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THE ESTIMATING OF THE COST OF THE
SUBSTRUCTURE CONTRACT FOR THE
DETROIT VENTILATOR BUILDING OF
THE DETROIT-WINDSOR TUNNEL

THESIS FOR THE DEGREE OF B. S.

R. J. Wicksall

1931

THESIS

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**THE ESTIMATING OF THE
COST OF THE SUBSTRUCTURE CONTRACT
FOR THE DETROIT VENTILATOR BUILDING OF
THE DETROIT-WINDSOR TUNNEL**

**A Thesis Submitted To
The Faculty of
MICHIGAN STATE COLLEGE
of
AGRICULTURE AND APPLIED SCIENCE**

By

R. J. Wicksall

**Candidate for the Degree of
Bachelor of Science**

July, 1931

PREFACE

This thesis is a problem selected by the author for the purpose of furthering his knowledge of the method of estimating substructure construction costs.

The contract selected was one done by Spencer, White and Prentis, the method of procedure being explained by Mr. Walter Ross and Mr. Frederick Spencer of that firm. Without their instruction and criticism it would have been impossible.

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SPENCER, WHITE & PRENTIS

ESTIMATE No. _____

SHEET No. _____

DATE _____

JOB Detroit Ventilation Bldg., ARCHITECT May 27, 1931
 MADE BY P. J. Wickesall FOR Thesis

ITEM	DESCRIPTION	QUANTITY	UNIT	PRICE	AMOUNT	REF.
Excavation	Steam Shovel	2000	yds	\$1.27	\$2540	
	Clam "	2545	"	151	3850	
	Wells	322	"	11.60	3770	
	Trenches	978	"	969	9550	
Concrete		1116	"			
				7.95	8360	
Forms	Walls	22700	sq. ft.	20	4540	
	Lower forms	2763	" "	23 $\frac{1}{2}$	652	
	Curved forms	9970	" "	37 $\frac{1}{2}$	1850	
	Struts & brk shafts	1387	" "	37 $\frac{1}{2}$	512	
Water proof	Sub-contract				1990	
Electrical	" "				2291	
Str. Steel	Erection only	73	Tons	20.00	1460	
	Louvers, panels, brackets, etc. (erection only)				320	
Rein. Steel		5022	"	50.00	2511	
	Placing	5022	"	20.00	1004	
Bracing	12"x12"-total cost	710	M	80.00	576	
Concrete Finish - Ducts, top & bottom		858	sq. ft.	15	1287	
	Walls & Floor	15200	" "	10	1520	
Office	Building				973	
	Pay roll				2690	
Machinery	Depreciation & Rent				1050	
Bond					750	
Pipeline					1000	
Total					\$9516	

QUANTITIES

Excavation

Steam Shovel		2,000 yds.
Clam Shovel		2,545
Wells)	(322	
) Included in clam excavation (		
Trenches)	(478	
Total		4,545 cu. yds.

Concrete 1,116 cu. yds.

Forms

Wall	22,700 sq. ft..
Lower	2,765
Curved	4,970
Stairways and Elevators	<u>1,387</u>
	31,820 sq. ft.

Reinforcing Steel 50.22 tons

Structural Steel 73.0 tons

Concrete Finish

Ducts, top and bottom 858 sq. ft.

Walls and Floor 15,200

Total 16,058 sq. ft.

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EXCAVATION

Steam Shovel

Cost per day:

1 Shovel - rent	\$60.00
1 Pitman	4.00
1 Foreman	10.00
10 Trucks at \$24	240.00
3 Laborers at \$4	12.00
Insurance at 7% (Workmens Comp.)	<u>2.10</u>
	\$328.

Unit Cost

Shovel at 400 yds./day = $\frac{328}{400}$	.82
Dump charge	.25
Runways	.07
Inelines and Approaches	.06
Shovel Transportation	<u>.07</u>
Unit Cost	\$1.27

2000 yds. at 1.27 = \$2,540

Note:

The unit cost given is too low due to the held-up of trucks by traffic and possible break-down of machinery. Also time required for moving. Actual unit costs may run well over \$1.50, though \$1.27 would cover the cost under good to fair conditions.

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Clam Shovel

Cost per day:

1 Shovel - rent	\$60.00
1 Pitman	5.00
1 Foreman	10.00
8 Trucks at \$24	192.00
2 Laborers at \$4	<u>8.00</u>
	\$275.00

Unit Cost

Shovel at 250 yds./day = $\frac{275}{25}$	\$1.10
Dump charge	.25
Runways	.05
Trim ¹	.10
Insurance	<u>.01</u>
	\$1.51

2,545 yds. at \$1.51 = \$3,850

Note:

Figured unit costs of \$1.51 are low, \$1.75 being a safer estimate.

(See note on steam shovel excavation.)

¹Item to cover hand trimming of bottom foot to leave smooth undisturbed surface to pour floor on.

•

Number of hauls	<i>P. setiferus</i> (%)	<i>P. setiferus</i> + <i>P. setiferus</i> + <i>P. setiferus</i> (%)
0	0	0
1	20	80
2	10	70
3	20	80
4	10	70
5	20	80
6	10	70
7	20	80
8	10	70
9	20	80
10	10	70

CAISSON EXCAVATION

(By Method of Chicago Open Wells¹)

Operating 5 wells at a time, shift cost at 6' per well per shift.

5 Dumpers at \$4	\$20.00
5 Winchmen at \$7	35.00
5 Diggers at \$10	50.00
1 Foreman	12.00
1 Mechanic	8.00
2 Laborers at \$4	8.00
Insurance at 7%	<u>2.31</u>
Total	\$142.31

Unit Cost

Labor 142.31/13.95	10.20
Lagging ² at \$35 M	1.00
Rings at \$50 ton	.10
Tools, Boats, Misc.	<u>.30</u>
	\$11.60 ³

322 yds at \$11.60 = \$ 3,740

¹Chicago Wells were used to obviate the use of steel sheating, and to allow work begun on superstructure at earlier date.

²2" x 6" x 6' finished (one side) matched maple.

³This price is for good ground conditions. It would probably be increased in this case to cover unknown conditions. In this case it would have covered the cost.

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Notes:

Bell excavation being in medium sized wells is figured at the same price, no shoring.

Wells to be carried down from elevation 572.00' - bottom of steam shovel excavation.

Any water encountered to be taken care of by pumping.

WALL EXCAVATION

Figuring 3 yds. per digger per shift.

Labor (1 shift)

1 Foreman	\$12.00
5 Winchmen at \$7	35.00
15 Differs at \$9	135.00
10 Dumpers at \$4	40.00
1 Labor Boss	8.00
6 Laborers at \$4	24.00
1 Mechanic at \$8	8.00
Insurance at 7%	<u>18.00</u>
	\$280.00

Unit Cost

Labor 280/45	\$ 6.22
3" Sheeting at \$30 M	1.83
Pipe and channels	1.22
Tools, Boats, etc.	<u>.42</u>
	\$ 9.69

477.6 yds at 9.69 = \$4,550.

Notes:

Walls placed in trenches because steel sheeting is not used. In this method the trenches are started at the bottom of the steam shovel excavation and are carried down at a minimum of 3' wide to the required depth. The trenches are walled with 3" sheeting and braced with pipe and channels, Jacks being used to take up pressure. See

diagram on print No. 1. Walls to be poured as shown leaving pipe and channels in place and using forms only on front face where practicable. No salvage is figured for plank and channels, as in wells, cost of removal being figured equal to salvage value - 3" plank at \$50 M.

CONCRETE

Estimated 30 yds. per day

1 Foreman	\$ 8.00
10 Laborers at \$4	40.00
Insurance at 7%	3.36
Sand & Gravel - 40.8 yds. at \$1.75	64.25
Cement - 45 bbl. at \$1.70	<u>76.50</u>
	\$192.11

Unit Cost

Pouring Cost 192.11/30	\$ 6.40
Runways ¹	1.00
Water ²	.05
Sand & Gravel loss ³	<u>.04</u>
	\$ 7.49

1116 yds. at \$7.49 = \$8,360

¹This includes miscellaneous work of cleaning forms just previous to pouring as well as actual work of building runways and shifting mixer and pipe lines.

²This includes installation of water openings and pipe lines as well as water consumed.

³Estimated at 2% of sand and gravel cost.

Note:

This figure (\$7.49 per yd.) is low. The source of this error is obscure, unless it is that it is not possible to average 30 yds. per

However, it should be easily done. In case of hold-up, however, the labor cost goes on due to the fact that is difficult to use the increased labor gang efficiently.

FORMS

Wall Forms (per sq.ft.)

Panels ¹	.05	
Tie Wires ²	.02	
Nails	.01	
Wales & Braces ³	.018	
Set-up ⁴	.04	
Stripping ⁵	.04	
Insurance at 7%	<u>.008</u>	
	.186	
22,704 sq.ft. at .186 =	\$4,220	
Plus \$320 ⁶	<u>320</u>	\$4,540

Curved Forms⁶

At double wall forms .372	
37.2¢ x 4970 sq.ft. =	\$1,850
	1,850

Lower Forms⁷

Wall forms + 5¢ = 25.6¢	
25.6¢ x 2763 sq.ft. =	\$652
	652

Elevator Shafts & Stairways⁶

At double wall forms = 37.2¢	
1,387 sq.ft. at 37.2¢ =	\$512
	512

¹In figuring panels the lumber is figured at 3 bd.ft. per sq.ft. of forms and the labor of equal cost. On this size of job the cost of using panels is not much less, but makes for simpler supervision. For

this reason the 3¢ per sq.ft. of exterior wall may be added to the total of wall forms without appreciable error, although the forms for the exterior walls will be straight forms and not panels. Typical wall form costs run from 15 to 25¢ depending on simplicity.

²Two cents includes cost of wire and tying.

³Cost of lumber only - all form lumber figured at \$25 M - 10% waste per use - 3 to 5 uses. Panels used 7 to 10 times.

⁴Panel erection cost.

⁵Stripping costs are figured at about half the erection labor costs.

⁶Due to the complicated forms and small salvage figure this double price is not too high by any means.

⁷The 5¢ additional is allowed for extra bracing and difficulty in erection. Lower forms are the forms used under floors and such types of work.

This method of panels is simply a method of making up sections which can be used repeatedly with cheaper stripping and set-up costs and a larger number of uses, although there is 10% less per use for repairs.

⁸Item at 3¢ additional per sq.ft. of outside wall forms due to the difficulty of installing in trenches.

• The first step in the process of creating a new product is to identify a market need. This involves conducting market research to determine what consumers want and what problems they are trying to solve. Once a need is identified, the next step is to develop a concept for a product that addresses that need.

• The second step is to create a prototype of the product. This involves designing and building a small-scale version of the product that can be used to test the concept and gather feedback from potential customers. The prototype is used to evaluate the feasibility of the product and to make any necessary adjustments to the design.

• The third step is to conduct a pilot test of the product. This involves producing a small batch of the product and distributing it to a group of potential customers. The purpose of the pilot test is to gather feedback on the product's performance, usability, and overall appeal.

• The fourth step is to conduct a full-scale test of the product. This involves producing a larger batch of the product and distributing it to a wider group of potential customers. The purpose of the full-scale test is to evaluate the product's performance in a real-world setting and to gather feedback on its overall acceptance by the market.

• The fifth step is to launch the product into the market. This involves distributing the product to a large number of potential customers and promoting it through various marketing channels. The goal is to achieve widespread adoption of the product and to establish it as a successful new offering in the market.

• The final step in the process is to monitor the product's performance in the market. This involves tracking sales, customer feedback, and other key metrics to ensure that the product is meeting its intended purpose and to make any necessary adjustments to the marketing strategy.

REINFORCING STEEL

The quantity was figured by rule of thumb, 90 lbs. per yd. of concrete. This works out surprisingly accurately for ordinary sub-structure work. The placing cost was used arbitrarily as \$20 a ton. Although it runs from \$15 up, the difficulty of placing the steel in trenches and the complicated curved forms warranted the higher figure.

WATERPROOFING AND ELECTRICAL WORK

Both were done on sub-contracts and their figures used in estimate.

STRUCTURAL STEEL, ETC.

Structural steel, louvers, frames for openings, hand rails, electrical conduits, etc. were furnished. Prices are for erection only.

BRACING

12" x 12" timber bracing with screw jacks was used to brace the walls as the clam shovel excavation was removed to take the load that the structural steel and ducts would take when placed. The vertical steel and as much horizontal was placed in the caissons and steam shovel cut before clam work started to take loads and bracing. \$80 per M covers lumber and placing.

OFFICE

The building item takes care of erection cost of office, tool house and hog house.

1. The first step in the process of the scientific method is to make an observation or ask a question. For example, a scientist might observe that a plant grows better in one type of soil than another. This leads to a question: "Does the type of soil affect the growth of a plant?"

2. The next step is to form a hypothesis, which is a prediction or an educated guess. In this case, the hypothesis might be: "If a plant is grown in rich soil, then it will grow taller than a plant grown in poor soil." This hypothesis is based on the initial observation and a logical assumption.

3. The third step is to design an experiment to test the hypothesis. This involves setting up two groups of plants: one group in rich soil and one group in poor soil. The scientist would then measure the height of the plants over a period of time to see if the hypothesis is supported.

4. After the experiment is completed, the next step is to analyze the data. The scientist would compare the heights of the plants in the two groups. If the plants in the rich soil are significantly taller than the plants in the poor soil, the hypothesis is supported. If not, the hypothesis is rejected, and the scientist might need to form a new hypothesis.

5. The final step in the scientific method is to draw a conclusion. Based on the results of the experiment, the scientist would conclude whether the hypothesis was supported or not. This conclusion is then used to inform further research or to apply the findings in a practical context.

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OFFICE

The building item takes care of erection cost of office, tool house and hog house.

OFFICE PAYROLL

Superintendent at \$125 per week - 10 weeks	\$1250.00
Engineer at \$225 per month - 2-1/2 months	615.00
Timekeeper at \$35 per week	350.00
Equipment and Home office work	<u>475.00</u>
	\$2690.00

CONCRETE FINISH

The prices were taken arbitrarily, the curved concrete for over-head work being figured half again as much as wall finish.

MACHINERY

This item covers depreciation and rent on light equipment at one year life.

6 Nigger heads at \$400	\$2400.00
1 Mixer - 2 bag	1000.00
2 Pumps at \$250	500.00
1 Saw table	250.00
1 Compressor	3000.00
6 Airspades at \$100 (those & connections)	<u>600.00</u>
	<u>\$7750.00</u> -
	6
	\$1300

PIPE LINE

The pipe line item seems to have been an adjacent pipe line that was to be underpinned.

BONDING

Bonding covers the bond demanded of contractors which is 1.5% of

1. Introduction

- The first part of the paper is devoted to the study of the asymptotic behavior of the solutions of the system (1.1) as $\epsilon \rightarrow 0$.
- In the second part, we study the asymptotic behavior of the solutions of the system (1.2) as $\epsilon \rightarrow 0$.
- In the third part, we study the asymptotic behavior of the solutions of the system (1.3) as $\epsilon \rightarrow 0$.
- In the fourth part, we study the asymptotic behavior of the solutions of the system (1.4) as $\epsilon \rightarrow 0$.
- In the fifth part, we study the asymptotic behavior of the solutions of the system (1.5) as $\epsilon \rightarrow 0$.

2. Asymptotic behavior of the solutions of the system (1.1) as $\epsilon \rightarrow 0$

- In this section, we study the asymptotic behavior of the solutions of the system (1.1) as $\epsilon \rightarrow 0$.
- We first consider the case where ϵ is small and positive.
- We then consider the case where ϵ is small and negative.
- We finally consider the case where ϵ is small and zero.

3. Asymptotic behavior of the solutions of the system (1.2) as $\epsilon \rightarrow 0$

- In this section, we study the asymptotic behavior of the solutions of the system (1.2) as $\epsilon \rightarrow 0$.
- We first consider the case where ϵ is small and positive.
- We then consider the case where ϵ is small and negative.
- We finally consider the case where ϵ is small and zero.
- We first consider the case where ϵ is small and positive.
- We then consider the case where ϵ is small and negative.
- We finally consider the case where ϵ is small and zero.

4. Conclusion

- In this section, we conclude the paper by summarizing the main results.
- We first summarize the results of the first part of the paper.
- We then summarize the results of the second part of the paper.
- We finally summarize the results of the third part of the paper.
- We first summarize the results of the first part of the paper.
- We then summarize the results of the second part of the paper.
- We finally summarize the results of the third part of the paper.

5. Acknowledgments

- The author would like to thank the referee for his/her valuable comments and suggestions.

total price of contract. Bonding of employees is covered in overhead.

INSURANCE

For the sake of convenience 7% was taken as compensation insurance for all trades, although carpenters and common laborers are only 5%, and other trades having other rates.

ELECTRIC POWER

This item was neglected on this job due to the small size and convenience of outlets. This item should be looked into ordinarily, as well as the actual cost of water installations, etc. These items may run into large amounts under certain conditions.

PROFIT & OVERHEAD

These two items are outside this problem. The question of maintaining a large home office and its consequent expense, and the share each job should pay are difficult to meet. The custom of charging cost plus ten plus ten - 10% for overhead and 10% for profit are obviously wrong, but as has been previously stated they are beyond the scope of this problem.

CONCLUSION

It becomes obvious after having estimated the cost of a job and then comparing them with an experienced estimate which has been proven correct that the inexperienced estimator can easily fall into difficulties. Aside from being unable to foresee possible difficulties, a good day's work is thought to be an average day's work and the petty hold-ups and friction that may hold up work are not foreseen. And for the last point, many items of expense, small in themselves, but large in their total are overlooked.

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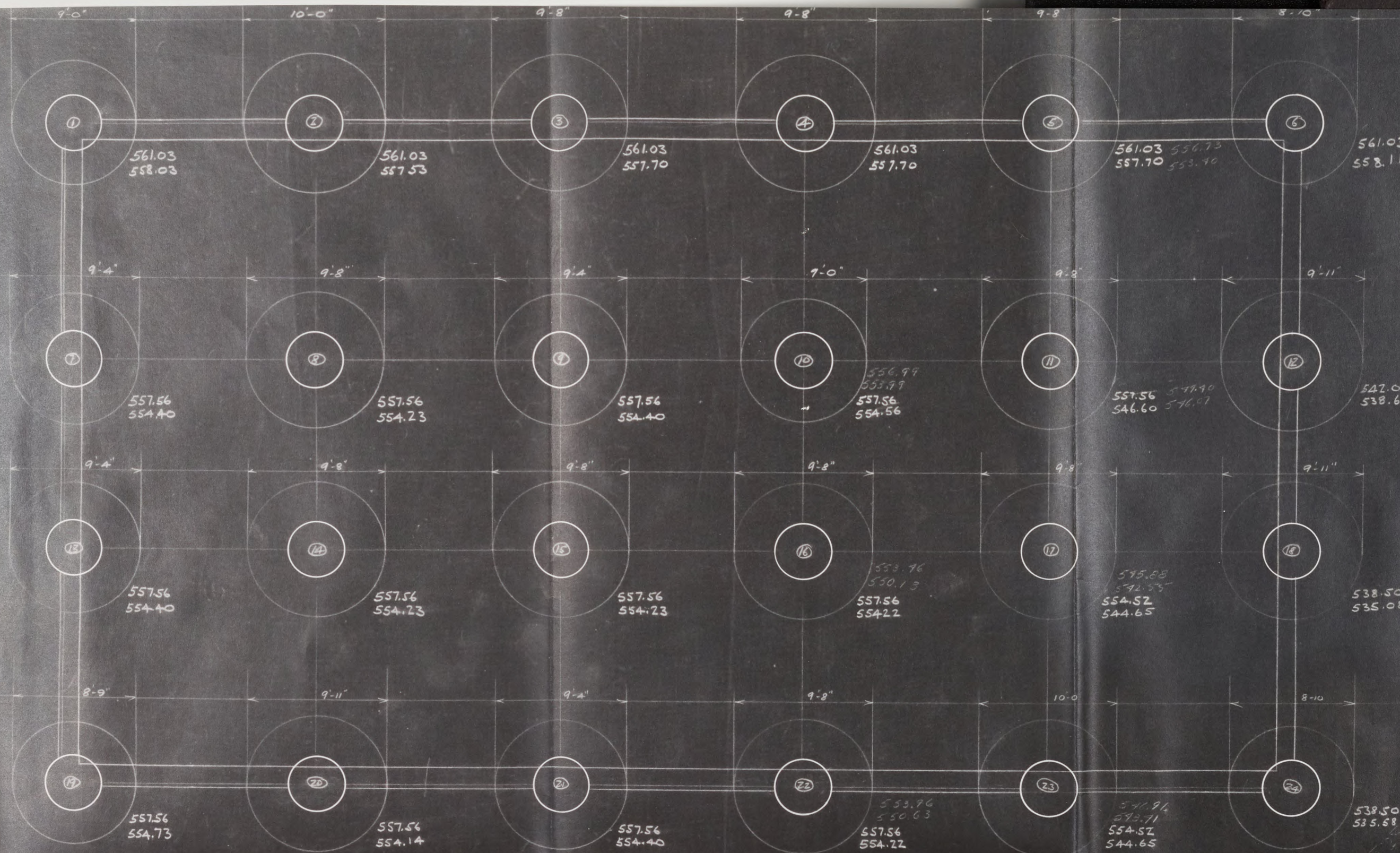
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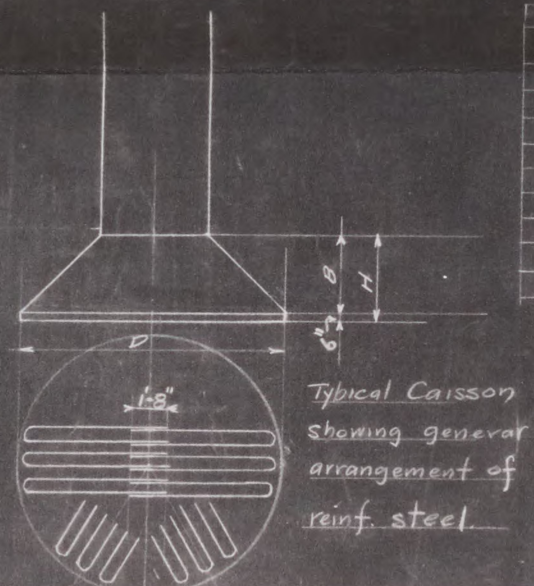
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Reinforcing
Method of Bracing
Exterior wall Trenches

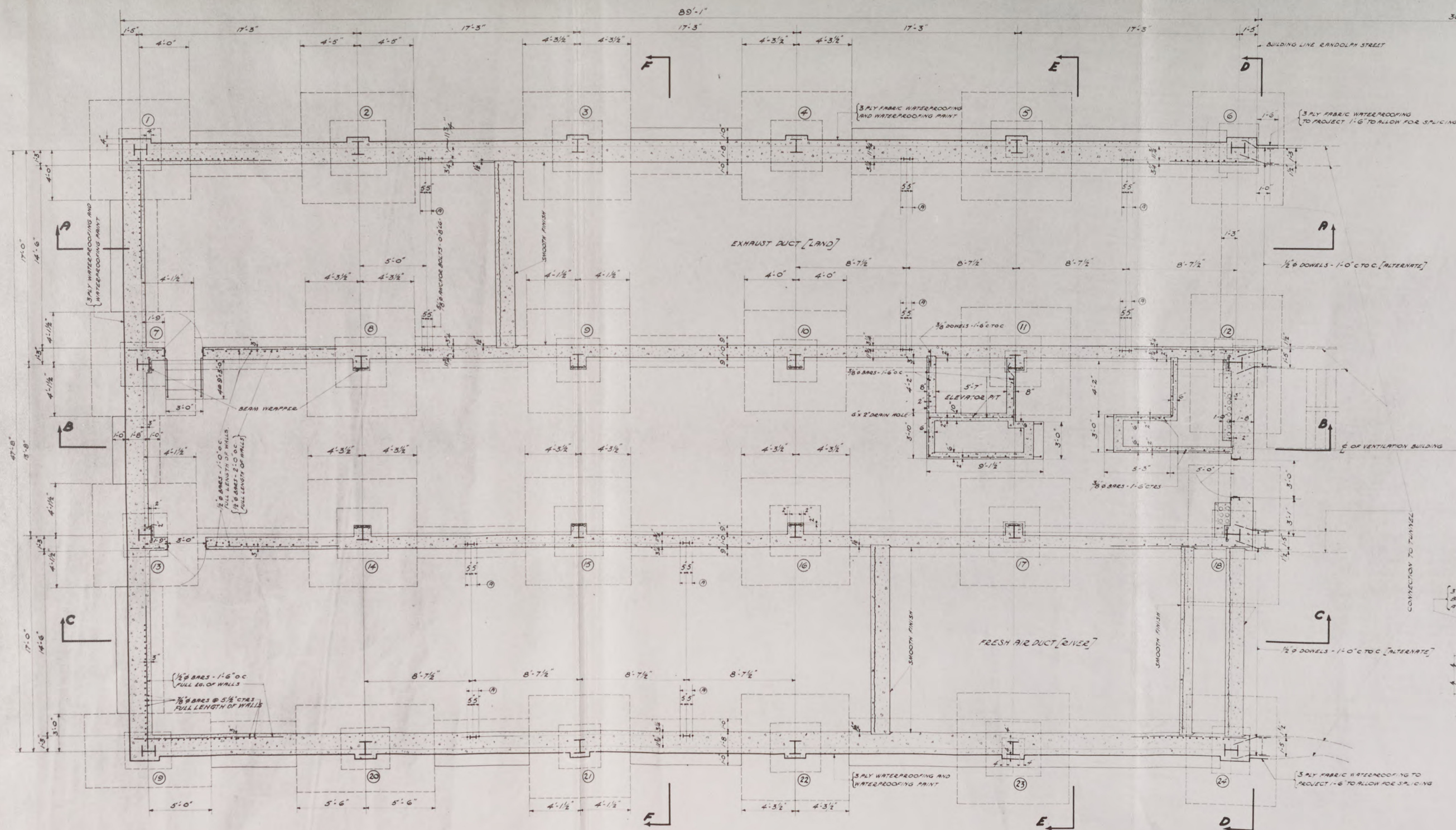


Caisson Schedule					
Col Nos	D	B	H	Total Bars	Notes
19	8-9"	2'-4"	2'-10"	18 - 1/2"	4-8
6, 24	8-10"	2'-5"	2'-11"	18 - 1/2"	4-9
1, 10	9-0"	2'-6"	3'-0"	18 - 1/2"	4-10
7, 9, 13, 21	9-4"	2'-8"	3'-2"	18 - 1/2"	5-0
3, 4, 5, 8	9-8"	2'-10"	3'-4"	18 - 1/2"	5-2
11, 14, 15, 16	9-8"	2'-10"	3'-4"	18 - 1/2"	5-2
17, 22	9-8"	2'-10"	3'-4"	18 - 1/2"	5-2
12, 18, 20	9-11"	2'-11"	3'-5"	18 - 1/2"	5-3
2, 23	10-0"	3'-0"	3'-6"	18 - 1/2"	5-4

Note All Caisson shafts 4'-0" diam
Reinf for bell as scheduled divided into six bands of three bars (six legs) each and arranged as shown.
All waterproofing to be Ironite Method
Elev. shown are top of conc. & bot. of bell.

$$V = \pi \left(\frac{d^3}{24} + \frac{16}{3} - 2d \right)$$

DETROIT VENTILATION BLDG		
FOOTING AND WALL PLAN		
THE SPENCER WHITE & PRENTIS CO. ENGINEERS & CONTRACTORS		
DATE 5/20/29	REVISIONS 6/1/29	FILE NO. 204-1



BASEMENT FLOOR PLAN

- LIST OF REFERENCE DRAWINGS
- 1 LOCATION PLAN
 - 2 FOOTING PLAN
 - 3 FIRST FLOOR FINISH PLAN
 - 4 LONGITUDINAL SECTION A-A
 - 5 LONGITUDINAL SECTION B-B
 - 6 LONGITUDINAL SECTION C-C
 - 7 LONGITUDINAL SECTION D-D
 - 8 CROSS SECTION D-D FINISH DETAILS
 - 9 CROSS SECTIONS E-E & F-F
 - 10 SECTION G-G
 - 11 ELECTRICAL CONDUIT SYSTEM BASEMENT FLOOR
 - 12 DUCT CLIMB CABLE GALLERY TO 1ST FLOOR ELECTRICAL SYSTEM

DETROIT & CANADA TUNNEL COMPANY

PARSONS, KLAPP, BRINCKERHOFF & DOUGLAS
ENGINEERS

DETROIT VENTILATION BUILDING
SUB STRUCTURE
BASEMENT FLOOR PLAN

MADE BY C.S. YR. F.P.C.

CHECKED BY F.V.

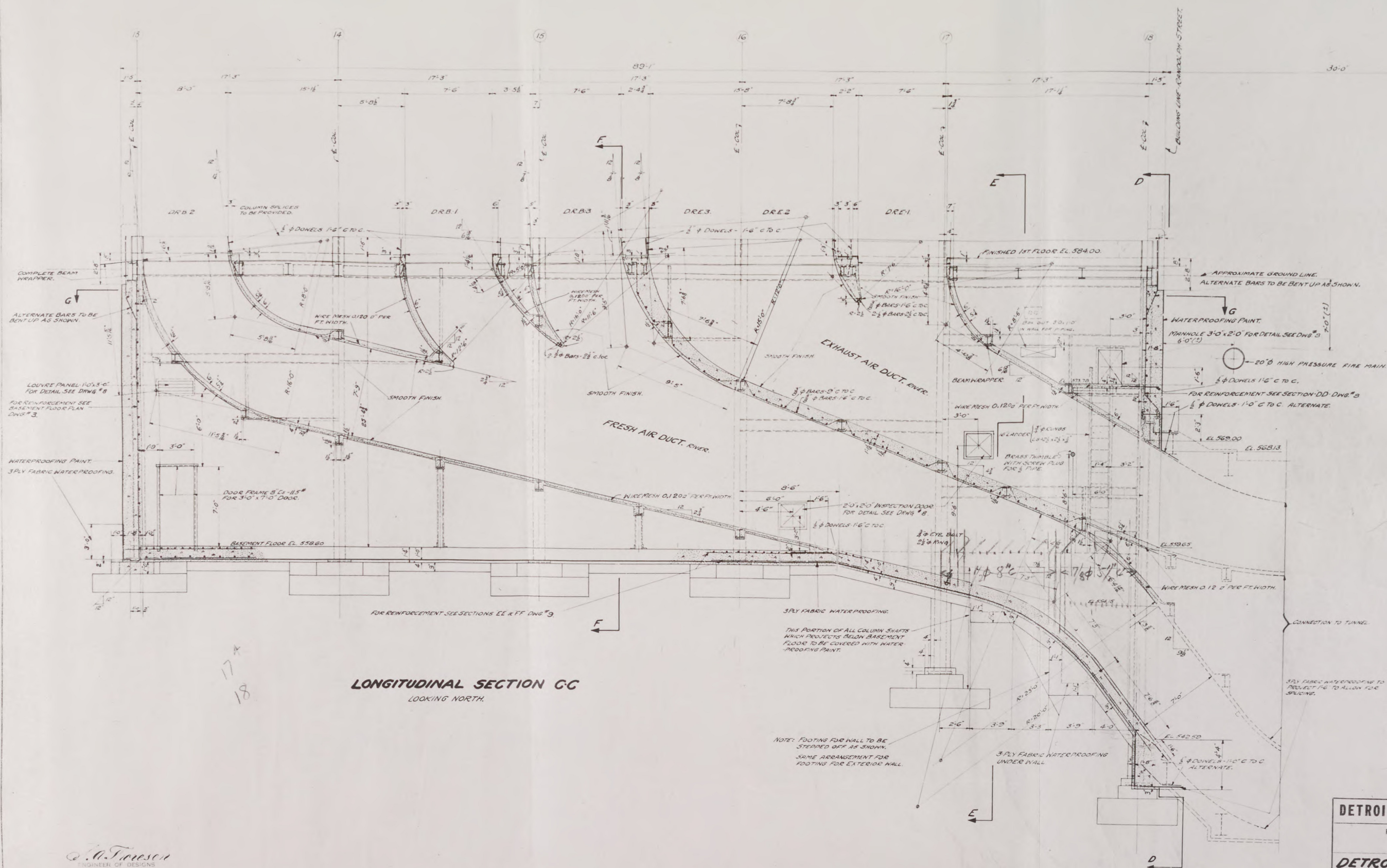
APPROVED

SCALE 1/4" = 1'-0" UNLESS NOTED

DATE 9-2-15

3

L.A. Thoresen
ENGINEER OF DESIGN



LONGITUDINAL SECTION CC
LOOKING NORTH.

NOTE:
FOR LIST OF REFERENCE DRAWINGS
SEE DWG. #3.
COMPLETE BEAM WRAPPER AROUND ALL
FIRST FLOOR BEAMS WHETHER FULLY
OR PARTIALLY ENCASED WITH CONCRETE
UNDER THIS CONTRACT.
ALL AIR DUCT SURFACES TO HAVE SMOOTH
FINISH.

DETROIT & CANADA TUNNEL COMPANY

PARSONS, KLAPP, BRINCKERHOFF & DOUGLAS
ENGINEERS
217 WOODWARD AVE., DETROIT, MICH.

**DETROIT VENTILATION BUILDING.
SUB-STRUCTURE.
LONGITUDINAL SECTION CC.**

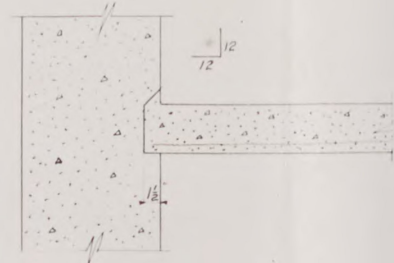
MADE BY C.S. TR. HAS
CHECKED BY F.J.
APPROVED

SCALE 1/4" = 1'-0"
DATE APR. 16, 1929
DRAWING NO. 7

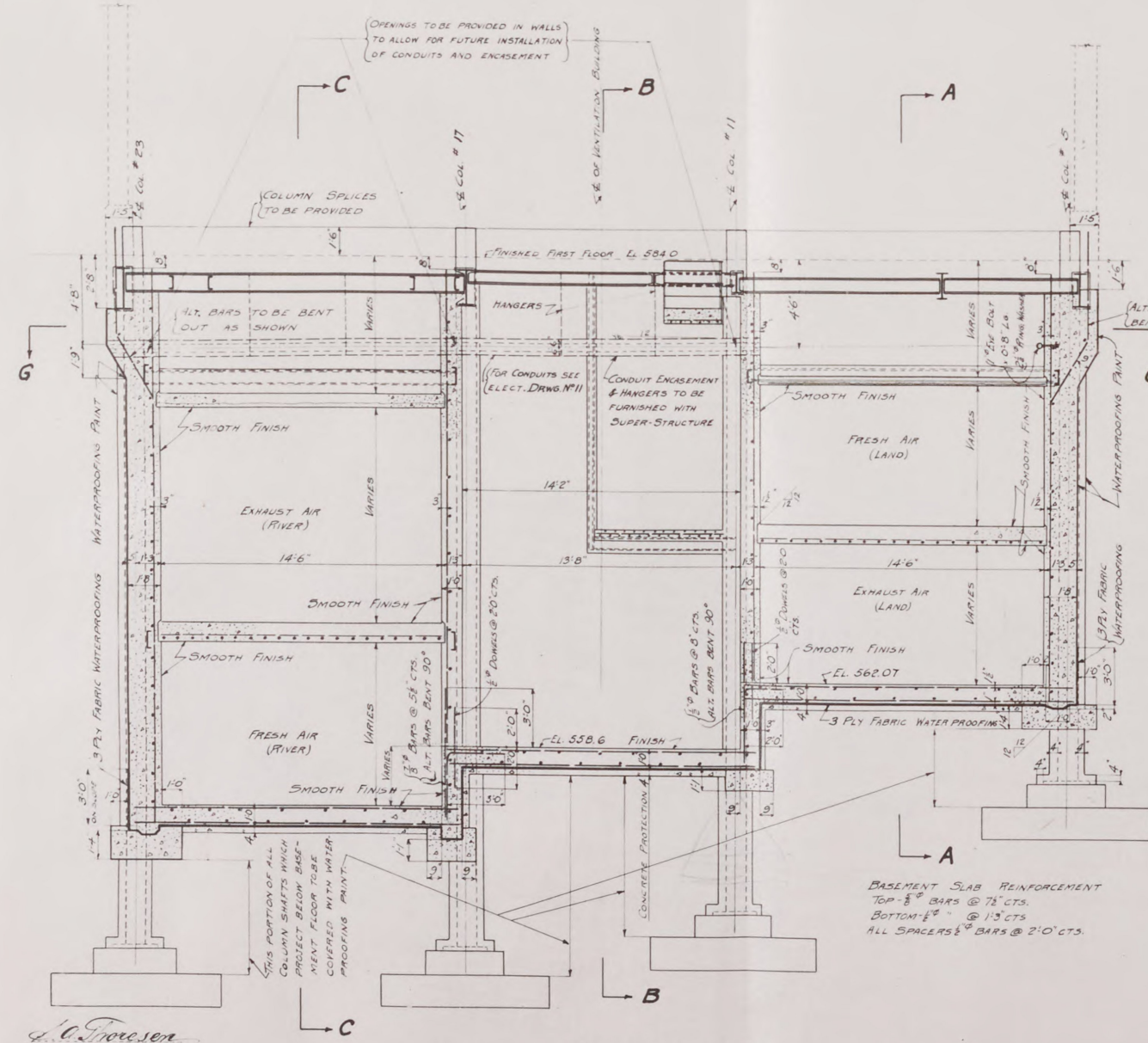
OF WALL
TAL PA

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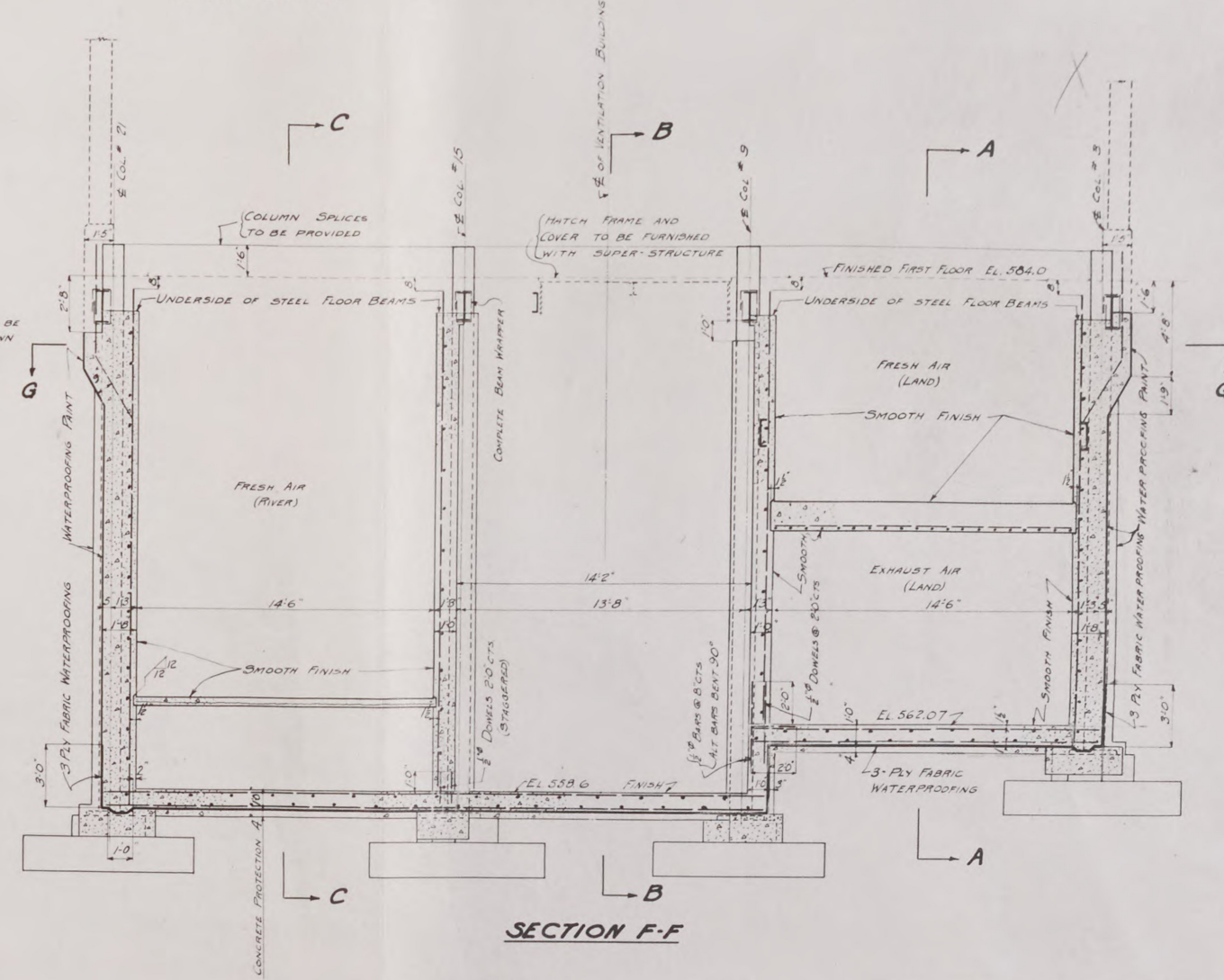
11



ENLARGED DETAIL OF WALL CHASE
TO TAKE HORIZONTAL PARTITIONS
OF AIR DUCTS.



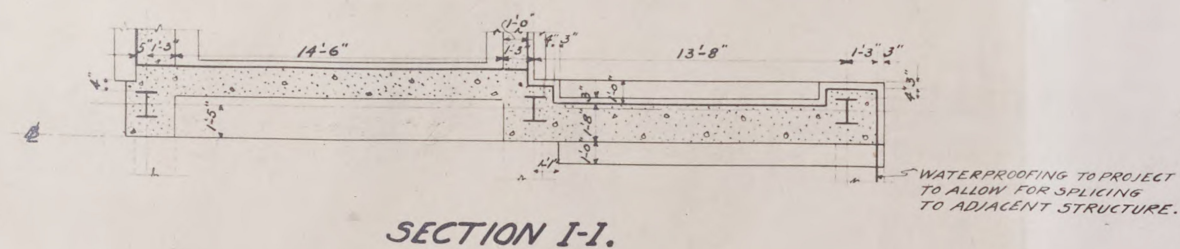
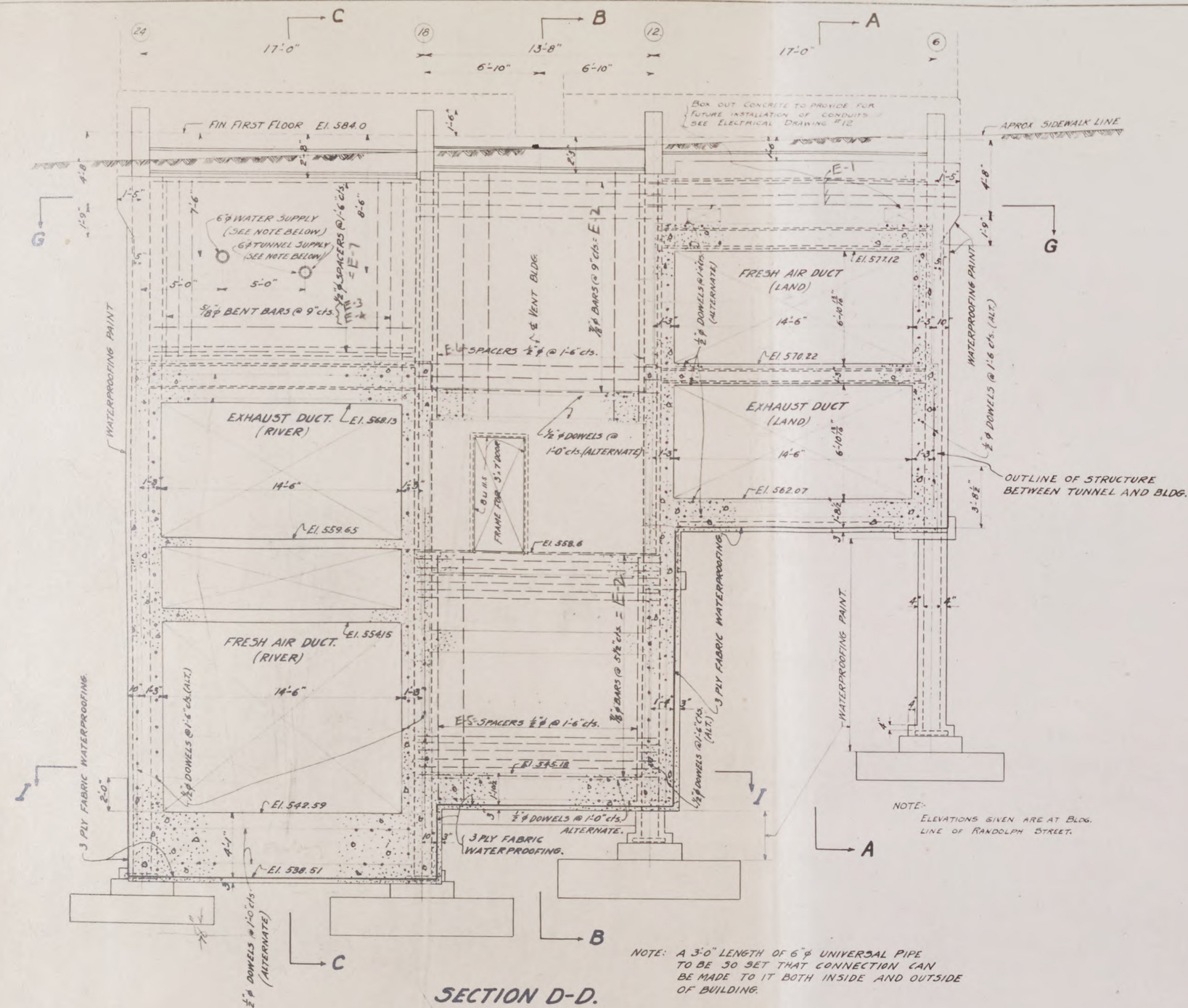
SECTION E-E



SECTION F-F

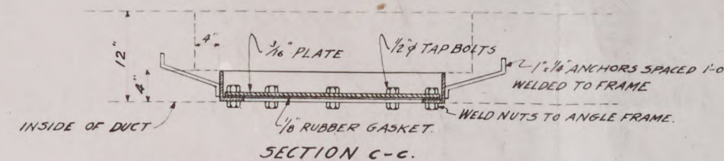
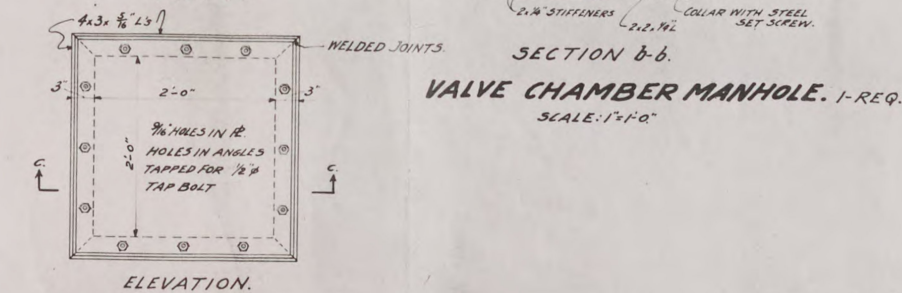
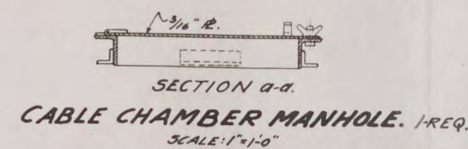
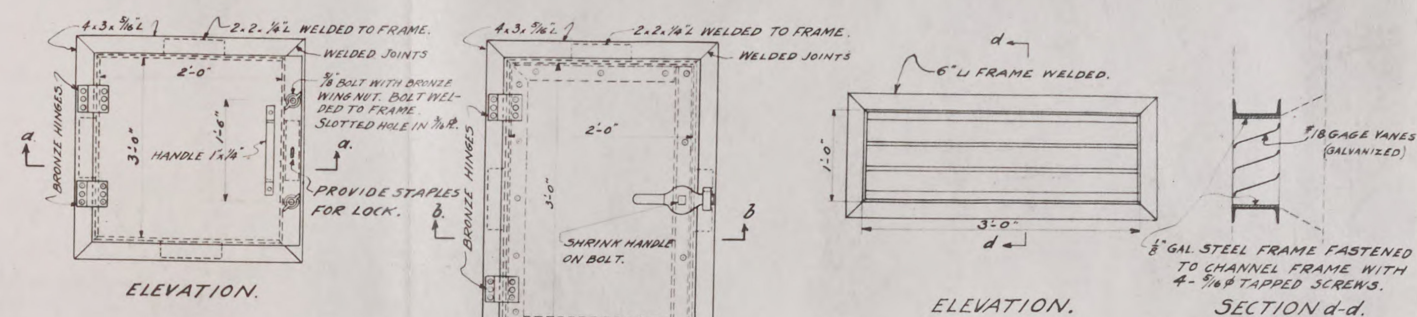
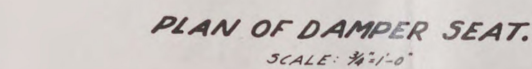
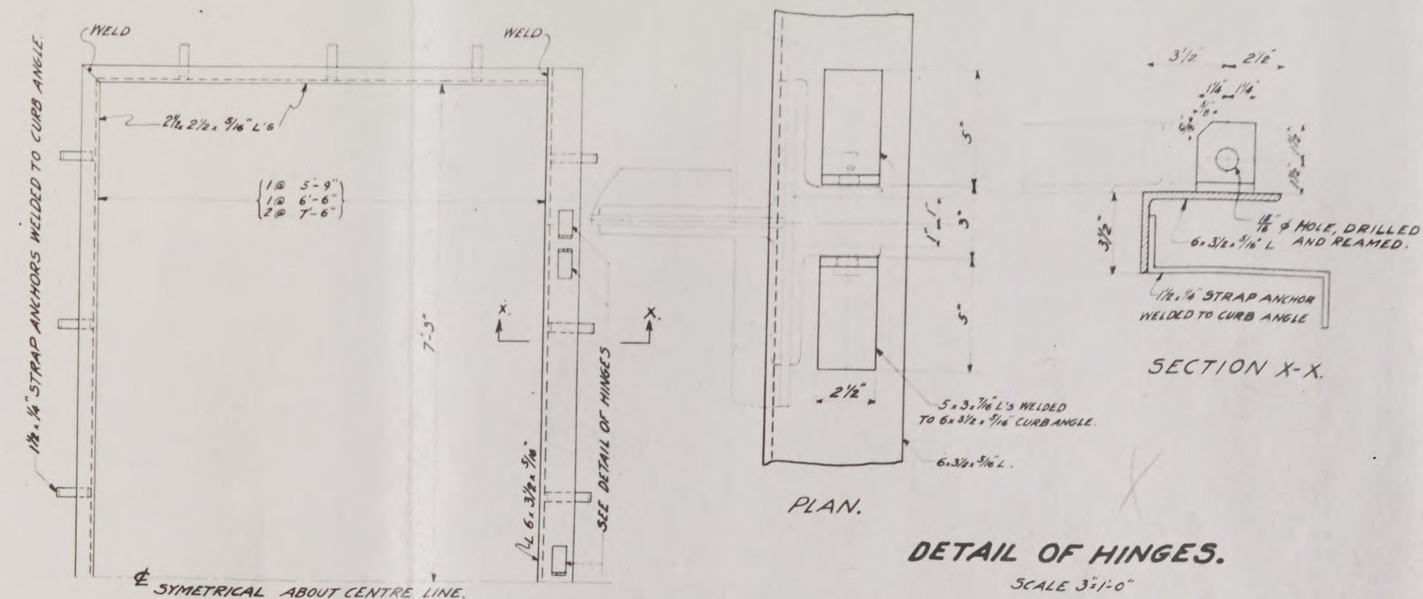
NOTE:
CONCRETE SLAB AND ENCASMENT OF FIRST FLOOR TO BE FURNISHED WITH SUPER-STRUCTURE. FOR SIZES OF REINFORCEMENT IN WALLS SEE DRAWING NO. 3 BASEMENT FLOOR PLAN. FOR SIZES OF REINFORCEMENT IN HORIZONTAL PARTITIONS OF AIR DUCTS SEE DRAWINGS NO. 5 AND 7. PORTIONS OF ALL COLUMNS WHICH PROJECT BELOW BASEMENT FLOOR TO BE ENCASED BY MEANS OF BEAM WRAPPER. FOR LIST OF REFERENCE DRWG. SEE DRWG. NO. 3.

DETROIT & CANADA TUNNEL COMPANY	
PARSONS, KLAPP, BRINCKERHOFF & DOUGLAS ENGINEERS 217 WOODWARD AVE. DETROIT, MICH.	
DETROIT VENTILATION BUILDING SUB-STRUCTURE.	
CROSS SECTIONS E-E AND F-F	
MADE BY <u>R.F.S. TR. EAC.</u>	SCALE <u>3/4" = 1'-0"</u>
CHECKED BY <u>F.J.</u>	DATE <u>APRIL 10 1923</u>
APPROVED _____	DRAWING NO. <u>9</u>



L. C. Shores
ENGINEER OF DESIGNS

ENGINEER OF DESIGNS



NOTE:
FOR LIST OF REFERENCE DRWG^s SEE DRWG #3

DETROIT & CANADA TUNNEL COMPANY

PARSONS, KLAPP, BRINCKERHOFF & DOUGLAS
ENGINEERS
217 WOODWARD AVE., DETROIT, MICH.

217 WOODWARD AVE., DETROIT, MICH.

2015-151701-1-1

DETROIT VENTILATION BLDG.
SUB STRUCTURE.

CROSS SECTION D-D & MISC. DETAILS.

MADE BY *A.B. JEFFS* TR. *AB*

SCALE $\frac{1}{4}" = 1'-0"$ Unless noted

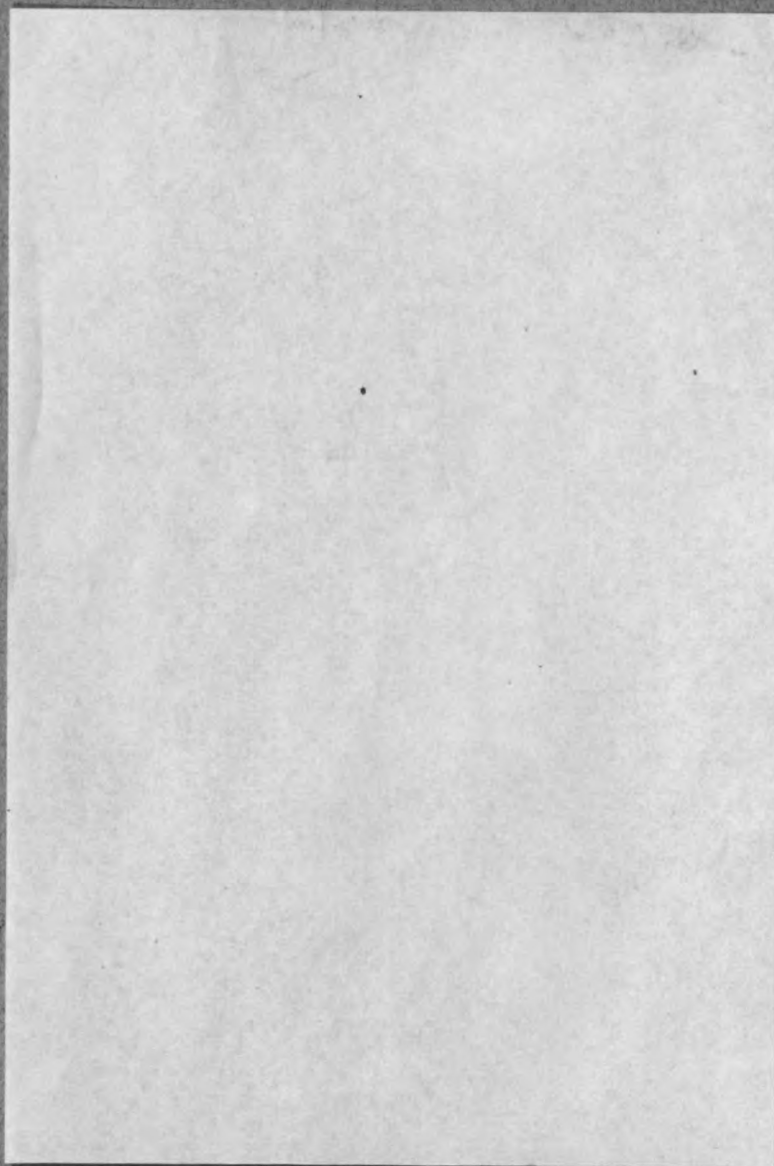
CHECKED BY *F.S.*

DATE April 16 1938

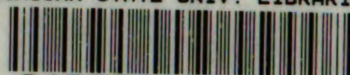
APPROVED

DRAWING NO. 8

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