.9

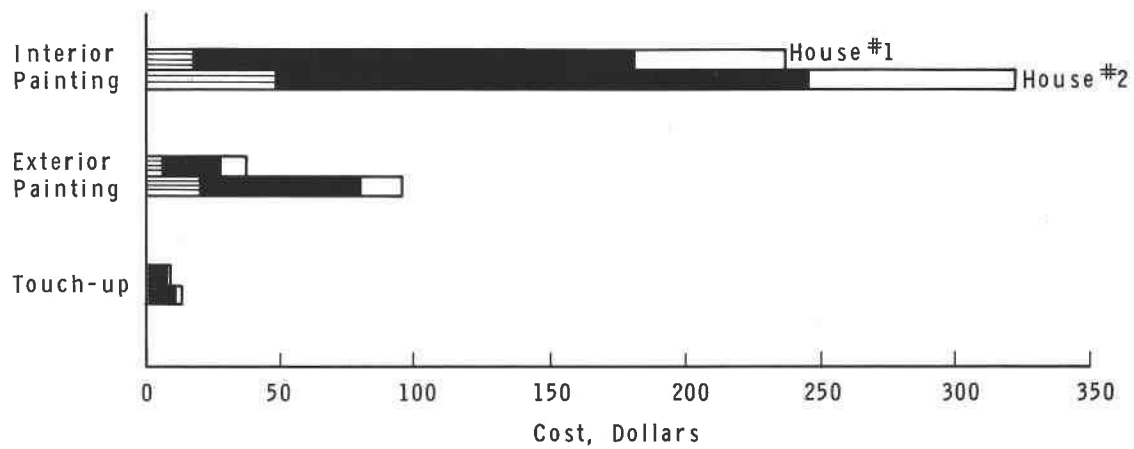


Figure 19. Painting costs

House No.	Cost	% total cost	% labour	% materials
1	\$283.	2.7	76.7	23.3
2	\$430.	4.0	78.1	21.9

■ Labour
 ■ Materials
 ▨ Men Idle
 ▩ Waste or Scrap

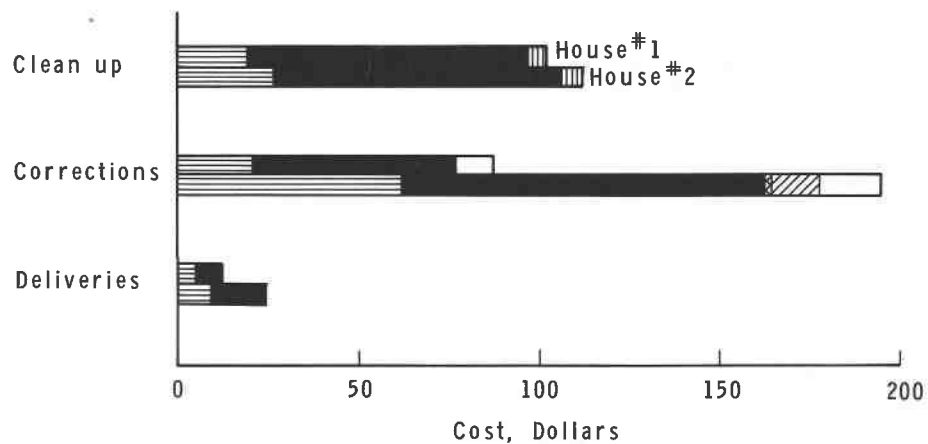


Figure 20. Miscellaneous operations costs

House No.	Cost	% total cost	% labour	% materials	% equipment rental
1	\$198.	1.9	94.7	5.3	—
2	\$332.	3.1	89.9	5.3	4.8

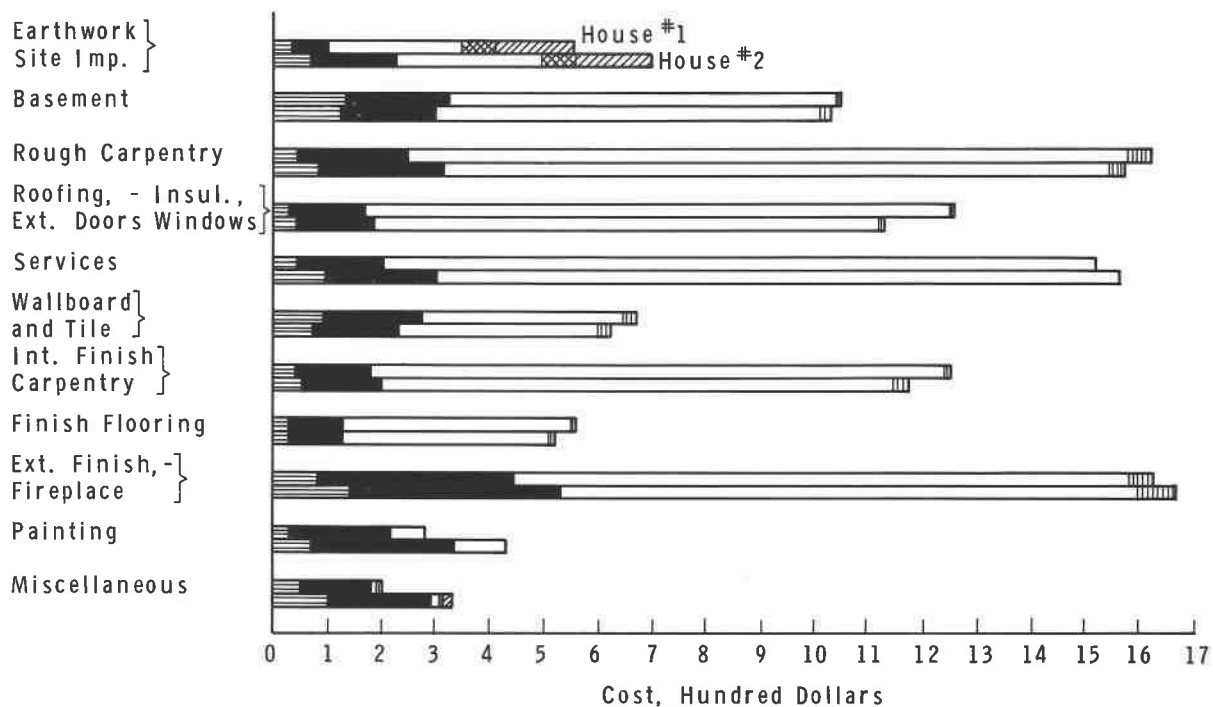


Figure 21. General summary of total costs

House No.	Cost	% labour	% materials	% equipment rental
1	\$10,585.	23.5	74.6	1.9
2	\$10,781.	28.3	69.6	2.1



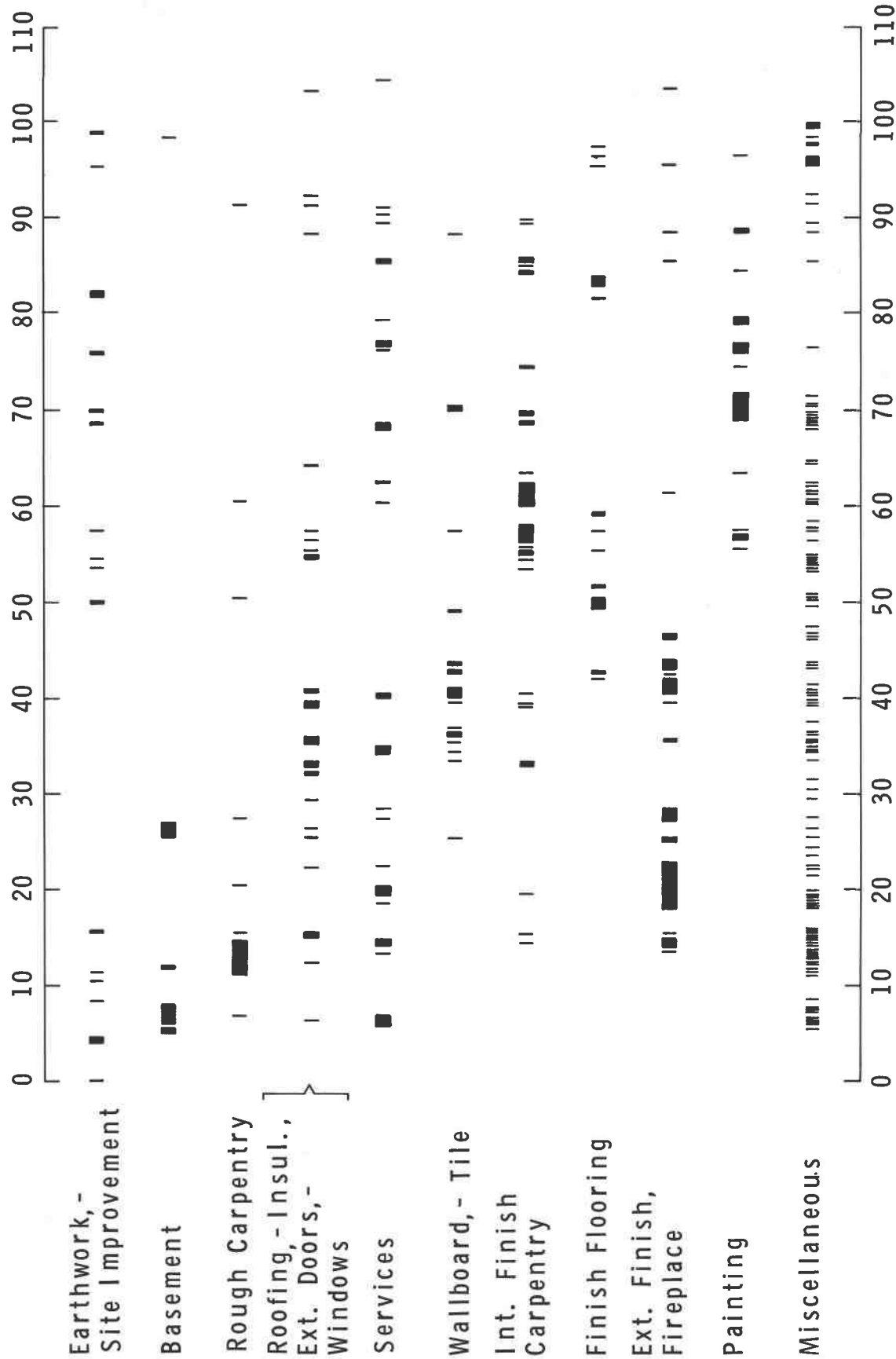


Figure 22. Activity chart for construction of house No. 2.

APPENDIX A

LIST OF CHANGES INCORPORATED IN HOUSE NO. 2

- (i) *Basement Slab*

Six-mil polyethylene film was used beneath the basement slab instead of crushed rock (Figure A-1).
- (ii) *Footings*

Formwork for the footings was eliminated. Because the crushed stone fill was eliminated, the footing trenches had to be dug by hand after the main excavation. The soil was the type that held its shape, so the footings could be directly placed in the trenches without the use of forms (Figure A-1).
- (iii) *Sill Plate*

Instead of bedding the sill plate on top of the wall after the formwork was removed, the sill plate was set on edge and nailed inside the wall forms complete with anchor bolts before the foundation wall was placed (Figure A-2).
- (iv) *Header Joists*

Header joists at the front and rear of the house were reduced from 2 in. by 8 in. to 1 in. by 8 in. (Figure A-2).
- (v) *Basement Beam Location*

In house No. 1 the basement beam was directly in the centre of the house. This made the joist length such that over a foot had to be cut off each joist. By relocating the beam a few inches to one side, it was possible to use 12-ft joists on one side and 14-ft joists on the other. This eliminated the waste.
- (vi) *Joist Layout*

The joist layout was replanned to eliminate unnecessary joists.
- (vii) *Stud Spacing*

Stud spacing on the exterior walls was increased from 16 in. o.c. to 24 in. o.c. Stud spacing in the partition walls was 24 in. o.c. in both houses.
- (viii) *Top Plates*

Single top plates were used for all non-load-bearing walls and partitions. As roof trusses were used, the two end walls and all the partiitons were considered as non-load-bearing.
- (ix) *Framing Around Partition Openings*

Cripples were eliminated over the tops of most of the openings in the partitions. Single rather than double studs were used at the sides of these openings wherever possible (Figure A-3).
- (x) *Wall Intersections*

Wall and partition intersections and corners were framed with three rather than four members (Figure A-3).
- (xi) *Wall Sheathing*

Sheathing was omitted on the wall protected by the carport. This wall had a brick veneer surface so that the omission of sheathing in this case was acceptable under the Residential Standards.¹²
- (xii) *Ridge Blocking*

Ridge blocking was eliminated between the trusses and metal H clips were used instead to support the butting edges of the plywood roof sheathing (Figure A-4).
- (xiii) *Truss Stringers*

In house No. 1, several rows of 2 by 4 stringers were nailed to the bottom truss members to keep the lower chords aligned for wallboard and insulation application. These were eliminated in house No. 2 since the trusses were kept in alignment over most of the ceiling area by nailing the lower chords to the partitions at fairly frequent intervals. In those areas where the partitions did not keep the trusses in alignment, 1-in. by 4-in. strapping was used for alignment instead of 2 by 4's.
- (xiv) *Roofing*

Asphalt shingles were nailed with 4 rather than 6 nails per shingle.
- (xv) *Plywood*

5/16-in. select sheathing-grade plywood was substituted for 3/8-in. sanded plywood for the carport ceiling and carport storage shed.
- (xvi) *Access Hatch*

Location of the access hatch was changed from the hallway to the carport ceiling. This simplified the interior ceiling finish and eliminated the need for insulating the trap door and installing trim around it.
- (xvii) *Basement Stairs*

The material used in making the basement stairs was changed from No. 1 pine to No. 1 spruce.
- (xviii) *Underlay*

Underlay beneath resilient flooring was changed from 3/8-in. Douglas fir plywood to 1/4-in. poplar (Figure A-5).

(xix) *Hardwood Floors*

Finish flooring was reduced from ½-in.-thick oak to ¾-in.-thick oak (Figure A-5).

(xx) *Ceramic Tile Flooring*

In house No. 1 the ceramic floor tile was applied over a mortar base. In house No. 2 the tile was laid with adhesive directly to the plywood underlay.

(xxi) *Heating System*

In house No. 1 the basement was heated by three branch ducts running from the main duct towards the outside basement walls. In house No. 2 these branch ducts were eliminated and registers were installed directly on the main duct (Figure A-6). In addition, the number of cold-air return inlets was reduced from 4, to 1 large one.

(xxii) *Plumbing*

The waste and vent piping in house No. 2 was changed from copper to plastic. In addition, the pressure relief discharge pipe from the hot water tank, which directed the discharge to the floor, was deleted and the discharge outlet was directed instead against the basement wall.

(xxiii) *Chimney—Fireplace*

The flues in both houses were enclosed in a 7-ft-wide chimney. In house No. 1 the chimney was built as a solid unit. In the second house, the chimney was built with the minimum required masonry thickness around each flue, and the remainder left hollow (Figure A-7). The chimney in house No. 1 was found to be 8 in. higher than required and the second chimney was therefore reduced in height.

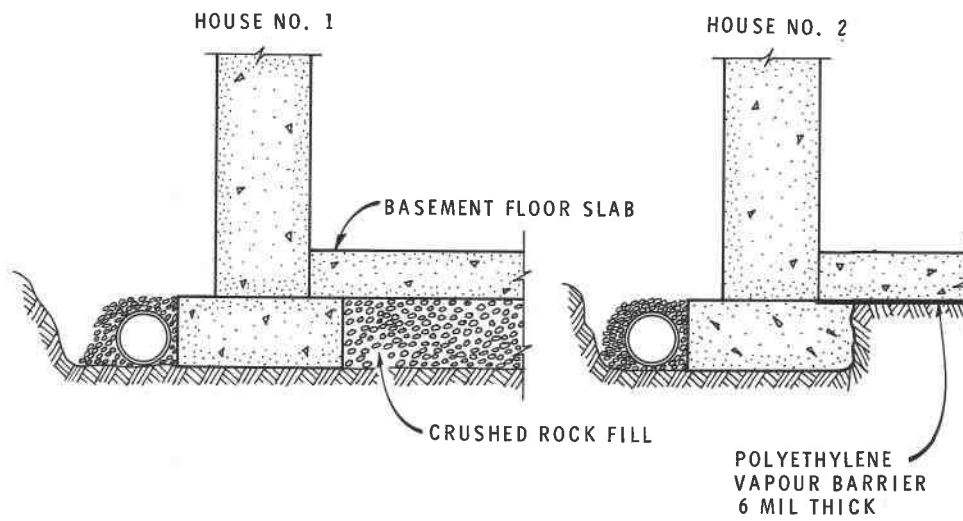


Figure A-1. Basement slab and footings.

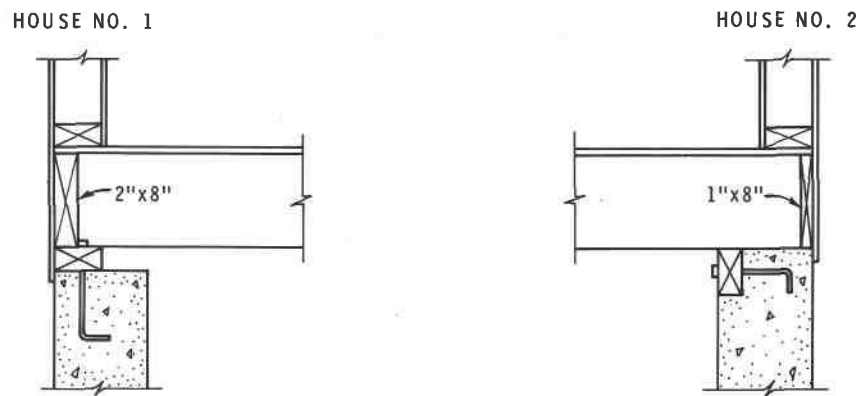


Figure A-2. Sill plate and floor framing.

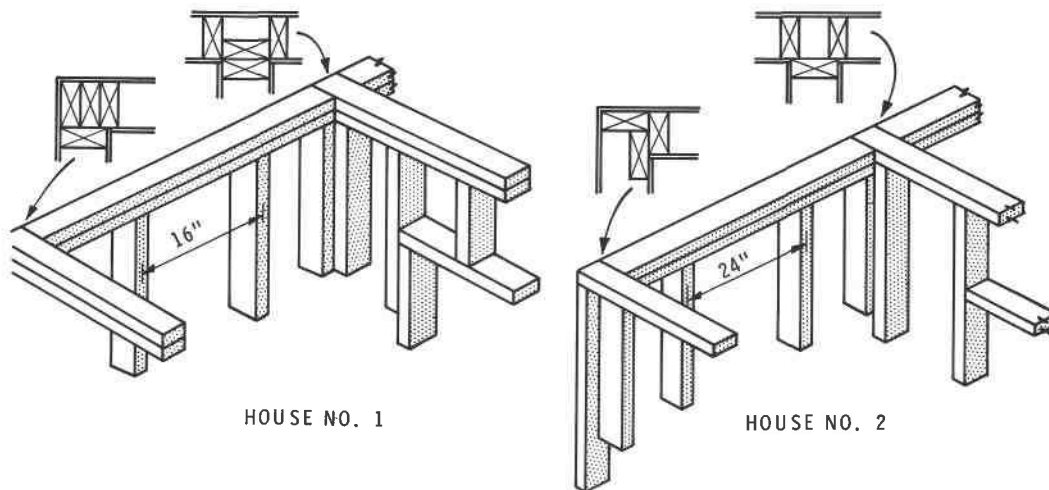


Figure A-3. Wall framing.

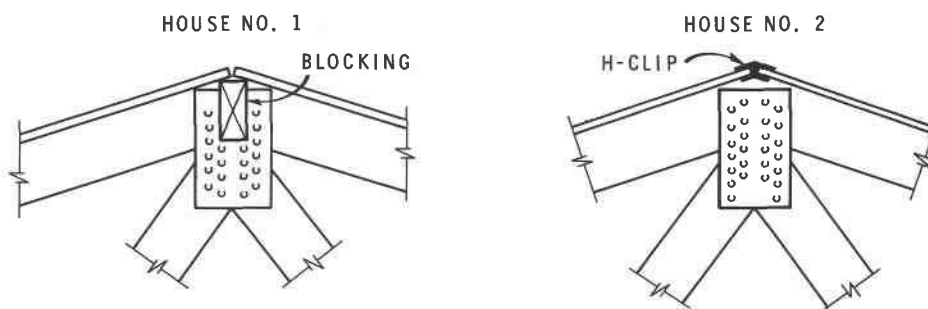


Figure A-4. Roof framing.

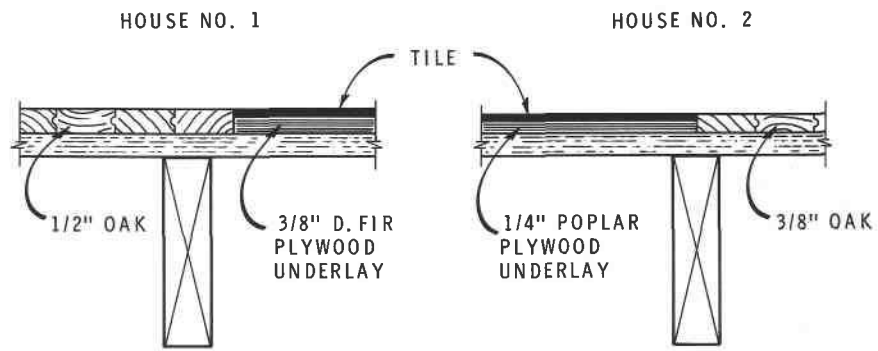


Figure A-5. Finish flooring.

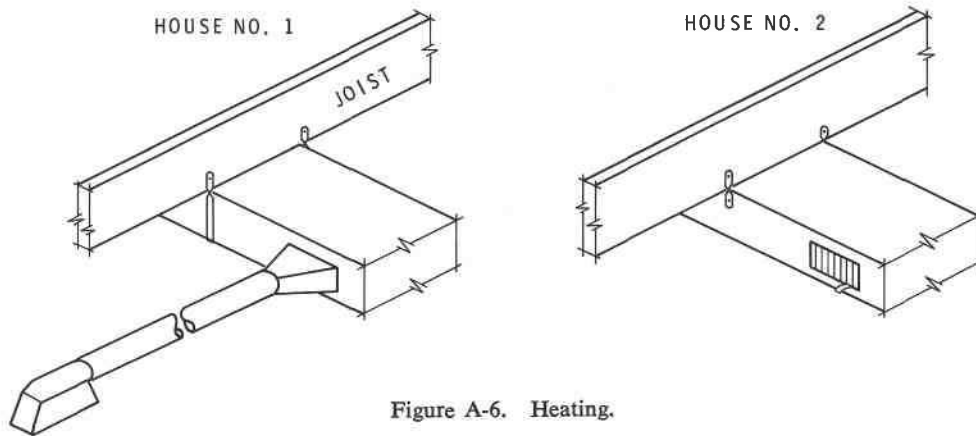


Figure A-6. Heating.

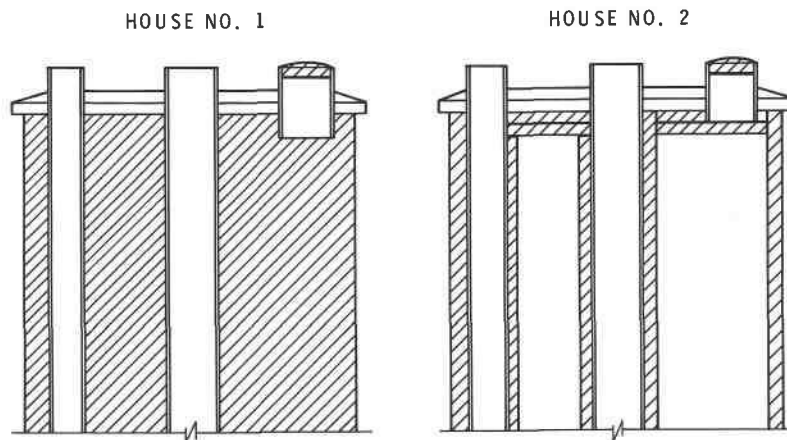


Figure A-7. Chimney.

NATIONAL RESEARCH COUNCIL OF CANADA
DIVISION OF BUILDING RESEARCH

SUPPLEMENT TO
"A COST STUDY OF TWO WOOD-FRAME BUNGALOWS"
(NRC 9590)

BY

A. T. HANSEN

35590



OTTAWA

JULY 1967

N.R.C. 9590 A

SUPPLEMENT TO
"A COST STUDY OF TWO WOOD-FRAME BUNGALOWS"
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by

A. T. Hansen

This paper has been prepared as a supplement to "A Cost Study of Two Wood-Frame Bungalows" (NRC 9590) and must be read in conjunction with that paper. It contains a number of tables that provide a detailed breakdown of the labour and material distribution in the two houses studied. Owing to the number and length of these tables, it was decided to publish this information separately for those who desire to have a more detailed summary of the records obtained in this project.

The project was carried out by the Division of Building Research, National Research Council of Canada, with the assistance of Central Mortgage and Housing Corporation and in cooperation with the National House Builders Association. With the agreement of the Research Committee of NHBA, this study formed part of their experimental house program as Mark V in the series. The program was undertaken through the cooperation and assistance of Connelly Developments Ltd. at their Glen Cairn Subdivision near Ottawa.

SCOPE

The immediate objective of this study was to determine the labour and material requirements for a typical wood-frame bungalow and to assess the savings in construction cost that could be achieved by taking advantage of the minimum requirements in Residential Standards, Canada, 1965, Supplement No. 5 of the National Building Code. This latter aspect of the study was limited to those changes that would not significantly alter the appearance of quality of the house.

The study was divided into two stages. The first stage consisted of an examination of a typical three-bedroom bungalow built in accordance with the builders' usual construction methods. Labour and materials observations were taken for all building operations - from the stake-out to the final

clean-up. This house was built during the latter part of 1965. The results were analysed, and on the basis of this analysis, in stage 2 of the study a number of changes in construction were incorporated in a second house built in the summer of 1966. Records were again taken of labour and materials for all phases of construction.

The study was confined to the on-site activity of the construction process. Items such as land cost, overhead, profit, finance charges, and mortgage insurance were not investigated.

PROCEDURE

The construction was analysed as various separate operations. All labour and materials connected with each operation were recorded to determine the total cost of each operation.

Labour activity was recorded for each worker at one-minute intervals throughout the entire job. Only on-site labour was recorded; no attempt was made to account for a workman's time after he had left the building site. The time spent by management personnel at the site who contributed no physical labour toward the construction of the house is not recorded in this Supplement. The time contributed by working foremen, however, is recorded.

In each operation, the worker's time was subdivided into activities such as sawing, nailing, measuring, carrying materials, and idle time.

For the purpose of this study, idle time was defined as the time during which a worker stopped building activity. Coffee breaks, awaiting or receiving instruction, or delays caused by other trades or the weather, are classed as idle time. No attempt was made to rate the effort of workmen to convert the "observed time" measurements to "standard time" equivalents.

In computing the cost of labour, a value of \$3.50 an hour was assumed. This was the average hourly rate of eight trades in the Ottawa area in 1965 with an allowance to cover costs such as contributions to holiday pay, workmen's compensation, unemployment insurance and other benefits. This average labour cost was used for all operations to simplify calculations.

The delivery of all material and the return of left-over material after the completion of each operation was recorded. In addition, the exact amount of material installed was recorded for each operation. From these observations, the values of waste or scrap were determined.

DESCRIPTION OF THE HOUSES

The houses studied were three-bedroom wood-frame bungalows of approximately 1150 square feet of floor area. The houses were completely site built with the exception of the roof trusses and cabinets. Only the studs were delivered precut. Each house had an attached carport, fire-place, and full basement. Brick veneer and aluminum siding were used on the exterior walls. Aluminum fascia and soffits were used at the eaves and rakes. The carport ceiling and storage shed were covered with plywood.

Gypsum wallboard was used as the interior finish with ceramic wall tile in the bathroom. Resilient flooring was used in the kitchens and foyers, ceramic tile in the bathroom, and hardwood strip flooring throughout the remainder of each house. Details of the first house are shown in Figures 1 to 3 in NRC Paper No. 9590. The first house was one of a number of similar houses built in the same development. It was in no way altered from the builder's usual construction.

The floor plan of house No. 2 is identical with that of the first house and the over-all appearance of the two houses is the same. A number of changes in construction details were introduced to improve efficiency in the use of materials and labour while still meeting the requirements of Residential Standards. In addition, because of a change in suppliers, some of the materials in house No. 2, such as windows and cabinets, are not identical to those used in house No. 1.

When the second house was built mortgage money was so scarce that it was the only house under construction in the development at the time. This had a considerable influence on the labour times observed as discussed in NRC 9590.

A description of the changes that were incorporated into house No. 2 to reduce costs are also presented in NRC 9590.

A detailed summary of labour observations are listed in Tables 1A to 11A for the various operations. All values are in terms of man-minutes.

The materials used are listed in Tables 1B to 11B. Table 1B lists the materials used in operations corresponding to the labour in Table 1A. Similarly Table 2B corresponds to Table 2A and so on.

These tables provide a breakdown of labour and materials for 62 separate operations and do not include allowances for waste and scrap.

A condensation of the results obtained from these tables are listed in Tables 1 and 11 in NRC 9590. The quantities of materials shown in Tables 1B to 11B are for the materials in place with no allowance made for waste or scrap. The breakdown of the construction into 62 operations made it practically impossible to determine the waste or scrap to be assigned to each operation. The waste or scrap from framing the exterior walls, for example, was partially used in the construction of the partitions. The quantities of waste or scrap are listed separately in Table 12 as percentage of material as well as in terms of cost.

Table 13 is a breakdown of most of the major items into costs per unit either in terms of unit area or other appropriate unit of measurement.

CONCLUDING NOTE

This Supplement was prepared to provide a more detailed breakdown of the information in NRC 9590. It must be read in conjunction with that report for a proper understanding of the information in the various tables and to appreciate the various qualifications that are more completely described in NRC 9590.

TABLE 1A
LABOUR FOR EARTHWORK AND SITE IMPROVEMENT (MAN MIN)
For House No. 1 with House No. 2 in brackets

Stake out	Measuring	Plumbing	Set up Instrument	Using Transit	Making Notes	Locating or Placing Pins	Misc.	Idle	Total
	5 (23)	3 (7)	4 (4)	7 (7)	2 (2)	9 (10)	14	24 (64)	68 (117)
Excavation (basement, sewer and water)	Machine Digging	Machine Emptying or Manoeuvring	Machine Idle	Total Machine Time	Hand Time Shovelling	Spotting Shovel	Miscellaneous	Idle	Total Man Time Excluding Machine Operation
	79 (140)	74 (59)	41 (164)	194 (363)	79 (173)	33 (4)	13 (1)	59 (98)	198 (314)
Backfill	Front End Loader Backfilling	Front End Loader Manoeuvring	Front End Loader Idle	Total Front End Loader Time					
	77 (83)	33 (3)	22 (13)	132 (99)					
Dirt Fill And Rough Grading	Front End Loader Working or Manoeuvring	Front End Loader Idle	Total Front End Loader Time	Truck operating on Site	Truck Away From Site	Truck Idle on Site	Spot Trucks	Men Idle	Total Man Time
	103 (27)	88 (14)	191 (41)	48 (31)	245 (55)	84 (15)	(3)	(6)	(9)
Top Soil and Grade	Front End Loader working or manoeuvring	Front End Loader Idle	Total Front End Loader Time	Truck operating on Site	Truck Idle on Site	Total Truck Time	Spot Trucks	Men Idle	Total Man Time Excluding Machine Operation
	105 (208)	1 (43)	106 (251)	91 (103)	92 (38)	183 (141)	51 (57)	108 (251)	159 (655)
Final Grading and Sodding	Rolling (pulled by tractor)	Tractor Idle	Total Tractor Time	Hand Shovel Rake or Wheel	Roll Sod by Hand	Carry Sod	Miscellaneous	Idle	Total Man Time
	17 (92)	2 (97)	19 (189)	195 (364)	(48)	156 (16)	12 (42)	168 (239)	722 (1012)
Laying Walkway	Carry or Lay Stone Slabs		Shovel or Rake Sand				Miscellaneous	Idle	Total
	38 (46)		26 (102)				3 (38)	30 (138)	97 (334)
Install Driveway	Front End Loader Spreading Gravel	Raking and Shovelling Stone or Gravel	Machine Rolling Stone or Gravel	Tamping	Shovel or Rake Asphalt	Rolling or Shovelling Sand Base	Machine Rolling Asphalt	Idle	Total
	6	74 (235)	17 (59)	76 (80)	80 (95)	(79)	23 (47)	110 (197)	421 (1046)
Install Steps (Exterior)	Driving Truck	Move Steps By Crane	Drill Foundation	Wedge and Bolt Steps in Place	Measure, Level and Plumb	Hand Excavation	Adjust and Position	Idle	Total
	6 (5)	9 (18)	13 (10)	14 (14)	11 (13)	4 (24)	9 (41)	14 (58)	86 (189)

TABLE 1B

MATERIAL FOR EARTHWORK AND SITE IMPROVEMENT

Operation	Material	Quantity in House No. 1	Place House No. 2
Excavation	Earth	221.0 cu yd removed	253.74 cu yd removed
Dirt fill and rough grade Top soil and finish grade	Top soil and fill obtained from builders site - no cost		
Final grading and sodding	Sod	267.0 sq yd	369.56 sq yd
Laying walkway	precast walks sand	16 0.4 cu yd	16 0.11 cu yd
Install driveway	asphalt concrete crushed base	7.5 tons 27.4 tons	7.0 tons 33.4 tons
Install exterior steps	precast rear step precast front step	1 1	1 1

TABLE 2A

LABOUR FOR BASEMENT (MAN MIN.)
For House No. 1 with House No. 2 in brackets

Stake out Footings	Mark or Measure	Move or Use Transit	Hold Rod	Place Markers			Miscellaneous	Idle	Total
	21 (16)	21 (25)	1 (8)	5 (2)			6 (2)	19 (21)	73 (74)
Form, Place and Strip Footings	Mark or Measure	Locate and Drive Stakes	Shovel Earth	Handling Forms and Accessories	Nailing	Wheel and Empty Concrete	Miscellaneous	Idle	Total
	11 (35)	47 (34)	47 (202)	34 (n/a) Install Ties, Clamp, and Re-inforcing	19 (n/a)	23 (17)	56 (28)	155 (274)	427 (631)
Erect Foundation Wall Forms	Mark or Measure	Carrying Material	Nailing		Erecting Forms	Plumbing, Levelling and aligning Spreaders	Miscellaneous	Idle	Total
	30 (11)	184 (204)	40 (32)	168 (127)	39 (45)	48 (59)	62 (56)	368 (329)	1006 (918)
Place Foundation Walls	Guide or Hold Chute	Shovel Concrete	Rodding or Hammering	Spot Trucks	Trowel Top of Concrete	Set Anchor Bolts	Miscellaneous	Idle	Total
	40 (26)	47 (59)	13 (11)	12 (3)	29 (17)	5 (n/a)	24 (27)	290 (483)	460 (626)
Strip Foundation Walls	Remove Clamps and Ties	Loosening Forms	Carry Clamps and Ties	Carry Forms and Braces	Remove Flue & Cleanout Forms	Remove Braces	Miscellaneous	Idle	Total
	111 (76)	24 (45)	66 (55)	109 (127)	25 (4)	15 (12)	40 (16)	238 (158)	628 (508)
Install Drain Tile	Install Crushed Stone	Carry Tile	Lay Tile	Cover Joints	Cut cover Strips	Hand Excavation	Miscellaneous	Idle	Total
	120 (95)	29 (19)	26 (61)	22 (28)	3	(76)	19 (11)	126 (69)	345 (359)
Parge Tie Holes and Dampproof Foundation Wall	Mix Mortar	Parge	Chip Concrete	Move Hose	Spray Dampproofing	Apply Mastic to Joints	Miscellaneous	Idle	Total
	9 (10)	38 (40)	17 (12)	8 (5)	17 (15)	13 (n/a)	14 (2)	41 (24)	157 (108)
Carport Piers and Columns	Dig and Backfill (hand)	Plumb and Measure	Move Scaffolding or Ladder	Nailing	Shovel Concrete	Push Wheel-Barrow	Miscellaneous	Idle	Total
	59 (98)	7 (26)	7	5 (1)	12 (13)	5 (4)	21 (79)	73 (58)	226 (298)
Parge Foundation Wall (top)	Carry Mortar	Mix Mortar	Trowel	Float	Shovel Earth	Chip Foundation	Miscellaneous	Idle	Total
	31 (22)	38 (17)	64 (75)	72 (92)	17 (4)	17 (12)	58 (32)	151 (199)	462 (464)
Crushed Rock Fill or Dampproofing	Unload or Load Equipment	Set up or Move Chute	Shovel Stone to Chute	Load, Empty or Push Wheelbarrow	Shovel or Rake Stone or Earth	Check Stone Depth	Miscellaneous	Idle	Total
	22 (9)	24 (n/a)	159 (n/a)	65 (n/a)	99 (126)	10	6 (2)	452 (76)	837 (244)
Place and Finish Basement Slab	Handle, Set Up or Move Equipment	Fill, empty or wheel Wheelbarrow	Rake or Shovel Concrete	Screed or Trowel Concrete	Power Trowel	Tool Contraction Joint	Miscellaneous	Idle	Total
	77 (32)	63 (66)	69 (102)	231 (139)	122 (162)	10	6 (32)	295 (364)	957 (911)

TABLE 2B
MATERIALS FOR BASEMENT

Operation	Material	Quantity in Place	
		House No. 1	House No. 2
Form, place and strip footings	lumber nails steel pins concrete	198 fbm 1.2 lb n/a 4.02 cu yd	n/a n/a 4 4.75 cu yd
Erect foundation wall forms	nails lumber plywood flue tile reinforcing rods tie rods anchor bolts	1.26 lb 21.5 fbm 7.0 sq ft 4 41.7 lb 10. 27	3.14 lb 17.9 fbm 4.22 sq ft 4 n/a 10 27
Place foundation walls	concrete	26.75 cu yd	26.0 cu yd
Install drain tile	drain tiles drain tile corners drain tile T asphalt cover strips crushed stone	136 16 1 49.0 sq ft 7.0 tons	134 8 1 40.5 sq ft 7.0 tons
Parge tie holes and dampproof foundation walls	cement sand asphalt cut back coating asphalt mastic	0.13 bag 0.20 cu ft 1 unit 12.2 lb	0.04 bag 0.29 cu ft 1 unit n/a
Parge foundation walls (top)	sand cement plasticizer	0.17 cu yd 1.66 bags 0.63 bags	0.15 cu yd 1.28 bags 0.46 bags
Basement slab fill	crushed rock	21.7 ton	n/a
Polyethylene dampproofing	polyethylene	n/a	1170 sq ft
Place and finish basement slab	concrete	10.0 cu yd	12.4 cu yd

TABLE 3A

LABOUR FOR ROUGH CARPENTRY (MAN MIN)
For House No. 1 with House No. 2 in Brackets

Install Basement Beam	Assemble or Remove Temporary Supports	Move Beam	Mix and Carry Mortar	Patch Concrete	Drill Holes	Bed Plate	Tighten Bolts	Miscellan- eous	Idle	Total
	17 (18)	21 (29)	16 (8)	24 (12)				10 (15)	18 (53)	106 (135)
Install Sill Plate	Carry or Move Sill 29 (38)	Mark or Measure 29 (6)	Level	Mix or Carry Mortar 30 (n/a)	17 (17)	57 (n/a)	14 (29)	Miscellan- eous	Idle	Total
Install Basement Columns	Carry and Position 7 (12)	Adjust Level	Carry Ramset	Load & Shoot Ramset				Miscellan- eous	Idle	Total
		14 (9)	4 (3)	9 (2)				7 (9)	3 (4)	44 (39)
Install Floor Framing and Strapping	Handle Material 115 (156)	Nail	Cut (saw)	Mark or Measure	Move Scaffold			Miscellan- eous	Idle	Total
		138 (275)	56 (79)	80 (112)	12 (9)			19 (35)	114 (220)	534 (886)
Install Subfloor	Handle Material 36 (56)	Nail	Cut (saw)	Mark or Measure				Miscellan- eous	Idle	Total
		121 (164)	28 (23)	29 (26)				9 (18)	40 (60)	263 (347)
Frame Exterior Wall	Handle or Carry Material 149 (148)	Nail	Cut (saw)	Mark or Measure	Tilt Up and Hold	Remove Nails and Braces	Align and Plumb Walls	Miscellan- eous	Idle	Total
		187 (258)	46 (54)	68 (83)	10 (31)	23 (53)	25 (19)	26 (22)	106 (295)	640 (963)
Frame Storage Shed & Carport	Handle or Carry Lumber 52 (66)	Nail	Cut (saw)	Mark or Measure	Level or Square			Miscellan- eous	Idle	Total
		46 (101)	15 (23)	15 (45)	6 (2)			6 (24)	46 (105)	186 (366)
Sheath Exterior Walls & Gables	Handle or Carry Sheathing 92 (70)	Nail	Cut (knife)	Cut (saw)	Mark or Measure			Miscellan- eous	Idle	Total
		157 (192)	39 (58)	3 (10)	30 (7)			4 (14)	58 (57)	373 (408)
Frame and Erect partitions	Handle or Carry Lumber 127 (116)	Nail	Cut (electric saw)	Cut (hand saw)	Mark or Measure	Plumb Walls		Miscellan- eous	Idle	Total
		204 (265)	46 (54)	20 (20)	86 (84)	8 (10)		27 (18)	118 (208)	636 (775)
Roof and Ceiling Framing	Handle or Carry Lumber or Trusses 166 (156)	Nail	Cut	Mark or Measure	Move Bench	Temporary Scaffolding		Miscellan- eous	Idle	Total
		178 (177)	42 (23)	86 (52)	1	12		21 (45)	121 (197)	624 (650)
Sheath Roof	Move or Carry Sheathing 79 (99)	Nail	Cut	Mark or Measure	Install Clips			Miscellan- eous	Idle	Total
		166 (219)	31 (24)	34 (17)	9 (14)			11 (19)	64 (84)	394 (476)
Miscellan- eous Framing Operation	Obtain or Put Away Equipment Material 152 (102)	Sort Delivered Material 32						Miscellan- eous	Idle	Total
								(4)	40 (72)	224 (178)

TABLE 3B
MATERIALS FOR ROUGH CARPENTRY

Operation	Material	Quantity in Place House No. 1 House No. 2	
Install basement beam	I-beam Cement and sand	1 neg	1 neg
Install sill plates	Lumber Cement Plasticizer Sand Nails	89.0 fbm 0.45 bag 0.10 bag 0.10 cu yd 0.24 lb	84.7 fbm n/a n/a n/a n/a
Install basement columns	Adjustable columns Ramset shot and fasteners Nails Lumber	4 6 0.05 lb n/a	3 6 0.2 lb 9.33 fbm
Install floor framing and strapping	Lumber Nails	1640.8 fbm 20.2 lb	1523.26 fbm 18.83 lb
Install subfloor	Plywood Lumber Nails	1079.3 sq ft 15.0 fbm 9.97 lb	1075.54 sq ft n/a 18.23 lb
Frame exterior walls	Lumber Plywood Nails	1160.50 fbm 3.9 sq ft 29.5 lb	935.70 fbm n/a 22.66 lb
Frame storage shed and carport beams	Lumber Nails	260.8 fbm 5.9 lb	247.6 fbm 5.7 lb
Sheath exterior walls and gables	Gypsum sheathing Plywood Nails	1067.40 sq ft 63.12 sq ft 19.3 lb	817.63 sq ft 60.0 sq ft 13.8 lb
Frame and erect partitions	Lumber Nails	1149.9 fbm 37.6 lb	997.7 fbm 29.5 lb
Roof and ceiling framing	Common roof trusses Gable end roof trusses Gable end roof ladders Lumber Nails	29 1 4 279.67 fbm 16.05 lb	28 1 4 152.70 fbm 13.52 lb
Sheath roof	Plywood H-clips Nails	1898.3 sq ft 156 12.10 lb	1906.42 sq ft 182 12.52 lb

TABLE 4A

LABOUR FOR INSULATION - ROOFING - EXTERIOR DOORS - WINDOWS (MAN MIN)
For House No. 1 with House No. 2 in brackets

Install shingles & eave protection	Carry or Handle Shingles	Carry or Handle Eave Protection	Nail	Cut (knife)	Mark or Measure	Open Bundles	Miscellaneous	Idle	Total
	204 (144)	6 (4)	353 (274)	25 (22)	3 (5)	11 (13)	15 (9)	92 (128)	719 (599)
Flash chimney saddle	Remove or Reapply Shingles	Handle or Move Flashing	Nail	Cut	Rake Brick Joints	Solder	Miscellaneous	Idle	Total
	52 (34)	21 (15)	17 (28)	18 (15)	23 (11)	40 (28)	29 (26)	66 (97)	280 (268)
Install insulation	Handle Insulation	Cut	Staple	Move Bench or Scaffold	Separate Insulation From Vapour Barrier	Reload Stapler	Miscellaneous	Idle	Total
	243 (345)	38 (92)	216 (233)	33 (43)	11 (43)	24 (41)	37 (25)	86 (201)	696 (1031)
Install Window Frames and Sash	Move or Carry Frames	Chisel, Plane and Wedge Frames	Nail	Level or Plumb	Drill and Screw Sash	Install or Remove Brick Stops	Miscellaneous	Idle	Total
	57 (106)	54 (37)	43 (61)	20 (19)	46 (51)	115 (62)	109 (187)	114 (163)	659 (755)
Exterior Doors and Frames	Move or Carry Material	Mark or Measure	Cut (hacksaw)	Wedge, nail and Plumb Frames	Plane or Saw Doors to Size	Install Hardware	Miscellaneous	Idle	Total
	33 (54)	32 (29)	18 (19)	40 (61)	49 (34)	169 (140)	74 (111)	66 (80)	505 (528)

TABLE 4B

MATERIALS FOR INSULATION - ROOFING - EXTERIOR DOORS - WINDOWS

Operation	Material	Quantity in Place	
		House No. 1	House No. 2
Install shingles and eave protection	Asphalt shingles Nails Polyethylene	19.09 sq 51.0 lb 324.0 sq ft	19.10 sq 33.8 lb 305.3 sq ft
Flash chimney saddle	Galvanized Sheet Steel 28 ga. Solder Asphalt caulking tubes Asphalt shingles Nails	68.88 sq ft 0.70 lb 3 0.06 sq 1.0 lb	62.64 sq ft 0.72 lb 4 0.31 sq 1.13 lb
Install insulation	Glass fibre insulation Staples Vapour Barrier	1852.0 sq ft 2.11 box 397.0 sq ft	1993.2 sq ft 2.24 box 482.3 sq ft
Install window frames, and sash	Windows and frames Asphalt sheathing paper Staples Nails Plywood Screws Glazing compound Crezon shims Lumber	8 0.27 roll 0.09 box 1.5 lb 10.1 sq ft 88 4.5 lb n/a 0.7 fbm	8 0.42 roll 0.50 box 1.4 lb 6.32 sq ft n/a 13.0 lb 2.29 sq ft n/a
Exterior doors and frames	Wood doors and frames Aluminium Storm door Aluminium threshold Weatherstripping Steel butt hinges Latch sets Screws Nails Staples Asphalt Sheathing paper Plywood Lumber Shingles	3 1 2 2 sets 8 3 4.67 doz .55 lb 0.02 box 75 sq ft 0.7 sq ft 0.6 fbm n/a	3 1 2 2 sets 9 3 4.25 doz 1.14 lb 0.15 box 48 sq ft n/a n/a 10

TABLE 5A

LABOUR FOR SERVICES (MAN MIN)
For House No. 1 with House No. 2 in Brackets

Plumbing	Carry Material or Equipment	Shovel, Tamp, etc.	Measure, Level, Position, Plumb	Cut, Solder, or Join Pipes and Fittings	Install Service to House	Cut or Drill Framing	Install Fixtures	Miscellaneous	Idle	Total
	99 (177)	121 (364)	89 (91)	122 (182)	35 (65)	27 (34)	188 (173)	106 (107)	153 (663)	940 (1056)
Electrical	Carry, Handle or Sort Materials	Install boxes, Switches, Receptacles and Plates	Drill for Wiring	Measure, Cut, Strip, and String Wire	Install Straps	Move Ladder	Install Fixtures and Appliances	Miscellaneous	Idle	Total
	264 (306)	283 (392)	69 (65)	303 (34)	81 (64)	40 (24)	219 (249)	65 (48)	262 (356)	1586 (1898)
Heating	Carry or Sort Materials and Equipment	Install Furnace and Flue Pipe	Install and Connect Humidifier	Install oil Line and Meter	Install Main and Ext. W.A. Plenums and Takeoffs	Install C.A. Returns and Grilles	Install Branch Ducts, Boots and Grilles	Miscellaneous	Idle	Total
	181 (232)	41 (53)	42 (23)	39 (70)	111 (301)	246 (171)	143 (197)	27 (23)	248 (543)	1078 (1613)

TABLE 5B
MATERIALS FOR SERVICES

Operation	Material	Quantity in Place	
		House No. 1	House No. 2
Plumbing	Drainage and vent pipe	140.9 ft	144.0 ft
	Drainage and vent pipe fittings and traps		
	Water pipe	45	50
	Water pipe fittings	163.9 ft	172.3 ft
	Standpipe	52	56
	S.S. sink and faucet	1	1
	Vanity and fittings	1	1
	Toilet and accessories	1	1
	Bath tub and shower assembly	1	1
	Laundry tub and faucet	1	1
	Hot water tank	1	1
	Sand	11.20 cu yd (value \$3.60)	10.33 cu yd (value \$4.80)
	Miscellaneous		
Electrical	Wire	1150.83 ft	1121.67 ft
	Outlet boxes	61	61
	Light fixtures	18	18
	Circuit panel	1	1
	Switches, rectp., cover plates	80	80
	Stove	1	1
	Bell chimes, buttons, transformer	1	1
	Air Filter	1	1
	Fan ventilator	1	1
	Light Bulbs	23	20
	Fuses	20	2
	Roof cap (fan vent)	1	1
	Miscellaneous	(value \$12.20)	(value \$11.70)
Heating	Furnace and fittings		
	Copper oil line	1	1
	Oil line fittings and fixtures	59'-4"	58'-7"
	Round ducts	7	9
	Dampers and elbows	148.02'	105.09'
	Plenum components	23	22
	Boots and takeoffs		
	Diffusers and grills	26	21
	Cleats and hangers	18	16
	Galvanized sheet metal	92.1'	89.0'
	Miscellaneous	42.42 sq ft (value 60¢)	15.45 sq ft (value 65¢)

TABLE 6A

LABOUR FOR GYPSUM DRYWALL AND WALLTILE (MAN MIN)
For House No. 1 with House No. 2 in Brackets

Install Drywall and Metal Bead	Carry or Move Material	Nailing	Measure and Cut	Plumb or Level Metal Bead	Move Bench		Miscellaneous	Idle	Total
	185 (178)	460 (342)	321 (270)	20 (4)	35 (25)		56 (51)	524 (404)	1613 (1274)
Finish Drywall	Carry or Move Material or Equipment	Mixing Cement	Trowel	Sanding	Protect and Spray Ceilings	Repair Drywall	Miscellaneous	Idle	Total
	239 (195)	40 (44)	774 (711)	298 (382)	46 (81)	229 (116)	104 (57)	1003 (747)	2831 (2398)
Install Wall Tile	Handle or Carry Tools or Material	Cut, Mark or Measure Tile	Install Tiles	Cut and Install Metal Moulding	Mix and Apply Joint Filler	Scrape Off Excess Joint Filler	Miscellaneous	Idle	Total
	30 (41)	19 (21)	94 (54)	15 (13)	21 (14)	7 (10)	15 (30)	39 (51)	256 (263)

TABLE 6B

MATERIALS FOR GYPSUM DRYWALL AND WALL TILES

Operation	Material	Quantity in Place House No. 1	House No. 2
Install drywall and metal bead	Gypsum wallboard Metal corner bead metal window bead Nails Lumber	3829.0 sq ft 162'-0" 143'-0" 16.85 lb n/a	3840.1 sq ft 160'-4" n/a 14.30 lb 2.33 fbm
Finish drywall	Tape Jointing cement Stippling compound Vermiculite aggregate Sandpaper	1354.0 ft 10.97 bags 1.33 bag 0.11 bag (value \$1.10)	1437.75 ft 13.20 bags 1.50 bag 0.20 bag (value 50¢)
Install wall tile	Ceramic wall tile Tile cement Tile joint filler Plaster of paris Metal edge moulding Nails	56.27 sq ft 0.59 gal 23.60 lb n/a 11.67 ft 0.08 lb	56.74 sq ft 0.69 gal 21.75 lb 0.67 lb 11.54 ft 0.10 lb

TABLE 7A

LABOUR FOR INTERIOR FINISH CARPENTRY (MAN MIN)
For House No. 1 with House No. 2 in Brackets

Kitchen Cabinets, Vanity, Mirror, and Wall Fixture	Carry or Move Materials or Tools	Mark, Measure or Level	Sawing or Cutting	Nailing	Drilling and Screwing	Glueing and Planing	Install Wall Fixtures	Miscellaneous	Idle	Total
	177 (261)	81 (93)	64 (68)	55 (86)	132 (146)	43 (34)	13 (9)	65 (99)	94 (182)	724 (978)
Interior Doors and Frames	Handle or Carry Materials	Mark or Measure	Saw and Plane	Nail or Screw	Sand, Chisel or Drill	Position and Wedge Frames	Move Bench	Miscellaneous	Idle	Total
	227 (146)	45 (42)	62 (86)	196 (181)	124 (84)	142 (126)	7 (3)	100 (91)	234 (294)	1137 (1053)
Base Trim	Handle or Carry Material	Nail or Set Nails	Sawing	Mark or Measure	Sanding	Glue	Move Bench	Miscellaneous	Idle	Total
	62 (79)	81 (81)	83 (81)	52 (51)	9 (3)	8 (2)	5 (2)	17 (43)	176 (130)	510 (472)
Basement Stairs and Handrail	Fabricate Stairs	Install Landing	Move Stairs into House	Install Stairs	Install Handrail			Miscellaneous	Idle	Total
	111 (92)	29 (33)	14 (1)	14 (13)	24 (13)			14 (22)	39 (125)	245 (299)
Miscellaneous Interior Woodwork	Handle or Carry Material	Nailing and Setting Nails	Sawing	Mark or Measure	Sanding and Planing	Glueing and Screwing	Chiselling	Miscellaneous	Idle	Total
	60 (104)	52 (130)	78 (64)	57 (62)	47 (70)	28 (24)	21	70 (57)	94 (131)	507 (642)
General	Carry or Move Table Saw	Remove and Sharpen Saw Blade						Miscellaneous	Idle	Total
	(10)	(15)						(3)	(2)	(30)

TABLE 7B

MATERIALS FOR INTERIOR FINISH CARPENTRY

Operation	Material	Quantity in Place	
		House No. 1	House No. 2
Kitchen cabinets, vanity, mirror and wall fixtures	Cabinets and hardware	14	11
	Medicine cabinet and mirror	1	1
Interior doors and frames	Miscellaneous	(value \$1.00)	(value 25¢)
	Bathroom wall fixtures	5	5
Base trim	Door frames	10	10
	Doors	14	14
Basement stair and handrail	Latch sets	7	7
	Lock sets	1	1
Miscellaneous interior woodwork	Butt hinges (with screws)	8 pr.	8 pr.
	Door stops	8	8
	Wedges	6	6
	Wood trim	237.2 lin ft	236.8 lin ft
	Nails	0.94 lb	0.95 lb
	Screws	32	32
	Base trim	317.00 lin ft	317.41 lin ft
	Plywood	0.22 sq ft	n/a
	Nails	1.40 lb	1.49 lb
	Lumber	104.10 fbm	105.42 fbm
	Plywood	11.5 sq ft	11.2 sq ft
	Handrail brackets with screws	2	2
	Asphalt paper	n/a	15.2 sq ft
	Nails	1.51 lb	1.74 lb
	Lumber	68.1 fbm	71.3 fbm
	Wood trim	16.6 lin ft	162.6 lin ft
	Plywood	6.40 sq ft	8.17 sq ft
	Fibreboard	12.8 sq ft	n/a
	Clothes hanger rails	24.6 lin ft	24.6 lin ft
	Frosted acrylic	0.69 sq ft	0.73 sq ft
	Hardboard screen	3 pc.	3 pc.
	Nails	1.33 lb	2.09 lb
	Screws	49	44

TABLE 8A

LABOUR FOR EXTERIOR FINISH AND FIREPLACE (MAN MIN)
For House No. 1 with House No. 2 in Brackets

Brick Veneer	Install Sheathing Paper and Flashing	Install Brick Ties	Mix Mortar	Carry Mortar and Bricks	Erect or Move Scaffold	Lay Bricks	Clean Brick	Miscellaneous	Idle	Total
	51 (138)	31 (40)	68 (197)	303 (286)	56 (70)	561 (814)	62 (69)	46 (95)	225 (498)	1403 (2207)
Chimney and Fireplace	Install Flashing, Ties and Hardware	Install Flue Tile and Cap	Mix and Carry Mortar and Masonry	Erect or Move Scaffold	Lay Masonry	Clean Brick and Misc. Cleanup	Caulk or Trim around Fireplace	Miscellaneous	Idle	Total
	48 (113)	93 (99)	670 (677)	71 (46)	1469 (1418)	155 (81)	26 (33)	161 (106)	640 (1183)	3333 (3756)
Carport Storage, Ceiling and Beam Cover	Carry or Move Plywood or Lumber	Nailing	Sawing	Mark or Measure	Plumbing and Squaring	Plane	Erect, Move & Dismantle Scaffold	Miscellaneous	Idle	Total
	81 (122)	265 (357)	64 (72)	40 (61)	11	14 (28)	57 (82)	20 (39)	134 (247)	686 (1433)
Aluminium Siding	Install Sheathing Paper	Install Furring	Carry or Handle Aluminium	Measure, Cut and Level Aluminium	Nail Aluminium	Caulking	Move Ladder or Scaffold	Miscellaneous	Idle	Total
	101 (65)	273 (166)	271 (133)	316 (321)	266 (297)	53 (38)	95 (81)	93 (64)	228 (268)	1696 (1433)
Aluminium Soffits and Fascia	Move or Carry Material	Mark or Measure	Fit or Adjust	Nail Fascia	Nail Soffits	Cut	Erect and Move Scaffold	Miscellaneous	Idle	Total
	62 (92)	18 (10)	19 (5)	71 (50)	50 (51)	17 (18)	76 (94)	11 (17)	54 (103)	378 (440)
Miscellaneous Trim	Move or Carry Material	Mark or Measure	Nail and Set Nails	Cutting	Erect and Move Scaffold	Lay Masonry	Caulk	Miscellaneous	Idle	Total
	18 (18)	23 (10)	37 (22)	12 (6)	19 (28)	(38)	(7)	9 (22)	50 (80)	168 (231)

TABLE 8B

MATERIALS FOR EXTERIOR FINISH AND FIREPLACE

Operation	Material	Quantity in Place	
		House No. 1	House No. 2
Brick veneer	Clay face brick	1880	1912
	Masonry cement	7.2 bags	7.4 bags
Chimney and fireplace	Sand	0.80 cu yd	0.82 cu yd
	Sheathing paper	291.50 sq ft	927.75 sq ft
	Brick ties	110	97
	Polyethylene flashing	35.17 sq ft	33.75 sq ft
	Nails	3.21 lb	4.49 lb
Carport storage, ceiling and beam cover	Clay face brick	1412	1602
	Back-up brick	599	564
	Firebrick	90	84
	Concrete block	212	55.5
	Artificial stone	244	226.4
	Flue tile	14	12
	Cement	17.2 bags	15.0 bags
	Sand	1.67 cu yd	2.10 cu yd
	Hardware	(value \$37.60)	(value \$37.60)
	Miscellaneous	(value \$4.00)	(value \$4.30)
Aluminum siding	Plywood	520.1 sq ft	494.1 sq ft
	Lumber	145.8 fbm	126.0 fbm
	Nails	12.2 lb	8.8 lb
Aluminum soffits and fascia	Vertical siding	824.9 sq ft	808.7 sq ft
	Siding accessories	302.11"	330.1-2"
	Galvanized steel flashing	26.1-0"	26.1-10"
	Miscellaneous	(value \$8.60)	(value \$10.55)
	Furring	122.0 fbm	137.0 fbm
Miscellaneous trim	Fascia	183.1-9"	183.1-8"
	Soffits	336.81 sq ft	336.04 sq ft
	J-trim	177.1-9"	178.1-0"
	Nails	0.98 lb	0.60 lb
Miscellaneous trim	Lumber	14.4 fbm	18.7 fbm
	Plywood	2.1 sq ft	n/a
	Face brick	n/a	13
	Cement	n/a	.05 bag
	Galvanized flashing	5.1-11"	3.1-1"
	Nails	0.75 lb	0.40 lb

TABLE 9A

LABOUR FOR FINISH FLOORING (MAN MIN)
For House No. 1 with House No. 2 in Brackets

Hardwood Flooring	Carry Material or Equipment	Mark or Measure	Cutting (saw or axe)	Nailing and Filling Nail Holes	Scrape and Sweep Floors	Sand Floors	Seal, Varnish and Buff Floors	Miscellaneous	Idle	Total
	201 (245)	33 (49)	90 (69)	320 (301)	125 (78)	229 (308)	109 (100)	76 (23)	337 (245)	1520 (1418)
Resilient Flooring	Handle or Carry Tools or Material	Mark or Measure	Sawing or Cutting	Nailing	Sanding	Lay Vinyl Asbestos Flooring	Cleanup, Wax & Polish Floors	Miscellaneous	Idle	Total
	53 (60)	24 (21)	45 (50)	51 (47)	11 (5)	38 (32)	53 (52)	29 (29)	90 (155)	394 (451)
Ceramic Tile Flooring	Carry Material or Equipment	Install Mortar base & Reinforcing	Measure or Cut Underlay	Nail Underlay	Trowel Adhesive	Lay Tile & Fill Joints	Clean Tiles	Miscellaneous	Idle	Total
	29 (42)	90 (n/a)	(15)	(6)	(5)	47 (36)	10 (30)	16 (25)	80 (99)	272 (258)

TABLE 9B

MATERIALS FOR FINISH FLOORING

Operation	Material	Quantity in Place House No. 1	House No. 2
Hardwood flooring	Red oak flooring Power nails Nails Sandpaper Lacquer sealer Lacquer thinner Varnish Building paper	772.9 sq ft 3955 1.38 lb (value \$4.20) 2.63 gal 0.75 gal 1.78 gal 51.7 sq ft	777.6 sq ft 3782 1.86 lb (value \$2.55) 2.04 gal n/a 1.80 gal n/a
Resilient flooring	Plywood underlay Floor tile Inlaid linoleum Cement Stair nosing Staples Nails	152.3 sq ft 96.75 sq ft 25.60 sq ft 14.7 lb 3'-3" n/a 2.05 lb	136.3 sq ft 99.56 sq ft 23.74 sq ft 13.9 lb 3'-2 1/2" 0.13 box 0.14 lb
Ceramic tile flooring	Floor tile Plywood underlay Staples Nails Aluminum threshold trim Reinforcing mesh Adhesive Cement Sand	30.0 sq ft n/a n/a 0.84 lb n/a 3.42 sq yd n/a 0.95 bag 0.2 cu yd	28.7 sq ft 30.7 sq ft 0.03 box 0.03 lb 2'-0" n/a 2.7 lb 0.16 bag n/a

TABLE 10A

LABOUR FOR PAINTING (MAN MIN)
For House No. 1 with House No. 2 in Brackets

Interior Painting and Varnishing (not floor)	Carry or Move Materials or Equipment	Dip Brush or Roller	Sand and Paint Walls & Ceiling	Sand, Paint Woodwork, Folding Doors, & Steel Door Frames	Sand and Varnish Doors, Divider & Mantle	Putty Nail Holes and Cracks	Cleaning	Miscellaneous	Idle	Total
	341 (291)	133 (270)	781 (798)	1023 (1270)	251 (279)	173 (231)	7 (42)	221 (340)	317 (848)	3247 (4369)
Exterior Painting and Touch-up	Carry or Move Materials or Equipment	Dip Brush or Roller	Brushing Paint or Shellac	Rolling Paint	Clean Equipment	Ascend or Descend Ladder	Putty Nail Holes	Miscellaneous	Idle	Total
	37 (112)	38 (103)	143 (586)	86 (101)	5 (18)	16 (9)	22 (39)	10 (79)	115 (336)	472 (1383)

TABLE 10B
MATERIALS FOR PAINTING

Operation	Material	Quantity in Place House No. 1	House No. 2
Interior painting and varnishing (except floors)	Paint Varnish Stain Spackling compound Masking tape Putty Touch up crayon Sandpaper	12.81 gal 0.80 gal 0.06 gal n/a 0.15 lb 1/6 stick (value 30¢)	16.15 gal 1.11 gal n/a 0.04 bag n/a 0.20 lb n/a (value 25¢)
Exterior painting and touchup	Paint Boiled linseed oil Putty	1.90 gal 0.06 gal n/a	3.24 gal n/a 0.4 lb

TABLE 11A

LABOUR FOR MISCELLANEOUS OPERATIONS
For House No. 1 with House No. 2 in Brackets

Cleanup	Before Basement Slab & After Brick Work	After Framing and Gypsum Board Installation	After Rough Wiring and Plumbing	After Installation of Drywall	After Aluminum Soffits	After Floor Installation	After Trim and During Painting	Final Cleanup	Idle	Total
	102 (155)	291 (157)	41	4 (109)	(11)	17 (12)	94 (98)	782 (799)	340 (464)	1671 (1805)
Correction of Errors or Repair of Damage	Earthwork and Site Improvement	Basement	Rough Carpentry	Insulation - Roofing - Exit Doors - Windows	Services	Interior and Exterior Finish	Finish Flooring	Painting	Idle	Total
	F.E.L. (62) MEN (8)	(189)	444 (323)	195 (488)	43 (250)	130 (320)	160 (83)	(56)	F.E.L. (10) 354 (1072)	F.E.L. (72) 1326 (2789)
Delivery of Materials (by other than supplier)	Framing, Sheathing, Sub-floor Underlay	Trim, Windows, Doors, Frames and Hardware	Insulation & Vapour Barrier	Masonry & masonry Hardware	Aluminium Siding & Carpet Piers	Drywall	Paint and Basement Stairs	Sand and Tile for Bathroom	Idle	Total
	43 (24)	15 (71)	11	31 (132)	11 (12)	6 (12)	6 (6)	8	81 (160)	212 (417)

TABLE 11B

MATERIALS FOR MISCELLANEOUS OPERATIONS

Operation	Material	Quantity in Place	
		House No. 1	House No. 2
Repair basement slab	Concrete	n/a	0.56 cu yd.
Basement columns	Ramset shots and piers	6	n/a
Repair floor framing	Lumber Nails	n/a n/a	8.61 fbm 0.39 lb
Repair subfloor (bathroom)	Plywood Lumber Nails	44.0 sq ft 1.25 fbm 0.69 lb	0.71 sq ft n/a 0.05 lb
Repair fireplace header	Lumber Nails	11.91 fbm 0.21 lb	n/a n/a
Framing exterior walls	Lumber Plywood Nails	2.19 fbm 1.5 sq ft 1.6 lb	n/a n/a n/a
Repair exterior sheathing	Gypsum sheathing Nails	20.24 sq ft .44 lb	n/a n/a
Repair glazing and doors	Nails Lumber	Neg 6.40 fbm	0.08 lb n/a
Repair insulation	Insulation Waxed paper vapour barrier Polyethylene Staples	n/a n/a n/a n/a	0.19 carton 41.92 sq ft - 0.26 box
Sewer and water service	Transite	n/a	10'-0"
Repair hardwood flooring	Red oak flooring Nails	n/a n/a	0.6 sq ft 0.02 lb
Repair underlay resilient flooring	Plywood underlay Nails	n/a n/a	0.62 sq ft Neg.

TABLE 12

SUMMARY OF MATERIALS WASTE OR SCRAP

Operation	Material	% Scrap or Waste		Cost	
		House #1	House #2	House #1	House #2
Basement	Crushed stone	10.00	n/a	4.75	n/a
	concrete	0.37	4.72	1.43	12.13
	4" clay drain tile	9.33	6.94	1.45	1.04
	4" clay corner tile	-	27.30	-	.86
Rough carpentry	2" x 8" No. 1 spruce	5.79	0.15	11.59	.25
	2" x 4" No. 1 spruce	4.61(est)	4.61	12.25	10.36
	1" x 8" No. 1 spruce	n/a	5.00	n/a	.32
	1" x 4" spruce strap-				
	ping	5.24	8.14	.97	1.66
	1/2" gypsum sheathing	4.18	7.53	2.24	3.14
	3/8" sheathing				
	grade spruce ply.	1.50	1.40	3.02	2.82
Insulation - roofing	insulation	0.43	0.38	.54	.52
	- exterior doors -	0.37	1.33	.56	2.08
windows					
Gypsum drywall	ceramic wall tile	.44	1.20	.19	.52
	1/2" gypsum wallboard	7.13	7.92	19.56	20.23
	metal corner bead	16.24	6.41	1.29	.44
Interior finish carpentry	2 1/4" base mould	9.3	21.8	2.73	7.49
	1/2" x 3/4" shoe mould	17.4	23.2	.23	.25
	steel clothes hanger				
	rail	10.2	9.5	.64	.54
	2 1/2" casing mould	n/a	21.7	n/a	3.52
	No. 1 white spruce	18.0	18.4	2.92	2.98
	2" x 10" No. 1 spruce	n/a	4.8	n/a	.46
	moulded counter top	7.4	13.9	5.96	11.24
Finish flooring	9" x 9" vinyl				
	asbestos tile	5.5	4.32	1.29	1.04
	embossed inlaid lino	8.57	11.02	1.47	1.80
	oak flooring	2.00	1.74	6.14	4.93
	ceramic floor tile	.00	4.33	.00	.64
	1/4" poplar underlay	n/a	4.88	n/a	.49
Exterior finish and fireplace	5" aluminum fascia	1.30(est)	1.30	.72(est)	.72
	40" x 24" soffit				
	panels	1.01(est)	1.01	1.16(est)	1.17
	vertical clapboard				
	siding	13.47	19.50	38.06	58.09
	1" x 2" spruce				
	strapping	8.55	6.90	.96	.75
	clay face brick	1.56	0.71	4.26	2.08
	artificial stone	1.29	1.60	.44	.52
	chimney cap	7.69	7.69	1.43	1.43
	fire brick	1.09	1.41	.23	.27
Other misc. scrap or waste	redwood mantel	11.53	8.03	1.69	1.18
				5.15	5.39
		TOTALS		140.94	167.59

TABLE 13
MARK V - COST/UNIT

Operation	Cost/Unit House #1	Cost/Unit House #2
1. Excavation	.29/cu yd	.45/cu yd
2. Top soil and grading	.21/cu yd	.26/cu yd
3. Laying sod	.36/sq yd	.40/sq yd
4. Laying walkways	.36/sq ft	.52/sq ft
5. Driveway (inc. base)	.14/sq ft	.17/sq ft
6. Footings (form, place and strip)	20.43/cu yd	22.02/cu yd
7. Foundation walls (form, place, strip, drain tile, parge and dampproof)	.75/sq ft of foundation wall	.73/sq ft of foundation wall
8. Basement slab (with crushed rock or polyethylene beneath)	.28/sq ft	.25/sq ft
9. Floor framing (basement columns beams, sill plates, joists, strapping)	.30/sq ft (based on ext. of found.)	.30/sq ft (based on ext. of found.)
10. Subfloor (including dropped subfloor)	.15/sq.ft. (based on ext. of found.)	.15/sq ft (based on ext. of found.)
11. Exterior wall framing and sheathing	.23/sq ft of wall	.25/sq ft of wall
12. Interior partition framing	.16/sq ft of wall	.17/sq ft of wall
13. Roof and ceiling framing (trusses, fascia, back-up, dropped ceiling, access hatch)	.28/sq ft of ceiling	.26/sq ft of ceiling
14. Roof sheathing (inc. chimney saddle)	.12/sq ft of roof surface	.12/sq ft of roof surface
15. Roofing	.12/sq ft of roof surface	.12/sq ft of roof surface
16. Insulation	.09/sq ft	.10/sq ft
17. Windows (frames, sash and glazing)	4.14/sq ft of rough opening	3.36/sq ft of rough opening
18. Exterior doors (frames, doors, hardware)	59.44/door 2.61/sq ft of rough opening	59.14/door 2.60/sq ft of rough opening
19. Storm door	25.21/unit	25.21/unit

Table 13 (cont'd)

- 2 -

Operation	Cost/Unit House #1	Cost/Unit House #2
20. Sewer and water service to house	3.41/lin.ft	5.52/lin.ft
21. Electrical (less range and hanging fixtures)	3.67/outlet	3.98/outlet
22. Heating system	.42/sq ft of floor area	.44/sq ft of floor area
23. Wallboard (gypsum board, beading, taping, finishing, touchup)	.15/sq ft	.14/sq ft
24. Ceiling finish (spray)	.02/sq ft of ceiling area	.03/sq ft of ceiling area
25. Wall tile (including joint filling)	1.26/sq ft	1.25/sq ft
26. Base trim	.20/lin.ft	.19/lin.ft
27. Basement stairs and hand rail	3.93/riser, or 43.25/unit	3.00/riser, or 32.98/unit
28. Interior sliding doors (frame, trim, and hardware)	28.57/unit, or 1.53/sq ft of rough opening	27.61/unit, or 1.56/sq ft (rough opening)
29. Interior swing doors (frame trim, doors, and hardware)	26.19/unit 1.52/sq ft of rough opening	26.02/unit 1.53/sq ft (rough opening)
30. Interior bifold doors	10.09/door .71/sq ft of rough opening	9.97/door .70/sq ft (rough opening)
31. Hardwood floors (lay, sand, and varnish)	.57/sq ft	.51/sq ft
32. Resilient flooring (underlay, tile, and waxing)	.68/sq ft	.63/sq ft
33. Ceramic floor tile (base, tile, and joint filling)	1.14/sq ft	1.20/sq ft
34. Brick veneer (paper, ties, masonry)	.85/sq ft	1.03/sq ft
35. Aluminum siding (paper, strapping, aluminum)	.48/sq ft	.48/sq ft
36. Aluminum soffit's and fascia	.63/sq ft of soffit area	.65/sq ft of soffit area

Table 13 (cont'd)

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Operation	Cost/Unit House #1	Cost/Unit House #2
37. Exterior wood trim	.76/bfm	.68/bfm
38. Interior painting (one coat work)	.02/sq ft	.02/sq ft
39. Interior painting (two coat work)	.05/sq ft	.08/sq ft
40. Exterior painting	.07/sq ft	.14/sq ft
41. Carport piers and columns	23.88/pier and column	24.28/pier and column
42. Carport ceiling and beam cover (and blocking)	.31/sq ft	.28/sq ft
43. Carport beam	.14/floor	.19/floor
44. Plywood siding and battens (storage)	.28/sq ft	.23/sq ft
45. Storage shed framing	.11/sq ft of wall	.13/sq ft of wall

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BLDG

NATIONAL RESEARCH COUNCIL OF CANADA
DIVISION OF BUILDING RESEARCH

SUPPLEMENT TO
"A COST STUDY OF TWO WOOD-FRAME BUNGALOWS"
(NRC 9590)

ANALYZED

BY

A. T. HANSEN

OTTAWA

JULY 1967

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SUPPLEMENT TO
"A COST STUDY OF TWO WOOD-FRAME BUNGALOWS"

(NRC 9590)

by

A. T. Hansen

This paper has been prepared as a supplement to "A Cost Study of Two Wood-Frame Bungalows" (NRC 9590) and must be read in conjunction with that paper. It contains a number of tables that provide a detailed breakdown of the labour and material distribution in the two houses studied. Owing to the number and length of these tables, it was decided to publish this information separately for those who desire to have a more detailed summary of the records obtained in this project.

The project was carried out by the Division of Building Research, National Research Council of Canada, with the assistance of Central Mortgage and Housing Corporation and in cooperation with the National House Builders Association. With the agreement of the Research Committee of NHBA, this study formed part of their experimental house program as Mark V in the series. The program was undertaken through the cooperation and assistance of Connelly Developments Ltd. at their Glen Cairn Subdivision near Ottawa.

SCOPE

The immediate objective of this study was to determine the labour and material requirements for a typical wood-frame bungalow and to assess the savings in construction cost that could be achieved by taking advantage of the minimum requirements in Residential Standards, Canada, 1965, Supplement No. 5 of the National Building Code. This latter aspect of the study was limited to those changes that would not significantly alter the appearance or quality of the house.

The study was divided into two stages. The first stage consisted of an examination of a typical three-bedroom bungalow built in accordance with the builders' usual construction methods. Labour and materials observations were taken for all building operations - from the stake-out to the final

clean-up. This house was built during the latter part of 1965. The results were analysed, and on the basis of this analysis, in stage 2 of the study a number of changes in construction were incorporated in a second house built in the summer of 1966. Records were again taken of labour and materials for all phases of construction.

The study was confined to the on-site activity of the construction process. Items such as land cost, overhead, profit, finance charges, and mortgage insurance were not investigated.

PROCEDURE

The construction was analysed as various separate operations. All labour and materials connected with each operation were recorded to determine the total cost of each operation.

Labour activity was recorded for each worker at one-minute intervals throughout the entire job. Only on-site labour was recorded; no attempt was made to account for a workman's time after he had left the building site. The time spent by management personnel at the site who contributed no physical labour toward the construction of the house is not recorded in this Supplement. The time contributed by working foremen, however, is recorded.

In each operation, the worker's time was subdivided into activities such as sawing, nailing, measuring, carrying materials, and idle time.

For the purpose of this study, idle time was defined as the time during which a worker stopped building activity. Coffee breaks, awaiting or receiving instruction, or delays caused by other trades or the weather, are classed as idle time. No attempt was made to rate the effort of workmen to convert the "observed time" measurements to "standard time" equivalents.

In computing the cost of labour, a value of \$3.50 an hour was assumed. This was the average hourly rate of eight trades in the Ottawa area in 1965 with an allowance to cover costs such as contributions to holiday pay, workmen's compensation, unemployment insurance and other benefits. This average labour cost was used for all operations to simplify calculations.

The delivery of all material and the return of left-over material after the completion of each operation was recorded. In addition, the exact amount of material installed was recorded for each operation. From these observations, the values of waste or scrap were determined.

DESCRIPTION OF THE HOUSES

The houses studied were three-bedroom wood-frame bungalows of approximately 1150 square feet of floor area. The houses were completely site built with the exception of the roof trusses and cabinets. Only the studs were delivered precut. Each house had an attached carport, fire-place, and full basement. Brick veneer and aluminum siding were used on the exterior walls. Aluminum fascia and soffits were used at the eaves and rakes. The carport ceiling and storage shed were covered with plywood.

Gypsum wallboard was used as the interior finish with ceramic wall tile in the bathroom. Resilient flooring was used in the kitchens and foyers, ceramic tile in the bathroom, and hardwood strip flooring throughout the remainder of each house. Details of the first house are shown in Figures 1 to 3 in NRC Paper No. 9590. The first house was one of a number of similar houses built in the same development. It was in no way altered from the builder's usual construction.

The floor plan of house No. 2 is identical with that of the first house and the over-all appearance of the two houses is the same. A number of changes in construction details were introduced to improve efficiency in the use of materials and labour while still meeting the requirements of Residential Standards. In addition, because of a change in suppliers, some of the materials in house No. 2, such as windows and cabinets, are not identical to those used in house No. 1.

When the second house was built mortgage money was so scarce that it was the only house under construction in the development at the time. This had a considerable influence on the labour times observed as discussed in NRC 9590.

A description of the changes that were incorporated into house No. 2 to reduce costs are also presented in NRC 9590.

A detailed summary of labour observations are listed in Tables 1A to 11A for the various operations. All values are in terms of man-minutes.

The materials used are listed in Tables 1B to 11B. Table 1B lists the materials used in operations corresponding to the labour in Table 1A. Similarly Table 2B corresponds to Table 2A and so on.

These tables provide a breakdown of labour and materials for 62 separate operations and do not include allowances for waste and scrap.

A condensation of the results obtained from these tables are listed in Tables 1 and 11 in NRC 9590. The quantities of materials shown in Tables 1B to 11B are for the materials in place with no allowance made for waste or scrap. The breakdown of the construction into 62 operations made it practically impossible to determine the waste or scrap to be assigned to each operation. The waste or scrap from framing the exterior walls, for example, was partially used in the construction of the partitions. The quantities of waste or scrap are listed separately in Table 12 as percentage of material as well as in terms of cost.

Table 13 is a breakdown of most of the major items into costs per unit either in terms of unit area or other appropriate unit of measurement.

CONCLUDING NOTE

This Supplement was prepared to provide a more detailed breakdown of the information in NRC 9590. It must be read in conjunction with that report for a proper understanding of the information in the various tables and to appreciate the various qualifications that are more completely described in NRC 9590.

TABLE 1A
LABOUR FOR EARTHWORK AND SITE IMPROVEMENT (MAN MIN)
For House No. 1 with House No. 2 in brackets

Stake out	Measuring	Plumbing	Set up Instrument	Using Transit	Making Notes	Locating or Placing Pins	Misc.	Idle	Total
	5 (23)	3 (7)	4 (4)	7 (7)	2 (2)	9 (10)	14	24 (64)	68 (117)
Excavation (basement, sewer and water)	Machine Digging	Machine Emptying or Manoeuvring	Machine Idle	Total Machine Time	Hand Shovelling	Spotting Shovel	Miscellaneous	Idle	Total Man Time including Machine Operation
	79 (140)	74 (59)	41 (164)	194 (363)	79 (173)	33 (44)	13 (1)	59 (98)	198 (314)
Backfill	Front End Loader Backfilling	Front End Loader Manoeuvring	Front End Loader Idle	Total Front End Loader Time					
	77 (83)	33 (3)	22 (13)	132 (99)					
Dirt Fill And Rough Grading	Front End Loader Working or Manoeuvring	Front End Loader Idle	Total Front End Loader Time	Truck operating on Site	Truck Away From Site	Truck Idle on Site	Spot Trucks	Men Idle	Total Man Time
	103 (27)	88 (14)	191 (41)	48 (31)	245 (55)	84 (15)	377 (101)	(3)	(9)
Top Soil and Grade	Front End Loader Working or Manoeuvring	Front End Loader Idle	Total Front End Loader Time	Truck operating on Site	Truck Idle on Site	Total Truck Time	Hand Shovel Rake and Wheeling	Men Idle	Total Man Time including Machine Operation
	105 (208)	1 (43)	106 (251)	91 (103)	92 (38)	183 (141)	347 (347)	51 (57)	159 (655)
Final Grading and Sodding	Rolling (pulled by tractor)	Tractor Idle	Total Tractor Time	Hand Shovel Rake or Wheel	Roll Sod by Hand	Carry Sod	Lay Sod	Miscellaneous	Total Man Time
	17 (92)	2 (97)	19 (189)	195 (364)	(48)	156 (16)	191 (303)	12 (42)	722 (1012)
Laying Walkway	Carry or Lay Stone Slabs		Shovel or Rake Sand					Miscellaneous	Total
	38 (46)		26 (102)					3 (38)	97 (334)
Install Driveway	Front End Loader Spreading Gravel	Raking and Shovelling Stone or Gravel	Machine Rolling Stone or Gravel	Tamping	Shovel or Rake Asphalt	Rolling or Shovelling Sand Base	Machine Rolling Asphalt	Idle	Total
	6	74 (235)	17 (59)	76 (80)	80 (95)	(79)	23 (47)	110 (197)	421 (1046)
Install Steps (Exterior)	Driving Truck	Move Steps By Crane	Drill Foundation	Wedge and Bolt Steps in Place	Measure, Level and Plumb	Hand Excavation	Adjust and Position	Miscellaneous	Total
	6 (5)	9 (18)	13 (10)	14 (14)	11 (13)	4 (24)	6 (6)	9 (41)	86 (189)

TABLE 1B

MATERIAL FOR EARTHWORK AND SITE IMPROVEMENT

Operation	Material	Quantity in Place House No. 1 House No. 2	
Excavation	Earth	221.0 cu yd removed	253.74 cu yd removed
Dirt fill and rough grade Top soil and finish grade	Top soil and fill obtained from builders site - no cost		
Final grading and sodding	Sod	267.0 sq yd	369.56 sq yd
Laying walkway	precast walks sand	16 0.4 cu yd	16 0.11 cu yd
Install driveway	asphalt concrete crushed base	7.5 tons 27.4 tons	7.0 tons 33.4 tons
Install exterior steps	precast rear step precast front step	1 1	1 1

TABLE 2A

LABOUR FOR BASEMENT (MAN MIN.)
For House No. 1 with House No. 2 in brackets

Stake out footings	Mark or Measure	Move or Use Transit	Hold Rod	Place Markers			Miscellaneous	Idle	Total
	21 (16)	21 (25)	1 (8)	5 (2)			6 (2)	19 (21)	73 (74)
Form, Place and Strip Footings	Mark or Measure	Locate and Drive Stakes	Shovel Earth	Handling Forms and Accessories	Nailing	Wheel and Empty Concrete	Miscellaneous	Idle	Total
	11 (35)	47 (34)	47 (202)	34 (n/a)	19 (n/a)	23 (17)	34 (41)	155 (274)	427 (631)
Erect Foundation Wall Forms	Mark or Measure	Carrying Material	Nailing	Install Ties, Clamps, and Re-inforcing	Erecting Forms	Plumbing, Levelling and aligning	Miscellaneous	Idle	Total
	30 (11)	184 (204)	40 (32)	168 (127)	39 (45)	48 (59)	67 (55)	368 (329)	1006 (918)
Place Foundation Walls	Guide or Hold Chute	Shovel Concrete	Rodding or Hammering	Spot Trucks	Trowel Top of Concrete	Set Anchor Bolts	Miscellaneous	Idle	Total
	40 (26)	47 (59)	13 (11)	12 (3)	29 (17)	5 (n/a)	24 (27)	290 (483)	460 (626)
Strip Foundation Walls	Remove Clamps and Ties	Loosening Forms	Carry Clamps and Ties	Carry Forms and Braces	Remove Flue and Cleanout Forms	Remove Braces	Miscellaneous	Idle	Total
	111 (76)	24 (45)	66 (55)	109 (127)	25 (4)	15 (12)	40 (16)	238 (158)	628 (508)
Install Drain Tile	Install Crushed Stone	Carry Tile	Lay Tile	Cover Joints	Cut cover Strips	Hand Excavation	Miscellaneous	Idle	Total
	120 (95)	29 (19)	26 (61)	22 (28)	3	(76)	19 (11)	126 (69)	345 (359)
Parge Tie Holes and Dampproof Foundation Wall	Mix Mortar	Parge	Chip Concrete	Move Hose	Spray Dampproofing	Apply Mastic to Joints	Miscellaneous	Idle	Total
	9 (10)	38 (40)	17 (12)	8 (5)	17 (15)	13 (n/a)	14 (2)	41 (24)	157 (108)
Carport Piers and Columns	Dig and Backfill (hand)	Plumb and Measure	Move Scaffolding or Ladder	Nailing	Shovel Concrete	Push Wheel-Barrow	Miscellaneous	Idle	Total
	59 (98)	7 (26)	7	5 (1)	12 (13)	5 (4)	21 (79)	73 (58)	226 (298)
Parge Foundation Wall (top)	Carry Mortar	Mix Mortar	Trowel	Float	Shovel Earth	Chip Foundation	Miscellaneous	Idle	Total
	31 (22)	38 (17)	64 (75)	72 (92)	17 (4)	17 (12)	58 (32)	151 (199)	462 (464)
Crushed Rock Fill or Dampproofing	Unload or Load Equipment	Set up or Move Chute	Shovel Stone to Chute	Load, Empty or Push Wheelbarrow	Shovel or Rake Stone or Earth	Check Stone Depth	Miscellaneous	Idle	Total
	22 (9)	24 (n/a)	159 (n/a)	65 (n/a)	99 (126)	10	6 (2)	452 (76)	837 (214)
Place and Finish Basement Slab	Handle, Set Up or Move Equipment	Fill, empty or wheel Wheelbarrow	Rake or Shovel Concrete	Screed or Trowel Concrete	Power Trowel	Tool Contraction Joint	Miscellaneous	Idle	Total
	77 (32)	63 (66)	69 (102)	231 (139)	122 (162)	10	77 (44)	295 (364)	957 (911)

TABLE 2B
MATERIALS FOR BASEMENT

Operation	Material	Quantity in Place	
		House No. 1	House No. 2
Form, place and strip footings	lumber nails steel pins concrete	198 fbm 1.2 lb n/a 4.02 cu yd	n/a n/a 4 4.75 cu yd
Erect foundation wall forms	nails lumber plywood flue tile reinforcing rods tie rods anchor bolts	1.26 lb 21.5 fbm 7.0 sq ft 4 41.7 lb 10. 27	3.14 lb 17.9 fbm 4.22 sq ft 4 n/a 10 27
Place foundation walls	concrete	26.75 cu yd	26.0 cu yd
Install drain tile	drain tiles drain tile corners drain tile T asphalt cover strips crushed stone	136 16 1 49.0 sq ft 7.0 tons	134 8 1 40.5 sq ft 7.0 tons
Parge tie holes and dampproof foundation walls	cement sand asphalt cut back coating asphalt mastic	0.13 bag 0.20 cu ft 1 unit 12.2 lb	0.04 bag 0.29 cu ft 1 unit n/a
Parge foundation walls (top)	sand cement plasticizer	0.17 cu yd 1.66 bags 0.63 bags	0.15 cu yd 1.28 bags 0.46 bags
Basement slab fill	crushed rock	21.7 ton	n/a
Polyethylene dampproofing	polyethylene	n/a	1170 sq ft
Place and finish basement slab	concrete	10.0 cu yd	12.4 cu yd

TABLE 3A

LABOUR FOR ROUGH CARPENTRY (MAN MIN)
For House No. 1 with House No. 2 in Brackets

	Assemble or Remove Temporary Supports	Move Beam	Mix and Carry Mortar	Patch Concrete			Miscellan- eous	Idle	Total
Install Basement Beam	17 (18)	21 (29)	16 (8)	24 (12)			10 (15)	18 (53)	106 (135)
Install Sill Plate	Carry or Move Sill 29 (38)	Mark or Measure 29 (6)	Level 58 (14)	Mix or Carry Mortar 30 (n/a)	Drill Holes 17 (17)	Bed Plate 57 (n/a)	Miscellan- eous 50 (48)	Idle 17 (36)	Total 301 (188)
Install Basement Columns	Carry and Position 7 (12)	Adjust Level 14 (9)	Carry Ramset 4 (3)	Load & Shoot Ramset 9 (2)			Miscellan- eous 7 (9)	Idle 3 (4)	Total 44 (39)
Install Floor Framing and Strapping	Handle Material 115 (156)	Nail 138 (275)	Cut (saw) 56 (79)	Mark or Measure 80 (112)	Move Scaffold 12 (9)		Miscellan- eous 19 (35)	Idle 114 (220)	Total 534 (866)
Install Subfloor	Handle Material 36 (56)	Nail 121 (164)	Cut (saw) 28 (23)	Mark or Measure 29 (26)			Miscellan- eous 9 (18)	Idle 40 (60)	Total 263 (347)
Frame Exterior Wall	Handle or Carry Material 119 (148)	Nail 187 (258)	Cut (saw) 46 (54)	Mark or Measure 68 (83)	Tilt Up and Hold 10 (31)	Remove Nails and Braces 23 (53)	Miscellan- eous 26 (22)	Idle 106 (295)	Total 640 (963)
Frame Storage Shed & Carport	Handle or Carry Lumber 52 (66)	Nail 46 (101)	Cut (saw) 15 (23)	Mark or Measure 15 (45)	Level or Square 6 (2)		Miscellan- eous 6 (24)	Idle 46 (105)	Total 186 (366)
Sheath Exterior Walls & Cables	Handle or Carry Sheathing 92 (70)	Nail 157 (192)	Cut (knife) 39 (58)	Cut (saw) 3 (10)	Mark or Measure 30 (7)		Miscellan- eous 4 (14)	Idle 58 (57)	Total 373 (408)
Frame and Erect Partitions	Handle or Carry Lumber 127 (116)	Nail 204 (265)	Cut (electric saw) 46 (54)	Cut (hand saw) 20 (20)	Mark or Measure 86 (84)	Plumb Walls 8 (10)	Miscellan- eous 27 (18)	Idle 118 (208)	Total 636 (775)
Roof and Ceiling Framing	Handle or Carry Lumber or Trusses 166 (156)	Nail 178 (177)	Cut 42 (23)	Mark or Measure 86 (52)	Move Bench 1	Temporary Scaffolding 12	Miscellan- eous 21 (45)	Idle 121 (197)	Total 624 (650)
Sheath Roof	Move or Carry Sheathing 79 (99)	Nail 166 (219)	Cut 31 (24)	Mark or Measure 34 (17)	Install Clips 9 (14)		Miscellan- eous 11 (19)	Idle 64 (84)	Total 394 (476)
Miscellan- eous Framing Operation	Obtain or Put Away Equipment Material 152 (102)	Sort Delivered Material 32					Miscellan- eous (4)	Idle 40 (72)	Total 224 (178)

TABLE 3B
MATERIALS FOR ROUGH CARPENTRY

Operation	Material	Quantity in Place	
		House No. 1	House No. 2
Install basement beam	I-beam Cement and sand	1 neg	1 neg
Install sill plates	Lumber Cement Plasticizer Sand Nails	89.0 fbm 0.45 bag 0.10 bag 0.10 cu yd 0.24 lb	84.7 fbm n/a n/a n/a n/a
Install basement columns	Adjustable columns Ramset shot and fasteners Nails Lumber	4 6 0.05 lb n/a	3 6 0.2 lb 9.33 fbm
Install floor framing and strapping	Lumber Nails	1640.8 fbm 20.2 lb	1523.26 fbm 18.83 lb
Install subfloor	Plywood Lumber Nails	1079.3 sq ft 15.0 fbm 9.97 lb	1075.54 sq ft n/a 18.23 lb
Frame exterior walls	Lumber Plywood Nails	1160.50 fbm 3.9 sq ft 29.5 lb	935.70 fbm n/a 22.66 lb
Frame storage shed and carport beams	Lumber Nails	260.8 fbm 5.9 lb	247.6 fbm 5.7 lb
Sheath exterior walls and gables	Gypsum sheathing Plywood Nails	1067.40 sq ft 63.12 sq ft 19.3 lb	817.63 sq ft 60.0 sq ft 13.8 lb
Frame and erect partitions	Lumber Nails	1149.9 fbm 37.6 lb	997.7 fbm 29.5 lb
Roof and ceiling framing	Common roof trusses Gable end roof trusses Gable end roof ladders Lumber Nails	29 1 4 279.67 fbm 16.05 lb	28 1 4 152.70 fbm 13.52 lb
Sheath roof	Plywood H-clips Nails	1898.3 sq ft 156 12.10 lb	1906.42 sq ft 182 12.52 lb

TABLE 4A

LABOUR FOR INSULATION - ROOFING - EXTERIOR DOORS - WINDOWS (MAN MIN)
For House No. 1 with House No. 2 in brackets

	Carry or Handle Shingles	Carry or Handle Eave Protection	Nail	Cut (knife)	Mark or Measure	Open Bundles	Miscellan- eous	Idle	Total
Install shingles & eave protection	204 (144)	6 (4)	353 (274)	25 (22)	3 (5)	11 (13)	15 (9)	92 (128)	719 (599)
Flash chimney saddle	Remove or Reapply Shingles	Handle or Move Flashing	Nail	Cut	Rake Brick Joints	Solder	Miscellan- eous	Idle	Total
	52 (34)	21 (15)	17 (28)	18 (15)	23 (11)	40 (28)	29 (26)	66 (97)	280 (268)
Install insulation	Handle Insulation	Cut	Staple	Move Bench or Scaffold	Separate Insulation From Vapour Barrier	Reload Stapler	Miscellan- eous	Idle	Total
	243 (345)	38 (92)	216 (233)	33 (43)	11 (43)	24 (41)	37 (25)	86 (201)	696 (1031)
Install Window Frames and Sash	Move or Carry Frames	Chisel, Plane and Wedge Frames	Nail	Level or Plumb	Drill and Screw Sash	Install or Remove Brick Stops	Miscellan- eous	Idle	Total
	57 (106)	54 (37)	43 (61)	20 (19)	46 (51)	115 (62)	109 (187)	114 (163)	659 (755)
Exterior Doors and Frames	Move or Carry Material	Mark or Measure	Cut (hacksaw)	Wedge, nail and Plumb Frames	Plane or Saw Doors to Size	Install Hardware	Miscellan- eous	Idle	Total
	33 (54)	32 (29)	18 (19)	40 (61)	49 (34)	169 (140)	74 (111)	66 (80)	505 (528)

TABLE 4B

MATERIALS FOR INSULATION - ROOFING - EXTERIOR DOORS - WINDOWS

Operation	Material	Quantity in Place	
		House No. 1	House No. 2
Install shingles and eave protection	Asphalt shingles Nails Polyethylene	19.09 sq 51.0 lb 324.0 sq ft	19.10 sq 33.8 lb 305.3 sq ft
Flash chimney saddle	Galvanized Sheet Steel 28 ga. Solder Asphalt caulking tubes Asphalt shingles Nails	68.88 sq ft 0.70 lb 3 0.06 sq 1.0 lb	62.64 sq ft 0.72 lb 4 0.31 sq 1.13 lb
Install insulation	Glass fibre insulation Staples Vapour Barrier	1852.0 sq ft 2.11 box 397.0 sq ft	1993.2 sq ft 2.24 box 482.3 sq ft
Install window frames, and sash	Windows and frames Asphalt sheathing paper Staples Nails Plywood Screws Glazing compound Crezon shims Lumber	8 0.27 roll 0.09 box 1.5 lb 10.1 sq ft 88 4.5 lb n/a 0.7 fbm	8 0.42 roll 0.50 box 1.4 lb 6.32 sq ft n/a 13.0 lb 2.29 sq ft n/a
Exterior doors and frames	Wood doors and frames Aluminium Storm door Aluminium threshold Weatherstripping Steel butt hinges Latch sets Screws Nails Staples Asphalt Plywood Lumber Shingles	3 1 2 2 sets 8 3 4.67 doz .55 lb 0.02 box 75 sq ft 0.7 sq ft 0.6 fbm n/a	3 1 2 2 sets 9 3 4.25 doz 1.14 lb 0.15 box 48 sq ft n/a n/a 10

TABLE 5A

LABOUR FOR SERVICES (MAN MIN)
For House No. 1 with House No. 2 in Brackets

Plumbing	Carry Material or Equipment	Shovel, Tamp, etc.	Measure, Position, Plumb	Cut, Solder, or Join Pipes and Fittings	Install Service to House	Cut or Drill Framing	Install Fixtures	Miscellaneous	Idle	Total
	99 (177)	121 (364)	89 (91)	122 (182)	35 (65)	27 (34)	188 (173)	106 (107)	153 (663)	940 (1056)
Electrical	Carry, Handle or Sort Materials	Install boxes, Switches, Receptacles and Plates	Drill for Wiring	Measure, Cut, Strip, and String Wire	Install Straps	Move Ladder	Install Fixtures and Appliances	Miscellaneous	Idle	Total
	264 (306)	283 (392)	69 (65)	303 (34)	81 (64)	40 (24)	219 (249)	65 (48)	262 (356)	1586 (1898)
Heating	Carry or Sort Materials and Equipment	Install Furnace and Flue Pipe	Install and Connect Humidifier	Install oil Line and Meter	Install Main and Ext. W.A. Plenums and Takeoffs	Install C.A. Returns and Grilles	Install Branch Ducts, Boots and Grilles	Miscellaneous	Idle	Total
	181 (232)	41 (53)	42 (23)	39 (70)	111 (301)	246 (171)	143 (197)	27 (23)	248 (543)	1078 (1613)

TABLE 5B
MATERIALS FOR SERVICES

Operation	Material	Quantity in Place	
		House No. 1	House No. 2
Plumbing	Drainage and vent pipe fittings and traps	140.9 ft	144.0 ft
	Water pipe	45	50
	Water Pipe fittings	163.9 ft	172.3 ft
	Standpipe	52	56
	S.S. sink and faucet	1	1
	Vanity and fittings	1	1
	Toilet and accessories	1	1
	Bathtub and shower assembly	1	1
	Laundry tub and faucet	1	1
	Hot water tank	1	1
	Sand	11.20 cu yd (value \$3.60)	10.33 cu yd (value \$4.80)
	Miscellaneous		
Electrical	Wire	1150.83 ft	1121.67 ft
	Outlet boxes	61	61
	Light fixtures	18	18
	Circuit panel	1	1
	Switches, rectp., cover plates	80	80
	Stove	1	1
	Bell chimes, buttons,		
	transformer	1	1
	Air Filter	1	1
	Fan ventilator	1	1
	Light Bulbs	23	20
	Fuses	20	2
	Roof cap (fan vent)	1	1
	Miscellaneous		
		(value \$12.20)	(value \$11.70)
Heating	Furnace and fittings	1	1
	Copper oil line	59'-4"	58'-7"
	Oil line fittings and fixtures	7	9
	Round ducts	148.02'	105.09'
	Dampers and elbows	23	22
	Plenum components		
	Boots and takeoffs	26	21
	Diffusers and grills	18	16
	Cleats and hangers	92.1'	89.0'
	Galvanized sheet metal	42.42 sq ft	15.45 sq ft
	Miscellaneous	(value 60¢)	(value 65¢)

TABLE 6A

LABOUR FOR GYPSUM DRYWALL AND WALLTILE (MAN MIN)
For House No. 1 with House No. 2 in Brackets

Install Drywall and Metal Bead	Carry or Move Material	Nailing	Measure and Cut	Plumb or Level Metal Bead	Move Bench			Miscellaneous	Idle	Total
Finish Drywall	185 (178)	460 (342)	321 (270)	20 (4)	35 (25)			56 (51)	524 (404)	1613 (1274)
	Carry or Move Material or Equipment	Mixing Cement	Trowel	Sanding	Protect and Spray Ceilings	Repair Drywall	Move Bench	Miscellaneous	Idle	Total
Install Wall Tile	239 (195)	40 (44)	774 (711)	298 (382)	46 (81)	229 (116)	98 (69)	104 (57)	1003 (747)	2831 (2398)
	Handle or Carry Tools or Material	Cut, Mark or Measure Tile	Install Tiles	Cut and Install Metal Moulding	Mix and Apply Joint Filler	Scrape Off Excess Joint Filler	Wash and Rub Down Walls	Miscellaneous	Idle	Total
	30 (41)	19 (21)	94 (54)	15 (13)	21 (14)	7 (10)	16 (29)	15 (30)	39 (51)	256 (263)

TABLE 6B

MATERIALS FOR GYPSUM DRYWALL AND WALL TILES

Operation	Material	Quantity in Place	
		House No. 1	House No. 2
Install drywall and metal bead	Gypsum wallboard	3829.0 sq ft	3840.1 sq ft
	Metal corner bead	1621'-0"	1601'-4"
Finish drywall	Metal window bead	1431'-0"	n/a
	Nails	16.85 lb	14.30 lb
	Lumber	n/a	2.33 fbm
	Tape	1354.0 ft	1437.75 ft
	Jointing cement	10.97 bags	13.20 bags
	Stippling compound	1.33 bag	1.50 bag
	Vermiculite aggregate	0.11 bag	0.20 bag
	Sandpaper	(value \$1.10)	(value 50¢)
Install wall tile	Ceramic wall tile	56.27 sq ft	56.74 sq ft
	Tile cement	0.59 gal	0.69 gal
	Tile joint filler	23.60 lb	21.75 lb
	Plaster of paris	n/a	0.67 lb
	Metal edge moulding	11.67 ft	11.54 ft
	Nails	0.08 lb	0.10 lb

TABLE 7A

LABOUR FOR INTERIOR FINISH CARPENTRY (MAN MIN)
For House No. 1 with House No. 2 in Brackets

	Carry or Move Materials or Tools	Mark, Measure or Level	Sawing or Cutting	Nailing	Drilling and Screw- ing	Glueing and Planing	Install Wall Fixtures	Miscellan- eous	Idle	Total
Kitchen Cabinets, Vanity, Mirror, and Wall Fixture	177 (261)	81 (93)	64 (68)	55 (86)	132 (146)	43 (34)	13 (9)	65 (99)	94 (182)	724 (978)
Interior Doors and Frames	Handle or Carry Materials	Mark or Measure	Saw and plane	Nail or Screw	Sand, Chisel or Drill	Position and Wedge Frames	Move Bench	Miscellan- eous	Idle	Total
	227 (146)	45 (42)	62 (86)	196 (181)	124 (84)	142 (126)	7 (3)	100 (91)	234 (294)	1137 (1053)
Base Trim	Handle or Carry Material	Nail or Set Nails	Sawing	Mark or Measure	Sanding	Glue	Move Bench	Miscellan- eous	Idle	Total
	62 (79)	81 (81)	83 (81)	52 (51)	9 (3)	8 (2)	5 (2)	17 (43)	176 (130)	510 (472)
Basement Stairs and Handrail	Fabricate Stairs	Install Landing	Move Stairs into House	Install Stairs	Install Handrail			Miscellan- eous	Idle	Total
	111 (92)	29 (33)	14 (1)	14 (13)	24 (13)			14 (22)	39 (125)	245 (299)
Miscellan- ous Inter- ior Wood- work	Handle or Carry Material	Nailing and Setting Nails	Sawing	Mark or Measure	Sanding and Planing	Glueing and Screwing	Chiselling	Miscellan- eous	Idle	Total
	60 (104)	52 (130)	78 (64)	57 (62)	47 (70)	28 (24)	21	70 (57)	94 (131)	507 (642)
General	Carry or Move Table Saw	Remove and Sharpen Saw Blade						Miscellan- eous	Idle	Total
	(10)	(15)						(3)	(2)	(30)

TABLE 7B

MATERIALS FOR INTERIOR FINISH CARPENTRY

Operation	Material	Quantity in Place House No. 1	House No. 2
Kitchen cabinets, vanity, mirror and wall fixtures	Cabinets and hardware Medicine cabinet and mirror Miscellaneous Bathroom wall fixtures	14 1 5 (value \$1.00)	11 1 5 (value 25¢)
Interior doors and frames	Door frames Doors Latch sets Lock sets Butt hinges (with screws) Door stops Wedges Wood trim Nails Screws	10 14 7 1 8 pr. 8 6 237.2 lin ft 0.94 lb 32	10 14 7 1 8 pr. 8 6 236.8 lin ft 0.95 lb 32
Base trim	Base trim Plywood Nails	317.00 lin ft 0.22 sq ft 1.40 lb	317.41 lin ft n/a 1.49 lb
Basement stair and handrail	Lumber Plywood Handrail brackets with screws Asphalt paper Nails	104.10 fbm 11.5 sq ft 2 n/a 1.51 lb	105.42 fbm 11.2 sq ft 2 15.2 sq ft 1.74 lb
Miscellaneous interior woodwork	Lumber Wood trim Plywood Fibreboard Clothes hanger rails Frosted acrylic Hardboard screen Nails Screws	68.1 fbm 16.6 lin ft 6.40 sq ft 12.8 sq ft 24.6 lin ft 0.69 sq ft 3 pc. 1.33 lb 49	71.3 fbm 162.6 lin ft 8.17 sq ft n/a 24.6 lin ft 0.73 sq ft 3 pc. 2.09 lb 44

TABLE 8A

LABOUR FOR EXTERIOR FINISH AND FIREPLACE (MAN MIN)
For House No. 1 with House No. 2 in Brackets

Brick Veneer	Install Sheathing, Paper and Flashing	Install Brick Ties	Mix Mortar	Carry Mortar and Bricks	Erect or Move Scaffold	Lay Bricks	Clean Brick	Miscellaneous	Idle	Total
	51 (138)	31 (40)	68 (197)	303 (286)	56 (70)	561 (814)	62 (69)	46 (95)	225 (498)	1403 (2207)
Chimney and Fireplace	Install Flashing, Ties and Hardware	Install Flue Tile and Cap	Mix and Carry Mortar and Masonry	Erect or Move Scaffold	Lay Masonry	Clean Brick and Misc. Cleanup	Caulk or Trim around Fireplace	Miscellaneous	Idle	Total
	48 (113)	93 (99)	670 (677)	71 (46)	1469 (1418)	155 (81)	26 (33)	161 (106)	640 (1183)	3333 (3756)
Garport Storage, Ceiling and Beam Cover	Carry or Move Plywood or Lumber	Nailing	Sawing	Mark or Measure	Plumbing and Squaring	Plane	Erect, Move & Dismantle Scaffold	Miscellaneous	Idle	Total
	81 (122)	265 (357)	64 (72)	40 (61)	11	14 (28)	57 (82)	20 (39)	134 (247)	686 (1133)
Aluminium Siding	Install Sheathing Paper	Install Furring	Carry or Handle Aluminium	Measure, Cut and Level Aluminium	Nail Aluminium	Caulking	Move Ladder or Scaffold	Miscellaneous	Idle	Total
	101 (65)	273 (166)	271 (133)	316 (321)	266 (297)	53 (38)	95 (81)	93 (64)	228 (268)	1696 (11433)
Aluminium Soffits and Fascia	Move or Carry Material	Mark or Measure	Fit or Adjust	Nail Fascia	Nail Soffits	Cut	Erect and Move Scaffold	Miscellaneous	Idle	Total
	62 (92)	18 (10)	19 (5)	71 (50)	50 (51)	17 (18)	76 (94)	11 (17)	54 (103)	378 (1140)
Miscellaneous Trim	Move or Carry Material	Mark or Measure	Nail and Set Nails	Cutting	Erect and Move Scaffold	Lay Masonry	Caulk	Miscellaneous	Idle	Total
	18 (18)	23 (10)	37 (22)	12 (6)	19 (28)	(38)	(7)	9 (22)	50 (80)	168 (231)

TABLE 8B

MATERIALS FOR EXTERIOR FINISH AND FIREPLACE

Operation	Material	Quantity in Place	
		House No. 1	House No. 2
Brick veneer	Clay face brick	1880	1912
	Masonry cement	7.2 bags	7.4 bags
Chimney and fireplace	Sand	0.80 cu yd	0.82 cu yd
	Sheathing paper	291.50 sq ft	927.75 sq ft
	Brick ties	110	97
	Polyethylene flashing	35.17 sq ft	33.75 sq ft
	Nails	3.21 lb	4.49 lb
Chimney and fireplace	Clay face brick	1412	1602
	Back-up brick	599	564
	Firebrick	90	84
	Concrete block	212	55.5
	Artificial stone	244	226.4
	Flue tile	14	12
	Cement	17.2 bags	15.0 bags
	Sand	1.67 cu yd	2.10 cu yd
	Hardware	(value \$37.60)	(value \$37.60)
	Miscellaneous	(value \$4.00)	(value \$4.30)
Carport storage, ceiling and beam cover	Plywood	520.1 sq ft	494.1 sq ft
	Lumber	145.8 fbm	126.0 fbm
Aluminum siding	Nails	12.2 lb	8.8 lb
	Vertical siding	824.9 sq ft	808.7 sq ft
	Siding accessories	302'-11"	330'-2"
	Galvanized steel flashing	26'-0"	26'-10"
	Miscellaneous	(value \$8.60)	(value \$10.55)
	Furring	122.0 fbm	137.0 fbm
Aluminum soffits and fascia	Fascia	183'-9"	183'-8"
	Soffits	336.81 sq ft	336.04 sq ft
	J-trim	177'-9"	178'-0"
	Nails	0.98 lb	0.60 lb
Miscellaneous trim	Lumber	14.4 fbm	18.7 fbm
	Plywood	2.1 sq ft	n/a
	Face brick	n/a	13
	Cement	n/a	.05 bag
	Galvanized flashing	5'-11"	3'-1"
	Nails	0.75 lb	0.40 lb

TABLE 9A
LABOUR FOR FINISH FLOORING (MAN MIN)
For House No. 1 with House No. 2 in Brackets

Hardwood Flooring	Carry Material or Equipment	Mark or Measure	Cutting (saw or axe)	Nailing and Filling Nail Holes	Scrape and Sweep Floors	Sand Floors	Seal, Varnish and Buff Floors	Miscellaneous	Idle	Total
	201 (245)	33 (49)	90 (69)	320 (301)	125 (78)	229 (308)	109 (100)	76 (23)	337 (245)	1520 (1418)
Resilient Flooring	Handle or Carry Tools or Material	Mark or Measure	Sawing or Cutting	Nailing	Sanding	Lay Vinyl Asbestos Flooring	Clean up, Wax & Polish Floors	Miscellaneous	Idle	Total
	53 (60)	24 (21)	45 (50)	51 (47)	11 (5)	38 (32)	53 (52)	29 (29)	90 (155)	394 (451)
Ceramic Tile Flooring	Carry Material or Equipment	Install Mortar base & Reinforcing	Measure or Cut Underlay	Nail Underlay	Trowel Adhesive	Lay Tile & Fill Joints	Clean Tiles	Miscellaneous	Idle	Total
	29 (42)	90 (n/a)	(15)	(6)	(5)	47 (36)	10 (30)	16 (25)	80 (99)	272 (258)

TABLE 9B
MATERIALS FOR FINISH FLOORING

Operation	Material	Quantity in Place House No. 1	House No. 2
Hardwood flooring	Red oak flooring Power nails Nails Sandpaper Lacquer sealer Lacquer thinner Varnish Building paper	772.9 sq ft 3955 (value \$4.20) 1.38 lb 2.63 gal 0.75 gal 1.78 gal 51.7 sq ft	777.6 sq ft 3782 (value \$2.55) 1.86 lb 2.04 gal n/a 1.80 gal n/a
Resilient flooring	Plywood underlay Floor tile Inlaid linoleum Cement Stair nosing Staples Nails	152.3 sq ft 96.75 sq ft 25.60 sq ft 14.7 lb 3'-3" n/a 2.05 lb	136.3 sq ft 99.56 sq ft 23.74 sq ft 13.9 lb 3'-2 1/2" 0.13 box 0.14 lb
Ceramic tile flooring	Floor tile Plywood underlay Staples Nails Aluminum threshold trim Reinforcing mesh Adhesive Cement Sand	30.0 sq ft n/a n/a 0.84 lb n/a 3.42 sq yd n/a 0.95 bag 0.2 cu yd	28.7 sq ft 30.7 sq ft 0.03 box 0.03 lb 2'-0" n/a 2.7 lb 0.16 bag n/a

TABLE 10A

LABOUR FOR PAINTING (MAN MIN)
For House No. 1 with House No. 2 in Brackets

Interior Painting and Varnishing (not floor)	Carry or Move Materials or Equipment	Dip Brush or Roller	Sand and Paint Walls & Ceiling	Sand, Paint Woodwork, Folding Doors, & Steel Door Frames	Sand and Varnish Doors, Divider & Mantle	Putty Nail Holes and Cracks	Cleaning	Miscellaneous	Idle	Total
	341 (291)	133 (270)	781 (798)	1023 (1270)	251 (279)	173 (231)	7 (42)	221 (340)	317 (848)	3217 (4369)
Exterior Painting and Touch-up	Carry or Move Materials or Equipment	Dip Brush or Roller	Brushing Paint or Shellac	Rolling Paint	Clean Equipment	Ascend or Descend Ladder	Putty Nail Holes	Miscellaneous	Idle	Total
	37 (112)	38 (103)	143 (586)	86 (101)	5 (18)	16 (9)	22 (39)	10 (79)	115 (336)	472 (1383)

TABLE 10B
MATERIALS FOR PAINTING

Operation	Material	Quantity in Place	
		House No. 1	House No. 2
Interior painting and varnishing (except floors)	Paint Varnish Stain Spackling compound Masking tape Putty Touch up crayon Sandpaper	12.81 gal 0.80 gal 0.06 gal n/a (value 30¢) 0.15 lb 1/6 stick (value 30¢)	16.15 gal 1.11 gal n/a 0.04 bag n/a 0.20 lb n/a (value 25¢)
Exterior painting and touchup	Paint Boiled linseed oil Putty	1.90 gal 0.06 gal n/a	3.24 gal n/a 0.4 lb

TABLE 11A

LABOUR FOR MISCELLANEOUS OPERATIONS
For House No. 1 with House No. 2 in Brackets

Cleanup	Before Basement Slab & After Brick Work	After Framing and Gypsum Board Installation	After Rough Wiring and Plumbing	After Installation of Drywall	After Aluminum Soffits	After Floor Installation	After Trim and During Painting	Final Cleanup	Idle	Total
	102 (155)	291 (157)	41	4 (109)	(11)	17 (12)	94 (98)	782 (799)	340 (464)	1671 (1805)
Correction of Errors or Repair of Damage	Earthwork and Site Improvement	Basement	Rough Carpentry	Insulation - Roofing - Exit Doors - Windows	Services	Interior and Exterior Finish	Finish Flooring	Painting	Idle	Total
	F.E.L. (62) MEN (8)	(189)	444 (323)	195 (488)	43 (250)	130 (320)	160 (83)	(56)	F.E.L. (10) 354 (1072)	F.E.L. (72) 1326 (2789)
Delivery of Materials (by other than supplier)	Framing, Sheathing, Sub-floor Underlay	Trim, Windows, Doors, Frames and Hardware	Insulation & Vapour Barrier	Masonry & Masonry Hardware	Aluminum Siding & Carport Piers	Drywall	Paint and Basement Stairs	Sand and Tile for Bathroom	Idle	Total
	43 (24)	15 (71)	11	31 (132)	11 (12)	6 (12)	6 (6)	8	81 (160)	212 (417)

TABLE 11B

MATERIALS FOR MISCELLANEOUS OPERATIONS

Operation	Material	Quantity in Place	
		House No. 1	House No. 2
Repair basement slab	Concrete	n/a	0.56 cu yd.
Basement columns	Ramset shots and piers	6	n/a
Repair floor framing	Lumber Nails	n/a n/a	8.61 fbm 0.39 lb
Repair subfloor (bathroom)	Plywood Lumber Nails	44.0 sq ft 1.25 fbm 0.69 lb	0.71 sq ft n/a 0.05 lb
Repair fireplace header	Lumber Nails	11.91 fbm 0.21 lb	n/a n/a
Framing exterior walls	Lumber Plywood Nails	2.19 fbm 1.5 sq ft 1.6 lb	n/a n/a n/a
Repair exterior sheathing	Gypsum sheathing Nails	20.24 sq ft .44 lb	n/a n/a
Repair glazing and doors	Nails Lumber	Neg 6.40 fbm	0.08 lb n/a
Repair insulation	Insulation Waxed paper vapour barrier Polyethylene Staples	n/a n/a n/a n/a	0.19 carton 41.92 sq ft - 0.26 box
Sewer and water service	Transite	n/a	10'-0"
Repair hardwood flooring	Red oak flooring Nails	n/a n/a	0.6 sq ft 0.02 lb
Repair underlay resilient flooring	Plywood underlay Nails	n/a n/a	0.62 sq ft Neg.

TABLE 12

SUMMARY OF MATERIALS WASTE OR SCRAP

Operation	Material	% Scrap or Waste		Cost	
		House #1	House #2	House #1	House #2
Basement	Crushed stone	10.00	n/a	4.75	n/a
	concrete	0.37	4.72	1.43	12.13
	4" clay drain tile	9.33	6.94	1.45	1.04
	4" clay corner tile	-	27.30	-	.86
Rough carpentry	2" x 8" No. 1 spruce	5.79	0.15	11.59	.25
	2" x 4" No. 1 spruce	4.61(est)	4.61	12.25	10.36
	1" x 8" No. 1 spruce	n/a	5.00	n/a	.32
	1" x 4" spruce strap-				
	ping	5.24	8.14	.97	1.66
	1/2" gypsum sheathing	4.18	7.53	2.24	3.14
	3/8" sheathing				
	grade spruce ply.	1.50	1.40	3.02	2.82
Insulation - roofing	insulation	0.43	0.38	.54	.52
	- exterior doors -	0.37	1.33	.56	2.08
windows	shingles				
Gypsum drywall	ceramic wall tile	.44	1.20	.19	.52
	1/2" gypsum wallboard	7.13	7.92	19.56	20.23
	metal corner bead	16.24	6.41	1.29	.44
Interior finish carpentry	2 1/4" base mould	9.3	21.8	2.73	7.49
	1/2" x 3/4" shoe mould	17.4	23.2	.23	.25
	steel clothes hanger				
	rail	10.2	9.5	.64	.54
	2 1/2" casing mould	n/a	21.7	n/a	3.52
	No. 1 white spruce	18.0	18.4	2.92	2.98
	2" x 10" No. 1 spruce	n/a	4.8	n/a	.46
	moulded counter top	7.4	13.9	5.96	11.24
Finish flooring	9" x 9" vinyl				
	asbestos tile	5.5	4.32	1.29	1.04
	embossed inlaid lino	8.57	11.02	1.47	1.80
	oak flooring	2.00	1.74	6.14	4.93
	ceramic floor tile	.00	4.33	.00	.64
	1/4" poplar underlay	n/a	4.88	n/a	.49
Exterior finish and fireplace	5" aluminum fascia	1.30(est)	1.30	.72(est)	.72
	40" x 24" soffit				
	panels	1.01(est)	1.01	1.16(est)	1.17
	vertical clapboard				
	siding	13.47	19.50	38.06	58.09
	1" x 2" spruce				
	strapping	8.55	6.90	.96	.75
	clay face brick	1.56	0.71	4.26	2.08
	artificial stone	1.29	1.60	.44	.52
	chimney cap	7.69	7.69	1.43	1.43
fire brick	fire brick	1.09	1.41	.23	.27
	redwood mantel	11.53	8.03	1.69	1.18
Other misc. scrap or waste				5.15	5.39
TOTALS				140.94	167.59

TABLE 13
MARK V - COST/UNIT

Operation	Cost/Unit House #1	Cost/Unit House #2
1. Excavation	.29/cu yd	.45/cu yd
2. Top soil and grading	.21/cu yd	.26/cu yd
3. Laying sod	.36/sq yd	.40/sq yd
4. Laying walkways	.36/sq ft	.52/sq ft
5. Driveway (inc. base)	.14/sq ft	.17/sq ft
6. Footings (form, place and strip)	20.43/cu yd	22.02/cu yd
7. Foundation walls (form, place, strip, drain tile, parge and dampproof)	.75/sq ft of foundation wall	.73/sq ft of foundation wall
8. Basement slab (with crushed rock or polyethylene beneath)	.28/sq ft	.25/sq ft
9. Floor framing (basement columns beams, sill plates, joists, strapping)	.30/sq ft (based on ext. of found.)	.30/sq ft (based on ext. of found.)
10. Subfloor (including dropped subfloor)	.15/sq.ft. (based on ext. of found.)	.15/sq ft (based on ext. of found.)
11. Exterior wall framing and sheathing	.23/sq ft of wall	.25/sq ft of wall
12. Interior partition framing	.16/sq ft of wall	.17/sq ft of wall
13. Roof and ceiling framing (trusses, fascia, back-up, dropped ceiling, access hatch)	.28/sq ft of ceiling	.26/sq ft of ceiling
14. Roof sheathing (inc. chimney saddle)	.12/sq ft of roof surface	.12/sq ft of roof surface
15. Roofing	.12/sq ft of roof surface	.12/sq ft of roof surface
16. Insulation	.09/sq ft	.10/sq ft
17. Windows (frames, sash and glazing)	4.14/sq ft of rough opening	3.36/sq ft of rough opening
18. Exterior doors (frames, doors, hardware)	59.44/door 2.61/sq ft of rough opening	59.14/door 2.60/sq ft of rough opening
19. Storm door	25.21/unit	25.21/unit

Table 13 (cont'd)

- 2 -

Operation	Cost/Unit House #1	Cost/Unit House #2
20. Sewer and water service to house	3.41/lin.ft	5.52/lin.ft
21. Electrical (less range and hanging fixtures)	3.67/outlet	3.98/outlet
22. Heating system	.42/sq ft of floor area	.44/sq ft of floor area
23. Wallboard (gypsum board, beading, taping, finishing, touchup)	.15/sq ft	.14/sq ft
24. Ceiling finish (spray)	.02/sq ft of ceiling area	.03/sq ft of ceiling area
25. Wall tile (including joint filling)	1.26/sq ft	1.25/sq ft
26. Base trim	.20/lin.ft	.19/lin.ft
27. Basement stairs and hand rail	3.93/riser, or 43.25/unit	3.00/riser, or 32.98/unit
28. Interior sliding doors (frame, trim, and hardware)	28.57/unit, or 1.53/sq ft of rough opening	27.61/unit, or 1.56/sq ft (rough opening)
29. Interior swing doors (frame trim, doors, and hardware)	26.19/unit 1.52/sq ft of rough opening	26.02/unit 1.53/sq ft (rough opening)
30. Interior bifold doors	10.09/door .71/sq ft of rough opening	9.97/door .70/sq ft (rough opening)
31. Hardwood floors (lay, sand, and varnish)	.57/sq ft	.51/sq ft
32. Resilient flooring (underlay, tile, and waxing)	.68/sq ft	.63/sq ft
33. Ceramic floor tile (base, tile, and joint filling)	1.14/sq ft	1.20/sq ft
34. Brick veneer (paper, ties, masonry)	.85/sq ft	1.03/sq ft
35. Aluminum siding (paper, strapping, aluminum)	.48/sq ft	.48/sq ft
36. Aluminum soffit's and fascia	.63/sq ft of soffit area	.65/sq ft of soffit area

Table 13 (cont'd)

- 3 -

Operation	Cost/Unit House #1	Cost/Unit House #2
37. Exterior wood trim	.76/bfm	.68/bfm
38. Interior painting (one coat work)	.02/sq ft	.02/sq ft
39. Interior painting (two coat work)	.05/sq ft	.08/sq ft
40. Exterior painting	.07/sq ft	.14/sq ft
41. Carport piers and columns	23.88/pier and column	24.28/pier and column
42. Carport ceiling and beam cover (and blocking)	.31/sq ft	.28/sq ft
43. Carport beam	.14/floor	.19/floor
44. Plywood siding and battens (storage)	.28/sq ft	.23/sq ft
45. Storage shed framing	.11/sq ft of wall	.13/sq ft of wall