THESIS

THE PRACTICABILITY OF CONSTRUCTING ONE STORY CONCRETE HOUSES IN VERTICAL PORTABLE SECTIONS

OSCAR R. BEAL

1921

The Practicability of Constructing One Story Concrete Houses in Vertical Portable Sections.....

By

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Technical Problem for Spring Term

1921.

Civil Engineering Division of M. A. C.

Order of Books.

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2. Detailed Drawings of Proposed Sections.
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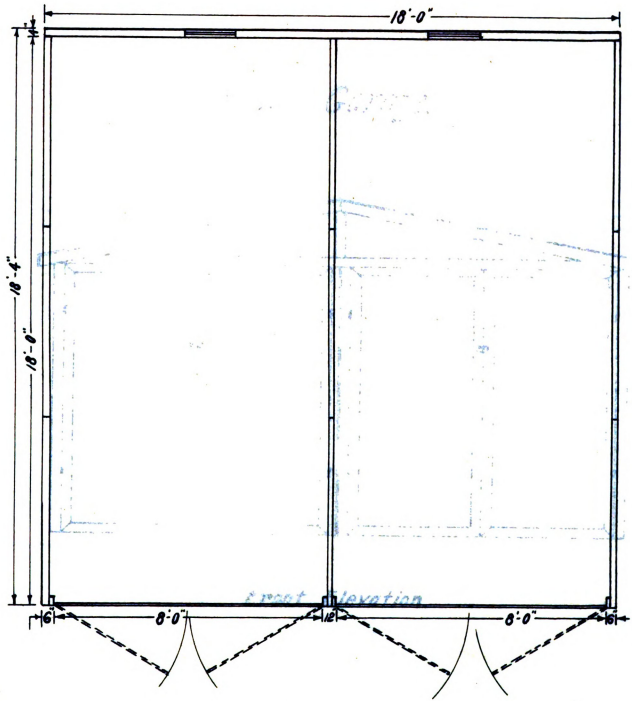
General Description of the Proposed Type.

About a year ago the idea was first conceived of building one story concrete houses and garages in vertical portable sections. At that time the idea did not seem practical. Now, however, after having given the subject considerable thot, it is believed that, with alterations, the idea may be all right. The object of this problem is to determine whether or not it would be practical to construct the proposed buildings in vertical portable sections.

Believing that the idea is practical, and attempt shall be made to prove three things; first, that it is possible to build the house in sections, second, that the cost of material will be less if the house be built in sections, third, that the house (including cost of labor) will cost less if built in sections.

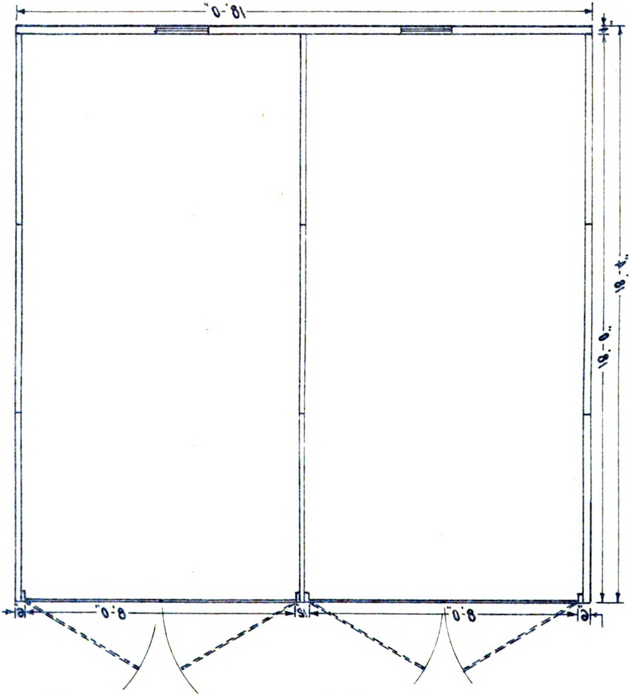
To prove the above, a model house and a model garage will first be designed. The house will be a small one story structure such as might be used for cottages at lakeside resorts or for workingmen's homes in the factory districts of our larger cities, or wherever a four to six room house is desirable. The garage will be a two car garage.

Model Garage.



Floor Plan.

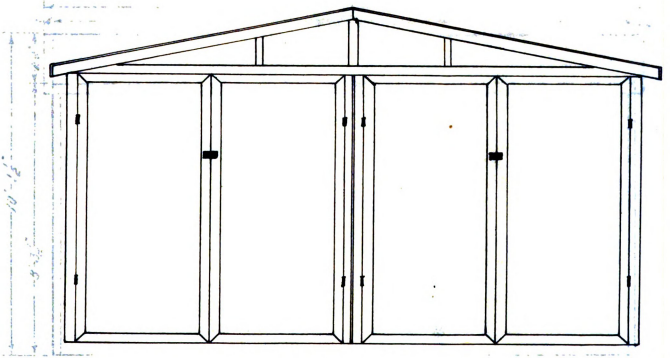
Model Garage.



Floor Plan.

(1.)

Model Garage.

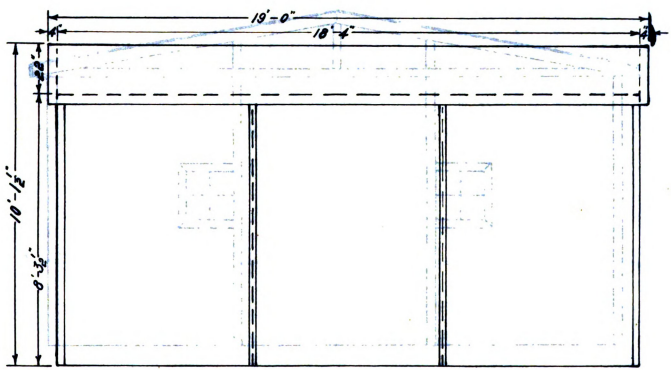


Front Elevation.

Model Garage.

Front Elevation.

Model Garage



Rear Elevation.

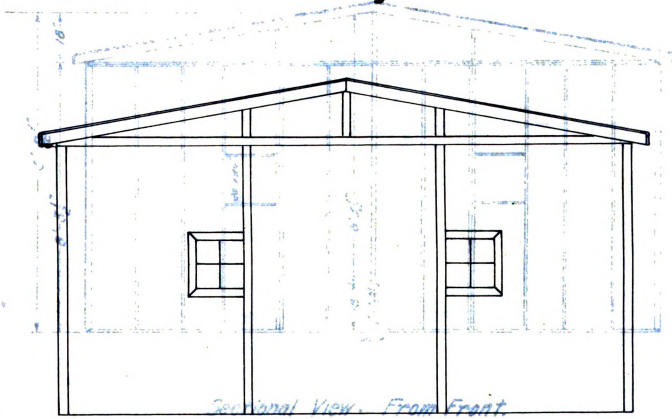
Side Elevation.

Model Carriage

Side Elevation.

Model Garage.

Model Garage.



Rear Elevation.

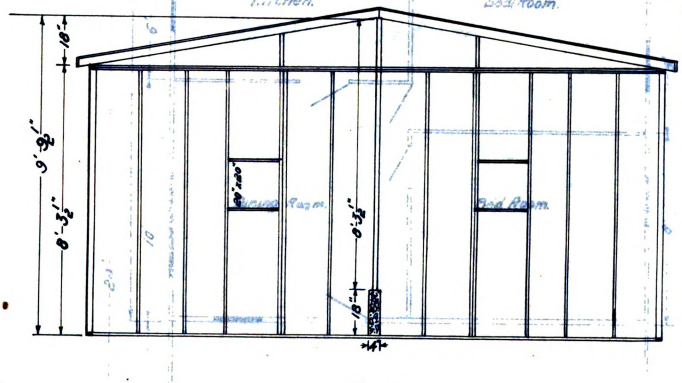
Model Garage

Rear Elevation

(4)

Model Cottage.

Model Garage.



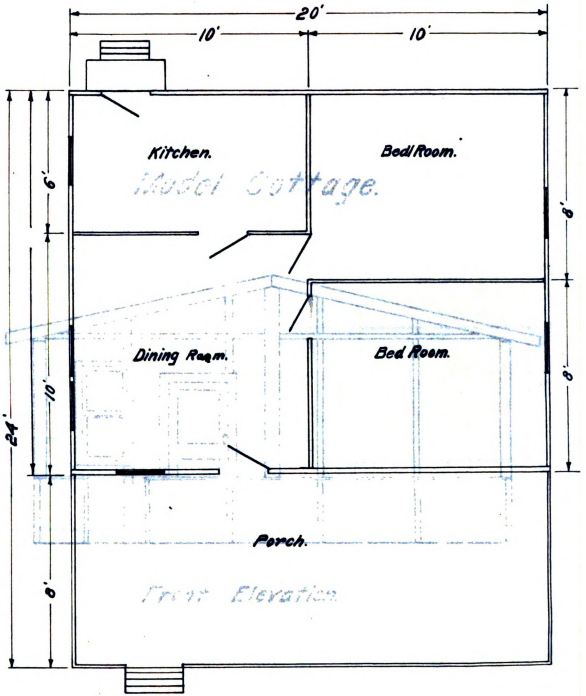
Sectional View: From Front.

Floor Plan.

Model Garage.

Sectional View: From Front.

Model Cottage.

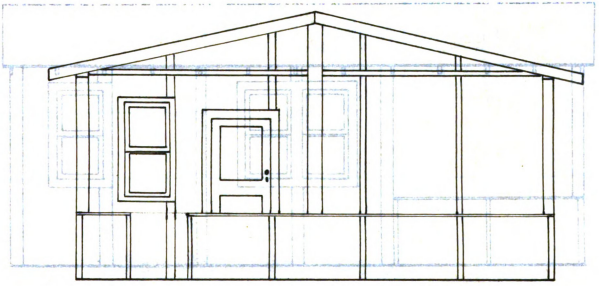


Floor Plan.

Model Cottage.

Floor Plan.

Model Cottage.



Front Elevation.

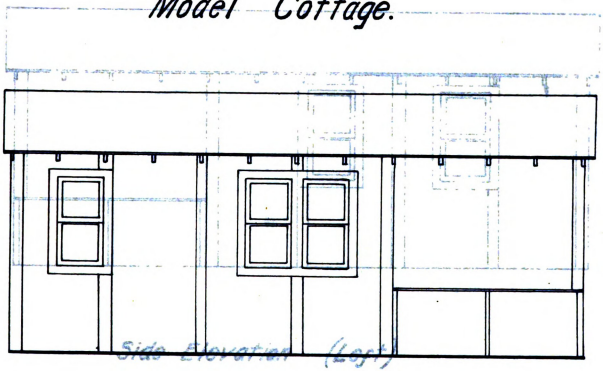
Side Elevation. (Right)

Model Cottage.

Front Elevation.

Model Cottage.

Model Cottage.

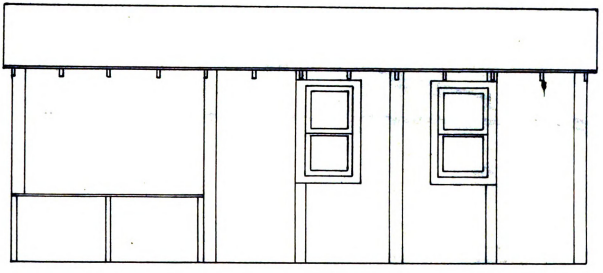


Side Elevation. (Right)

Model Cottage.

Side Elevation. (Right)

Model Cottage.



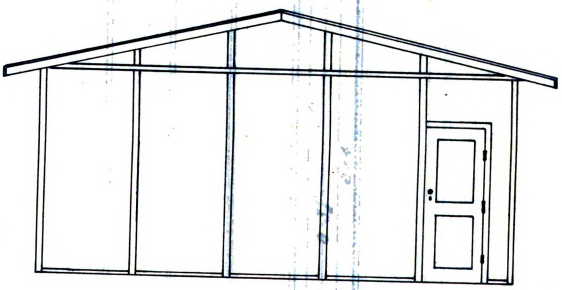
Side Elevation (Left)

Model Cottage.

Side Elevation (Left)

Model Cottage

Model Cottage.



Rear Elevation.

Concrete
Wire
Paper

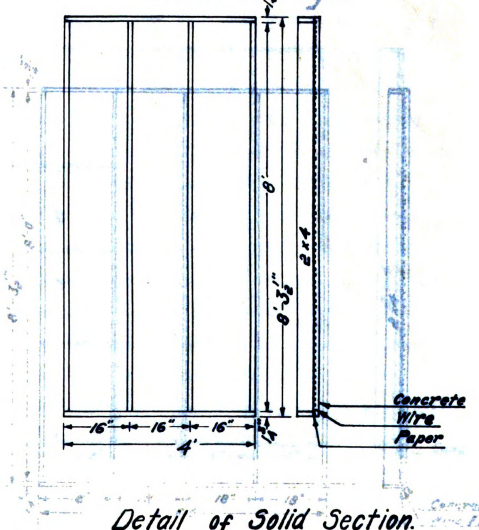
of Solid Section.

Model Cottage.

Rear Elevation.

Model Cottage

Model Garage.



Detail of Solid Section.

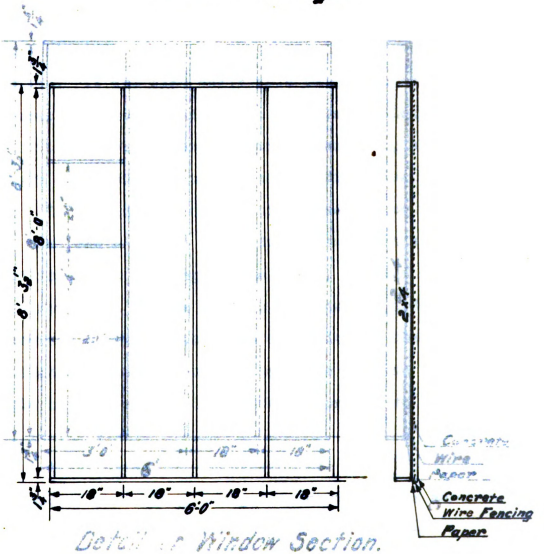
Detail of Solid Section.

Model Cottage

Detail of Solid Section.

Model Garage.

Model Garage.



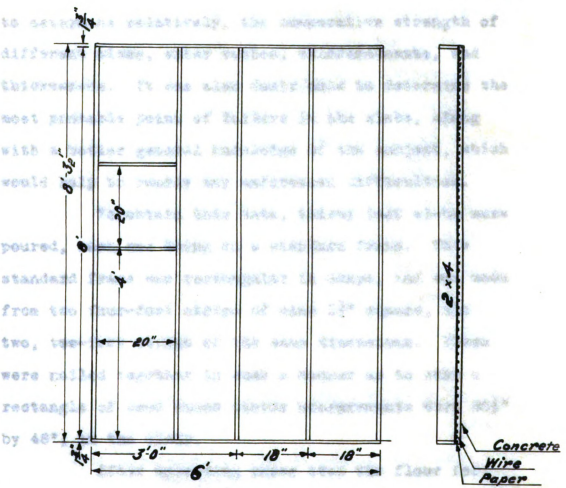
Detail of Window Section.

Detail of Solid Section.

Model Garage.

Detail of Solid Section.

Model Garage.



Detail of Window Section.

Model Garage.

Detail of Window Section.

Tests for Concrete Walls Variously Reinforced.

The first tests conducted were with test slabs. The purpose of this series of experiments was to determine relatively, the comparative strength of different mixes, water ratios, reinforcements, and thicknesses. It was also desir able to determine the most probable point of failure in the slabs, along with a better general knowledge of the subject, which would help to remedy any unforeseen difficulties.

To obtain this data, thirty test slabs were poured, each one being on a standard frame. This standard frame was rectangular in shape, and was made from two four-foot strips of pine $1\frac{3}{4}$" square, and two, two-foot strips of the same dimensions. These were nailed together in such a manner as to make a rectangle of wood whose inside measyrements were $20\frac{1}{2}$" by 48", in the clear.

After spreading paper over the floor for the purpose of preventing the green concrete from adher ing to the floor, the frames were laid on the paper and the concrete poured in, and leveled off to the proper depth. When wire was used, it was nailed to the upper side when the frame was laying in the

pouring position, care being taken to let the wire hang loose enough so as to nearly touch the floor half way between the supports.

Portland cement was used with good gravel, which showed practically no organic matter under the sodium hydroxide test. The gravel was not screened, and as a result, a little trouble was encountered due to the presence of stones which were too large to be covered in so thin a slab. However, this did not slow up the pouring to any great extent, and in practically every case, the concrete was poured within 40 minutes after it was mixed. The concrete was mixed by shoveling over the gravel and cement four times before the water was added, and two times after the water was supplied.

The slabs were tested comparatively, by placing the actual weight on a two by four, eight inches long, which was placed on the center of each slab. The two by four was really only 1½" thick, and as it was 8" long, there were 12 square inches of bearing surface. This bearing strip was placed with its long edge parallel to the long sides of the slab.

Unless otherwise stated, the mix was just wet enough so that there was a slight slump, and no

more. In other words, the concrete, when poured, was just wet enough so that when it was slightly tamped, a very little water would be noticeable at the surface.

The slabs were sprinkled every few days while they were hardening, but much better care could be given very easily. The temperature of the garage in which the slabs set, was rather high, and a good drying atmosphere resulted. If the slabb had been allowed to dry more slowly, they would have been much stronger and better results would have been obtained in the tests.

Data on Test Slabs.

To Test Mixes.

1. Standard frame with 2" wire mesh, 1 : 4½ mix, poured 1½" deep. Weight when tested 128 lbs. Tested at 20 days.

The slab failed by breaking in center. The failure was very slow and gradual, and was due to tension failure. The bond between the concrete and the wire was very strong, the wire actually breaking in several places. The fact that the concrete clung tightly to the frame was particularly noticeable. The slab failed under a 900 lb. load.

2. Same slab and same failure as No. 1, failing under a 800 lb. load.

3. Standard frame with 2" wire mesh, 1 : 6 mix, poured 1½" deep. Weight when tested 130 lbs. Tested at 18 days.

The slab failed by breaking in the center, very gradually. The failure was due to inability to resist tension stresses. The concrete clung tightly to the frame. The breaking load was 650 lbs.

4. Same slab and same failure as No. 3, breaking under a 550 lb. load.

5. Standard frame with 8" wire mesh, 1 : 7½ mix, poured 1½" deep. Weight when tested 125 lbs. Tested at 18 days.

The slab failed in the center due to tensional stresses, breaking very gradually. The concrete clung well to the frame. The breaking load was 450 lbs.

6. Same sla b and same failure as No. 5, breaking under a 450 lb. load.

7. Same sla b and same failure as No. 5, breaking under a 500 lb. load.

8. Standard frame with nails at eight inch intervals, no wire, 1 : 9 mix, poured ¾" deep. Weight when tested, 71 lbs.

Slab failed in the center from inability to resist tensional stresses. The concrete clung very well to the frame. It failed under a 100 lb. load. Tested at 15 days.

Tests With Nails Only.

9. Standard frame with nails at eight inch intervals, 1 : 4½" mix, poured 1" deep, tested at 17 days. Weight when tested 85 lbs.

The slab failed first in one corner where a nail was covered with only 1/8 inch of concrete, and

then it broke around the other nails and across the center. After craking slightly, it failed suddenly thru shear. It was tested bottom side up which might account for its failure to withstand a larger weight. It broke under a 225 lb. load.

10. Same slab as No. 9, but weighed 101 lbs.

The slab failed by cracking thru the center. As the nails were spaced comparatively deeply, the concrete was secure to the frame. Slab broke under a load of 375 lbs.

11. Standard frame with nails at eight inch intervals, 1 : 4½ mix, poured 1½" deep, tested at 17 days. Weight when tested 126 lbs.

The slab failed to crack or to show any signs of failure under a 800 lb. load. An accident occurred at this point tho, and the weights fell onto the slab. Upon replacing the weights, the slab broke under a 700 lb. load. The concrete failed first to cracking, and then to general failure. The concrete stuck to the frame very well.

12. Same slab and same failure as No. 11, slab weighing 133 lbs. and failing under a 600 lb. load.

13. Standard frame with nails at eight inch intervals, 1 : 4½ mix, poured 2" deep, tested at 17 days. Weight when tested 161 lbs.

The slab held up 950 lbs. without showing any signs of failure. At this point the weights tipped off the beam and fell onto the slab. The slab was set aside for twenty four hours until some more weights could be secured. It was then reloaded failing under 1050 lbs. The concrete stuck very closely to the frame and failed in the center only.

Tests With Wire Mesh Only.

14. Standard frame with 2" wire mesh, 1 : 4½ mix, poured 1" deep, tested at 17 days. Weight when tested 90 lbs.

The slab cracked under 325 lbs. and broke gradually under 400 lbs. It seemed to fail first near the wood thru shearing. The presence of nails would probably have strengthened it considerably. It was tested with the under side up. In this case the wire was nailed to the under side, instead of to the upper side, as the slab was to be only 1" thick.

15. Same slab as No. 14, weighing when tested 89 lbs.

Failure is very gradual. It does not really break, but fails rather from bending, as it seems to bend and still not break. The concrete sticks to

the frame very well but the presence of nails would probably increase the strength. It was tested with the under side up and failed under a 360 lb. load.

16. Standard frame with 2" wire mesh, 1 : 4½ mix, poured 1½" deep, tested at 20 days. Weight when tested 131 lbs.

The slab failed in the center very gradually. The concrete stuck to the frame very well. The breaking load was 750 lbs.

17. Same slab and same failure as No. 16, except that the breaking load was600 lbs.

18. Standard frame with 2" wire mesh, 1 : 4½ mix, poured 2" deep, tested at 18 days. Weight when tested 166 lbs.

Slab breaks under a 1025 lb. load. It failed very slowly and gradually, and in the center only. The concrete stuck firmly to the frame.

19. Same slab as No. 18, weighing 168 lbs.

Slab breaks at 1350 lbs., failing along the edge where the wire was covered with only 1/2 inch of concrete.

20. Same slab as No. 18, weighing 165 lbs.

Slab fails very gradually under 1300 lb. load. It seemed to fail in the center first.

For the Effect of Water Ratio.

21. Standard frame with 2" wire mesh, 1 : 4½ mix, poured 1½"deep, tested at 18 days, 2" slump when poured. Weight when tested 125 lbs.

Slab breaks gradually under 650 lbs., failing thru the center.

22. Same slab and same failure exactly as No. 21 except weight of slab when tested was 135 lbs.

23. Standard frame with 2" wire mesh, 1 : 4½ mix, poured 1½" deep, tested at 18 days, 5" slump when poured. Weight when tested 130 lbs.

Slab breaks under 550 lb. load, gradually failing in the center from inability to withstand tensional stresses.

Wire and Nails.

24. Standard frame with 2" wire mesh, and nails spaced at eight inch intervals, 1 :4½ mix, poured 1½" deep, tested at 18 days. Weight when tested 130 lbs.

Slab breaks in the center under a 850 lb. load. It failed very gradually, and the concrete stuck very firmly to the frame.

25. Slab and failure is identical to No. 2 4 .

Test for Moving of Slab.

26. Standard frame with 2" wire mesh, 1 : 4½ mix, poured 1½" deep, tested at 18 days, moved 150 feet after 2 days. Weight when tested 125 lbs.

Slab breaks under 750 lbs., failing in tension in the center. It stuck to the frame very well.

27. Slab same as number 26 except it was moved after four days.

Slab breaks in the center, gradually, under a load of 700 lbs.

Special Slabs.

28. A special slab was made by covering a standard frame with tar-paper, over which was placed the 2" wire mesh; the concrete being poured on top of this and being held, while setting, by the tar paper. A 1 : 4½ mix was used, with a dry mixture, poured 1½" deep and tested at 17 days. Weight when tested 139 lbs.

Slab breaks very gradually inder 1075 lb. load. It failed in the center, sticking very tightly to the frame.

29. A special slab was made the same as No. 28, except nails were added at approximately eight inch intervals. Weight when tested was 130 lbs.

Breaks under 900 lb. load, failing along the edge where the concrete was only about 1/2 " thick.

30. A special slab was made from a standard frame and nails, using a 1 : 7½ mix, pouring 1" deep, and testing at 15 days. Weight of slab when tested, 78 pounds.

Slab cracks and breaks under 150 lbs. Shears thru at three nails. There was only ¼" of concrete between the nails and the upper surface. The concrete stuck to the frame very well.

Results of Tests.

Mixes.

The slabs, each 1½" thick held approximately the following loads;

1 : 4½ mix, held 850 lb. average.
1 : 6 mix, " 600 " "
1 : 7½ mix, " 450 " "

From this it would seem that the 1 : 4½ mix is the proper one to use, altho it is possible that the 1 : 6 mix might be practical.

Nails Only.

From these slabs we find that the nails help considerably to tie the concrete to the wood frame. However, we also notice that the slabs without the wire hold up only about 2/3 of the load that the slabs with the wire will hold. This is not all, for it is readily seen that in every instance, the slabs having nails only, failed instantly, whereas, the slabs with the wire failed very gradually. This shows conclusively that the presence of the wire is very desirable, and that the slabs with only nails, would, in most cases, be unpractical.

Wire Only.

The slabs with 2" wire Mesh, and a 1 : 4½ mix, held up the following loads;

1"	thick	350 lb.	average.
1½"	"	875 "	"
2"	"	1200 "B	"

This shows that, as far as actual strength is concerned, the wire does not seem to help to any great extent, altho it does seem to strengthen the slab a little, say approximately 15%- 20%. The most noticeable feature of this test is the fact that the slabs reinforced with the wire mesh never break instantly. They always break very gradually, and do not fall to pieces, upon breaking, but simply crack into pieces which are held together by the wire mesh. Furthermore, the wire mesh s eems to bind the concrete more firmly to the frame, which is also very important.

Water Ratio.

The 2" slump did not seem to make a large enough difference to prove much of anything. The test slabs averaged about 25 lbs. less than those having practically no slump, which is about what we might expect, and therefore we may conclude that the 2" slump

will destroy about 7% of the strength of the slab.

The slabs with the 5" slump broke under a 550 lb. load, which was 150 lbs. below the slabs with practically no slump, and we might conclude that a 5" slump will destroy about 22% of the strength of the slab.

Wire and Nails.

The slabs both broke under 850 lb. loads, and, as they were each 1½" thick, it seems that they held up more than the slabs with the wire only, by 175 lbs. However, these tests are only comparative, and so we will conclude only, that the nails will increase the efficiency of the slabs, a small unknown amount.

Moving of Slabs.

These slabs both held up more than the average assumed for their class of slabs, and so we may say conclusively that slabs may be carried about carefully, after they have set two days, without harming the slab in the least.

Special.

Slabs with tarpaper and wire held up 1075 lbs.

and 900 lbs. which shows that they seem to be much stronger than the plain slabs. Furthermore, as the stronger slab had no nails while the weaker slab did have nails, we may conclude that when the concrete over-laps the studding, the nails are not of much value.

Conclusions From Tests.

1. Use 1 : 4½ mix.

2. Use just enough water to make the mix workable, or so it will show a very slight slump.

3. Use 2" mesh wire stretched over tar paper.

4. Do not use nails until it is shown that it is impossible to do without them.

5. Slabs may be moved two days after being poured without weakening their strength at all.

6. If the gravel were screened so as to take out the larger stones much time would be saved in the pouring.

The second part of the tests consisted in the construction of several of the proposed sections. These were built according to the plan on blueprint No. 11, being made 8'-3½" high and 4' wide. Five sections were made as follows:

1. The first section was a solid section made of (2 x 4)s, barbed wire, building paper, and concrete.

2. The second was a window section made in the same manner as number one.

3. The third was a solid section the same as number one, except, 2" wire mesh was used in place of the barbed wire.

4. The fourth section was a door section made like number one.

5. The fifth section was a solid section made similar to number three.

- - - - - - - - - - - -

The barbed wire was placed at six to eight inch intervals and in a horizontal position. The object of using the barbed wire was to determine the practicability of using it in place of the two inch mesh which was comparatively expensive.

Trouble was encountered in the pouring of section number one. The first difficulty was caused

by the paper giving way before the concrete had set. This was caused by using a mixture which had a trifle more water than was needed, and also from the fact that the nails which held the barbed wire, and which also held the paper, were from six to eight inches apart. The paper failed by pulling out where the nails fastened it to the frame. This trouble was remedied by placing (2 x 4)s under the paper in such a manner that they held the greater share of the weight of the concrete between the studding.

Using these precautions, the second section was cast without any similar difficulty. However, some of the barbed wire was not very straight, and after the concrete was in place, the wire seemed to come to the surface while the concrete was setting. Owing to the fact that the barbs on the wire were, in some cases, nearly and inch in diameter, the wire showed quite plainly in the concrete and made an unsightly slab. It seems that this characteristic of the barbed wire is probable serious enough to prohibit its use.

Next the third section was poured. Here again difficulty was encountered, due to the stretching of the paper. In the test slab, with a 23" clear span, the paper did not seem to stretch in nearly so

noticeable a manner as it did in this section, where it stretched for nearly a half hour, and perhaps longer. The paper did not pull out around any of the nails, but simply stretched, making cracks appear over the studding, due to the settling of partly set con - crete between the studding. The (2 x 4)s were not placed between the studding in this section because in the test slab, the combination of 2" mesh and paper held the concrete in a satisfactory manner, over a larger span.

The fourth section was poured satisfactorily using the precautions mentioned above.

The fifth section was poured, with the above precautions, satisfactorily.

The sections were sprinkled thoroughly every day or two, and allowed to set for eight days. They were then set up and spiked together, using spikes thru the end studding of each section and also spiking down one plate across the tops of the sections. The sections went together in a very satisfactorily manner and showed absolutely no ill effects due to the pounding of the large nails. This was one of the most important tests, showing that the sections may be fastened together with spikes, and still have the concrete firmly and solidly attached to the studding. The

weight of the sections are such that two men can handle them satisfactorily, altho the full sections could be handled easier with three men. The weight of a section is approximately, 200 lbs. for door section, 300 lbs. for window section, and nearly 400 lbs. for the solid section. The sections when finished with stucco appear to be one solid wall, and have a very good appearance. The sections were strong enough to resist the pressure of a ladddr leaning against the wall and supporting one man, and as the concrete was only eight days old, it will certainly increase in strength several hundred percent, making the walls much stronger. Any failure caused by a ladder leaning against the walls, or some other exterior pressure, would be very slow and gradual, due to the wire reinforcing in the concrete.

The sections have held up admirably and fully as well as was hoped for. We shall now investigate the cost of construction and the advisability of the same.

Cost of Materials.

The following calculations are based on this price list, obtained in Lansing, Michigan, Mar. 26, 1921.

From the Cove Lumber Co., Bell 30.
Citz 2439.

2 x 4 (fir) 38.00
2 x 8 " 38.00
1 x 4 " 65.00
Roof boards 35.00
1 x 6 siding drop 50.00 bevel clear 55.00
3¼" matched pine flooring #1.- 60.00, #2- 45.00
maple flooring #1- 125.00
2 x 10 45.00
2 x 12 47.00
Building paper 2.00
Three-ply roofing paper 3.00
Cedar shingles clear 7.00
Lathe 32" 35¢, 48" 60¢
Beaver board 50.00
Window frames and sashes 3.50 frames 3.00 with 7/8" case
Approx. 2' x 5' sash approx. 1.50 per window
Door frames and doors
2½' x 6½' 4.00 no sill, 3.50 - 7/8" casings
2" mesh fencing 4' wide costs 1½¢ per sq.ft. at hardware store in East Lansing, but in-as-much as I am sure that it can be purchased, by the roll for 1¢ per sq.ft., or less, I shall consider it as costing 1¢ per sq.ft. in these calsulatiens.

Cement is sold for 80¢ per sack, or 3.15 per barrel.

Gravel cost 3.75 per load. There is approximately 1½ cu.yds. to the load.

Cost of Sections.

Garage.

Cost of a 4' section with studding spaced 2' center to edge.

(2 x 4)s	32 x (8/12) x 3.8¢	$ .81
paper		.10
wire		.32
nails		.06
Concrete (2 2/3 cu.ft.)		.62
Cost of one four-foot section		$ 1.91

Cost of a 6' section with studding spaced 2' center to edge.

(2 x 4)s	44 x (8/12) x 3.8¢	$ 1.12
paper		.15
wire		.48
nails		.08
Concrete @ $6.20 per cu. yd.		.89
Cost of one six-foot section		$ 2.72

House.

The house sections will be the same as the 4' garage sections except, there will be an additional studding, due to the fact that th s studding in the house sections are placed 16" center to center. This will make the house sections cost $ 2.14 .

Estimated Cost of Model House When Constructed In Sections Without Porches.

In-as-much as the house is the same with the exception of the outer walls, the differences in the cost of these walls when built in sections, and when built by the present method, will equal the difference in the cost of the house when built in sections and when built by the present methods.

Walls.

18 - 4' sections required. @ $3.14	$ 38.52
Plates. (180/1000) x (8/12) x $38.00	4.56
Beaver Board (same as by present method)	65.00
Windows. (same)	36.00
Doors. (same)	37.50
Latches and locks etc.	20.00
Total	$201.58

This amounts to approximately $200.00 or, in other words, the house material can be purchased for $50.00 less money if the house is built in sections. This means a saving of at least 10% of the cost of the material for the building of the house by the p resent methods, without sheathing.

The sheathing would cost (580/1000) x $35.00 or $20.30

The concrete sections are better than sheathing plus siding (see sumary), and so it might be considered that the houses, if built by the present methods, would cost about $70.00 more than it would if it were built in sections. In other words, the house built by the present methods costs about 15% - 20% more than it would if it were built in sections.

Estimated Cost of Model House by Present Methods.

Without Porches.

Walls.

Studding. 85 x 8 x (2 x 4/12) is 454 bd.ft. Use 460.

(460/1000) x $38.00 is $18.24 — $18.24

Plates. 162 x (2 x 4/12) is 108 bd.ft.

(108/1000) x $38.00 is $4.11 — 4.11

Siding, 6"; 4½" to weather.

(850/1000) x $50.00 is $42.50 — 42.50

Other Exterior Lumber.

(80/1000) x $65.00 is $5.20 — 5.20

Building Paper.

6 rolls at $2.00 is $12.00 — 12.00

Beaver Board.

(1300/1000) x $50.00 is $65.00 — 65.00

Windows, sash and frame,

6 @ $6.00 is $36.00 — 36.00

Doors with door frames.

5 @ $7.50 is $3750 — 37.50

Latches and locks for doors and windows including window weights etc. $20.00 — 20.00

Total $240.55

Allowing for nails makes walls amount to approximately $ 250.00 without sheathing, which means that with sheathing, the material would cost approximately $270.00 .

Floor.

Joists. 26 x 10 x (2 x 8/12) is 347 bd.ft. Use 350.

(350/1000)x $45.00 is $1575 — $15.75

Sub-flooring.

320/1000 x $35.00 is — 11.20

Pine flooring.

(320/1000) x $60.00 is $19.20 — 19.20
Add $4.00 for waste. — 4.00

Finishing lumber.

(175/1000) x $70.00 is $1252 — 12.52
$62.67

Allowing for nails makes total of $65.00

Roof.

Rafters. 18 x 12 x(2 x 4/12) is 144 bd.ft. Use 150.

(150/1000) x $38.00 is $5.70 — $ 5.70

Roof boards. 24 x 17 is 408 bd.ft. Use 425.

(425/1000) x $35.00 is $14.88 — 14.88

Roofing paper, 3-ply.

5 rolls @ $3.00 is $15.00 — 15.00
$35.58

Allowing for nails makes total of $37.00

Ceiling.

Joists. 18 x 10 x (2 x 4/12) is 120 bd.ft.

(120/1000) x $38.00 is $4.56 — $4.56

Beaver board

(400/1000)x $50.00 is $20.00 — 20.00

$24.56

Allowing for nails makes approx. $26.00

Paints.

Total inside and out approx. $40.00 — $40.00

The total cost of the house comes to $412.81 without sheathing, or $433.00 with sheathing.

Cost of Front Porch as Designed.

Studding (30/1000)x $38.00	$ 1.14
Siding (250/1000)x $50.00	12.50
Joists (140/1000)x $45.00	6.30
Flooring (180/1000)x $45.00	8.10
Roof rafters (32/1000)x $38.00	1.22
Roof boards (200/1000)x $35.00	7.00
Post and beam	3.00
Roofing paper, 2 rolls @ $3.00	6.00
Paint	5.00
	$50.26

Allowing for nails makes total of $53.00

Cost of rear porch — $ 2.00

Cost of steps for front and rear — 6.00

$ 8.00

Cost of 1' concrete foundation 6" thick 2¼ cu.yd. @ $6.15 is — $13.84

Total cost of house without foundation $473.81 , sheathing not included. Total cost with foundation $486.65. Allow $500.00 for material, Allow $520.00 if sheathing is to be used.

Estimated Cost of Model Garage Built in Sections.

In-as-much as only the walls are to be built in sections, the cost of the other parts of the garage will be the same as tho built by the present methods. Therefore, the difference in cost between the wall built in sections and the wall built by the present methods, will also be the difference between the cost of building the garage in sections, and the cost of building the garage by the present methods. Hence, we need only consider the cost of the wall, when built in sections.

Wall.

3 - 6' sections	$ 8.16
9 - 4' "	17.19
Plate on top 72 x (8/12) x $38.00/1000	1.63
Nails etc.	1.82
	$29.00

Total cost of wall $29.00

This is $26.00 less than the walls would cost if built by the present methods. In other words, the garage can be built for $26.00 less, if it be built in sections. The total estimate would be $114.00 but it would be advisable to allow $120.00 for the total estimated cost of materials for the garage built in sections. This estimates the cost of concrete included.

Estimated Cost of Model Garage by Present Method.

Roof.

Roof boards. 2 x 10 x 19 or 380 bd.ft. Use 400.

(400/1000) x $35.00 is $14.00 — $14.00

Joists 20 x (2 x 4/12) x 10 is 133 bd.ft.

(140/1000) x $38.00 is $5.32 — 5.32

Roofing paper(3-ply) 4 rolls at $3.00 — 12.00

Total $31.32

Walls.

Studding 44 x 8 (2 x 4/12) is 235 bd.ft.
Plates 9 x 18 (2 x 4/12) is 108 bd.ft. Use 130/

(355/1000) x $38.00 is $ 13.49 — $13.49

Siding for exterior walls(6" siding, 4½" out)
850/1000 x $50.00 is $42.50 — 42.50

Total $55.99

Windows.

2 sash @ $1.50 is $3.00
2frames @ $3.00 is $6.00

Total $ 9.00

Doors.

Lumber.(300/1000) x $50.00 is $15.00
Hinges and latch 2.00

Total $17.00

Masonry.

18 x 19½ x (4/12)/27 is 4 1/3 cu.yds. concrete reqd.
4 1/3 yds. @ $6.15 is $26.65 — Total $26.65

The total estimated cost of material is $139.96 and allowing for incidentals brings total to approximately $ 150.00 .

Summary.

After giving the subject careful thought, it has been concluded that the labor required to put the sections in place(and make them), is about equivalent to the labor required to put the studding in place in the ordinary manner and to nail the siding thereto. If sheathing were also used, the section method would save the time required to place the sheathing. This means that in a building where only siding is to be used, a saving of material only, would be the result. If, however, sheathing were to be used also, a saving of both labor and materials, would be the result of building with the concrete sections . The cost of stuccoing just about offsets the cost of painting, and will be considered in that manner.

It is necessary to consider the labor cost in the above manner because the cost of labor for the building of the sections is very indeterminant. If a mixer were used, the labor item would probably be much lower than that estimated in the above paragraph, while on the other hand, if no machine were used, the labor might be a trifle higher than the above estimate. However, taking all things into consideration, the above estimate can be considered as being quite fair and re-

liable.

In the garage, as in the houses, the comparison between the two methods was based on the assumption that the house and garage built by the present methods, would not have sheathing. It has been shown that the house can be built in concrete sections much cheaper than the very cheapest of houses can be built. The concrete sectional house is, however, in reality, much more practical than the common frame house, built with both sheathing and siding. To prove this we need only to investigate the heat conductivity, and impervicusness characteristics of the concrete.

In 'Hool and Johnson's' "Concrete Engineers Handbook", we find beginning on page 254 an article on "Durability of Cement Mortar and Concrete", from which the following statements were taken. "Concrete ranks highly as a fire resistant and fire proofing material, principally because it possesses a low rate of heat conductivity and has a low coefficient of expension, practically equal to that of steel, in addition to being incombustible. Other masonry materials like some of the natural stones and terra-cotta are no less incombustible than concrete, but are inferior to the latter as a fireproofing material, because they possess

either greater conductivity or a higher coefficient of expansion. All concretes, stone gravel, and cinder, have a very low thermal conductivity. When a surface of a mass of concrete is exposed to a high heat for hours, the concrete one inch below the surface will be several hundred degrees below the outside temperature."

The 1 : 4½ mix used for these concrete sections, is practically impermeable. In a vertical wall such as these sections would be used in, there w ould be no danger of dampness, with so rich a mix. Furthermore, the air space between the studding, would not only aid in preventing heat conductivity, but would also prevent any moisture collecting, which would tend to make the house damp. Then with the presence of the building paper also, it can be safe ly gauranteed that the sectional house of concrete, is not only cheaper, but that it is also more practical.

The advantage of the section method over the present method would be most noticeable in the smaller buildings, and therefore it would be wise to limit it to single story, four or five room houses, and garages for one or two cars. Of coures larger one-story buildings could be built, but the saving gained by this method, over the present method, would not be so noticeable, by any means.

The initial cost of a construction plant would be very small. In fact, if the concrete were mixed by hand, and it could be quite well mixed that way, there would be practically no initial cost except the cost of a few tools such as pails, hoes, shovels, trowels, wire cutters, hammers, saws, and mixing platform, which altogether would cost about $10.00 . If the mixing were to be done by machine, which would really be more practical if many sections were to be made, there would be the additional cost of the machine to take into consideration.

It would be advisable, if many sections were to be constructed, to purchase additional lumber for forms, or for the (2 x 4)s that are used for supporting the concrete while it is setting. These forms could afterward be entirely used formframes, and so would not necessarily be included in the expense account as, forms.

The cost of concrete house construction by present methods, is enormous. It is much more than the cost of the little frame house used, for the comparison of prices. The cost of the stucco finished house is also a great deal more than the cost of the little frame house used in these comp arisons. This

emphasizes the fact that the cheapest house that can be constructed by present methods was used in these comparisons. In other words, this sectional built house is far cheap er than any concrete-finished house built by the present methods. It should be a successful building proposition.

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