IV–43. Loadbearing Masonry for Moderate Income Single Family Housing

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ABSTRACT

In Canada, the recent use of masonry in single-family housing has been largely limited to basements and complete or partial veneer attached to wood frame constuction. Individual houses built with loadbearing masonry have tended to be designed for a particular purchaser and generally have been in the high price range. This paper describes the venture into the housing market by a group of masonry contractors in Saskatoon, Saskatchewan. They decided that loadbearing masonry construction could be competitive with frame construction on an economic basis and would be superior on the basis of quality, maintenance, heating and general user acceptance for moderate income single family housing. Several different sets of plans were prepared but all incorporated the same basic structural form. This consisted of block basements which supported precast concrete floor slabs and loadbearing 4 in. (100 mm) or 6 in. (150 mm) brick walls. The insides of the walls were insulated with 2.5 in. (62 mm) of polystyrene and covered with drywall. Wood trusses were used for the roof construction. During the past two years parts of several sub-divisions have been built using this form of construction. The costs and the selling prices have been competitive with frame houses of similar size. The initial sales had to be made essentially on the basis of competitive price. However, there is evidence from interviews with the home owners that they are not only happy with their homes but also place some substantial, but unquantified, value on the quality, low heating costs and low maintenance attributes of their homes. One owner even asked that a similar home be built for him in the town where he is moving. Details of the form of construction and information on comparative costs are provided in the paper.

Au Canada, le récent usage de la maconnerie dans les maisons unifamiliales a été limité principalement aux soubassements et à la finition extérieure, totale ou partielle, attachée à la charpente de bois. Les maisons individuelles construites avec des murs portants en maconnerie ont été concus pour un acheteur particulier et ont généralement été vendues à un prix élevé. Cet article décrit l'entreprise risquée à l'intérieur du marché du logement un groupe de contracteurs en maconnerie à Saskatoon, Saskatchewan. Ils ont juge que la construction avec de la maconnerie portante pouvait être compétitive avec la construction à charpente sur une base économique, et pouvait même être supérieure au niveau de la qualité, de l'entretien, du chauffage et des exigences générales de l'usager des maisons unifamiliales pour familles à revenu moyen. Différentes séries de plans ont été préparées mais toutes étaient basées sur la même forme structurale. Celle-ci consistait en un soubassement en blocs de maconnerie supportant un plancher composé de dalles de béton préfabriquées, et des murs portants en briques de 4 po. (100 mm) ou 6 po. (150 mm). L'intérieur des murs a été isolé avec 2.5 po. (62 mm) de polystyrène, et recouvert d'une feuille de gypse. Des poutres en bois ont été utilisées pour la construction du toit. Au cours des deux dernières années, certaines parties de plusieurs développements domiciliaires ont été fabriquées en utilisant ce type de construction. Les coûts et les prix de vente ont été compétitifs avec les maisons à charpente de format similaire. Les ventes initiales se devaient d'être faites essentiellement sur la base du prix compétitif. Cependant, à la suite d'entrevues avec les propriétaires des maisons, il est évident que ces derniers ne sont pas uniquement heureux dans leurs nouveaux foyers mais qu'ils attachent une importance substantielle, mais non-quantifiable, à la qualité, aux coûts minimes de chauffage et au peu d'entretien nécessité par leurs maisons. Un propriétaire a même demandé qu'une maison similaire lui soit construite dans la ville où il deménage. Les détails du type de construction et l'information sur les coûts comparatifs se retrouvent dans cet article.

In Kanada der neuzeitliche Gebrauch des Mauerwerks in Einfamilien-häuser wäre hauptsächlich begrenzt zu Kellern und vollkommen oder teilweises Mauerwerk verbunden zur Holzrahmenkonstruktion. Einzelne Häuser gebaut mit lastragendem Mauerwerk zeigten die Tendenz zum Entwurf für den einzelnen Käufer und waren im hohen Preisrang. Diese Arbeit beschreibt ein Wagnis im Häusermarkt von einer Gruppe von Mauerwerk Unternehmern in Saskatoon, Saskatchewan.

Sie entschieden dass die Konstruktion des lasttragenden Mauerwerkes ökonomisch Konkurrenzfähig mit Rahmenkonstruktion sein könnte und dabei überlegen auf der Base der Erhaltung, Heizung und allgemeiner Gebrauchsannahme für Einfamilien-häuser der Mittlestand. Verschiedene Pläne wurden vorbereitet aber alle enthielten dieselbe grundsätzliche structurform. Diese bestand aus Block-kellern die "precast" Betonfussböden-

platten uterstützen und die 4 zoll (100 mm) oder 6 zoll (150 mm) dicken lasttragende Ziegelmauern. Die Innenseite der Wände wurden mit 2.5 zoll (62 mm) dicken Polystyren insuliert und mit "Trockenwand" (drywall) verkleidet. Holzfachwerk wurde für die Dachkonstruction benutzt. Während der vergangenen zwei Jahre Teile von einigen Unter-siedlungen (sub-divisions) wurden mit dieser Art von Konstruktion gebaut. Die Kosten und die Verkaufspreise wäre wettbewerbungsfähig mit Rahmenhäusern von ähnlicher Grösse. Die erste Verkäufe mussten wesentilich auf der Base der wettbewerblichen Kosten. Aber es gibt Beweise durch Besprechungen mit Hausbesitzern, dass sie nicht nur zufrieden mit ihren Häusern sind, sondern geben auch einen wesentlichen, abert nicht-quantitativen Wert für die Qualität, die niedrige Heizungskosten und die neidrigen Erhaltungsattributen ihrer Häuser. Ein Besitzer forderate sogar dass ein ähnliches Heim für ihn in der Stadt gebaut würde in die er zeiht. Einzelheiten der Form der Konstruktion und Auskunft über Kostenvergleiche sind in dieser Arbeit gegeben.

INTRODUCTION

In Canada, the recent use of masonry in single family housing has been mainly limited to basements and to complete or partial veneer attached to wood frame construction. The relatively few individual houses which have been built with loadbearing masonry have tended to be custom designed for particular purchasers and generally have been in the high price range.

This paper provides some details of the venture into the housing market by a group of masonry contractors in Saskatoon, Saskatchewan. They felt that loadbearing masonry construction could be competitive with frame construction on an economic basis. In addition it was hoped that the superior quality of construction, the low maintenance, and the thermally efficient design would be significant factors in gaining general buyer acceptance for moderate income single family housing.

BASIC DESIGN DETAILS

Several different sets of house plans were prepared but all incorporated the same basis system which is described below according to component area.

Basement

An 8 ft. high basement wall consisting of reinforced concrete block masonry was supported on reinforced concrete strip footings as shown on the drawing of the typical wall section. With allowance for the 3 in. thick concrete basement floor, this left ample head room for possible full utilisation of the basement as living area. The block walls were reinforced horizontally with standard continuous joint reinforcement spaced at 2 ft. centres. In addition the top block of the wall was a lintel block which formed a horizontal bond team around the perimeter of the basement when filled with grout and reinforced with a 5/8 in. diameter reinforcing bar. Vertical reinforcement consisted of 5/8 in. diameter bars grouted into the block cores coinciding with similar dowels in the footing. The spacing of the vertical bars varied from 2 to 4 ft. depending upon the height of backfill around the basement.

In most cases a 1.5 in. thickness of rigid polystyrene insulation was placed on the inside of the basement wall over which was placed a 2 mil. thick polyethylene vapour barrier. This was protected by covering with ½in. thick gypsum board (dry wall) fastened to nailing strips at the top and bottom. The outside of the wall was parged and had an exterior waterproof coating applied below grade.

In some of the houses which were constructed in the early stages of this venture and where the ground level was fairly high, insulation was placed on the outside of the basement wall as shown in the drawing of Figure 2. This positioning of the insulation had the consequence of requiring a protective covering on the outside of the wall and of requiring provision of a continuous 4 in. by ¼in. steel bearing plate for the brick masonry above in order to permit it to extend out over the insulation (see Figure 2). The bearing plate was anchored to the bond beam using 3/8 in. diameter studs as shown in Figure 2.

Floor

The floors were constructed using 8 in. deep by 4 ft. wide precast concrete slabs. The slabs were set in place on top of the concrete block basement walls using ¼ in. thick bearing pads made of flexibile material. This permitted deflection of the slabs without resulting in edge bearing along the inside of the basement wall.

Use of this type of precast concrete floor system has the practical advantages of:

1. Providing a floor system which is quickly installed and therefore permits backfilling around the basement and work on the above grade walls to continue without much delay.
2. Spanning across the full width of the basement and thereby eliminating the need for intermediate column and a centre beam to support the floor. Therefore, because the floor has this sufficient strength and stiffness, head room and flexibility of the use of the basement area are preserved.
3. Providing the air ducts for distribution of heating by using some of the hollow cores within the precast slabs. Therefore only a relatively small external feeder duct system was needed which again eliminated most of one of the major sources of loss of head room in many basements.

Additional advantages of the precast concrete floor system included providing fire resistance and an excellent barrier to airborne sound. Provision of carpets with underpadding also eliminated most of the transmission of noise due to impact.

Above Grade Walls

The load carrying function as well as the aesthetic quality of the above grade walls was provided by the reinforced brick. The minimal reinforcing with ½ in. diameter vertical bars at 4 ft. spacing is necessary to resist the bending due to wind loading when the 4 in. wide brick walls are simply supported only at the top and bottom of an 8 ft. clear height as is shown in Fig. 1.

The wall was insulated with a 3 in. thickness of polystyrene (styrofoam) placed on the inside of the wall and covered with a 2 mil. thick polyethylene vapour barrier and ½ in. thick gypsum board (dry wall). A 1½ in. thickness of polystyrene was carried down between the floor slab and the wall to reduce the thermal bridging in this region. Also, as shown in Figure 2, flashing was provided at the base of the brickwork in order to prevent any water which might have entered the ungrouted cores of the brick from passing through the wall.

The usual brick used was 2¼ in. high by 8 in. long but the larger 12 in. long by 3.⅝ in. high brick was easily substituted in some homes. The bricks were a type which had two large rectangular cores and therefore grout was fairly easy to place around the ½ in. diameter bars as construction progressed. In addition to the normal 4 ft. spacing of the reinforcement, bars were grouted in the cores immediately next to door and window openings.

In the initail stages some homes were built using the 6 in. wide SCR brick. However, the 4 in. brick proved to be more economical in terms of labour and materials as well as having the advantages of leaving more usable floor area and eliminating some problems associated with bearing areas on the 7.⅝ in. thick basement wall.

Roof

The roof was designed to use prefabricated roof trusses at 2 ft. spacing covered with ⅜ in. thick plywood and cedar shakes. The 2 ft. roof overhang was fitted with a soffit as shown in Figure 1. The roof trusses were attached to a 2 x 8 in. wood plate which was anchored into the brick as shown in Figure 3. Later designs used a 2 x 4 in. plate over the brick which allowed the wall insulation to extend to the ceiling and eliminated the thermal bridge caused by the 2 x 8 in. plate.

Initial designs called for a ceiling insulation with a thermal resistance rating of R-20. Very recently this has been increased to R-35.

SURVEY OF HOME OWNERS IN SASKATOON

Although the resources were not available to permit an extensive survey of home owners to be carried out, it was thought that some comparison between the masonry homes and other standard single family housing might provide an indication of the relative performance and of the potential of this type of construction.

It was decided that the principal areas for comparison should be value of the home, heating cost, and general comments concerning comfort and maintenance.

General Description of the Sample

Seven replies were received from owners of the masonry homes and 14 data sheets were obtained from owners of other homes. Each owner was asked to indicate the year when the house was built and the year of purchase as well as the purchase price. In addition a general description of the type of construction was requested, including the square footage of the main floor living area, type of insulation and type of heating. Also heating costs for 1978 and 1977 (if applicable) were requested as well as indicating if any other charges were included in the heating costs.

Table 1 contains a summary of the mean values of the collected data. The masonry homes were all of the same basic single storey type of construction and had been built between 1975 and 1977. (This assured at least one complete year of heating cost information.) The other homes were all of wood frame construction and had been built in the period between 1952 and 1978. Because of this wide variation in age of homes, the data from sub sets of this group were also averaged according to period of construction or exceptional insulation features. Of these 14 homes, 5 had stucco exteriors, 5 had a combination of stucco and various types of siding, 1 had a wood and brick combination, 1 had masonite siding, and 2 did not have the exterior cladding adequately described.

All the homes surveyed were heated by gas and all but one of the non masonry homes included heating the water in the heating costs. Therefore, to be consistent, the cost of heating this home was only used in the summaries for the total number of non masonry homes where the mean values were not sensitive to this modification.

Almost all the houses had finished or partially finished basements and all the basements received some degree of heating. Therefore, since the effects of the basements would tend to be similar, no attempt was made to account for basement living area in the recorded main floor areas of the houses.

Mean Cost of the Homes

Since the houses were purchased at different times and had different floor areas, it is difficult to devise a meaningful basis for comparison of value. However, in order to achieve some form of standardisation, the purchase prices were converted to 1978 values by arbitrarily increasing the purchase price by 9 percent per year from the year of purchase. Obviously the reliability of this information is better for groups of relatively new homes.

Several of the non masonry homes had been built by the owner and therefore the reported purchase price may have varied considerably depending on the value placed on the owner's own labour. This plus the other factors mentioned make it necessary to emphasise the approximate nature of the house value figures and to make the point that for the non masonry homes, these values should only be used as very approximate indications of cost.

Mean Heating Cost for the Homes

The insulation standard for the masonry homes was quite uniform whereas for the other houses, the standard

was quite variable but with a definite trend for higher thermal resistances for the newer homes. The extreme of this were four houses built in 1977 and 1978 where the minimum thermal resistances for the walls and ceilings were R-20 and R-40 respectively. The data from these four houses had a significant beneficial effect on the mean values of the data for all the sub sets of the non masonry homes. Therefore the mean values for these four houses alone were also presented in Table 1.

DISCUSSION OF THE RESULTS OF THE HOME OWNER SURVEY

As might be expected the heating costs per square foot were less for the masonry homes than for the non masonry homes until all those homes built before 1975 were excluded from the sample. Then the influence of the four homes with the very good insulation can be seen as the non masonry homes exhibit better thermal performance. Since the costs of the masonry homes are similar to the non masonry homes built in this period, the recent change in masonry home design to include a thermal resistance of R-35 in the ceiling seems to be a sound idea. This should not increase the cost of the house much and will result in significant additional energy saving.

The owners of the non masonry homes were generally pleased with the comfort of their homes and did not seem to think that the maintenance was very significant (basically stucco and prefinished siding). The owners of the masonry homes also felt that their homes were very comfortable and solid. Some commented on the even heating due to using the concrete floors as heating ducts, and mentioned that the furnace fan should be run at low speed to keep the warm air circulating during long periods when the furnace is not on. They all indicated an appreciation for the feature of very little maintenance being required in the future.

CONCLUSIONS

The venture which Masonry Homes Ltd. has undertaken has provided some interesting if not conclusive information regarding the potential for single wythe loadbearing masonry for moderate income single family housing. Although several dozens of this type of masonry home have been built each year since 1975, it would require a much more thorough financial analysis to be able to provide an absolute comparison of relative housing costs. This would have to include such aspects as relative profit margins for the developers and builders as well as assessment of the influence of marketing. Therefore, from the information gathered, about the most definite statement that can be made is that the first price cost of this type of masonry is competitive with similar costs of modern homes having good thermal resistance features. This in itself is significant since the cost of double wythe cavity construction and even brick veneer have not been found to be competitive with wood frame and siding construction.

If the first cost price of this type of home can be maintained at a competitive level with adequate profit margin for the developers then it would seem that a steady market for this type of construction can be developed. However, it is suggested that the development of this type of market could be helped by acting on several factors:

1. The thermal resistance of the original design was considerably better than standard housing at that time. However, the increased awareness of heating costs has resulted in modern housing having significantly better insulation. The recent increase in thermal resistance to R-35 will make the masonry homes competitive in this area. Since increases in thermal resistance beyond this range are not generally considered to be very efficient, advantage should be taken of the relative air tightness of the masonry form of construction by assuring that other areas such as around windows and around dampers in fireplaces are airtight.
2. Those who are familiar with masonry construction may have the idea or even the experience of single wythe masonry suffering from leakage due to rain penetration. This perceived problem could have a negative influence unless it is pointed out that rain penetration has not been a problem. This is attributable to several factors, the most important of which is that the design calls for adequate roof overhang and that specific details have been prepared for around doors and windows. In addition the general airtightness of the wall and the fact that it is held together by reinforcing tend to decrease the potential for rain penetration.
3. Most owners and particularly first home buyers are not very concerned about what are considered to be minor differences in maintenance between siding and brick. Data on maintenance and on long term resale value would likely have some positive effect on sales. However, it is suggested (1) that factors such as this and aspects such as improved sound insulation, better fire protection, more usable basement area, and overall soundness of this type of masonry home must in general be promoted as extra benefits without much extra cost until home buyers become educated to placing a monetary value on them such as is the case now for thermal insulation.
4. In some other parts of Canada, there has been more of a tendency for brick exteriors to be considered to be indicative of better quality homes (1) whereas stucco and to a lesser extent some of the siding materials are thought to be less desirable. Therefore, this type of masonry home may have a greater competitive advantage in such regions.

In general it is concluded that the type of venture which was briefly described in this paper is the kind of thing that the masonry industry should be doing to increase the use of masonry in single family housing. Unless the economic advantages were very obvious and substantial, it cannot be expected that current developers and home builders will want to deviate from their established and successful modes of operation. Therefore, it seems to be a sound approach to prove the value and competitiveness of

masonry construction by competing in the housing market.

REFERENCES

1. Drysdale, R. G., "Factors Affecting the Selection of Masonry for Single Family and Low Rise Multiple Housing," Masonry Report, McMaster University, Hamilton, Ontario, Aug. 1979.

ACKNOWLEDGEMENTS

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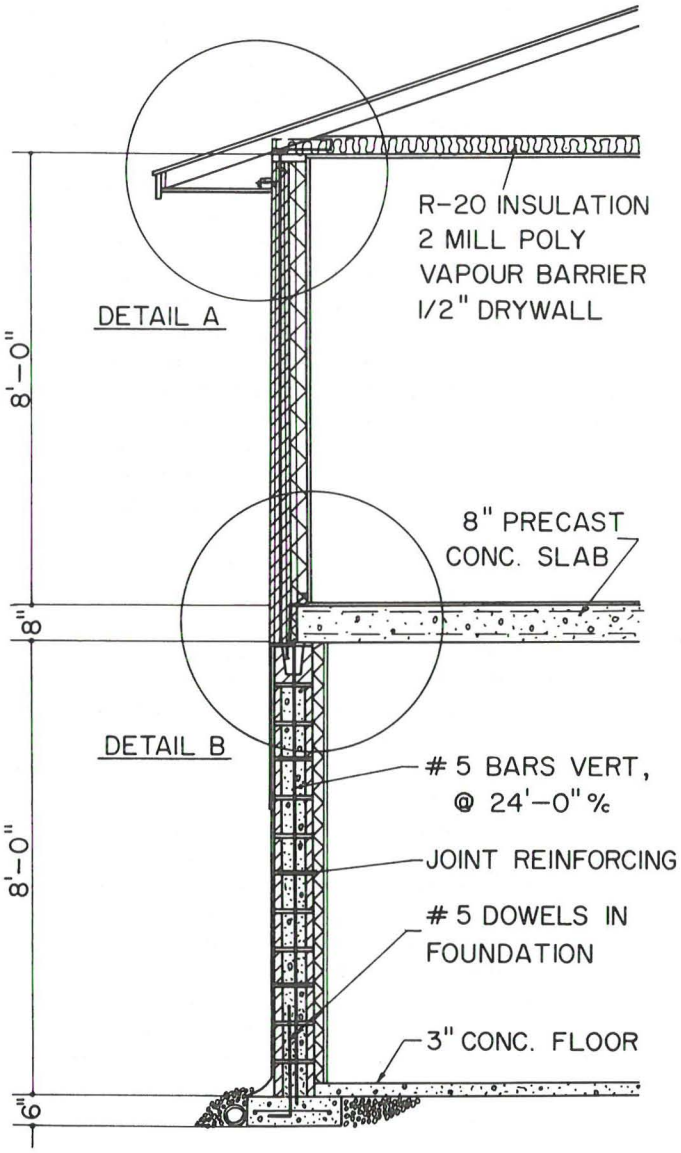

Figure 1. Typical wall section

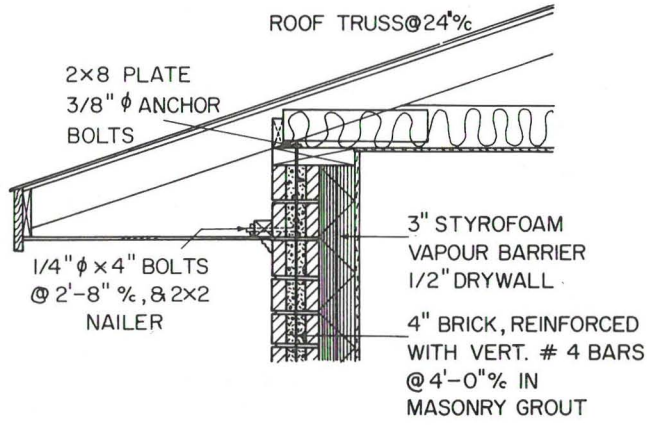

Figure 3. Detail A. Section thru eave

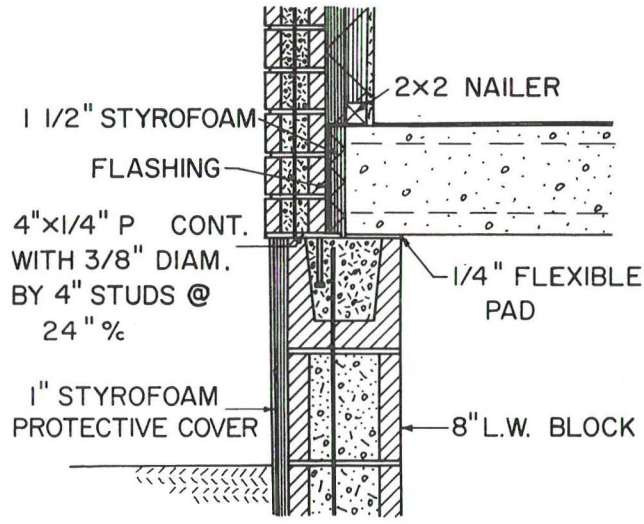

Figure 2. Detail B. Conc. slab to bond beam detail

Table 1—Summary of Survey Data (Mean Values)

	Group	No. of Houses	Year of Constr.	Year Purchased	Living Area ($ft.^2$)	1978 Value ($/home)	1978 Value ($/$ft.^2$)	1978 Heating Cost ($/home)	1978 Heating Cost ($/$ft.^2$)
	Masonry Homes	7	1976	1977	1190	61,600	51.80	318	0.27
Non Masonry Homes	Total	14	1970	1974	1095	45,000	41.10	334	0.31
	Built since 1970	9	1975	1976	1123	50,400	44.90	327	0.29
	Built since 1975	6	1976	1976	1215	58,300	48.00	319	0.26
	High Insulation	4	1977	1977	1292	66,900	51.75	291	0.23